Engineering

SAN/0499-82
MDC G9705

10 MWe Solar Thermal
Central Receiver Pilot Plant

SOLAR FACILITIES DESIGN INTEGRATION

PLANT MAINTENANCE/TRAINING MANUAL (RADL ITEM 2-37) SECTION 1 — ROTATING APPARATUS (BOOK 1 OF 3)

Revised September 1982
July 1981

WORK PERFORMED UNDER CONTRACT
DE-AC03-79SF10499

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
5301 BOLSA AVENUE
HUNTINGTON BEACH, CA 92647

U.S. Department of Energy

McDonnell Douglas Corporation | Rockwell International Rocketdyne Division | Stearns-Roger | Solar Energy

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PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
SOLAR ENERGY
UNDER CONTRACT DE-AC03-79SF10499

UPDATE FOR
PLANT MAINTENANCE/TRAINING MANUAL
(RADL ITEM 2-37)
SECTION 1 - ROTATING APPARATUS

INSTRUCTIONS:

1. This update is issued to incorporate corrections and additions to the preface, table of contents, index pages of the original July 1981 document and to incorporate additional information in paragraph 1.2, Pumps. This update has resulted in the addition of several books for this section (for paragraph 1.2) due to the large volume of data. Accordingly, Section 1 has been completely revised and reprinted in its entirety. Therefore you can destroy the original July 1981 issue.

2. For information, the following items were changed in the original issue:

   - Revised index pages 1.2-3, 1.3-1, 1.4-1 and 1.5-1

3. The following new data was incorporated in paragraph 1.2, Pumps:

Book 1

   - Oil Circulating Pump - Pages 1.2.1-45 thru 1.2.1-49.
   - Fluid Makeup Pump - Pages 1.2.3-1 thru 1.2.3-16.
   - Flash Tank Drain Pump - Pages 1.2.4-1 thru 1.2.4-36.
   - Raw/Service Water Pumps - Pages 1.2.6-1 thru 1.2.6-28.
   - Primary and Secondary Fire Water Pumps - Pages 1.2.7-1 thru 1.2.7-441.

Book 2

   - Fire Maintenance Jockey Pump - Pages 1.2.8-1 thru 1.2.8-51.
   - Demin. Water Transfer Pump - Pages 1.2.9-1 thru 1.2.9-23.
   - Separator Waste Water Pump - Pages 1.2.10-1 thru 1.2.10-24.
   - Oil Sump Pump - Pages 1.2.11-1 thru 1.2.11-27.
   - Raw/Service Water Sump Pump - Pages 1.2.12-1 thru 1.2.12-20.
   - Oil Sludge Pump - Pages 1.2.13-1 thru 1.2.13-14.
   - TSU Area Sump Pump - Pages 1.2.14-1 thru 1.2.14-13.

Book 3

   - Receiver Feedwater Pump - Pages 1.2.23-1 thru 1.2.23-563.
   - BCS Fluid Receiver Pump - Pages 1.2.36-1 thru 1.2.36-17.

PREFACE

This document is provided by the McDonnell Douglas Astronautics Company (MDAC) in accordance with Department of Energy Contract Number DE-AC03-79SF10499, Reports and Deliverables List Item 2-37. The material presented here is intended for training and maintenance usage by Southern California Edison Operations Personnel.

Specific notes on the organization and content of the document are as follows:

1. This document is organized in major sections that reflect the top level breakdown of the Master Equipment List as defined in RADL Item 2-19. This is in contrast to the subsystem approach used in designing the plant, however, is consistent with the Southern California Edison operating plant equipment lists.

   Section 1 - Rotating Apparatus
   Section 2 - Stationary Apparatus
   Section 3 - Electrical Apparatus
   Section 4 - Valves
   Section 5 - Instrumentation
   Section 6 - Control and Data Systems
   Section 7 - Collector System
   Section 8 - Special Heliostat Instrumentation and Meteorological Measurements Equipment
   Section 9 - Heating Ventilating and Air Conditioning
   Section 10 - Facilities

2. Assignments to categories are made on the basis of the lowest level tag numbers. For example, maintenance information for the thermal storage extraction pump skid assembly (SA-309) is not listed in the stationary apparatus section, but broken down to the generic categories as defined by the tag number; i.e., pumps (Section 1.2), air operated stop valves (Section 4.2), pressure transmitter (Section 5.2), etc.

3. The Process Instrumentation Section (Section 5.0) is organized on the basis of sensor type as defined by the first letter of the designating tag number. It contains sensor-related information only. Signal conditioning equipment is treated in Section 6.0.

4. The information on the Collector System, which was provided by the Martin Marietta Corp. (MMC) and the major items of the Electrical Power Generation System equipment, provided by Southern California Edison is not provided herein. However, the various sections were structured for their inclusion where applicable.

Technical questions concerning this RADL Item should be directed to Mr. R. G. Riedesel at (714) 896-3357 or Mr. R. J. Perkins at (714) 896-3073.

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Book 2

   - Oil Sump Pump - Pages 1.2.11-1 thru 1.2.11-27.
   - Raw/Service Water Sump Pump - Pages 1.2.12-1 thru 1.2.12-20.
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1.1 TURBINE GENERATOR

Equipment Number	Description	Maintenance Section	P&ID Dwg. Number
TG-901	Steam turbine generator and accessories	1.1.1	5163149

1.2 PUMPS

1.2 PUMPS

Equipment Number	Description	Maintenance Section	P&ID Dwg. Number
P-301	Charging oil pump	1.2.1	5163142
P-302	Charging oil pump	1.2.1	5163142
P-303	Extraction oil pump	1.2.1	5163145
P-304	Extraction oil pump	1.2.1	5163145
P-305	Aux. extraction oil pump	1.2.2	5163145
P-306	Caloria fluid makeup pump	1.2.3	5163163
P-307	Flash tank drain pump	1.2.4	5163143
P-308	Ullage makeup unit. pump	1.2.5	5163147
P-703	Raw/service water pump	1.2.6	5163157
P-704	Raw/service water pump	1.2.6	5163157
P-705	Primary elec. fire pump	1.2.7	5163161
P-706	Secondary diesel fire pump	1.2.7	5163161
P-707	Fire main. jockey pump	1.2.8	5163161
P-710	Demin. water Xfr. pump	1.2.9	5163160
P-711	Separator waste water pump	1.2.10	5163155
P-712	Separator waste water pump	1.2.10	5163155
P-714	Oil sump pump	1.2.11	5163155
P-715	Raw/service water sump pump	1.2.12	5163155
P-716	Separator sludge pump	1.2.13	5163155

Equipment Number	Description	Maintenance Section	P&ID Dwg. Number
P-717	TSU area sump pump	1.2.14	5163155
P-901	Cooling water pump	1.2.15	5163153
P-903	Thermal storage feedwater pump	1.2.16	5163151
P-904	Aux. boiler/TSS feedwater pump	1.2.17	5163151
P-905	Circulating water pump	1.2.18	5163154
P-906	Circulating water pump	1.2.18	5163154
P-907	Condensate hotwell pump	1.2.19	5163151
P-910	Condenser vacuum pump	1.2.20	5163151
P-912	Cooling tower acid pump	1.2.21	5163154
P-916	Turbine lube oil Xfr pump	1.2.22	
P-917	Receiver feedwater pump	1.2.23	5163151
P-919	Caustic feed pump	1.2.24	5163158
P-920	Caustic feed pump	1.2.24	5163158
P-923	C.T. duplex chemical pump	1.2.25	5163154
P-925	Sample chiller circ. pump	1.2.26	
P-926	Turbine lube oil pump	1.2.27	G. E. lube oil
P-927	Turbine lube oil aux. pump	1.2.27	G. E. lube oil
P-928	Turbine lube oil emerg. pump	1.2.27	G. E. lube oil

Equipment Number	Description	Maintenance Section	P&ID Dwg. Number
P-930	Sodium hypochlorite pump	1.2.28	5163154
P-931	Acid feed pump	1.2.29	5163158
P-932	Acid feed pump	1.2.29	5163158
P-933	Hydrazine feed pump	1.2.30	5163158
P-934	Ammonia feed pump	1.2.30	5163158
P-935	Acid transfer pump	1.2.31	5163158
P-936	Polishing demin. sump pump	1.2.32	5163158
P-937	Polishing demin. sump pump	1.2.32	5163158
P-938A&B	Turbine control oil pump	1.2.33	G. E. lube oil
P-939	Sluice water pump	1.2.34	
P-940	Sluice water pump	1.2.34	
P-941	Gland steam exhauster	1.2.35	
P-942	Receiver F.W. Lube Oil Pump	Included in 1.2.23	
P-943	Hydraulic Oil Recirculating Pump	1.1.1*	
P-945	Turbine Lube Oil TK Vapor Extractor	1.1.1*	
P-201	BCS Fluid Receiver Pump	1.2.36	5133152
P-718	Maintenance Oil Sump Pump (TSU Area - Portable)	1.2.37	

*Furnished w/Turbine Generator

1.2 PUMPS

1.2.1 Oil Circulation Pumps

1.2.1.1 Identification Tag Number / Description

Identification Tag Number	Description
P301	Charging Oil Pump
P302	Charging Oil Pump
P303	Extraction Oil Pump
P304	Extraction Oil Pump

1.2.1.2 Description

Manufacturer	:	Dean Brothers Pumps, Inc. P.O. Box 68172, Indianapolis, Indiana 46268
Part Number	:	6 X 8 X 15½ R484-132370
Specification No.	:	Rocketdyne Specification GA000-90907-T10 (following)
Material	:	
Weight	:	919 lb.

1.2.1.3 Prescribed Service

Oil, 130 PSIA, 600° F.

1.2.1.4 Vendor

Paul L. Armstrong Co., Inc., P.O. Box 928, South Pasadena, CA 91030

1.2.1.5 Special Cautions

See Dean Bros. manual MC-1.4.40 (Sec. 1.2.1.12)

1.2.1.6 Periodic Service

See Dean Bros. manual MC-1.4.40 (Sec. 1.2.1.12)

1.2.1.7 Parts List

See Dean Bros. manual MC-1.4.40 (Sec. 1.2.1.12)

1.2.1.8 Special Tools

None

1.2.1.9 Maintenance Instructions

See Dean Bros. manual MC-1.4.40 (Sec. 1.2.1.12)

1.2.1.10 Acceptance Tests

See Dean Bros. manual MC-1.4.40 (Sec. 1.2.1.12)

1.2.1.11 Description of Auxiliary Piping Connections

Seal Flush Loop. The seal flush loop is a 1/2 inch steel tubing running from a connection under the pump discharge flange to the pump stuffing box. The purpose of this is to supply a small amount of pump fluid to the mechanical seal area. The stuffing box is angle drilled so that this flush actually enters the stuffing box near the mechanical seal faces. The flow is regulated with an orifice in the tubing system. This is a totally self-contained flush system, requiring no external connections.

Stuffing Box and Bearing Bracket Cooling System. To reduce the temperature in the stuffing box for longer mechanical seal life, the stuffing box is equipped with a water jacket. This same water is piped in series around the bearing bracket for cooling the bearing areas. The pump is equipped with two 3/4 inch valves. Water usage of 3 to 5 GPM during pump operation is expected. The inlet valve can be distinguished because it is followed by a solenoid valve and flow switch. The cooling water then enters the pump stuffing box jacket. An interconnecting tubing link is furnished between the offside cooling water jacket and the bearing bracket. The single cooling water discharge line comes from the pump bearing bracket.

General Electric provides a connection for the solenoid valve which will allow a time delay shut down after the pump stops. This is simply to allow a short period of time for water flow to continue through the unit so that there is no hot spot development from sudden shut down of the cooling water. The flow switch is set at a minimum flow of 1.5 GPM. Should it activate, it would indicate higher loss of cooling water flow, or a blocked valve bearing closed. There is nothing wrong with running water through the jackets of idle pumps if desired.

Seal Blanket System. Between the flow switch and the stuffing box is a 1/4 inch tubing connection, equipped with a 1/4 inch needle valve. The tubing is bent around the pump discharge nozzle and connected to the vent connection of the mechanical seal gland.

The drain connection of the mechanical seal gland is equipped with a 3/4 inch pipe terminating in a thermal switch. This thermal switch is adjustable in temperature ranges between 100 and 600^{o}F, and is currently adjusted to approximately 300^{o}F.

The purpose of this tubing is to allow generation of a small amount of steam. This steam is going to be directed through the area in back of the mechanical seal. The steam is used to exclude oxygen from that area. Oxygen in that area will allow a small amount of heat medium fluid leaking past the seal faces to carbonize.

In time, this carbonization can effect the operation of the mechanical seal. By excluding oxygen, this small amount of leakage will be directed into the drain, and cooled at that point. This should eliminate the seal problem.

The thermal switch terminates near the base plate drain because steam, containing a small amount of heat medium fluid, will be continually condensing. A small continual flow of condensate is normal. Lack of condensate flow indicates the system is not performing properly. A large steam discharge also indicates the system is not performing properly. The needle valve must be adjusted somewhere between these two extremes. Final needle valve adjustment must be determined in the field. The pump casing and the steam generation tube may be insulated but the tubing must make contact with the pump casing to generate the small amount of steam required.

Casing Drain Valve. A casing drain valve has been provided. The placement is slightly awkward because it was desireable to have this drain in the pocket in the base plate. This valve should always be closed unless there is some reason to open the pump for inspection or repair.

Pump Mounting. Filling the cavity under the pump base plate with cement will result in a firmer foundation, fewer mechanical seal and bearing problems, and consequently reduced maintenance.

ROCKWELL INTERNATIONAL CORPORATION
ROCKETDYNE DIVISION
6633 CANOGA AVENUE, CANOGA PARK, CALIFORNIA 91304

FACILITIES ENGINEERING, DEPARTMENT 541

SPECIFICATION NUMBER GA000-90907-T10

FOR

CHARGING AND EXTRACTION OIL PUMPS AND DRIVES
THERMAL STORAGE SYSTEM
10 MWe SOLAR PILOT PLANT

BARSTOW, CALIFORNIA

J. A. BOWMAN
MANAGER
FACILITIES ENGINEERING

A. E. MOORE
CHIEF PROJECT ENGINEER

J. REPAS
SENIOR PROGRAM COORDINATOR
QUALITY PROJECT MANAGEMENT

A. DJORDJEVIC
PROJECT ENGINEER
FACILITIES ENGINEERING

10 DECEMBER 1979

THIS SPECIFICATION WAS APPROVED, CHECKED, AND PREPARED BY THE UNDERSIGNED

MECHANICAL DESIGN UNIT

APPROVED BY R. H. Lynch DATE 12/14/79

CHECKED BY Robert Smith DATE 12-13-79

PREPARED BY Walter Q. Knippel DATE 12-13-79

ELECTRICAL DESIGN UNIT

APPROVED BY H. L. Stephens DATE 12-13-79

CHECKED BY Paul E. Hamilton DATE 12-13-79

PREPARED BY H. L. Stephens DATE 12-13-79

CONTENTS

KEY ITEM HEADINGS

1.0 SCOPE

1.1 FOUR SINGLE STAGE, CENTRIFUGAL, VOLUTE-TYPE, HORIZONTAL, HOT OIL PUMPS SHALL BE FURNISHED, EACH FACTORY ASSEMBLED, ALIGNED WITH COUPLING AND MOTOR ON A BASEPLATE, AND FOUR VARIABLE SPEED CONTROL SYSTEMS, DELIVERED IN ACCORDANCE WITH THE REQUIREMENTS OF THIS SPECIFICATION.

1.1.2 EACH PUMP SHALL BE DESIGNED FOR SERVICE IN HEATING OIL, EXXON CALORIA HT-43, AND TO OPERATE AT VARIABLE SPEED WITH VARYING CAPACITIES AGAINST A SPECIFIED VARIABLE DISCHARGE HEAD THROUGH THE SPECIFIED TEMPERATURE RANGE.

1.1.3 TWO OF THE PUMPS WILL PROVIDE OIL CHARGING SERVICE AND TWO PUMPS WILL PROVIDE OIL EXTRACTION SERVICE.

2.0 APPLICABLE DOCUMENTS.

2.1 THE FOLLOWING DOCUMENTS OF THE LATEST REVISION IN EFFECT ON THE DATE OF ISSUE OF THIS SPECIFICATION FORM A PART OF THIS SPECIFICATION. THE ABSENCE OF SPECIFIC REFERENCE TO THESE DOCUMENTS THROUGHOUT THESE SPECIFICATIONS SHALL NOT IN ANY WAY RELIEVE THE SUPPLIER FROM COMPLIANCE. DEVIATIONS FROM ANY SPECIFICATION OR DOCUMENT SHALL REQUIRE THE WRITTEN APPROVAL OF ROCKWELL INTERNATIONAL.

2.1.1 AMERICAN NATIONAL STANDARDS INSTITUTE CODE FOR PRESSURE PIPING, ANSI B31.1 AND STEEL PIPE FLANGES AND FLANGED FITTINGS B16.5

2.1.2 HYDRAULIC INSTITUTE STANDARDS, 1975 EDITION, 13.

2.1.3 CALIFORNIA ADMINISTRATIVE CODE, TITLE 8, CHAPTER 4, SUBCHAPTER 4, CONSTRUCTION SAFETY ORDERS, AND SUBCHAPTER 7, GENERAL INDUSTRY SAFETY ORDERS.

2.1.4 OCCUPATIONAL SAFETY AND HEALTH STANDARDS, PART 1910.

2.1.5 THE NATIONAL ELECTRICAL CODE, NFPA 70.

2.1.6 UNDERWRITERS LABORATORY OR FACTORY MUTUAL ELECTRICAL TEST PROCEDURES FOR LISTED ELECTRICAL EQUIPMENT.

2.1.7 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SURFACE PREPARATION SPECIFICATION SSPC-SP, 3-1973.

3.0 DOCUMENT SUBMITTALS

3.1 ONE REPRODUCIBLE COPY OF THE FOLLOWING DATA SHALL BE SUBMITTED WITH THE BIDS, TO ROCKWELL INTERNATIONAL.

3.1.1 OVER-ALL DRAWINGS OF THE PUMPS SHOWING ENVELOPE DIMENSIONS AND ALL INTERFACE DIMENSIONS.

3.1.2 PROPOSED MATERIAL SPECIFICATIONS.

3.1.3 SECTIONAL DRAWING OF COMPLETE PUMP WITH PART IDENTIFICATIONS.

3.1.4 CENTRIFUGAL PUMP PERFORMANCE CURVES AT MINUMUM RPM, 50% RPM, 100% RPM AND 125% RPM, INCLUDING NPSH, EFFICIENCY, TOTAL HEAD, HP AND RPM DATA, FOR CALORIA HT-43 AT 580°F FOR THE EXTRACTION PUMPS AND 425°F FOR THE CHARGING PUMPS.

3.1.5 INFORMATION REGARDING MAXIMUM ALLOWABLE FLUID THERMAL TRANSIENT FOR BOTH HEATING AND COOLING.

3.1.6 A LIST OF RECOMMENDED SPARE PARTS AND TOOLS, WITH INSTRUCTIONS FOR PUMP DISASSEMBLY AND REASSEMBLY.

3.1.7 DRAWINGS OF OUTLINE AND BASE DIMENSIONS OF THE PUMP AND MOTOR ASSEMBLY.

3.1.8 DRAWINGS OF OUTLINE AND OVERALL DIMENSIONS OF THE VARIABLE SPEED DRIVE.

3.2 CERTIFIED COPIES OF THE AFOREMENTIONED DATA, PARAGRAPHS 3.1.1 THROUGH 3.1.7 INCLUSIVE, SHALL BE SUBMITTED TO ROCKWELL INTERNATIONAL WITHIN (14) DAYS AFTER THE RECEIPT OF ORDER.

3.3 THREE COPIES OF COMPLETE PARTS LIST, INSTALLATION, MAINTENANCE AND OPERATING INSTRUCTIONS SHALL BE SUBMITTED TO ROCKWELL INTERNATIONAL AT THE TIME OF PUMP DELIVERY.

3.4 ONE SET OF REPRODUCIBLE ELECTRICAL SCHEMATICS, WIRING DIAGRAMS, INTERCONNECTION DIAGRAMS, AND COMPONENT SCHEMATICS SUCH AS POWER SUPPLIES, FIRING CIRCUITS, ETC. SHALL BE SUPPLIED AT THE TIME OF DELIVERY.

3.5 CERTIFIED PUMP TEST REPORTS, INCLUDING DATA LISTED IN PARAGRAPH 3.1.4, SHALL BE SUBMITTED PRIOR TO SHIPMENT.

4.0 DESIGN AND CONSTRUCTION.

4.1 PUMPS SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS SET FORTH BY THE 13TH EDITION OF THE HYDRAULIC INSTITUTE STANDARDS.

4.2 PUMPS SHALL BE DESIGNED AND CONSTRUCTED SO THAT THERMAL EXPANSION WILL NOT DISTURB ALIGNMENT OF SHAFT BEARINGS, SHAFT PACKING, SHAFT COUPLINGS, OR SEALS.

4.3 EACH OF THE PUMPS SHALL BE CENTERLINE MOUNTED, END SUCTION, VERTICAL DISCHARGE, FURNISHED ON A RIGID PUMP/MOTOR BASEPLATE COUPLED TO THE MOTOR WITH PROVISION FOR OIL SPILL DRAINAGE TO A SINGLE POINT. A COUPLING GUARD SHALL BE FURNISHED.

4.4 THE ELEVATION OF THE SUCTION FLANGE CENTERLINE ABOVE THE BOTTOM OF THE BASEPLATE SHALL NOT EXCEED ONE FOOT NINE INCHES.

4.5 PUMP CASTINGS AND BEARING HOUSINGS SHALL BE MACHINED WITH A DEEP GROOVE OR DOWELLING TO MAINTAIN RIGID ALIGNMENT OF THE TOTAL ASSEMBLY.

4.6 PUMP SUPPORTS AND BEARING HOUSINGS SHALL BE STRESS RELIEVED.

4.7 COOLING OF PUMP BEARINGS AND SEALS, IF REQUIRED, SHALL BE ACCOMPLISHED IN A MANNER THAT SHALL MINIMIZE THE LOSS OF HEAT FROM THE OIL.

4.8 TO ENSURE COMPATIBILITY OF THE EXXON CALORIA HT-43 HEAT TRANSFER FLUID WITH THE MATERIALS USED FOR THE CONSTRUCTION OF THE PUMPS, NO COPPER OR ALLOYS CONTAINING A SIGNIFICANT AMOUNT OF COPPER SHALL BE USED.

5.0 PERFORMANCE REQUIREMENTS

THE PUMP SHALL BE DESIGNED TO PROVIDE CHARGING, EXTRACTION, AND WARM UP SERVICE ACCORDING TO THE FOLLOWING REQUIREMENTS.

5.1 EXTRACTION PUMP SERVICE

EACH PUMP SHALL PRODUCE AN OPERATING PRESSURE WITHIN THE LIMITS SPECIFIED IN FIGURE 1 OVER THE FLOW RANGE OF 177 GPM to 2030 GPM. OPERATION BELOW 1767 GPM SHALL BE CONSIDERED CONTINUOUS DUTY. OPERATION ABOVE 1767 GPM SHALL OCCUR FOR A MAXIMUM OF 20 MINUTES IN EACH 24 HOUR PERIOD STARTING FROM STABILIZED THERMAL OPERATION AT 1770 GPM.

THE PUMP SHALL OPERATE OVER THE REQUIRED FLOW RANGE WITHIN THE TEMPERATURE RANGE OF 350 F TO 580 F. PUMP HEAD AS GIVEN IN FIGURE 1 SHALL BE DEVELOPED OVER THE REQUIRED FLOW RANGE WITH FLUID INLET TEMPERATURES FROM 560 F TO 580 F.

5.2 CHARGING PUMP SERVICE

EACH PUMP SHALL PRODUCE AN OPERATING PRESSURE WITHIN THE LIMITS SPECIFIED IN FIGURE 2 OVER THE FLOW RANGE OF 148 TO 1700 GPM. OPERATION BELOW 1480 GPM SHALL BE CONSIDERED CONTINUOUS DUTY. OPERATION ABOVE 1480 GPM SHALL OCCUR FOR A MAXIMUM OF 20 MINUTES IN EACH 24 HOUR PERIOD STARTING FROM THE MAXIMUM TEMPERATURE.

THE PUMP HEAD AS SHOWN IN FIGURE 2 SHALL BE DELIVERED OVER THE REQUIRED FLOW RANGE WITH THE HEAT TRANSFER FLUID IN THE RANGE OF 350 F TO 500 F. THE PUMP SHALL BE CAPABLE OF OPERATION WITHOUT DAMAGE OR ABOVE-NORMAL WEAR AT TEMPERATURES UP TO 580 F.

5.3 WARM UP SERVICE (60F TO 350F)

ALL PUMPS SHALL BE CAPABLE OF CONTINUOUS OPERATION AND MEET THE HEAD REQUIREMENTS UP TO A FLOW RATE OF 900 GPM WITH FLUID TEMPERATURE DOWN TO 60 F. IF THE PUMP CANNOT MEET THE REQUIRED FLOW FOR THE WARM UP SERVICE, THE MANUFACTURER SHALL IDENTIFY THE FLOW FOR THE WARM UP SERVICE THAT THE PUMPS ARE CAPABLE OF DELIVERING.

5.4 POWER CONSUMPTION

PUMP SHAFT POWER SHALL NOT EXCEED 200 HORSEPOWER.

5.5 NPSH

A NPSH OF AT LEAST 25 FT IS AVAILABLE UNDER ALL OPERATING CONDITIONS.*

5.6 OPERATING ENVIRONMENT

5.6.1 FLUID TEMPERATURE OPERATING RANGE WILL BE 60 F TO 580 F.

5.6.2 AMBIENT TEMPERATURE RANGE WILL BE 16 F TO 113 F.

5.6.3 PUMP SHALL BE LOCATED IN THE OUTSIDE ATMOSPHERE AT A SITE ELEVATION OF 1950 FEET (13.72 PSIA)

5.6.4 INLET PRESSURE

STATIC PRESSURE AT THE PUMP INLET WILL COVER THE RANGE OF -5 PSIG WHEN OPERATING AND A MAXIMUM OF 13 PSIG DURING NON-OPERATION. NEGATIVE VALUES ARE ASSOCIATED WITH OPERATION OF THE FLUID BELOW 100 F.

5.7 LOADS

5.7.1 PIPING

IT IS DESIRABLE THAT THE PUMP ASSEMBLY BE CAPABLE OF SUPPORTING THE FOLLOWING LOADS:

PUMP SUCTION FLANGE

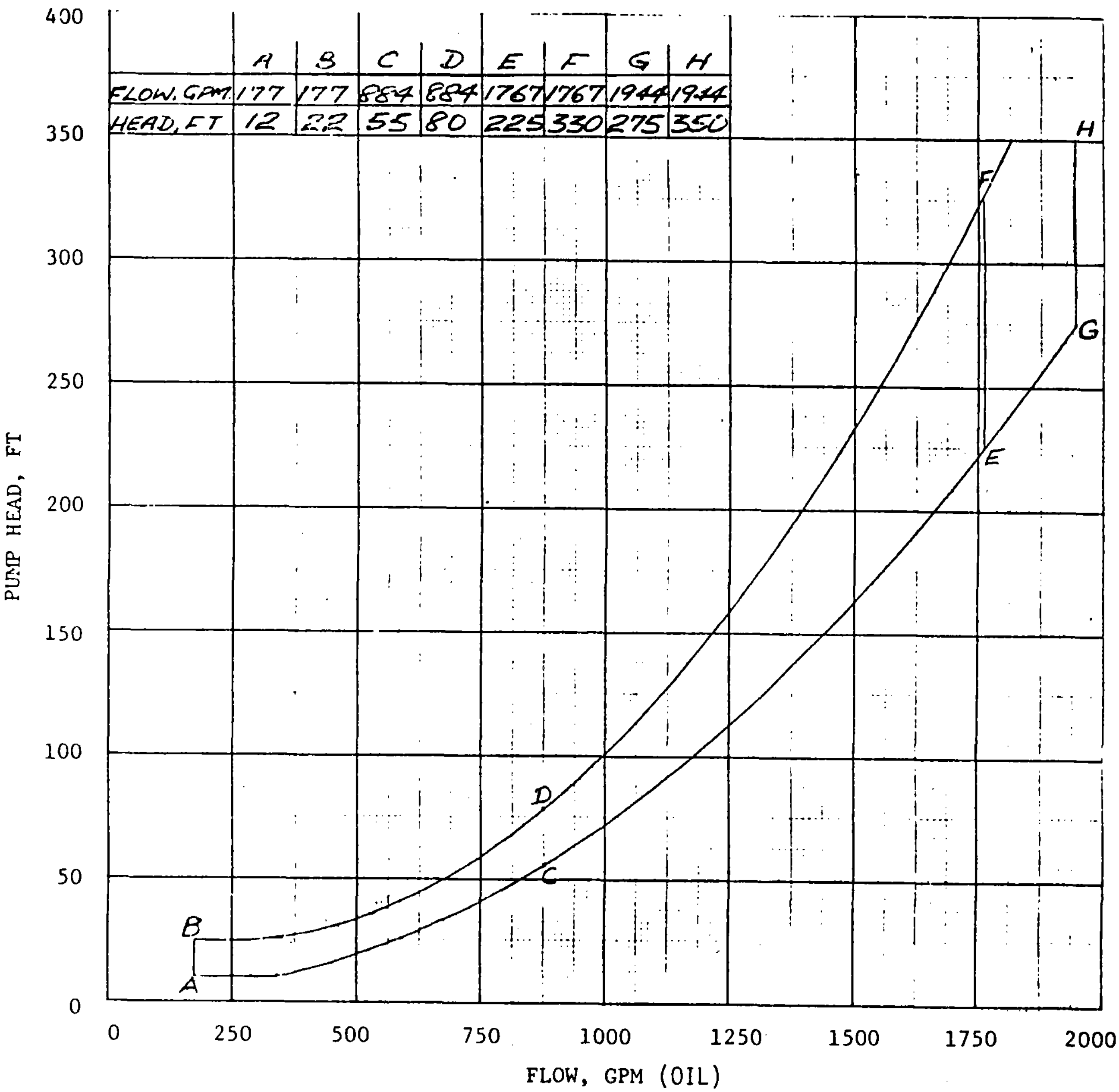
	Fx	Fy	Fz	Fr	Mx	My	Mz
ALLOWABLE LOADS	1103	552	919	2000	3000	1615	1500

PUMP DISCHARGE FLANGE

	Fx	Fy	Fz	Fr	Mx	My	Mz
ALLOWABLE LOADS	960	1102	780	2000	3000	1615	1500

FORCE UNITS = LBS. MOMENT UNITS = LB. FT.

* BASED ON OIL



	A	B	C	D	E	F	G	H
FLOW, GPM	177	177	884	884	1767	1767	1944	1944
HEAD, FT	12	22	55	80	225	330	275	350

Figure 1. Extraction Pump Service Requirements

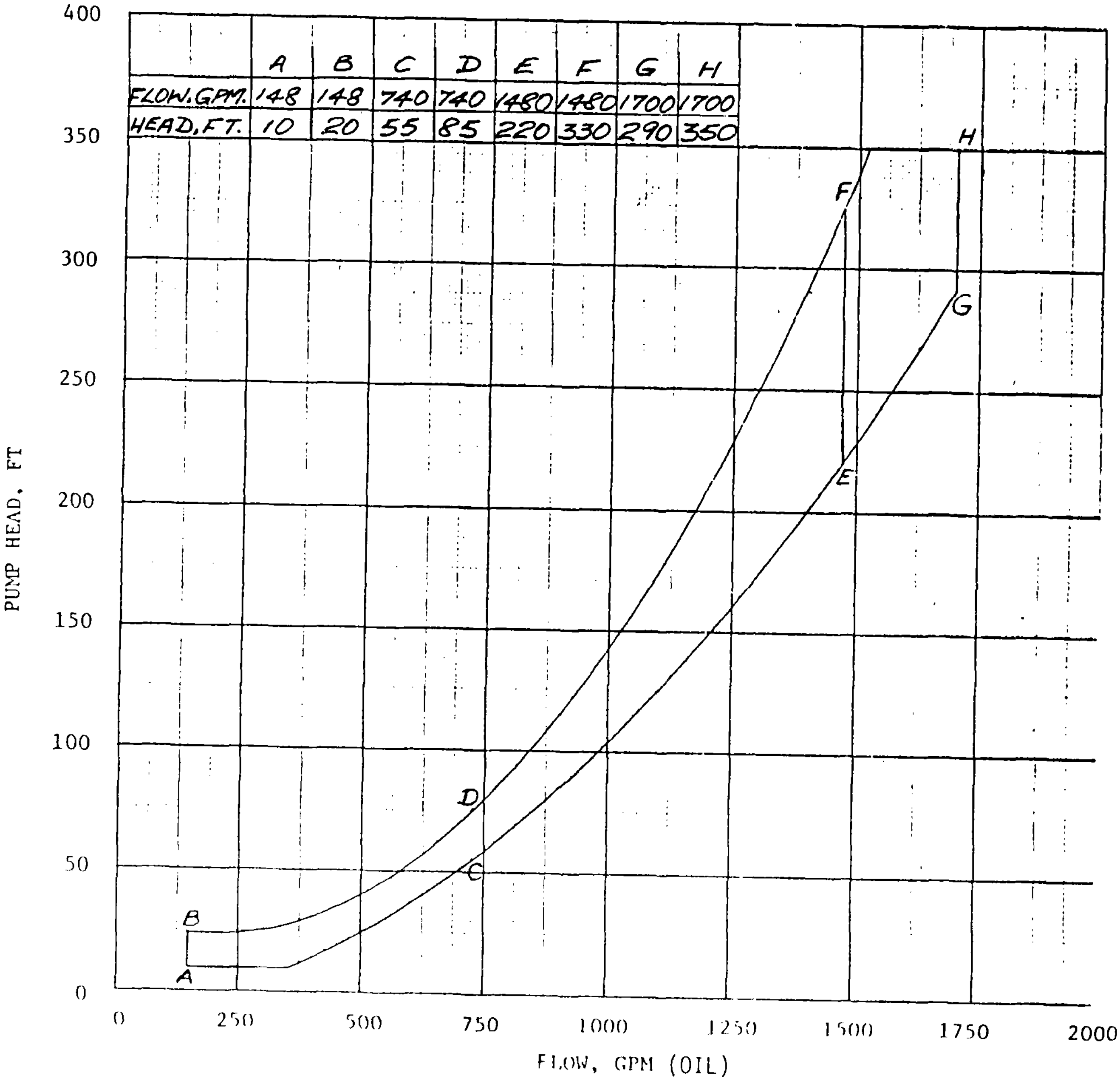


Figure 2. Charging Pump Service Requirements

6.0 PROPERTIES OF EXXON CALORIA HT-43 HEAT TRANSFER FLUID

6.1 THE FLUID IS A COMMERCIAL PRODUCT MANUFACTURED BY EXXON CORPORATION AND IS DESCRIBED BY THEM AS "A PETROLEUM FRACTION SIMILAR TO LIGHT LUBE OIL". PROPERTY VALUES FOR DENSITY, HEAT CAPACITY, THERMAL CONDUCTIVITY, AND VISCOSITY ARE GIVEN AS FUNCTIONS OF TEMPERATURE IN TABLE 1. OTHER PROPERTY DATA IS SUMMARIZED BELOW:

MAXIMUM RECOMMENDED BULK TEMPERATURE: 600F

MAXIMUM RECOMMENDED FILM TEMPERATURE: 680F

POUR POINT: 15F (-9C)

FLASH POINT: 400F (204C)

AUTOIGNITION TEMPERATURE: 759F (404C)

VAPOR PRESSURE:

TEMP.	FRESH FLUID	WEATHERED FLUID
400F	0.57 PSIA	0.09 PSIA
450F	1.8 PSIA	0.3 PSIA
500F	3.7 PSIA	0.8 PSIA
575F	9.0 PSIA	2.7 PSIA
600F	11.3 PSIA	3.7 PSIA

TABLE 1, PROPERTIES OF EXXON CALORIA HT-43 AT SELECTED TEMPERATURES

TEMPER-ATURES	DENSITY			SPECIFIC HEAT	THERMAL CONDUCTIVITY	VISCOSITY	
	GR/CC	LB/FT3	LB/GAL	BTU/LB-F	BTU/FT-HR-F	CENTI POISE	LBm/HR-FT
40F	0.863	53.9	7.20	0.42	0.073	240	580
77F	0.850	53.1	7.09	0.44	0.070	57.9	140
100F	0.841	52.5	7.02	0.45	0.069	27.7	67
200F	0.805	50.3	6.72	0.50	0.064	4.96	12.0
300F	0.768	48.0	6.41	0.55	0.060	1.98	4.80
400F	0.730	45.6	6.09	0.60	0.056	1.03	2.50
425F	0.719	44.9	6.00	0.61	0.055	0.91	2.20
450F	0.709	44.3	5.92	0.63	0.053	0.79	1.92
500F	0.689	43.0	5.75	0.65	0.051	0.64	1.54
575F	0.657	41.0	5.48	0.69	0.048	0.47	1.13
600F	0.645	40.3	5.38	0.70	0.047	0.43	1.03

7.0 ELECTRICAL

7.1 GENERAL

7.1.1 EACH PUMP SHALL BE DRIVEN BY AN ELECTRIC MOTOR WHICH SHALL BE CONTROLLED BY AN ADJUSTABLE FREQUENCY INVERTER POWER UNIT.

7.1.2 FACILITY SOURCE POWER AND CONTROL SUPPLIED BY CUSTOMER

7.1.3 POWER SOURCE WILL BE 480V, 60HZ, 3 PHASE ALTERNATING CURRENT HI-RESISTANCE GROUNDED "WYE", 3 WIRE.

7.1.4 SPEED CONTROL REFERENCE SIGNAL WILL BE A 4 TO 20 MILLIAMPERE D.C. SIGNAL.

7.1.5 REMOTE "START-STOP" CONTROL VOLTAGE WILL BE 5 TO 10 VOLTS D.C. THE START SIGNAL WILL BE MAINTAINED AND THE REMOVAL OF THE SIGNAL SHALL CAUSE A STOP.

7.1.6 VARIABLE FREQUENCY CONTROLLER WILL BE LOCATED INSIDE A MOTOR CONTROL BUILDING.

7.1.7 PUMP DRIVE MOTOR WILL BE LOCATED OUTSIDE.

7.1.8 SERVICE ATMOSPHERE OF PUMP AND MOTOR IS CLASS I, DIVISION II, GROUP "D" AS DESCRIBED IN THE NATIONAL ELECTRIC CODE.

7.1.9 ALL PUMP AND MOTOR PROTECTIVE PROVISIONS SHALL BE SELF CONTAINED WITHIN THE PUMP DRIVE CONTROL SYSTEM.

7.2 DESIGN AND CONSTRUCTION

7.2.1 ADJUSTABLE FREQUENCY INVERTER POWER UNIT SHALL BE RATED TO PROVIDE POWER AND SPEED RANGE REQUIRED TO DRIVE A 1750 RPM, SQUIRREL CAGE INDUCTION MOTOR THAT WILL MEET THE PUMP PERFORMANCE SPECIFIED IN SECTION 5.0, AND SHALL INCLUDE THE FOLLOWING PROVISIONS:

7.2.1.1 SELF-CONTAINED IN NEMA 1 ENCLOSURE SUITABLE FOR FLOOR MOUNTING.

7.2.1.2 ADJUSTABLE FREQUENCY, CONSTANT VOLTAGE CONTROL (CONSTANT HORSEPOWER) AT THE EXTENDED RANGE TO A MAXIMUM OF 25 PERCENT ABOVE THE 60HZ BASE SPEED OF 1750RPM, IF REQUIRED BY THE PUMP CHARACTERISTICS.

7.2.1.3 A SIZE 5 MOTOR CONTACTOR FOR INCOMING POWER WITH PROVISIONS FOR REMOTE "START-STOP" CAPABILITY BY A 5 TO 10 VDC LOGIC CONTROL SIGNAL. THE NECESSARY SOLID-STATE RELAYS TO ACCEPT THE LOGIC LEVEL CONTROL SHALL BE PROVIDED IN THE ENCLOSURE AND INPUTS WIRED WITH SHIELDED CABLE TO A CUSTOMER TERMINAL CONNECT POINT. ONE SET OF N.O. AND N.C. AUXILIARY CONTACTS ON STARTER SHALL BE WIRED TO TERMINAL BOARD FOR CUSTOMER USE.

12

7.2.1.4 CURRENT LIMITING OR FAST ACTING FUSES NECESSARY TO PROTECT THE RECTIFIERS.

7.2.1.5 INSTANTANEOUS OVERCURRENT PROTECTION FOR THE D.C. BUS AND SCR'S.

7.2.1.6 INVERSE TIME OVERCURRENT PROTECTION OF THE DRIVE MOTOR, UNDER VOLTAGE AND OVERSPEED PROTECTION AS REQUIRED.

7.2.1.7 SURGE PROTECTION ON THE D.C. BUS.

7.2.1.8 SPEED REFERENCE INPUT BROUGHT OUT TO TERMINAL STRIPS TO ACCEPT THE 4 TO 20 MILLIAMPERE D.C. CURRENT SIGNAL. THE MAXIMUM ALLOWABLE IMPENDANCE (LOAD) ON THIS CIRCUIT IS 600 OHMS. SPEED CONTROL LOOP TO BE CLOSED FROM THE AC TACHOMETER ON THE PUMP DRIVE MOTOR, NOT FROM OUTPUT FREQUENCY. SEE 7.2.2.5

7.2.1.9 ONE KILOWATT TRANSMITTER, WITH 4 TO 20 MILLIAMPERE D.C. OR 0 TO 5V D.C. OUTPUT, INSTALLED TO MONITOR POWER SUPPLY OUTPUT (IN KILOWATTS) TO THE PUMP MOTOR. SIGNAL LEADS TO BE SHIELDED AND BROUGHT TO TERMINALS FOR CUSTOMER CONNECTION.

7.2.1.10 PROVISION TO LIMIT "EMI" REFLECTED BACK ONTO INCOMING POWER LINES BY SUITABLE FILTERS.

7.2.1.11 SERVICE DEVIATION SHALL BE 0.1% OF SET SPEED. DRIVE CONTROL TO BE APPLIED IN A CLOSED LOOP UTILIZING PUMP SPEED AS THE FEED BACK CONTROL SIGNAL. AC TACHOMETER ON PUMP DRIVE MOTOR PER 7.2.2.5.

7.2.1.12 PROVIDE A 0-5VDC SIGNAL FROM THE AC TACHOMETER INTO THE CONTROLLER AND FOR A SPEED INDICATION FOR CUSTOMER USE. WIRE WITH SHIELDED WIRE TO A TERMINAL BOARD. WILL WORK INTO A HIGH IMPEDANCE LOAD SO WILL NOT LOAD THE FEEDBACK SIGNAL.

7.2.1.13 PROVIDE AN ADJUSTABLE TIMED ACCELERATION/DECELERATION FUNCTION IN THE FORWARD LOOP. ADJUSTABLE FROM 2 TO 15 SEC.

7.2.1.14 PROVIDE CURRENT-LIMIT OVERRIDE ADJUSTABLE FROM 50 to 150% OF FULL LOAD CURRENT.

7.2.1.15 DO NOT GROUND SHIELDS OF WIRING BROUGHT OUT FOR CUSTOMER USE. TERMINATE THE SHIELD ON THE CUSTOMER TERMINAL STRIP AND FLOAT SHIELD AT DEVICE TERMINATION POINT.

7.2.2 PUMP MOTOR SHALL BE OF TOTALLY ENCLOSED, FAN COOLED DESIGN WITH THE FOLLOWING PROVISIONS:

7.2.2.1 CLASS "H" INSULATION.

7.2.2.2 SUITABLE FOR OPERATION ON THE POWER PROVIDED BY THE ADJUSTABLE FREQUENCY INVERTER POWER SUPPLY.

7.2.2.3 NOMINAL 1800 RPM BASE SPEED, A.C. SQUIRREL CAGE INDUCTION MOTOR.

7.2.2.4 CAPABLE OF OPERATING AT A MAXIMUM RPM OF 2250 RPM AT 75HZ, IF REQUIRED BY PUMP CHARACTERISTICS.

7.2.2.5 SHAFT MOUNTED, PERMANENT MAGNET, A.C. TACHOMETER ON END OPPOSITE DRIVE SHAFT, FOR MEASURING AND CONTROLLING PUMP SPEED.

7.2.2.6 PUMP MANUFACTURER TO SPECIFY ADDITIONAL MECHANICAL DETAILS SUCH AS BEARINGS, SHAFT EXTENSION AND COUPLING, ETC.

7.2.2.7 DRAIN BREATHER ELEMENT, CROUSE-HINDS TYPE ECD "UNIVERSAL" OR APPROVED EQUAL.

8.0 TESTING

8.1 SHOP TESTS

8.1.1 EACH PUMP AND DRIVE SYSTEM SHALL BE FACTORY TESTED. THE TESTS SHALL BE IN ACCORDANCE WITH THE "HYDRAULIC INSTITUTE STANDARDS". CERTIFIED TEST CURVES AND CERTIFIED TEST REPORTS SHALL BE SUBMITTED FOR APPROVAL, PRIOR TO SHIPMENT IN ACCORDANCE WITH SPECIFIED DOCUMENTATION REQUIREMENTS.

8.1.2 ALL NECESSARY PERFORMANCE TESTS SHALL BE CONDUCTED TO VERIFY CURVES PREVIOUSLY SUBMITTED AS PART OF THE BIDDER'S PROPOSAL.

9.0 CLEANING

9.1 ALL INTERNAL AND EXTERNAL SURFACES OF EQUIPMENT SHALL BE CLEANED OF ALL MILL SCALE, LOOSE METAL PARTICLES, WELD SPATTER, SLAG, DIRT, GREASE, OIL AND OTHER FOREIGN MATTER. ALL EXTERNAL FERROUS SURFACES SHALL BE CLEANED, IN ACCORDANCE WITH SSPC SURFACE PREPARATION SPECIFICATION SSPC-SP 3, "POWER TOOL CLEANING." ALL BURRS AND FLASHING SHALL BE REMOVED AND ALL SHARP EDGES SHALL BE EASED.

9.2 A REPRESENTATIVE OF ROCKWELL INTERNATIONAL CORPORATION MAY VISUALLY INSPECT THE EQUIPMENT AFTER CLEANING. ANY EVIDENCE OF FOREIGN MATTER WILL BE CAUSE FOR REJECTION AND RE-CLEANING.

10.0 SEALING AND MARKING

10.1 ALL OPENINGS SHALL BE SEALED AGAINST CONTAMINATION IMMEDIATELY AFTER CLEANING.

10.2 FLANGE OPENINGS SHALL BE PROTECTED BY BLIND FLANGES AND GASKETS, OR BY POLYETHYLENE SHEETING (MINIMUM 0.008 INCH THICK), BACKED WITH CLEAN METAL, CLEAN PLYWOOD, OR HEAVY CARDBOARD, AND BOLTED OR SECURELY TAPED IN PLACE. POLYETHYLENE SHEETING SHALL BE SEALED TO PREVENT DUST INFILTRATION THROUGH FLANGE BOLT HOLES.

10.3 SCREWED PIPE PORTS SHALL BE SEALED WITH PIPE PLUGS.

10.4 PUMPS AND MOTORS SHALL BE PERMANENTLY IDENTIFIED BY STAMPING OR ELECTRO-ETCHING A METAL NAMEPLATE WITH ALL PERTINENT INFORMATION CLEARLY INSCRIBED THEREON. EACH NAMEPLATE SHALL BE PERMANENTLY ATTACHED TO EQUIPMENT IN A CONSPICUOUS PLACE.

11.0 PAINTING

11.1 ALL EXPOSED SURFACES OF THE EQUIPMENT, EXCLUDING NAME AND DATA PLATES, TAGS, AND MACHINED MATING SURFACES, SHALL BE GIVEN ONE (1) SHOP COAT EACH OF RUST INHIBITIVE PRIMER AND FINISH PAINT.

11.2 NAMEPLATES, DATA PLATES, TAGS, AND MACHINED MATING SURFACES SHALL BE COATED WITH A SLUSHING COMPOUND.

12.0 PREPARATION FOR SHIPMENT.

12.1 EQUIPMENT SHALL BE BOXED, CRATED AND/OR SKID MOUNTED, AND COVERED TO SUCH AN EXTENT TO PREVENT DAMAGE DURING SHIPMENT AND TO FACILITATE HANDLING.

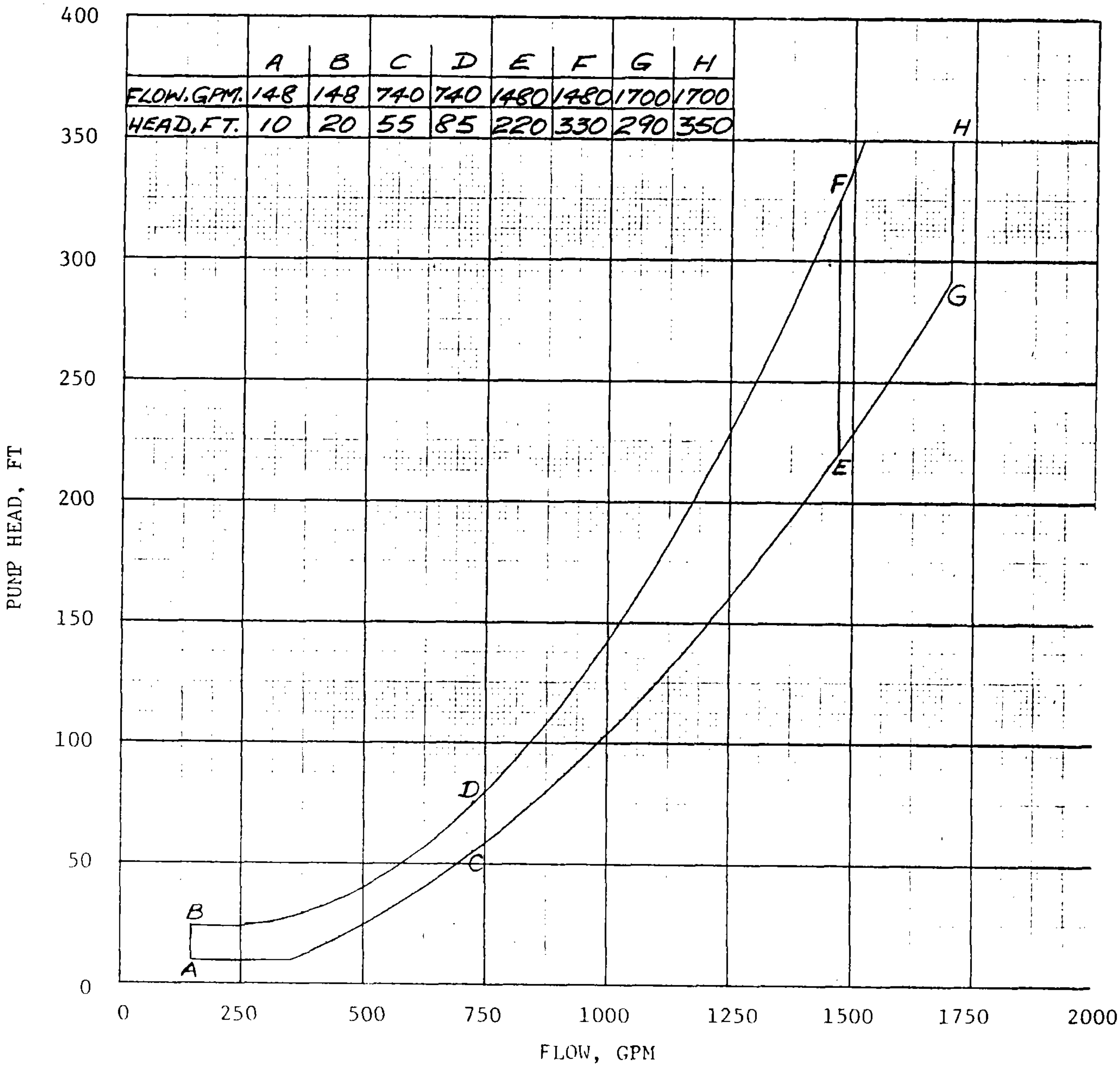


Figure 2 . Charging Pump Service Requirements

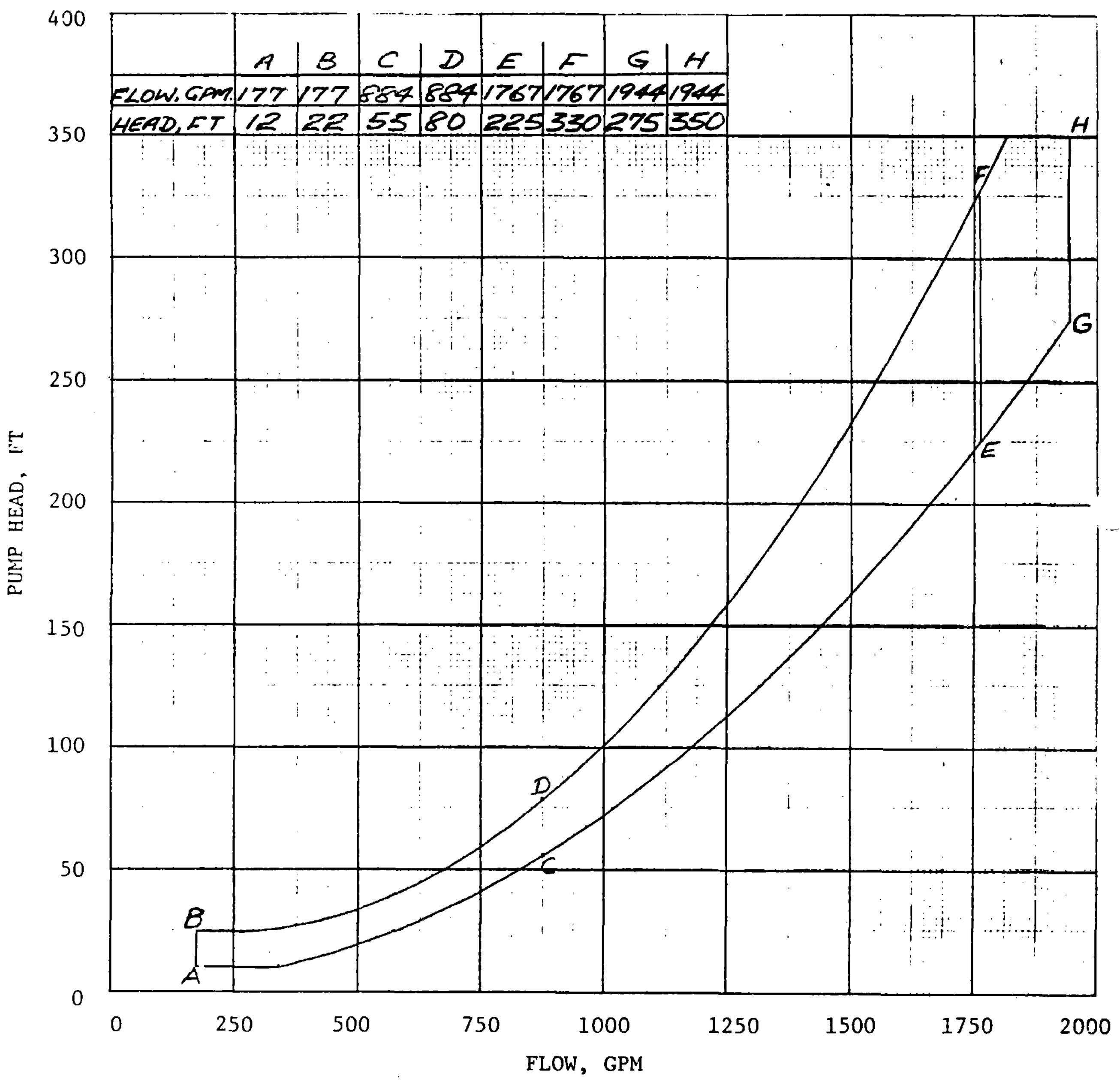


Figure 1. Extraction Pump Service Requirements

Rockwell International Corporation
Rocketydne Division
Specification No. GA000-90907-T10
Addendum No. 1

CHARGING AND EXTRACTION OIL PUMPS AND DRIVES

THERMAL STORAGE SYSTEM

10 MWe SOLAR PILOT PLANT

BARSTOW, CALIFORNIA

The specifications are hereby amended as set forth on the attached page. This addendum shall become a part of the original specification.

C. J. Nordquist
Manager
Facilities Engineering

A. E. Moore
Chief Project Engineer

J. Repas
Senior Program Coordinator
Quality Project Management

A. Djordjevic
Project Engineer
Facilities Engineering

January 11, 1980

1. The specification is ammended as follows:

1.1 Revise the first sentence in Paragraph 7.2.1.11 to read:

"Service deviation shall be 1.0% of set speed."

1.2 Revise the first sentence of Paragraph 7.2.1.12 to read:

"Provide a 0-5V DC signal from the AC tachometer voltage into the controller for a speed indication for customer use."

PREPARED BY: ______ APPROVED BY: [signature] DATE: 1-10-80

RECEIVED

' 1980

SUB CONTRACTING

Rockwell International Corporation
Rocketdyne Division
Specification No. GA000-90907-T10
Addendum No. 2

CHARGING AND EXTRACTION OIL PUMPS AND DRIVES

THERMAL STORAGE SYSTEM

10 MWe SOLAR PILOT PLANT

BARSTOW, CALIFORNIA

Applicable portions of the original Specifications and Addenedum No. 1 are hereby amended as set forth on the attached page. This addendum shall become a part of the original specification.

C. J. Nordquist
Manager
Facilities Engineering

A. E. Moore
Chief Project Engineer

J. Repas
Senior Program Coordinator
Quality Project Management

Alex Djordjevic

A. Djordjevic
Project Engineer
Facilities Engineering

March 7, 1980

The specification is amended as follows:

1.1 Add the following paragraphs

4.9 Mechanical Seals

4.9.1 The pumps shall be provided with a John Crowe Type 15 WT mechanical seal with tungsten carbide versus tungsten carbide faces.

4.9.2 The pumps shall be provided with a seal flushing system.

4.10 Cooling Water Piping

4.10.1 The pumps shall be provided with cooling water piping which shall include the following.

4.10.1.1 An inlet and outlet 3/4" globe valve at the pump base plate.

4.10.1.2 A 3/4" solenoid valve.

4.10.1.3 A paddle-type flow switch.

4.10.1.4 All piping for the cooling water flow between the inlet and outlet valves and the pump including a 1/4" line to the stuffing box with a coil wound around the pump casing to provide steam for the flushing of the stuffing box.

4.10.1.5 A 1/4" needle valve in the 1/4" flushing line.

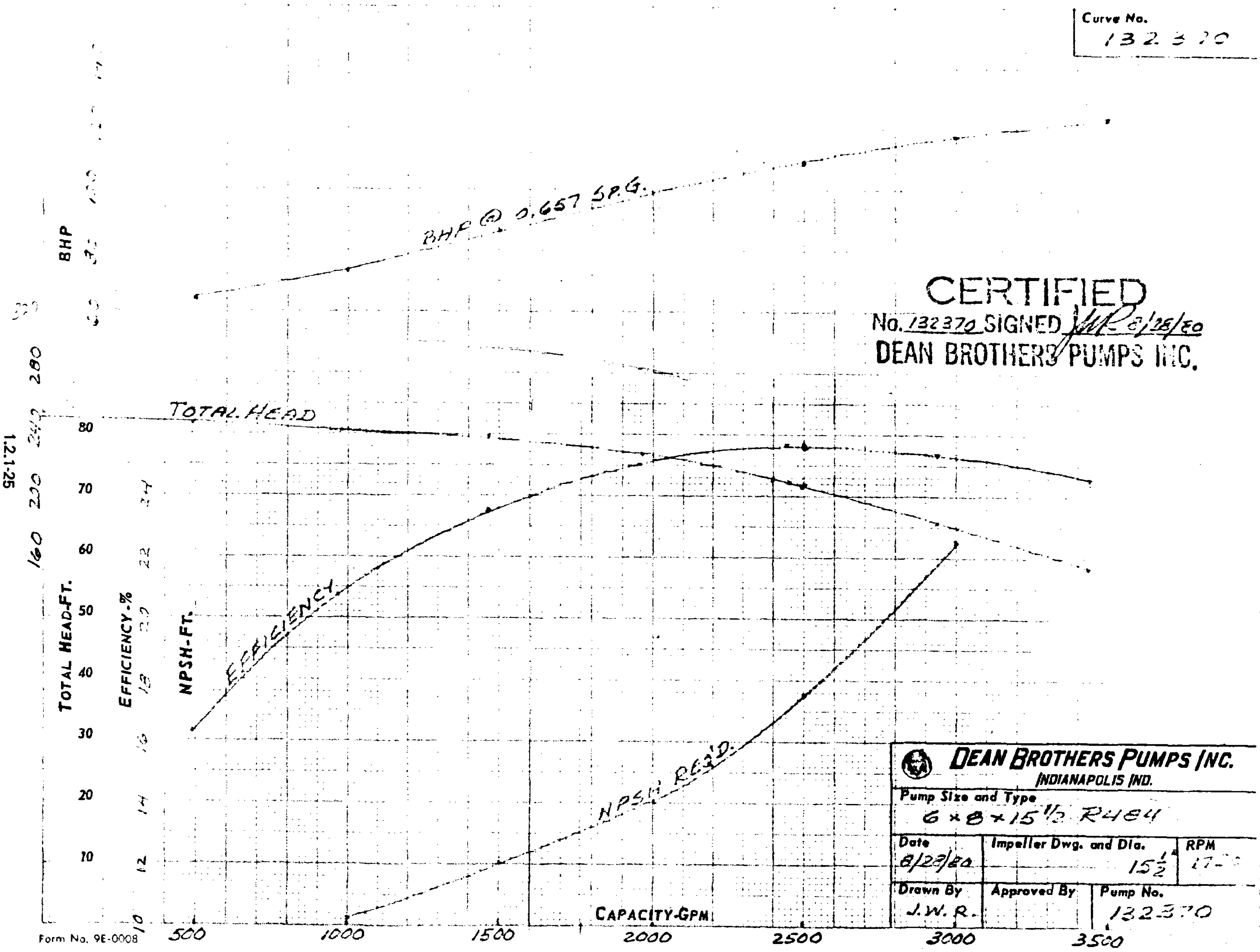
4.10.1.6 A thermal switch at the outlet of the flushing system for the detection of oil leaks.

7.9.1.1 Provide shutdown annunciator lights with nameplates, resets and audible alarms for the following detection points:

a. Mechanical Seal Leakage
b. Water Flow
c. Thermal overload in the motor (Inverse Time Over Current Protection)
d. Instantaneous Over Current (IOC)

Annunciators shall be equipped with lockout capability such that initial failure point detected by sensors will be the sole annunciator activated.

7.9.1.2 Provide solenoid water valve start control with 10-minute delay upon shutdown.


Curve No. 132370
BHP @ 0.657 SP.G.
BHP
CERTIFIED
No. 132370 SIGNED 8/25/80
DEAN BROTHERS PUMPS INC.
TOTAL HEAD
EFFICIENCY
NPSH REQ'D.
1.2.1-25
TOTAL HEAD-FT.
EFFICIENCY-%
NPSH-FT.
280
160
80
70
60
50
40
30
20
10
CAPACITY-GPM
500
1000
1500
2000
2500
3000
3500
Form No. 9E-0008
DEAN BROTHERS PUMPS INC.
INDIANAPOLIS IND.
Pump Size and Type
6 × 8 × 15 1/2 R484
Date
8/23/80
Impeller Dwg. and Dia.
15 1/2
RPM
Drawn By
J.W.R.
Approved By
Pump No.
132370

INSTRUCTION MANUAL
MC-1.4.40
MAY, 1980

1.2.1.12

DEAN BROTHERS PUMPS

INSTALLATION OPERATION AND MAINTENANCE MANUAL

SERIES R400 PUMPS

DO NOT OPERATE PUMP BEFORE READING THIS MANUAL

ESTABLISHED 1869
DEAN BROTHERS PUMPS INC.
INDIANAPOLIS INDIANA, 46268
P.O.Box 68172

THE BEST IS OUR STANDARD

STANDARD, HORIZONTAL, SINGLE STAGE, END SUCTION, ENCLOSED IMPELLER, CENTRIFUGAL PROCESS PUMPS

TYPES R434, R454 and R484

MECHANICAL DESIGN SPECIFICATIONS

Direction of Rotation (Viewed from Coupling End) .... CCW
Casing Thickness—Minimum .... $^{5}/_{16}$''
  Corrosion Allowance .... $^{1}/_{8}$''
Impeller—Standard .... Mechanically and Electronically Balanced
  Optional Extra .... Dynamically Balanced
Flanges: A.N.S.I. Rating .... 300 lb.
  Facing: Standard: Raised Face, Optional Extra: Ring Type Joint
  Finish .... 125 rms
Stuffing Box & Bearing Housing Jacket Pressure, Maximum .. 125 psig
Suction Pressure, Maximum ..... 500 psig less pump developed head

	R434	R454	R484
Horsepower Rating—Maximum			
@ 3500 rpm	75	250	
@ 1750 rpm	40	125	300
@ 1160 rpm	25	75	200
Bearings Type-Ball Bearings, Oil Lubricated			
Thrust Bearing (Angular Contact Pair)	7309BG	7312BG	7317BG
Radial Bearing	6309	6312	6316
Packing Size, Square	3/8''	1/2''	1/2''
Number of Rings with Lantern Gland	6	6	6
Spacing	3G3	3G3	3G3
Number of Rings, Lantern Gland Omitted	7	7	8
Stuffing Box Dimensions			
Length (Depth)	3''	3 7/8''	4 1/8''
Inside Diameter (Bore Diameter)	2 1/2''	3 1/4''	4''
Shaft Sleeve Diameter	1 3/4''	2 1/4''	3''
Lantern Gland Width	5/8''	3/4''	1''
Lantern Gland to Open End of Stuffing Box	1 1/2''	1 1/2''	2 3/8''
Pump Shaft Dimensions			
Span Between Bearings, ℄ to ℄	5 3/4''	8''	10''
Span Between Radial Bearing ℄ and Impeller ℄	8''	10 3/4''	12 5/16''
Diameter at Coupling	1 7/8''	1 5/8''	2 3/8''
Diameter Between Bearings	2''	2 3/4''	4''
Diameter at Impeller	1 7/8''	1 1/2''	2 1/4''

MATERIAL CLASS	MAXIMUM WORKING PRESSURE	PUMPING TEMPERATURE		HYDROSTATIC TEST PRESSURE	
		MINIMUM	MAXIMUM	R434	R454/R484
40†	500 psig.	-20°F	+800°F.	850	850
50	500 psig.	-20°F	+850°F.	psig.	psig.

†Carbon Steel with Cast Iron Trim. Also available with 316S/S Trim.

WARNING: ***The maximum pressures are not compatible with the maximum temperatures listed in the chart above. See curve in lower right corner for proper relation.***

STUFFING BOX PRESSURE - R400 SERIES PUMPS

**With Impeller Balance Holes—Stuffing Box Pressure Equals Pump Suction Pressure.

Without Impeller Balance Holes—Stuffing Box Pressure Equals Pump Suction Pressure Plus 0.6 X Pump Developed Pressure in PSI.

$$P_{SB} = P_{SUCT.} + .6\,(P_{devel.})$$

**Within the Press. Limit of Seal, Balance Holes Are Normally Used.

STANDARD MATERIALS OF CONSTRUCTION

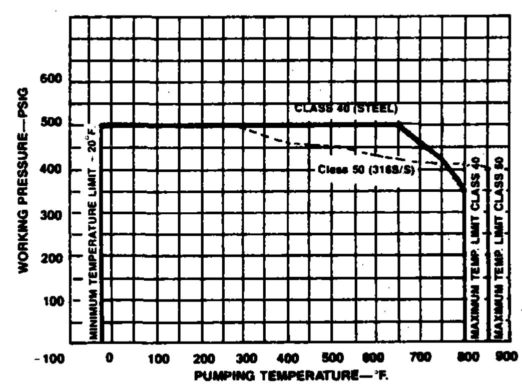
PART NO.	PART NAME	CLASS 40	CLASS 50
3	Impeller	C.I. (1)	316 (3)
5	Casing	Stl. (6)	316 (3)
6 *	Backhead Ring	Iron (7)	316 (3)
6A	Casing Ring	Iron (7)	316 (3)
7	Cradle Spacer	C.I. (1)	C.I. (1)
9	Bearing Housing Foot	C.I. (1)	C.I. (1)
9A *	Brg. Hsg. Ft. Capscrew	Stl. (2)	Stl. (2)
9F *	Brg. Hsg. Ft. Jack Bolt **R434 Only**	Stl. (2)	Stl. (2)
9G *	Brg. Hsg. Ft. Jack Bolt Nut **R434 Only**	Stl. (2)	Stl. (2)
10 *	Shaft Sleeve	316 (8)	316 (8)
10K *	Shaft Sleeve Key	304 (9)	304 (9)
12 *	Impeller Bolt	Stl. (2)	316 (8)
12A *	Impeller Washer	Stl. (2)	316 (8)
13 *	Stuffing Box Gland	Stl. (6)	316 (3)
14 *	Stuffing Box Gland Stud	Stl. (4)	304 (9)
15 *	Stuffing Box Gland Stud Nut	Stl. (5)	304 (9)
17 *	Lantern Gland	C.I. (1)	316 (3)
18 *	Splash Collar	(13)	(13)
22	Backhead	Stl. (6)	316 (3)
26 *	Bearing Housing	C.I. (1)	C.I. (1)
27 *	Seal Ring	C.I. (1)	C.I. (1)
28 *	Bearing End Cover	C.I. (1)	C.I. (1)
29 *	Pump Shaft	Stl. (10)	316 (8)
54 *	Throat Bushing	C.I. (1)	316 (8)
56	Casing Foot	C.I. (1)	C.I. (1)
77	Casing Gasket	Asbestos (11)	Asbestos (11)
77B *	Bearing End Cover Gasket	Paper (12)	Paper (12)
87 *	Impeller Ring—Back (Optional)	Stl. (2)	316 (3)
87A	Impeller Ring—Front (Optional)	Stl. (2)	316 (3)

*Denotes parts interchangeable in all pump sizes of same type.

—MATERIAL SPECIFICATIONS (Refer to numbers in Parentheses)

(1) Cast Iron
(2) AISI 1020
(3) 316S/S—ASTM #296 Grade CF-8M
(4) AISI 4140, ASTM #A 193-B7 Steel
(5) ASTM #A194 Grade 2 Steel
(6) ASTM #A216 Grade WCB Cast Steel (—20 + 800°F)
(7) Hardened Iron
(8) AISI—316S/S
(9) AISI—304S/S
(10) Alloy Steel—125,000 TS, 100,000 UP
(11) Asbestos Sheet—High Temperature
(12) Manila Paper

ALLOWABLE WORKING PRESSURE
VS. PUMPING TEMPERATURE
R400 SERIES PUMPS



Specifications are subject to change without notice

MC - 1.4.40

PRODUCT INSPECTION AND TEST

The Products of Dean Brothers Pumps Inc. are subject to thorough and rigorous quality control and inspection procedures throughout the whole of the manufacturing process to assure proper operation in full conformity with established performance standards. On completion of inspection, each unit is oiled, sealed against the entrance of dirt, and tagged with a signed certificate of inspection prior to shipment. Each pump when shipped is ready to perform the service for which it was designed with minimum maintenance and expense if properly installed and operated in accordance with the instructions furnished.

DEAN BROTHERS PRODUCT WARRANTY

We warrant to the purchaser from us of Dean Brothers products and parts of our own manufacture (Dean Products) that the Dean Products are free under rated use and service from defects in design, material and workmanship for a period of one (1) year from the date of installation, but not to exceed eighteen (18) months from the date of shipment by us. This warranty does not cover (I) any loss or damage resulting from wear, corrosion, abrasion or deterioration due to normal use in rated service: (II) replacement of service items such as shaft packings and mechanical seals; (III) products or parts manufactured by others but furnished by us which, if defective, shall be repaired or replaced only to the extent of the original manufacturer's warranty; (IV) any loss or damage to or defects in any Dean Products resulting from the misuse or improper storage, installation, or operation thereof; or (V) any loss or damages to or defects in any Dean Products resulting from any alteration or modification thereof not expressly authorized and approved by us in writing. We shall not be liable, directly or indirectly, under any circumstances for consequential or incidental damages, including, but not limited, to: (I) any loss of business or profits; and (II) labor, material or other charges, claims, losses or damages incurred or suffered from, in connection with or in consequence of the working upon, alteration, or repair of any defective Dean Products by persons or firms other than us. Our liability for breach of warranty hereunder is limited solely to the repair in our factory or the replacement F.O.B. our factory, as the case may be, or any Dean Products which shall have been determined by us, after notice to us and inspection by us within the warranty period, to be so defective when shipped by us.

THIS WARRANTY AND THE LIABILITY SET FORTH HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER LIABILITIES AND WARRANTIES, EXPRESS OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSE.

WARNING

Proper storage while not in use and proper installation and startup are essential for successful pump operation. Misuse or improper storage, installation or operation of pumps may result in serious loss or damage. Dean Brothers Pumps Inc. is not responsible for any loss or damage resulting from causes beyond its control, and is not liable for charges for work performed or materials furnished to repair such loss or damage.

All installation, operation, and maintenance must be done by thoroughly qualified personnel in strict accordance with this manual and must comply with all local, state and Federal codes. Only Dean Brothers authorized service parts should be used in the repair of these pumps.

RECEIVING PUMP

When the pump is received from the transportation company, it should be promptly inspected for damage and such damage noted on the bill of lading before it is signed. Claims for shipping damage must be filed against the carrier.

Care should be exercised in unloading and handling the pump.

STORAGE

Pumps must be properly covered and protected against moisture, dirt, and physical damage during storage prior to installation. If prolonged storage is anticipated, a heavy protective coating should be applied to bearings and all exposed machined surfaces. A rust preventative must be used to protect all steel or cast iron parts. Stuffing box shaft packing or mechanical seals should be removed and stored as well as protected separately.

Pumps must also be protected from moisture, dirt, and physical damage during and after installation while the system is being completed. Pumps "stored" on their foundations must be completely checked for proper installation prior to start-up.

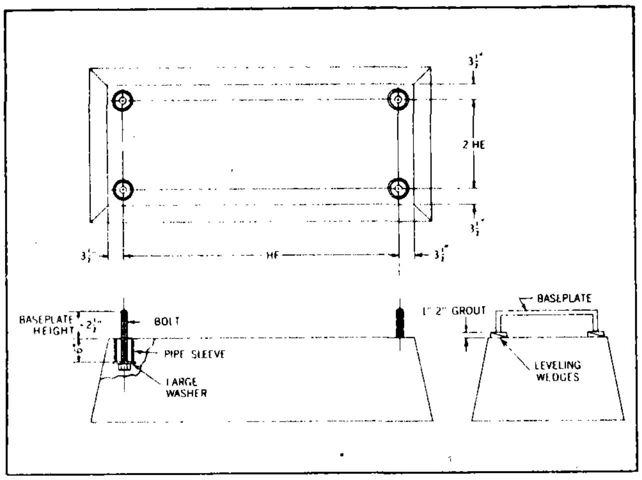
Care in storage and installation will preserve the built in quality of each Dean Brothers Product.

INSTALLATION

PUMP FOUNDATION

The pump foundation provides rigid support to the baseplate and maintains the exact alignment of the pumping unit. Baseplates are designed to rigidly support the pump and driver without vibration or distortion only when they are properly set, leveled, and secured to the foundation.

The purchaser may elect to mount the pump without grouting the baseplate. In any case the baseplate must be fully supported by the customer's mounting means to prevent vibration and distortion.



TYPICAL FOUNDATION LAYOUT

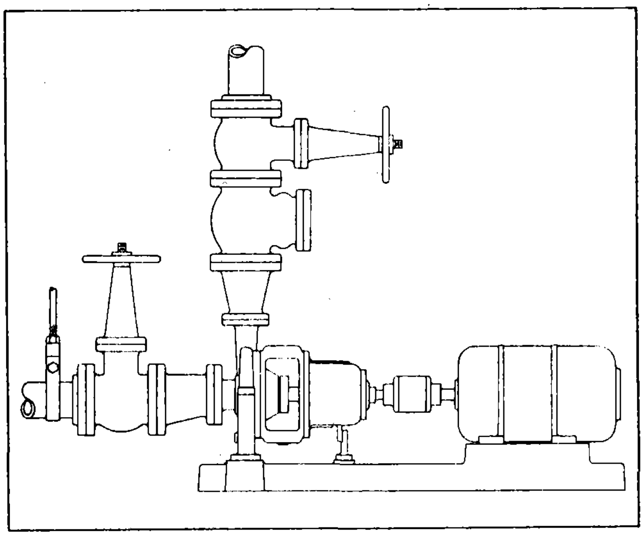
SUCTION AND DISCHARGE PIPING

Suction and discharge nozzles sizes of Dean Brothers pumps are selected for proper performance of the pumping unit and are not intended to determine the suction and discharge pipe sizes. Pipe sizes must be determined by the user based on the system requirements.

Suction piping should have a minimum friction loss and thus should be as short and straight as possible with a pipe diameter as large as economically feasible for the flow rate handled. Suction piping should never be smaller in diameter than the suction nozzle size. When the suction piping is larger than the suction nozzle size an eccentric reducer is required at the suction flange and must be installed with the taper located on the underside to eliminate air or vapor pockets.

Discharge piping may be the same size as, larger, or smaller than the discharge nozzle as the system flow may demand.

In new installations or rebuilt systems, dirt, pipe scale, welding slag, and general construction debris may get into the piping. It is important to prevent this material from entering the pump and damaging pump parts, mechanical seal faces, or stuffing box packing. Mechanical seal parts are especially subject to damage even by very small particles. To prevent damage, a strainer or filter installed in the suction line is recommended. When the pump utilizes a packed stuffing box, the strainer may take the simple form of a piece of ordinary window screen backed up by 1/4" mesh hardware cloth and placed between two flanges at the pump suction. If the pump employs a mechanical seal the strainer should provide much more protection. Commercially available strainers or filters as recommended by their manufacturers can do an excellent job. Another form may be a cone strainer of 100 mesh installed in a pipe cross placed with the cross in a vertical position and utilizing blank flanges to cover the openings. In this set-up the top flange may be opened for inspection and the bottom flange opened for cleanout. In addition special filtering and mechanical seal flushing guards may be required. Consult your Dean Brothers representative. Suction line screens or strainers may usually be removed when, after several days of use, no dirt has been collected and the system is clean.



TYPICAL PUMP PIPING

Remember that screens and filters in the suction line are restricting devices which reduce the net positive suction head (NPSH) available to the pump and should be considered at the time the system is designed.

BASEPLATE MOUNTING AND ALIGNMENT

The sequence of mounting which must be observed for proper baseplate and pump mounting is:

1) Place baseplate, with pump and driver mounted thereon, on the pump foundation.

2) Use wedges under the baseplate edges to properly level the unit. Check this with a spirit level. Pull down the baseplate mounting bolt nuts tightly and recheck for level. Correct if necessary.

3) Check driver rotation by removing the coupling spacer and bumping the motor starting button. ***Operating the pump in reverse rotation may cause extensive damage.*** If driver rotation is correct, proceed with alignment. If not, reconnect the motor wiring properly and

again check for rotation. When the driver rotation is correct, proceed with the alignment.

4) Align the driver to the pump.

5) Grout the baseplate. ***Do not grout the baseplate to the foundation until the pump and driver are correctly aligned.***

6) Determine that piping to the pump is in exact alignment with the pump flanges and imposes no piping strain on the pumping unit. When the alignment is exact the piping may be bolted in place.

7) Recheck pump and driver alignment to ensure that no distortion of the pump unit has been caused by piping strain. Correct piping if misalignment has occurred and again align pump and driver.

8) The pump and driver alignment must again be checked at the operating temperature and alignment corrected under the hot condition.

9) After about two weeks of normal pump operation the pump and driver alignment should again be checked under the hot condition. If alignment is still correct, the driver feet may be doweled to the baseplate. If the alignment has changed, realign the unit and recheck after two weeks.

PUMP AND DRIVER ALIGNMENT

Proper running life of a pump and driver unit depends on the accuracy with which the axis of the driver shaft coincides with the axis of the pump shaft when the unit is running. Although pumps and drivers are check aligned at the factory, handling during shipment and installation will cause the alignment to change. ***The pump and driver alignment must always be checked and corrected before the baseplate is grouted to the foundation and again before the pump is first started.*** If the baseplate mounting instructions have been carefully followed, no difficulties in making the alignment should be experienced. ***Failure to properly align the unit will result in vibration, short bearing life,*** and reduced mechanical seal or shaft packing life.

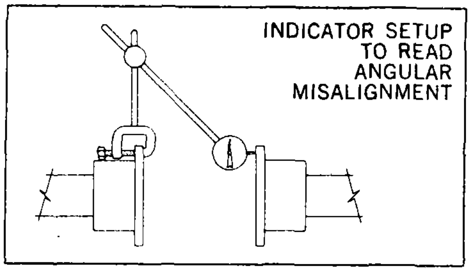
Pumps are not constructed to be used as pipe anchors. Both suction and discharge piping must be supported independently of the pumping unit and thermal expansion joints provided to guard against expansion loads on the pump. Pipes should be anchored between the expansion joint and the pump and as closely to the pump as possible. Failure to provide proper piping support and expansion joints may impose strains on the pumping unit which will result in serious misalignment. Maximum allowable piping loads are shown on Data Sheet 1198 in this manual.

No allowance for thermal expansion is made for motor driven units in mounting the driver. Allowance for turbine mounting should be in accordance with the turbine manufacturer's recommendations. Final alignment must always be checked and corrected at the operating temperatures of the pump and driver.

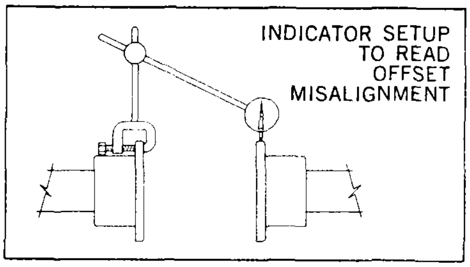
Misalignment of the two shafts is of two kinds. The first of these is angular misalignment where the axis of one shaft is at an angle from the other. The other is offset alignment where the center of one shaft is offset from the center of the other shaft. These effects usually occur together so that both angular and offset misalignment are present.

Coincident alignment of the driver and pump shaft is measured at the faces of the coupling hubs. Because of the variety of coupling types furnished at customer's request, the procedure here given is general in nature but may be applied by simple adaption to most coupling types.

The first step is to remove the spacer from the coupling. To one of the remaining coupling hubs, firmly seated on the shaft, attach a dial indicator. Let the indicator button ride on the face of the other coupling hub and near the outside diameter. Rotate the shaft on which the dial indicator is mounted, allowing the indicator button to move on the stationary coupling hub. The indicator dial movement will show the difference in distance between the two hubs. This indicates the amount of angular misalignment between the hubs and therefore the shaft axes. Good practice suggests alignment to within 0.002" T.I.R.



To check the offset alignment, mount the dial indicator as shown but with the indicator button on an outside diameter of the stationary coupling hub. Rotate the shaft on which the dial indicator is mounted, allowing the indicator button to ride on the outside diameter of the stationary hub. The indicator dial movement will show the difference in the center locations of the two shafts. Good practice suggests alignment to within 0.002" T.I.R.



Angular and offset alignment is adjusted by placing thin metal shims under the driver mounting feet to bring the driver into exact alignment with the bolted down pump. ***If misalignment is of major proportions, the baseplate has been improperly installed on the foundation and must be releveled before proceeding with alignment.***

Moderate alignment adjustments may be made by using the jack bolts provided on some bearing housing feet. Loosen the two bearing housing foot hold-down bolts and the jack bolt lock nuts. Adjustments of the jack bolts may then be made.

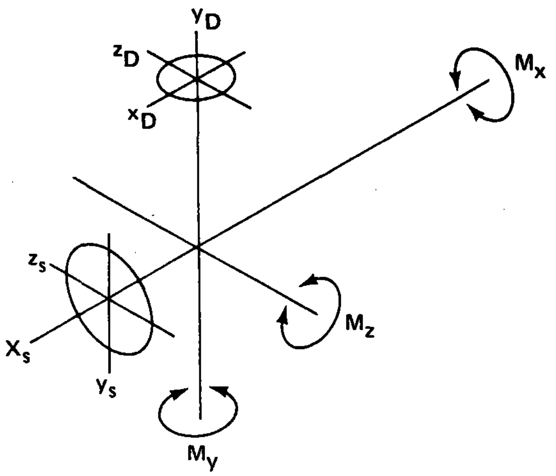
After each change, by shims or jack bolts, it is necessary to recheck both angular and offset alignment of the coupling. After the pump and driver are aligned, tighten all hold-down and jack bolt lock nuts and then recheck alignment.

Allowable error of shaft alignment is somewhat dependent on the coupling type. *However, the closer the running alignment, the better the running life will be.*

GROUTING THE BASEPLATE

Channel type baseplates are made with open ends to allow easy grouting and do not require grouting holes in the baseplate. Cast iron baseplates are provided with grouting holes. ***Do not grout the baseplate until the alignment explained under "Baseplate Mounting and Alignment," steps 1 through 4 has been completed.*** Fill the entire void under the baseplate with grout and firmly embed the baseplate edges.

ALLOWABLE PIPING LOADS R400 SERIES PUMPS



MAXIMUM FORCES ON FLANGES

FOR SUCTION FLANGE

$F_x \leq 200$ LBS./NOM.IN. $\leq 1.2W$
$F_y \leq 130$ LBS./NOM.IN. $\leq 0.6W$
$F_z \leq 160$ LBS./NOM.IN. $\leq 1.0W$
$F_r = (F_y^2 + F_z^2)^{1/2} \leq 2000$ LBS.

FOR DISCHARGE FLANGE

$F_x \leq 1.3W \leq 160$ LBS./NOM.IN.
F_y (COMPRESSION) ≤ 200 LBS./NOM.IN. $\leq 1.2W$
F_y (TENSION) ≤ 100 LBS./NOM.IN. $\leq 0.5W$
$F_z \leq 1.0W \leq 130$ LBS./NOM.IN.
$F_r = (F_x^2 + F_z^2)^{1/2} \leq 2000$ LBS.

WHERE

F = FORCE IN POUNDS
F_r = RESULTANT FORCE
W = WEIGHT OF PUMP ONLY, IN POUNDS

MAXIMUM MOMENTS APPLIED TO A PUMP ON A FULLY BOLTED AND GROUTED BASEPLATE. LOADS ARE TO BE APPLIED ONLY THROUGH THE SUCTION AND DISCHARGE FLANGES.

PUMP SIZE & TYPE		WT.—LBS. PUMP ONLY	M LB. FT.	M LB. FT.	M_Z LB. FT.
1 x 3 x 8½	R434	210	690	340	725
1½ x 3 x 8½	R434	235	690	340	725
2 x 3 x 8½	R434	260	690	340	725
3 x 4 x 8½	R434	285	725	295	600
4 x 6 x 8½	R434	325	785	320	600
1½ x 3 x 10	R434	255	760	310	600
2 x 3 x 10	R434	290	760	310	600
3 x 4 x 10	R434	320	830	340	600
4 x 6 x 10	R434	360	950	340	600
1 x 2 x 11½	R434	240	850	350	600
1½ x 3 x 11½	R434	275	850	350	600
2 x 3 x 11½	R434	315	870	355	600

PUMP SIZE & TYPE		WT.—LBS. PUMP ONLY	M LB. FT.	M LB. FT.	M_Z LB. FT.
3 x 4 x 11½	R434	345	930	335	575
4 x 6 x 11½	R434	430	980	350	760
1½ x 3 x 13½	R434	400	1015	365	525
2 x 3 x 13½	R434	414	1015	365	525
3 x 4 x 13½	R434	430	1045	375	630
4 x 6 x 10	R454	480	2300	1850	800
6 x 8 x 12½	R454	560	2740	1490	800
2 x 4 x 15½	R454	575	2530	1375	800
3 x 4 x 15½	R454	587	2550	1385	800
4 x 6 x 15½	R454	604	2740	1490	800
6 x 8 x 15½	R484	919	3000	1615	1500
8 x 10 x 15½	R484	942	3340	1810	1500

Maximum allowable forces and moments calculated from these force equations or the tabulated moment tables are those resulting in a maximum of .010 inch movement of the shaft measured at the shaft coupling when the pump is mounted on its baseplate and that baseplate is fully bolted to a properly designed foundation and is fully grouted in place. For a full discussion see API Standard 610, 5th Edition.

MC-1.4.40

PUMP COOLING REQUIREMENTS

Pumps may be furnished with optional jacketing of the stuffing box, mechanical seal gland, bearing housing, and (in some pump types) casing pedestals. Depending upon the pump service, these jackets may or may not be used. Cooling through these jackets is recommended under these conditions:

STUFFING BOX COOLING

1) With a mechanical seal when the pumping temperature is above 350°F. Individual plant specifications may require cooling above 250°F. Specific applications may require cooling at lower temperatures.

2) With a mechanical seal when pumping liquids of 0.75 specific gravity or less when the pumping temperature permits further cooling.

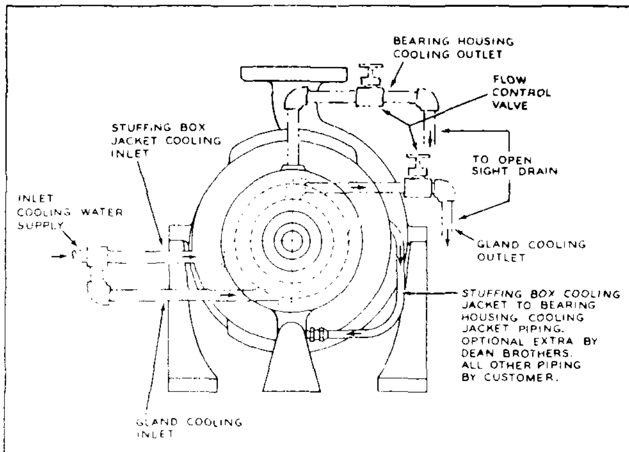
3) With packing at temperatures above 250°F.

MECHANICAL SEAL GLAND COOLING

Mechanical seal gland cooling is generally applied under the same conditions as those for stuffing box cooling. For pumping temperatures only slightly above those requiring stuffing box cooling, gland cooling may not be required on a specific application.

BEARING HOUSING COOLING

Cooling of the bearing housing is applied to cool the lubricating oil and bearings. At pumping temperatures below 500°F. such cooling is rarely necessary. Excessive cooling of the bearing housing may lead to early bearing failure from moisture condensation contamination of the oil.



COOLING PIPING DIAGRAM

COOLING PIPING DIAGRAM

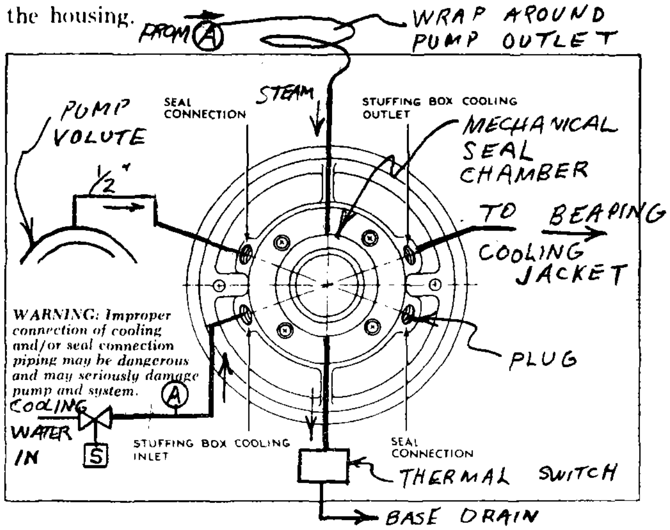
CASING PEDESTAL COOLING

Casing pedestal cooling is used to equalize and minimize thermal expansion of the pedestal supports. Such cooling is seldom required with Dean Brothers pumps but can be furnished when specified by the customer.

COOLING WATER PIPING

Optional cooling piping furnished for Dean Brothers pumps provides series cooling water flow, first through the stuffing box jacket and then through the bearing housing jacket. Inlet and outlet pipe tap connections are provided. The inlet piping provided by the customer must include a tee branch connection for the gland cooling connection. The bearing housing and gland outlet connections should be fitted with separate globe valves to control the cooling water flow rates and each should be piped separately to an open sight drain or through suitable flow indicating devices so that each flow may be observed.

Series piping has the advantage of providing warmed water to the bearing housing to minimize moisture condensation within the housing.

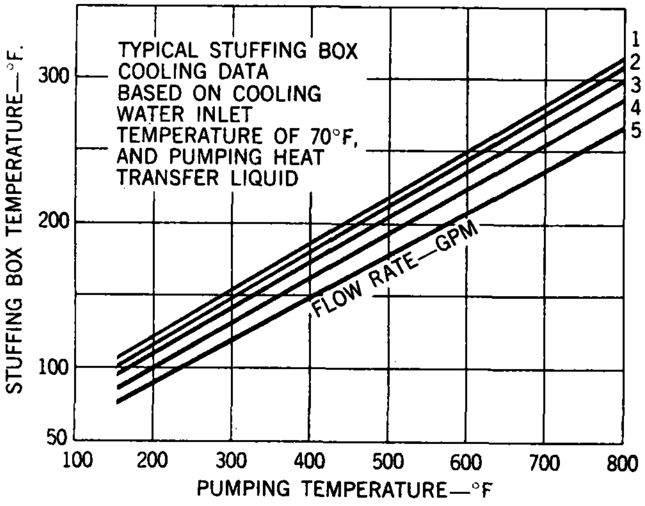


REAR VIEW OF PUMP BACKHEAD SHOWING PIPING CONNECTIONS

Alternate piping may be run with separate parallel supply lines to each individual jacket, each provided with a valve for flow control and with each jacket discharging individually to an open sight drain or through a flow indicating device.

IMPORTANT WARNING: Improper connection of cooling water piping may result in the injection of cooling water into the pump stuffing box and into the pumpage. Depending on temperature this may cause a violent steam explosion in the pump, piping, or associated equipment with extreme hazard to personnel. It may also cause serious contamination of the pumpage and heavy corrosion of pump or equipment parts.

Cooling jacket piping should be run to provide inlet water at the lowest jacket connection and outlet from the highest connection.



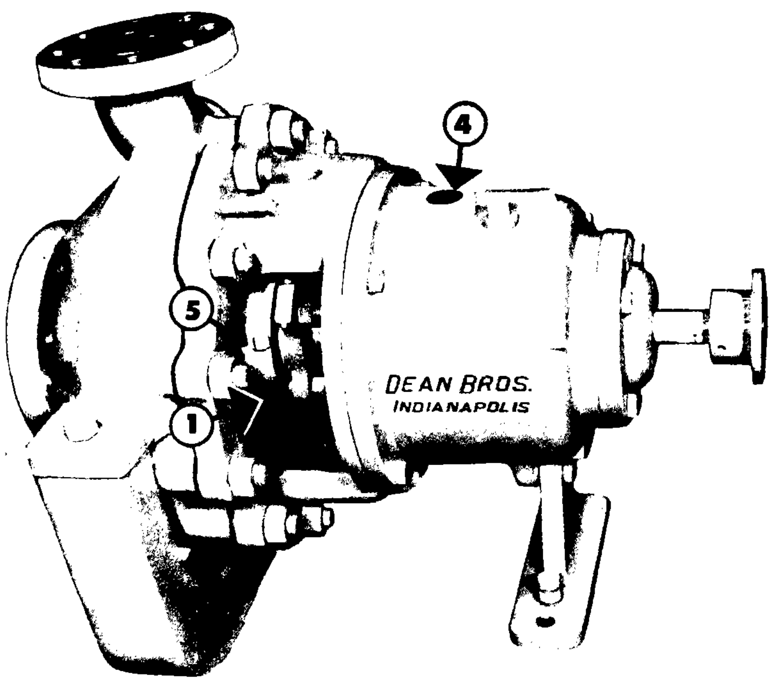
COOLING WATER FLOW RATES

Stuffing box cooling water flow rates are related to pumping temperature. See the chart on the left. Lower flow rates will lead to higher cooling water temperature and promote more rapid scaling within the jacket. Higher flow rates do no harm.

Mechanical seal gland cooling flow should be adjusted to about ½ GPM.

Bearing housing jacket cooling water flow rates depend on the cooling piping arrangement used. When series piping is used, the flow rate is that required for stuffing box cooling since this water passes first through the stuffing box jacket and then the bearing housing jacket. When parallel piping is used, the bearing housing jacket flow rate should be adjusted to maintain the bearing housing temperature in the 120°F. to 160°F. range. The pump may be operated without bearing housing cooling if experience in the particular installation shows that the bearing housing temperature does not rise above 200°F. without cooling.

SERIES FLOW COOLING CONNECTIONS FOR SERIES R400 PUMPS



Pipe cooling water supply to connection (1). Hook connection (2) directly to connection (3). Pipe connection (4) to drain through a flow control valve. Do not control cooling water flow with a valve on connection (1).

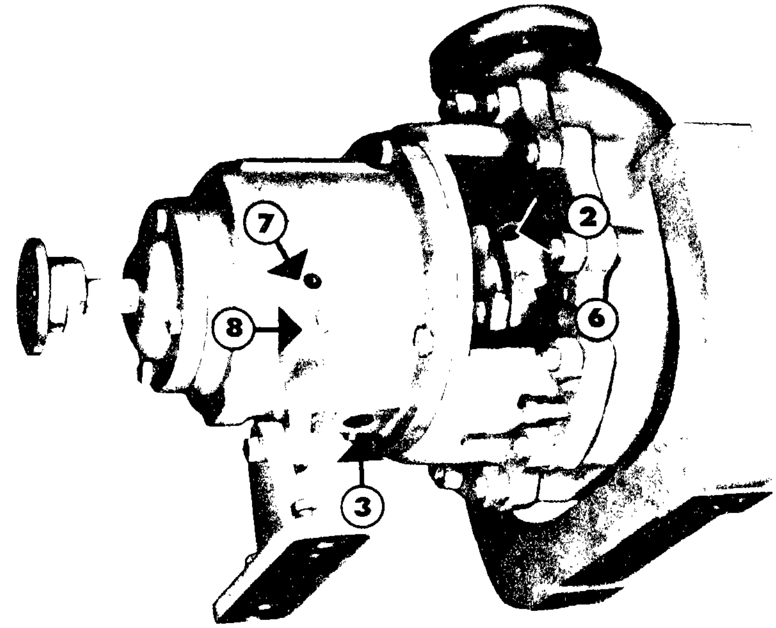
Openings (1) and (2) are stuffing box cooling jacket connections, plugged at factory with metal thread protectors.

Openings (3) and (4) are bearing housing cooling jacket connections.

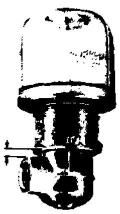
Openings (5) and (6) are mechanical seal flush connections (or lantern ring connections), plugged at factory with regular pipe plugs. Use only one of these connections for seal flushing. Leave the other opening plugged.

Connection (7) is for the constant level oiler. Connection (8) is the oil drain hole.

NOTE: Number 4 connection on R484 will be the last connection to the rear on top of the pump.



PUMP LUBRICATION



The ball type radial and thrust bearings are oil lubricated from the bearing housing oil sump. The oil level is controlled by an adjustable constant level oiler. This oiler is removed from the pump and packed separately for pump shipment to avoid damage. Install the oiler in the upper of the two pipe tapped holes on the side of the bearing housing. The lower is the oil drain hole.

Adjust the oiler height by loosening the three set screws in the outer sleeve, setting, and retightening the screws. Heights are ⅛" for R430 Series pumps (see illustration), and all the way down (0") for R450 and R480 Series pumps.

Failure to level pump when installed on the foundation may result in an improper oil level. Use care in installation.

Use a good grade of rust and oxidation inhibited, non-foaming, industrial oil of 250-350 SSU viscosity @ 100° F. to fill the sump.

Oil filling may be made through the opening with the vent plug removed. Fill only until the oil appears in the very bottom of the constant level oiler base when the cup is removed. Replace the vent plug. Fill the oil reservoir cup and install it. The oil will slowly bubble into the bearing housing until the proper level is reached. Remove, refill, and replace the oil cup. The oil level will remain constant as long as oil remains in the oil cup. To maintain the oil level between oil changes, keep the oil cup refilled. ***Do not overfill the bearing housing or bearings may be damaged.***

The oil should be drained and replaced at regular intervals, the intervals depending on the atmospheric conditions (dust, soot, corrosive vapors, humidity, temperature variations, etc.) prevailing at the pump installation site. The bearing housing should be flushed with a good solvent before the oil is replaced. ***Pumps are shipped from the factory without oil in the bearing housing.***

STARTING THE PUMP

A centrifugal pump should be started with the suction valve open and the discharge valve opened a slight amount.

When the source of liquid supplied to the pump is below atmospheric pressure or located below the pump, the pump must be primed prior to start up. The priming may be accomplished in any of several ways, three of which are listed.

1. An exhauster may be connected to the discharge piping between the pump and the discharge shut-off valve. With the discharge shut-off valve closed and the suction valve open, the air can be exhausted from the pump and piping.
2. With a foot valve installed in the suction piping, the pump may be filled with liquid introduced somewhere above the pump in the discharge line. The stuffing box should be vented to allow complete filling. A foot valve may create extensive losses and should be taken into consideration in calculating the available NPSH.
3. A vacuum pump (preferably a wet vacuum pump) may be used for evacuating air from the pump and piping. The vacuum pump should be connected as is the exhauster covered in No. 1.

When the source of liquid supplied to the pump is above atmospheric pressure or above the pump centerline, the pump may be filled by venting through a bleed off line to atmosphere or back to the pump suction source.

WARNING—EXTREME HAZARD TO PERSONNEL: ***Do not operate a pump at no flow condition. Do not operate a pump at a low flow condition, unless provision has been made to prevent dangerous heat build up within the pump casing. At no flow and low flow conditions, without the above provision, the liquid in the pump will heat up and may result in a high pressure in a short time. This pressure may result in a rupture of the pressure containing parts of the pump or system and cause extreme hazard to personnel and damage to the system.***

A centrifugal pump should never be run without liquid in the casing. Extensive damage may result, particularly to the mechanical seal or stuffing box packing. When the pump is equipped with a mechanical seal, vent the pump stuffing box through the seal connection to provide lubrication to the mechanical seal faces.

It is important that a pump should never be subjected to thermal or pressure shock. The liquid should therefore be allowed to flow into the casing slowly. A centrifugal pump should never be started until all the parts are up to the temperature of the liquid to be pumped.

If the pump is equipped with cooling water piping this should be turned on before filling the pump.

It is most important to check the direction of rotation of the pump before allowing the pump to come up to speed. To check rotation direction, push the starting button and instantly push the stop button. This will allow the motor to turn over a few revolutions and the direction of rotation to be observed. A direction of rotation arrow is shown on the front of the pump casing. If rotation direction is incorrect, change the wiring connections and recheck rotation. *Operating the pump in reverse rotation may cause extensive damage.*

If rotation direction is correct and the pump properly filled with liquid, it may now be started.

As soon as the pump is up to speed, the discharge valve must be opened slowly. A centrifugal pump cannot be operated with discharge valve closed without heating up dangerously. During the first several minutes of operating watch the pump carefully for overheating, vibration, and other abnormal conditions. If trouble develops, stop the pump at once and correct the problem.

PUMP START UP CHECK LIST

These points must be checked after pump installation and before starting up the pump.

1) Read instruction manual thoroughly and understand it.

2) Review pump order head sheet for the service rating of the pump and any special features.

3) Check all piping connections making certain that they are both tight and in the proper places. All piping includes seal, cooling, or heating piping.

4) Make sure that baseplate has been properly installed.

5) Check the electrical or steam line connections to the driver.

6) Break the coupling by removing the coupling spacer and bump the motor starting button to check motor rotation. Operating the pump in reverse rotation may cause extensive damage. If driver rotation is correct, replace the coupling spacer. If not, connect the wiring for proper rotation and recheck.

7) Check coupling for proper alignment. Realign if necessary.

8) If pump stuffing box is packed, check to be sure that gland stud nuts are pulled up only finger tight and that the gland is not cocked.

9) Rotate the pump shaft by hand to be sure there is no binding or rubbing within the pump or driver. Correct any difficulties at once.

10) Check to see that the pump is properly lubricated.

11) Remove all dirt, waste, tools, and construction debris from the area.

SPARE PARTS

To avoid prolonged down time and facilitate rapid repair of damaged pump parts, Dean Brothers recommends that the pump user maintain a minimum stock of spare parts. If the pump service is critical or the pump parts are of special materials, a spare parts stock is even more important to the user. Such a spares inventory may extend from a spare mechanical seal or seal parts through complete backhead-impeller-bearing housing assemblies prepared for immediate insertion in the pump casing. Consult your Dean Brothers representative who will assist you in selecting your spares stock.

ORDERING SPARE PARTS

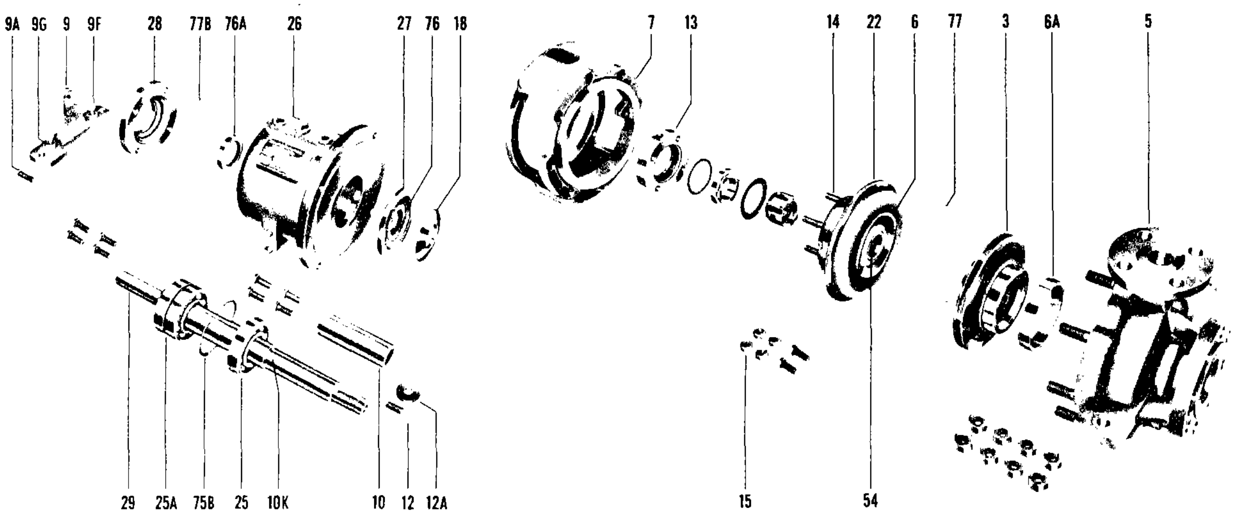
Spare parts orders will be handled with a minimum delay if the following information is furnished by the customer with the order:

1) Give the pump serial number and size. These may be found on the pump name plate. The serial number is also stamped on the suction flange or the top edge of the bearing housing front flange.

2) Give the part name, part number, and material of part. These should agree with the standard parts list.

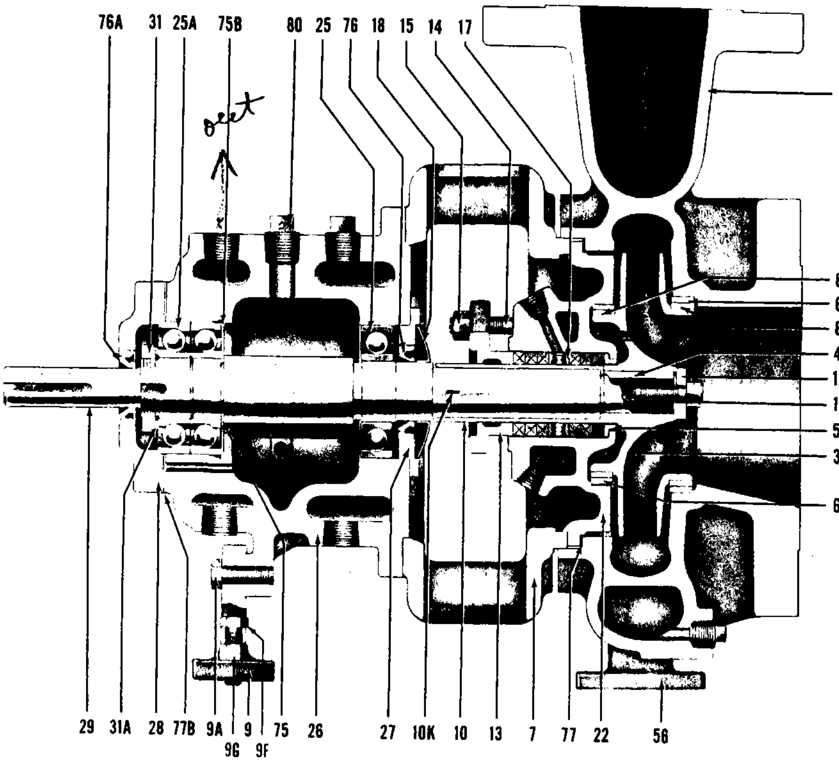
3) Give the quantity of each part required.

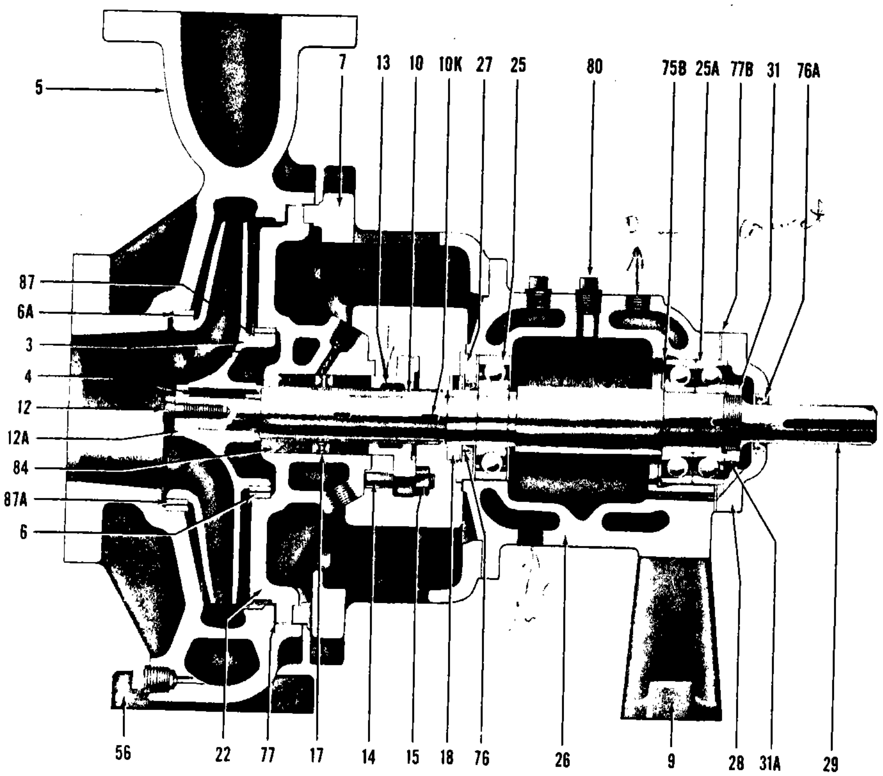
4) Give complete shipping instructions.



TYPE R434 PUMP PARTS

SECTION DRAWING 01919C—TYPE R434 PUMPS





SECTION DRAWING 01930A—TYPE R454 AND R484 PUMPS

PARTS LIST

3 Impeller
4* Impeller Key
5 Casing
6* Backhead Ring
6A Casing Ring
7 Cradle Spacer
9 Bearing Housing Foot
9A* Bearing Housing Foot Capscrew
9F* Bearing Housing Foot Jack Bolt **R434 Only**
9G* Bearing Housing Foot Jack Bolt Nut **R434 Only**
10* Shaft Sleeve
10K* Shaft Sleeve Key
12* Impeller Bolt
12A* Impeller Bolt Washer
13* Stuffing Box Gland
14* Stuffing Box Gland Stud
15* Stuffing Box Gland Stud Nut
17* Lantern Ring
18* Splash Collar
22 Backhead
25* Shaft Bearing—Radial
25A* Shaft Bearing—Thrust (Pair)
26* Bearing Housing
27* Seal Ring
28* Bearing End Cover
29* Pump Shaft
31* Thrust Bearing Lock Nut
31A* Thrust Bearing Lock Nut Washer
54* Throat Bushing
56 Yoke Mount or Pedestal
75* Snap Ring
75B* Snap Ring
76* Oil Seal—Front
76A* Oil Seal—Rear
77 Casing Gasket
77B* Bearing End Cover Gasket
80* Bearing Housing Vent
87* Impeller Ring—Back (Optional)
87A Impeller Ring—Front (Optional)

*Denotes parts interchangeable in all pump sizes of same type.

DISASSEMBLY AND ASSEMBLY PROCEDURES

The Dean Brothers centrifugal pump design of "back pull out" allows the complete disassembly of the pump without disturbing the suction or discharge piping. To remove the bearing housing-backhead-impeller assembly, follow these steps:

a) Remove the spacer portion of the coupling.

b) Remove the bearing housing foot mounting bolts.

c) Remove the cradle spacer to casing stud nuts.

d) The casing jack screws are used to loosen the casing joint and the bearing housing assembly may now be removed and taken to any convenient place for further servicing.

DISASSEMBLY PROCEDURE

To further dismantle the pump perform the following steps in the sequence shown:

a) Remove stuffing box gland stud nuts and slide gland (13) away from stuffing box.

b) Remove packing from stuffing box if pump is packed. Use packing extractor.

c) Remove impeller bolt (12) (right hand thread) and impeller retaining washer (12A). The impeller may now be removed from the shaft (29). Remove impeller key (4) from the shaft.

d) Remove the two capscrews securing the backhead (22) to the cradle spacer (7) and lift out the backhead.

e) Remove the four capscrews securing the cradle spacer (7) to the bearing housing (26) and remove the cradle spacer.

f) Remove the shaft sleeve (10), packing gland (13), shaft sleeve key (10K) from the shaft.

g) Remove pump half of spacer coupling from shaft (29).

h) Remove bearing end cover (28) and gasket from bearing housing (26).

i) Push shaft to rear of bearing housing. The splash collar (18) will be pushed off of the shaft when this is done. Push shaft to one side and reach in and remove snap ring (75B) (not on R484) from bearing housing. Remove shaft and bearing assembly from rear of bearing housing.

j) Remove bearing lock nut (31) and lock nut washer (31A) from shaft. Press bearings (25 and 25A) from shaft. Hammering bearings in any way may result in serious damage to the bearings. Remove snap ring (75) (not on R454 & R484) from shaft. Remove snap ring (75B) (not on R484) from shaft.

k) Press seal ring (27) from bearing housing (26).

l) Press shaft seal (76) from seal ring (27).

m) Press oil seal (76A) from bearing end cover (28).

n) Remove casing ring (6A) by prying it out of the casing (5).

o) Remove backhead ring (6) by prying it out of the backhead (22).

p) Press the throat bushing (54) out of the backhead (22).

REASSEMBLY PROCEDURE

To reassemble the pump, perform the following steps:

a) Clean all parts thoroughly.

b) Press throat bushing (54) carefully into the backhead (22).

c) Press the backhead ring (6) into the backhead (22).

d) Press the casing ring (6A) into the casing (5).

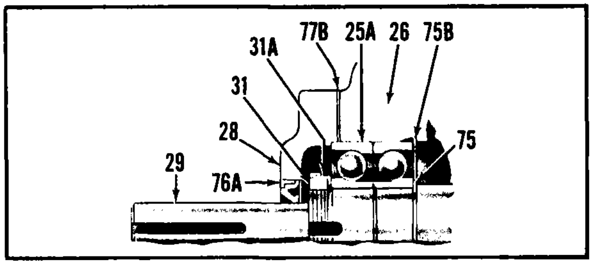
e) Press the oil seal (76A) into the bearing end cover (28) with the oil seal lip towards the flanged side.

f) Press the oil seal (76) into seal ring (27). Be sure that the lip of the seal faces away from the flanged side of the seal ring.

g) Replace snap ring (75) (not on R454 & R484) on shaft (29) and press bearings (25 and 25A) onto shaft. The thrust bearing (25A) is a matched pair of angular contact bearings and must be assembled back to back. See the illustration. Be sure to slide snap ring (75B) (not on R484) over shaft before pressing on the last bearings.

h) Replace bearing lock washer (31A) and bearing lock nut (31). If lock washer tabs are damaged use a new lock washer.

i) Slide the shaft (29), assembled with the bearings, into the bearing housing (26) from the rear. After the radial bearing (25) has passed through the opening, reach into the opening and put the thrust bearing retainer snap ring (75B) (not on R484) in place in its groove. The shaft may now be fully inserted with the thrust bearing (25A) firmly against the snap ring (75B) (not on R484).



THRUST BEARING ADJUSTMENT

j) Bearing manufacturing tolerances are such that the combined width of the two outer races, when the bearings are assembled back to back, will exceed the depth of the bearing seat from the rear face of the bearing housing (26) to retainer snap ring (75B) (not on R484), plus the recess depth in the bearing end cover (28). Check this condition when the shaft and bearing assembly have been fitted snugly into the bearing housing against the retainer snap ring (75B) (not on R484) and the bearing end cover (28) is firmly in place. A gap exists between the rear face of the bearing housing and the flange of the bearing end cover. Measure this with a feeler gauge. Add 0.002 inch to this measurement and use a paper gasket (77B) of the remaining thickness. Bolt the bearing end cover (28) in place.

k) Press the seal ring (27) assembled with the oil seal (76) into the front of the bearing housing (26).

l) Slide the splash collar (18) onto the shaft and tap it gently into position until the outer rim of the splash collar is just slightly entered into the recess in the front of the seal ring (27). This can best be done by slipping a piece of tubing over the shaft to drive the collar into place. Be sure that the splash collar does not rub in the recess.

m) Replace the pump half of the coupling on the shaft (29). The hub should be even with the end of the shaft.

n) Dean Brothers pumps are made with a lapped metal-to-metal joint between the shaft sleeve (10) hook and the locating shoulder on the shaft (29) to prevent liquid leakage under the shaft sleeve. The following instructions should be carefully observed when the shaft sleeve is reassembled to the shaft:

1. Apply a small amount of fine grit lapping compound (similar to automobile valve grinding compound) to the inside shoulder of the shaft sleeve hook.
2. Slide the shaft sleeve (10) onto the shaft. Do not install the shaft sleeve key (10K).
3. Rotate the shaft sleeve repeatedly by hand in its place on the shaft until the markings on both shaft and sleeve hook show that complete metal-to-metal contact has been made.
4. Remove the shaft sleeve and flush all lapping from the sleeve and shaft. Reassemble the shaft sleeve on the shaft with the shaft sleeve key (10K) in place.

o) If the pump stuffing box is to be packed, slide stuffing box gland (13) over the shaft sleeve and back against the splash collar.

p) If the pump is equipped with a mechanical seal, assemble the seal parts on the shaft sleeve at this time. See separate mechanical seal installation instructions.

q) Assemble the cradle spacer (7) to the bearing housing (26).

r) Slide the backhead (22) carefully into place and secure it to the cradle spacer with the two capscrews. Be especially careful not to damage mechanical seal parts.

s) Install the impeller (3), impeller key (4), impeller washer (12A), and impeller bolt (12). Tighten the impeller bolt securely.

t) If the pump is fitted with stuffing box packing this packing may now be installed. See separate packing installation instructions.

u) Assemble the pump bearing housing and cradle assembly to the pump casing (5) after replacing the casing gasket (77).

v) Rotate the pump shaft by hand to be certain there is no internal interference.

w) Bolt the pump to the baseplate, reassemble the coupling parts, and realign the pump and driver. See separate instructions.

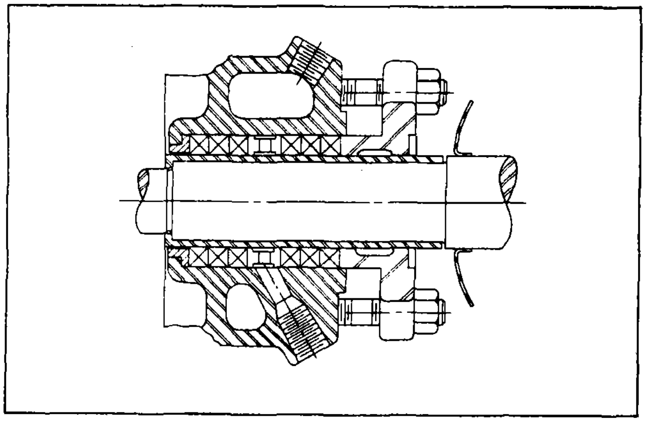
x) Lubricate the pump according to lubrication instructions before operating.

INSTALLATION AND MAINTENANCE OF STUFFING BOX PACKING

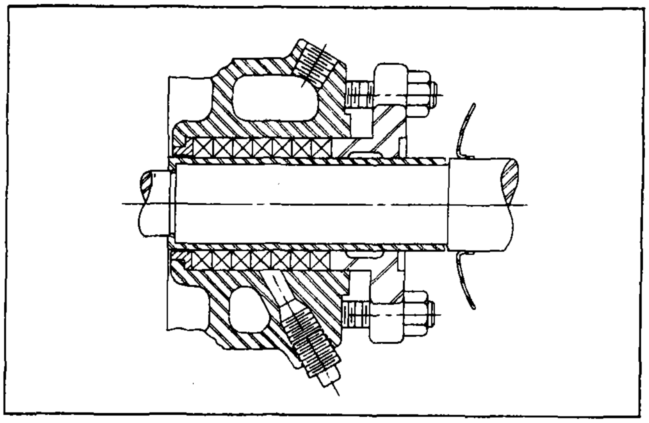
The proper installation and maintenance of packing to seal a pump shaft is not difficult but must be properly done to provide good packing and pump shaft sleeve life. All packing must be allowed to leak. This leakage is the only lubrication for the packing and additionally provides cooling to remove part of the frictional heat built up between the shaft sleeve and the packing. Failure to allow sufficient leakage will result in short packing and shaft sleeve life and increased power consumption of the pumping unit. It is entirely possible to stall a centrifugal pump by clamping the packing gland down.

Most Dean Brothers pumps are shipped from the factory without packing in the stuffing box. A complete set of die molded packing specified for the service is shipped with the pump in a separately labeled carton. The pump stuffing box must be properly packed before the pump is put into service.

The stuffing box may be packed either with or without a lantern ring (also known as a seal cage or lantern gland) as the service of the pump dictates. When the pump suction pressure is above 100 psig a lantern ring is not recommended.



PACKED STUFFING BOX WITH LANTERN RING



PACKED STUFFING BOX WITHOUT LANTERN RING

PURPOSE OF LANTERN RING

Lantern rings are made of Teflon or suitable metal as the service demands. They are of split construction and may be easily installed or removed without disassembling the pump. A lantern ring is used in the stuffing box with packing for these reasons:

1) To permit the introduction of a sealing liquid into the stuffing box to prevent leakage of air into the pump through the packing when the pump suction pressure is less than atmospheric pressure. The sealing liquid may be from an internal seal connection or from an external source.

2) To permit introduction of grease, oil, or other suitable lubricant to the packing to provide lubrication or cooling.

INTERNAL SEAL CONNECTION TO THE LANTERN RING

An internal seal connection is used to inject pumpage from the pump casing into the lantern ring through the lantern ring connection of the stuffing box to seal the pump against air leakage as noted above. It can be used only when the pumped liquid is clean and non-abrasive.

The pumped liquid introduced through the internal seal connection to the lantern ring will not seal the pump against air leakage through the packing when the pump is idle or on stand-by service.

EXTERNAL SEAL CONNECTION TO THE LANTERN RING

The sealing liquid introduced to the lantern ring may be from a source external to the pump. It must be introduced at a pressure above stuffing box pressure and must be non-corrosive, non-abrasive and 150°F. or less in temperature. The connection is made to the lantern ring connections on the pump stuffing box.

The lantern ring connection on the pump stuffing box is also used to introduce grease, oil, or other suitable lubricants to the lantern ring.

LANTERN RING NOT USED

When the pump suction pressure is above atmospheric pressure or the stuffing box is pressure sealed (no impeller balance holes) and neither internal nor external liquid or lubricant is required to the packing, the lantern ring is not used and the stuffing box is packed full with rings of packing.

PACKING INSTALLATION

These instructions apply to the conventional woven, braided, folded, and wrapped packings. Packings of multifilament Teflon, brained carbon filament, compressed carbon sheet, and other special types or materials may require special installation techniques.

The way in which the packing is installed in the stuffing box is important to the good service life of the packing and the shaft sleeve. Incorrect installation will lead to excessive leakage and may cause higher power requirements.

The use of a packing tamper (split bushing) is recommended to properly seat the packing rings. Such a tool is easily made from wood or metal in the form of a hollow cylinder. The inside diameter must be slightly larger than the shaft sleeve and the outside slightly smaller than the stuffing box bore. Split the piece lengthwise to allow insertion in the stuffing box. More than one length of packing tamper may be necessary. Suit the lengths to the particular pump.

All packing rings furnished by Dean Brothers Pumps are die-molded to fit the stuffing box. To place a ring on the shaft sleeve, open the ring at the split at a right angle to the plane of the ring. This will best retain the molded form and avoid distortion. Successive rings should be installed with the joints at 90° intervals.

Foil wrapped packings must be installed with the foil laps running in the direction of shaft sleeve rotation on the inside of the ring. Metallic packing should be lubricated, on the wearing face only, with a dry graphite lubricant before insertion.

Foil wrapped packing sets are furnished with soft rings of asbestos packing which are placed between the hard metallic rings in the locations shown in the diagrams. These rings help to furnish lubrication during the run in period. Being soft, they are more sensitive to compression loads and care must be taken during the adjustment period.

Follow these steps:

1) With the packing gland slid back against the flinger, or removed if it is a two piece gland, place a ring of packing on the shaft sleeve and enter it carefully into the stuffing box. Insert the halves of the packing tamper and push the packing ring to the bottom of the stuffing box. Slide the packing gland up against the end of the packing tamper with the gland studs indexed in the gland holes, put on the gland stud nuts and tighten them firmly and evenly to seat the packing ring.

2) Back off the gland, remove the packing tamper, and insert a second ring of packing, staggering the ring joint 90° from that in the first ring. Repeat the seating procedure above.

3) If a lantern ring is to be used, check the pump specifications to determine its position in relation to the number of rings between the bottom of the stuffing box and the lantern ring. Insert packing rings as above until the lantern ring position is reached and then install the lantern ring.

4) If no lantern ring is to be used, or after the lantern ring is put in place, continue to add packing rings, one at a time, staggering joints at 90° intervals, until the stuffing box is nearly full.

5) Put the packing gland in place and pull up the gland stud nuts firmly. Back the gland stud nuts off to finger tightness.

6) Rotate the pump shaft by hand to be sure it is not locked.

7) *Final adjustment of the packing compression must be made with the pump running.* Start and stop the pump several times to begin the running in period. Allow sufficient leakage to assume good lubrication during the adjustment. Pull up the gland stud nuts ⅛ turn at a time. Allow a running in period between adjustments. Continue adjustment until the desired leakage control is reached. The minimum leakage rate depends on a number of things: liquid pumped, packing used, temperature, stuffing box pressure, and the condition of the pump. In any case, some leakage is necessary to both lubricate and cool the packing. Minimum rates may vary from a few drop per minute to as much as ½ pint per minute.

8) As the packing wears in service, the gland should be readjusted to maintain the minimum leakage.

9) After the gland has been taken up to full travel, an additional ring of packing may be placed in the stuffing box. When the gland has again been taken up to full travel the stuffing box should be repacked completely.

USUAL CAUSES OF PACKING FAILURE AND EXCESSIVE STUFFING BOX LEAKAGE

1) Packing has not been installed properly.

2) Packing used is not suitable for the temperature and pressure involved or may be subject to attack by liquid handled.

3) Inner rings are not thoroughly seated in the stuffing box so that outer rings are carrying all the load.

4) Dirt and foreign particles in stuffing box are causing rapid scoring of shaft sleeve.

5) Stuffing box cooling water not turned on.

6) Packing gland pulled up too tight.

When ordering additional packing sets, always refer to packing set number and to pump serial number.

INSTALLATION OF STANDARD MECHANICAL SEALS

Clean, careful, and correct installation of the mechanical seal is essential to successful mechanical seal operation. Cleanliness and accuracy of setting cannot be overemphasized.

For instructions on pump disassembly and assembly see the instruction manual relating to the specific pump type.

A correct mechanical seal drawing is furnished with each pump and the mechanical seal setting dimension is given on this drawing.

Use the setting for the specific pump type in which the installation is being made.

The pump is first assembled according to the applicable assembly instructions through the step of backhead installation.

The mechanical seal rotary unit must be properly located in relation to the face of the pump stuffing box in order to establish the proper seal spring tension and resultant proper force on the seal faces. An error in setting of more than several thousandths may well cause seal failure by excessive or insufficient seal face pressure.

INSTALLATION OF SINGLE INSIDE SEALS

To make the seal installation, with the pump partially assembled as noted above, scribe a mark on the shaft sleeve (10) exactly in line with the face of the pump stuffing box. (Note 1). The impeller (3), and backhead (22) are now removed from the pump. If the mark causes roughness on the shaft sleeve remove the burr carefully with crocus cloth. Any roughness on the shaft sleeve may damage the mechanical seal shaft packing when the seal is assembled.

Referring to the mechanical seal drawing, determine the proper "D" dimension for the seal and pump type. Measure carefully from the mark which you have made on the shaft sleeve and make a new mark on the shaft sleeve, towards the pump end, exactly to this dimension.

If the mechanical seal insert is of the clamped-in style, put the mechanical seal gland (300) on the pump shaft and slide it back against the flinger. Put one mechanical seal gland insert gasket (325), the gland insert (315) and the other gland insert gasket (326) on the shaft. Make sure that the lapped face of the gland insert is towards the stuffing box.

Flexibly mounted inserts are of two types, depending on the service of the pump. The insert may be of rectangular cross section grooved for an "O" ring or it may be of L-shaped cross section used with a Teflon mounting ring.

To position the "O" ring mounted insert, lubricate the inside of the mechanical seal gland. Place the "O" ring in the groove of the insert and carefully slide the insert into position. Be careful not to damage the "O" ring. Make sure that the lapped face of the insert faces towards the pump.

To position the Teflon mounted insert, lubricate the inside of the mechanical seal gland. Carefully slide the Teflon mounting ring into position in the gland and then slide the insert into place. The slot (or pin) in the stationary insert must index with the drive pin (or slot) in the gland.

Put the mechanical seal gland and insert on the shaft and slide it back against the flinger. Be careful not to damage the insert or its mounting. Put the gland gasket (324) on the shaft. Slide the seal rotary unit assembly carefully onto the shaft sleeve being particularly careful not to damage the seal shaft packing (345). Be sure that the shaft sleeve hook is firmly against the shoulder on the shaft. Set the rotary unit carefully to the setting mark you have made on the shaft sleeve and lock it tightly in place with the set screws. Recheck the setting. Slide the pump backhead carefully into place and guide the seal gland insert and gaskets together with the gland carefully into position. Reassemble the pump. Now tighten the gland stud nuts carefully and evenly to avoid cocking the gland, making sure that the gland insert and gaskets are in place. Tighten gland stud nuts evenly to approximately 15 foot pounds of torque.

Before starting the pump, bleed the air from the stuffing box. The stuffing box must be full of liquid or the seal faces may be damaged by lack of lubrication when the pump is started.

Occasionally a seal may leak very slightly when the pump is first started. If the leakage continues more than a few moments the pump should be shut down and the seal removed to discover the cause.

> NOTE 1—Pumps using a single inside balanced seal (except metal bellows) are furnished with a short shaft sleeve. The mark is made on the shaft because the sleeve does not extend to this point. The second mark (setting mark) is made on the shaft sleeve and measured from the mark on the shaft.

INSTALLATION OF SINGLE OUTSIDE UNBALANCED SEALS

If the seal rotary unit is scribed with a setting mark, the shaft marking procedure outlined below may be omitted. The setting mark can be found on the outer shell of the rotary unit running circumferentially between the four round holes in the shell. Visible through each hole is the edge of the metal disc against which the seal springs bear. To set the seal with the proper spring pressure, first assemble the pump as noted below with the seal rotary unit slid back against the shaft flinger and left loose until the entire bearing housing-impeller assembly is bolted in place in the pump casing. Then slide the seal rotary unit into place against the stationary insert and compress the springs until the metal disc visible through the holes is aligned with the setting mark scribed on the shell. Tighten the set screws and check through each hole to determine that the seal rotary unit is correctly compressed and not cocked.

If the seal rotary unit is not marked with a setting line, a setting mark must be made on the shaft sleeve. To make the seal installation, with the pump partially assembled as noted above, scribe a mark on the shaft sleeve (10) exactly in line with the face of the pump stuffing box. The impeller (3), and backhead (22) are now removed from the pump. If the mark causes roughness on the shaft sleeve remove the burr carefully with crocus cloth. Any roughness on the shaft sleeve may damage the mechanical seal shaft packing when the seal is assembled.

Referring to the mechanical seal drawing, determine the proper "D" dimension for the seal and pump type. Measure carefully from the mark which you have made on the shaft sleeve and make a new mark on the shaft sleeve, towards the bearing housing, exactly to this dimension. Remove the burr if necessary. This mark is the seal setting mark.

Put the mechanical seal rotary unit on the shaft and slide it back against the flinger. Assemble the seal insert gasket (326), the mechanical seal insert (315), and seal insert gasket (325) to the face of the stuffing box and, placing the gland (300) in position, pull down the gland stud nuts evenly to approximately 15 foot pounds of torque. Make sure that the lapped face of the seal insert is towards the rotary unit. Reassemble the pump. Now carefully slide the rotary unit against the seal insert, compress the rotary unit and set it to the mark on the shaft sleeve and lock the rotary unit tightly in place with the set screws. Be careful not to cock the rotary unit.

Before starting the pump, bleed the air from the stuffing box. The stuffing box must be full of liquid or the seal faces may be damaged by lack of lubrication when the pump is started.

Occasionally a seal may leak very slightly when the pump is first started. If the leakage continues more than a few moments the pump should be shut down and the seal removed to discover the cause.

INSTALLATION OF DOUBLE INSIDE UNBALANCED SEALS

To make the seal installation, with the pump partially assembled as noted above, scribe a mark on the shaft sleeve (10) exactly in line with the face of the pump stuffing box. The impeller (3) and backhead (22) are now removed from the pump. If this marking or subsequent marking causes roughness on the shaft sleeve remove the burr carefully with crocus cloth. Any roughness on the shaft sleeve may damage the mechanical seal shaft packing when the seal is assembled.

Referring to the mechanical seal drawing, determine the two "D" dimensions for the two rotary units. Be sure to determine those for the particular pump type. Measure carefully from the mark which you have made on the shaft sleeve and make two new marks on the shaft sleeve, towards the pump end, exactly to these dimensions.

Double seal stationary inserts are of two types depending on the service conditions of the pump. The insert may be of rectangular cross section grooved for a "O" ring or the insert may be of L-shaped cross section used with a Teflon mounting ring.

To position the "O" ring mounted insert, lubricate the inside of the stuffing box and the inside of the mechanical seal gland. Place the "O" rings in the grooves and carefully slide the inserts into position in the stuffing box and seal gland. Be most careful to not damage the "O" ring.

To position the Teflon mounted insert, lubricate the inside of the stuffing box and the inside of the seal gland. Carefully slide the Teflon mounting rings into position and then slide the stationary inserts into place. The slots (or pins) in the stationary inserts must index with the drive pins (or slots) in gland and stuffing box.

Put the mechanical seal gland, with insert installed, on the pump shaft sleeve and slide it back against the flinger. Put the seal gland gasket on the sleeve and slide it back against the gland. Slide one seal rotary unit on the sleeve with the carbon face towards the bearing housing. Be careful not to damage the seal shaft packing. Be sure that the shaft sleeve hook is firmly against the shoulder on the shaft. Set the rotary unit carefully to its setting mark on the shaft sleeve and lock it tightly in place with the set screws. Slide the second rotary unit onto the shaft sleeve with the carbon face away from the bearing housing. Set it carefully to its setting mark and lock it tightly in place. Recheck both rotary settings and correct if necessary. Slide the pump backhead very carefully in place over the seals. Slide the gland gasket and seal gland into place and carefully and evenly tighten the gland stud nuts to approximately 15 foot pounds of torque. Do not cock the gland. The Pump may now be reassembled.

Double seals require a liquid in the stuffing box between the seal inserts to provide lubrication. This barrier liquid must be supplied at a pressure of 10 to 15 psi above stuffing box throat pressure to activate the inboard seal. Before starting the pump, be sure that the stuffing box is full of this lubrication and that all supply lines for this liquid are in place and in operation.

Leakage from the outboard seal can be easily spotted. Leakage through the inboard seal can be detected only by the loss of the barrier (lubricating) liquid from between the seals. If leakage occurs, the pump must be disassembled and the cause of leakage determined.

CUSTOMER'S PLANT MAINTENANCE RECORD

DEAN BROTHERS PUMP SERIAL No.

PLANT PROPERTY No.

SERVICE

LOCATION

Capacity ____________; T.D.H. ____________; Imp. Dia. ____________; Temp. ____________; RPM ____________.

MATERIALS OF CONSTRUCTION: Casing ________; Impeller ________; Shaft ________; Shaft Sleeve ________.

SPARE PARTS IN PLANT STOCK ROOM: ____

____

____

____

____

INTERCHANGEABLE WITH DEAN SERIAL NUMBERS ____________________________

____

____

____

____

Paul L. Armstrong Co., Inc.
Engineering Representatives

October 23, 1981

McDonnell-Douglas Co.
P.O. Box 103
Daggett, Ca.

Attn: Mr. Dick Morgan   Subject: Dean Brothers Pumps

Dear Mr. Morgan:

Reference your telephone conversation with Bill Warren the other day. Attached are copies of parts pages applying to the Dean Brothers Model R434 and R454 pumps, indicating the nine digit parts numbers for these pumps.

If you need additional information, please let us know.

Yours very truly,

Dona Steely

Dona C. Steely
Paul L. Armstrong Co., Inc., for
DEAN BROTHERS PUMPS, INC.

ds

enc.

1134 El Centro St. • P.O. Box 928 • South Pasadena, Ca. 91030
Telephone (213) 682-3633 • Telex 67-5317

DEAN BROTHERS PUMPS INC.
P.O. BOX 68172
INDIANAPOLIS, IND. 46268

Refer to GENERAL SECTION, pages 11-17 for SERVICE PARTS PRICES

PART NO.	QTY/ PUMP	PART NAME	MAT'L. CODE	PART CODE
		ASSEMBLED POWER FRAME KITS, COMPLETE		
		Steel or 316s/s shaft, for sleeve; jacketed bearing housing. See GENERAL Section, page 17.		
		Kits contain these Parts...		
7A	1	Constant Level Oiler		9351520
7B	1	Oiler Pipe Nipple,	CST-09	9453218
7C	1	Oil Drain Plug,	CST-07	9454018
9A	1	Brg.Hsg.Ft.Capscrew,	CST-24	9051572
9B	2	Brg.Hsg.Ft.Jkscr.set,	CST-24	9051578
{26	1	Bearing Housing	CI-10	1252949}
{26A	2	BH Core Pipe Plug set,	CST-30	9454330}
27	1	Brg.Hsg. Seal Ring,	CI-10	1602529
28	1	Brg.Hsg. End Cover,	CI-10	1081690
28A	4	BH End Cvr Cpscr set,	CST-24	9051509
80	1	Brg.Hsg.Vent Plug,	CST-07	9454545
9	1	Bearing Housing Foot,	CI-05	1721563
		And the Power Frame Changeout Set:		
10K	1	Shaft Sleeve Key,	SS-09	9715010
18	1	Splash Collar,	SS-03	1600422
25	1	Shaft Bearing-Radial 6312		9010151
25A	2	Shaft Brg.set-Thrust 7312BG		9010176
29	1	Shaft, for sleeve, Steel	CST-55	1136720
	opt.	" " " , 316s/s	SS-20	1136721
31	1	Thrust Bearing Locknut		9212524
31A	1	Thrust Brg.Locknut Washer		9656524
75B	1	Thrust Brg.Snap Ring-Large		9714518
76	1	Front Oil Seal,	RUB-09	9603041
76A	1	Rear Oil Seal,	RUB-09	9603031
77B	1	BH End Cvr.Gasket,	PPR-05	9153052
		Other Non-Kit Parts:		
29	opt.	Solid Shaft, Steel,	CST-55	1136725
36H	1	Coupling Key,	CST-30	9715061
563	8	Capscrew, Cas.Ft./Base	CST-24	9051578

* For exploded or cross-sectional views of parts to which P/N (part number) refers, please see R400 Series Circular C 1.4.40 or Instruction Manual MC 1.4.40.

+ For Mechanical Seal applications, please select service parts from the list accompanying the specific Seal Drawing in the Stuffing Box Section of your Price Book.

PART NO.	QTY/ PUMP	PART NAME	MAT'L. CODE	PART CODE
		Parts for Backhead Assembly:+		
10	1	Sleeve for Packing, 316s/s		1768350
	opt.	" Hardened 420s/s		1768355
10A	1	Packing Sets, Asbestos 45-1		6403060
	opts.	Babbitt Foil 45-2		6403063
		Aluminum Foil 45-3		6403066
		(9) Woven Teflon 45-4		6403067
{13	1	Packing Gld Ass'by,	CST-30	1763046
	2	w/screws		9052019
14	4	Gland Stud set,	CST-88	9552020
15	4	Gland Stud Nut set,	CST-10	9252483
17	1	Lantern Ring, Alloy Iron		1764238
54	1	Stuff.Box Bush., Alloy Iron		1760715
7	1	Cradle Spacer,		
		10" pumps,	CI-17	1251314
		12½" "	CI-17	1251330
		15½" "	CI-17	1251318
7G	4	Cradle Spacer-Brg.Hsg. Bolt set,	CST-24	9051536
		Alternate Fittings:		
{13	1	Packing Gld Ass'by, 316s/s		1763051
	2	ss-, w/screws		9052019
14	4	Gland Stud set, 304s/s, SS-		955202[illegible]
15	4	Gld.Std.Nuts, 304s/s, SS-		9252486
17	1	Lantern Ring 316s/s		1764239
54	1	Stuff.Box Bush., 316s/s		1760717
	1	Min Flo Bushing, Type S		1768854
	1			1768887
	1			9053534
	4			1406000
22	1	Backhead - NO FLUSH**		
		include gland stud, nut codes:		
14	4	Gland Stud	CST-88	9552020
15	4	Gland Stud Nut	CST-10	9252483
14A	2	Seal Port Plug	CST-07	9454041
		include stuff.box bushing code:		
54	1		CI-10	1760715
		10" Backhead, CS, C1.40	CST-05	1081151
		12½" Backhead, CS, C1.40	"	1081169
		15½" Backhead, CS, C1.40	"	1081185

**NOTE: if flush connection required, state on your order, "WITH FLUSH", and include the price addition shown on pg.11, GENERAL Section.

Impellers are furnished full diameter unless pump serial number is given when ordering or unless otherwise specified by customer.

For positive identification, specify pump serial number when ordering service parts. Service parts not described on printed pages will be quoted from Indianapolis.

Discounts, Specifications and Prices Subject to Change Without Notice.

DEAN BROTHERS PUMPS INC.
P.O. BOX 68172
INDIANAPOLIS, IND. 46268

Refer to GENERAL SECTION, pages 11-17 for SERVICE PARTS PRICES

PART NO.	QTY/PUMP	R454 PART NAME	MAT'L. CODE	PART CODE
		Parts for Liquid Ends:		
77	1	Casing Gasket, 10"	ASB-05	9156099
		12½"		9156175
		15½"		9156171
6	1	Backhead Ring, all sizes,	CI-09	1555960
6A	1	Casing Ring, by pump size,	CI-09	
		4X6X10, 2X4X15½, 3X4X15½		1555960
		6X8X12½		1556038
		4X6X15½		1556030
5	1	Casing - NO DRAIN + include stud codes		
5D	12	if ref.below is A:	CST-88	9552512
5D	16	if ref.below is B:	CST-88	9553012
		for 4X6X10 CS, Cl.40 A:	CST-05	1327404
		6X8X12½ B:	CST-05	1327680
		2X4X15½ B:	CST-05	1327550
		3X4X15½ B:	CST-05	1327561
		4X6X15½ B:	CST-05	1327582
		+NOTE: if drain required, state on your "WITH DRAIN", and include the price addition shown on pg. 13, GENERAL SECT.		
5C		Casing Stud Nuts	CST-10	
	12	10" size		9252630
	16	all other sizes		9252660

PART NO.	QTY/PUMP	R454 PART NAME	MAT'L. CODE	PART CODE
56A	2	Casing to Support Bolt set,	CST-24	9051589
56C	4	Cas. to Support Dowel Pin set,	CST-00	9690507
	2	Bkhd to Cradle Drawscrew set,	CST-24	9051518
	2	Cas. to Cradle Jackscrew set,	CST-24	9053028
		Impeller Assembly, all R434 Sizes, Cl.40*		
4	1	Impeller Key,	CST-30	9715058
12	1	Impeller Bolt,	CST-34	9051531
12A	1	Impeller Washer,	CST-30	1216720
3	1	Impeller, Integral Rings, CI-10		
		for 4 X 6 X 10		1286300
		for 6 X 8 X 12½		1286492
		for 2X4X15½, 3X4X15½		1286440
		for 4 X 6 X 15½		1286458

* Impellers are furnished full diameter unless pump serial number is given when ordering, or unless otherwise specified by customer.

Service parts not described on these printed pages will be quoted from Indianapolis.

For positive Identification, SPECIFY PUMP SERIAL NUMBER when ordering service parts.

Discounts, specifications and Prices are Subject to Change Without Notice.

DEAN BROTHERS PUMPS INC.
P.O. BOX 68172
INDIANAPOLIS, IN 46268

Refer to GENERAL SECTION, pages 11-17 for SERVICE PARTS PRICES

ASSEMBLED POWER FRAME KITS, COMPLETE
Steel or 316S/S shaft, for sleeve; jacketed bearing housing. See GENERAL SECTION, Page 17.

PART NO.	QTY/ PUMP	PART NAME	MATL CODE	PART CODE
		Kits contain these Component Parts:		
7A	1	Constant Level Oiler		9351510
7B	1	Oiler Pipe Nipple	CST-09	9453212
7C	1	Oil Drain Plug	CST-07	9454018
9A	1	Brg.Hsg.Ft.Capscrew	CST-24	9051506
9B	2	Brg.Hsg.Ft.Jkscr.set	CST-24	9051509
9F	2	Brg.Hsg.Ft.Jkblt.set	CST-24	9051509
9G	2	BkHd.Ft.Jb.Lknut.set	CST-10	9250530
26	1	Bearing Housing	CI-10	1252934
26A	1	BkHd.Core Pipe Plug	CST-07	9454336
27	1	Brg.Hsg.Seal Ring	CI-10	1602520
28	1	Brg.Hsg.End Cover	CI-10	1081582
28A	4	BH End Cvr.Cpscr.set	CST-24	9051506
80	1	Brg.Hsg.Vent Plug	CST-07	9454545
9	1	Bearing Housing Foot:		
		for 8½" sizes:1x3,1½x3,2x3		1721500
		for 8½" sizes:3x4,4x6		
		for 10" sizes:1½x3,2x3,3x4		1721501
		for 11½"sizes:1x2,1½x3,2x3		
		for all other R434 sizes:		1721502
		And the Power Frame Changeout Set:		
10K	1	Shaft Sleeve Key	SS-09	9715010
18	1	Splash Collar	SS-03	1600416
25	1	Shaft Brg.Radial,6309		9010148
25A	2	Shaft Brg.Set-Th'st,7309BG		9010174
29	1	Shaft,forsleeve,Steel	CST-55	1136705
	Opt.	" " " ,316 S/S	SS-20	1136706
31	1	Thrust Brg.Locknut		9212512
31A	1	Thrust Brg.Locknut Washer		9656515
75	1	Thrust Brg.Snap Ring-Small		9714529
75B	1	Thrust Brg.Snap Ring-Large		9714512
76	1	Front Oil Seal	RUB-09	9603020
76A	1	Rear Oil Seal	RUB-09	9603010
77B	1	BH End Cvr.Gasket	PPR-05	9153065
		Other Non-Kit Parts		
29	Opt.	Solid Shaft,Steel	CST-55	1136709
	Opt.	" " ,316 S/S	SS-20	1136710
36H	1	Coupling Key	CST-30	9715051
56B	8	Capscrew,Cas.Ft./Base	CST-24	9051509
56A	2	Capscrew,Cas/Cas.Ft.	CST-24	9051539
--	2	Jackscrew,Cas/Cradle	CST-47	9052566
56C	2	Dowel,Casing/Cas.Ft.	CST-00	9690150
--	4	Washer,Coupling Guard	CST-00	9651510

+For sealed box refer to Seal Service Parts Descriptor with required seal drawing.

PART NO.	QTY/ PUMP	PART NAME	MATL CODE	PART CODE
		Parts for Backhead Assembly		
10	1	Sleeve for Pkg. 316S/S		1768103
	Opt.	" Hardened 420S/S		1768104
10A	1	Packing Sets:Asb.43-1		6403050
	Opts:	Babbitt Foil 43-2		6403053
		Aluminum Foil 43-3		6403056
		Woven Teflon(9) 43-4		9405287
13	1	Pkg.Gld.Asmbly,w/screws	CST-30	1763009
17	1	Lant'n Rng,Alloy Iron		1764222
54	1	Stuff.Box Bush, " "		1760705
7	1	Cradle Spacer:		
		8½" pumps	CI-17	1251308
		10" pumps	CI-17	1251312
		11½" pumps	CI-17	1251315
		13½" pumps	CI-17	1251316
		Alternate Fittings		
13	1	Pkg.Gld.Assblh,316S/S		1763007
	2	S/S - w/screws		9052018
14	4	Gld.StudSet, 304S/S,S/S		9551552
15	4	Gld.Std.Nuts,304S/S,S/S		9252455
17	1	Lantern Ring,316S/S		1764223
54	1	Stuff.Bx.Bush.,316S/S		1760708
	1	MinFlo Bushing,Type S		1768844
	1			1768879
	1			9053533
	4			1406000
22	1	Backhead--NO FLUSH*-Class 40		
		include Gland Stud, Nut Codes		
14	4	Gland Stud	CST-88	9551550
15	4	Gland Stud Nut	CST-10	9252460
14A	2	Seal Port Plug	CST-07	9454027
54	1	Stuffing Box Bush	CI-10	1760705
		include Cap Screw Code:		
--	2	if ref.below is A:	CST-24	9051515
--	2	if ref.below is B:	CST-24	9051539
		8½" CS, Cl.40 A	CST-05	1081130
		10" CS, Cl.40 A	CST-05	1081163
		11½" CS, Cl.40 A	CST-05	1081179
		13½" CS, Cl.40 B	CST-05	1081181

*NOTE: If flush connection required, state on your order "WITH FLUSH" and include the price addition shown on page 11, GENERAL SECTION.

PART NO.	QTY/ PUMP	PART NAME	MATL CODE	PART CODE
7G	1	Cradle Spacer-Brg.Hsg. Bolt Set	CST-24	9051506

Impellers furnished full diameter unless pump serial number is given when ordering or unless otherwise specified by customer.

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DEAN BROTHERS PUMPS INC.
P.O. BOX 68172
INDIANAPOLIS, IND. 46268

Refer to GENERAL SECTION, pages 11-17 for SERVICE PARTS PRICES

PART NO.	QTY/ PUMP	PART NAME	MAT'L. CODE	PART CODE
		Parts for Liquid Ends:		
77	1	Casing Gasket, 8½"	ASB-05	9155924
		10"		9156099
		11½"		9156129
		13½"		9156168
6	1	Bkhd Ring, all sizes,	CI-09	1555935
6A	1	Casing Ring, by pump size, CI-09		
		1X3X8½, 1½X3X8½		1555900
		2X3X8½, 2X3X11½, 1½X3X13½, 2X3X13½		1555935
		1½X3X10, 2X3X10, 1X2X11½ and 1½X3X11½		1555905
		3X4X8½, 3X4X10, 3X4X11½ and 3X4X13½		1555950
		4X6X8½		1556009
		4X6X10		1556020
		4X6X11½		1555965
5	1	Casing - NO DRAIN+ include stud codes:		
5D	8	if ref. below is A:	CST-88	9552512
5D	12	if ref. below is B:	CST-88	9552512
5D	16	if ref. below is C:	CST-88	9552516
for		1X3X8½, CS Cl.40 A	CST-05	1327110
		1½X3X8½ " " A		1327126
		2X3X8½ " " A		1327150
		3X4X8½ " " A		1327210
		4X6X8½ " " A		1327241
		1½X3X10 " " B		1327061
		2X3X10 " " B		1327091
		3X4X10 " " B		1327260
		4X6X10 " " B		1327411
		1X2X11½ " " B		1327281
		1½X3X11½ " " B		1327290
		2X3X11½ " " B		1327320
		3X4X11½ " " B		1327350
		4X6X11½ " " B		1327380
		1½X3X13½ " " C		1327415
		2X3X13½ " " C		1327420
		3X4X13½ " " C		1327430

+ NOTE: if drain required, state on your order, "WITH DRAIN", and include the price addition shown on page 13, GENERAL Section -

PART NO.	QTY/ PUMP	PART NAME	MAT'L CODE	PART CODE
		Impeller Assy, all R434 Sizes, Cl.40 *		
4	1	Impeller Key,	CST-30	9715051
12	1	Impeller Bolt,	CST-34	9051502
12A	1	Impeller Washer,	CST-30	1216705
3	1	Impeller, Integral Rings, CI-10		
		for 1X3X8½, 1½X3X8½		1286105
		for 2X3X8½		1286121
		for 3X4X8½		1286150
		for 4X6X8½		1286179
		for 1½X3X10, 2X3X10		1286240
		for 3X4X10		1286262
		for 4X6X10		1286295
		for 1X2X11½, 1½X3X11½		1286305
		for 2X3X11½		1286315
		for 3X4X11½		1286335
		for 4X6X11½		1286355
		for 1½X3X13½, 2X3X13½		1286375
		for 3X4X13½		1286380
	2	Backhead-Cradle Drawscrew set,	CST-24	
		8½ & 10" Sizes		9051515
		11½" Sizes		905[illegible]
		13½" Sizes		9051[illegible]

* Impellers are furnished full diameter unless pump serial number is given when ordering, or unless otherwise specified by customer.

PART NO.	QTY/ PUMP	PART NAME	MAT'L CODE	PART CODE
		Casing Stud Nuts		
5C	8	8½" pumps	CST-10	925263[illegible]
	12	10", 11½" pumps	CST-10	925263[illegible]
	16	13½" pumps	CST-10	925263[illegible]

For positive identification, specify pump serial number when ordering service parts. Service parts not described on printed pages will be quoted from Indianapolis.

1.2.2 AUXILIARY EXTRACTION OIL PUMP

1.2.2.1 Identification

Tag Number	Description
P-305	Auxiliary Extraction Oil Pump

1.2.2.2 Description

Manufacturer	:	Dean Brothers Pumps, Inc. P.O. Box 68172, Indianapolis, Indiana 46268
Part Number	:	3 X 4 X 8½ R434-133261
Rockedyne Specification No.	:	GA000-90907-T11 (following)
Material	:	
Weight	:	285 lb.

1.2.2.3 Prescribed Service

Oil, 130 PSIA, 600° F.

1.2.2.4 Vendor

Paul L. Armstrong Co., Inc., P.O. Box 928, South Pasadena, CA 91030

1.2.2.5 Special Cautions

See Dean Brothers manual MC-1.4.40 (Section 1.2.1.12)

1.2.2.6 Periodic Service

See Dean Brothers manual MC-1.4.40 (Section 1.2.1.12)

1.2.2.7 Parts List

See Dean Brothers manual MC-1.4.40 (Section 1.2.1.12)

1.2.2.8 Special Tools

None

1.2.2.9 Maintenance Instructions

See Dean Brothers manual MC-1.4.40 (Section 1.2.1.12)

1.2.2.10 Acceptance Tests

See Dean Brothers manual MC-1.4.40 (Section 1.2.1.12)

ROCKWELL INTERNATIONAL CORPORATION
ROCKETDYNE DIVISION
6633 CANOGA AVENUE, CANOGA PARK, CALIFORNIA 91304

FACILITIES ENGINEERING, DEPARTMENT 541

SPECIFICATION NUMBER GA000-90907-T11

FOR

SEAL STEAM OIL PUMP AND MOTOR
THERMAL STORAGE SYSTEM
10 MWe SOLAR PILOT PLANT

BARSTOW, CALIFORNIA

C. J. NORDQUIST
MANAGER
FACILITIES ENGINEERING

A. E. MOORE
CHIEF PROJECT ENGINEER

J. REPAS
SENIOR PROGRAM COORDINATOR
QUALITY PROJECT MANAGEMENT

Alex Djordjevic
A. DJORDJEVIC
PROJECT ENGINEER
FACILITIES ENGINEERING

09 JUNE 1980

THIS SPECIFICATION WAS APPROVED, CHECKED, AND PREPARED BY THE UNDERSIGNED.

MECHANICAL DESIGN UNIT

APPROVED BY K. H. Lynch DATE 6/9/80

CHECKED BY R. Spruill DATE 2 June 80

PREPARED BY Walter O Knippel DATE 5 June 80

ELECTRICAL DESIGN UNIT

APPROVED BY H. L. Hughes DATE 6-9-80

CHECKED BY R. A. Thompson DATE 6-6-80

PREPARED BY J. D. Chambers DATE 9 June 80

C O N T E N T S

LIST OF DRAWINGS

KEY ITEM HEADINGS

ITEM	HEADING
1.0	SCOPE
2.0	APPLICABLE DOCUMENTS
3.0	DOCUMENT SUBMITTALS
4.0	DESIGN AND CONSTRUCTION
5.0	PERFORMANCE REQUIREMENTS
6.0	PROPERTIES OF EXXON CALORIA HT-43 TRANSFER FLUID
7.0	ELECTRICAL
8.0	TESTING
9.0	CLEANING
10.0	SEALING AND MARKING
11.0	PAINTING
12.0	PREPARATION FOR SHIPMENT

1.0 SCOPE

1.1 A SINGLE STAGE, CENTRIFUGAL, VOLUTE-TYPE, HORIZONTAL, HOT OIL PUMP SHALL BE FURNISHED, FACTORY ASSEMBLED, ALIGNED WITH COUPLING AND MOTOR ON A BASEPLATE, AND DELIVERED IN ACCORDANCE WITH THE REQUIREMENTS OF THIS SPECIFICATION.

1.1.2 THE PUMP SHALL BE DESIGNED FOR SERVICE IN HEATING OIL, EXXON CALORIA HT-43, AND TO OPERATE AT 1750 RPM AND SPECIFIED GPM AGAINST A SPECIFIED DISCHARGE HEAD THROUGH THE SPECIFIED TEMPERATURE RANGE.

2.0 APPLICABLE DOCUMENTS

2.1 THE FOLLOWING DOCUMENTS OF THE LATEST REVISION IN EFFECT FORM A PART OF THIS SPECIFICATION. THE ABSENCE OF SPECIFIC REFERENCE TO THESE DOCUMENTS THROUGHOUT THESE SPECIFICATIONS SHALL NOT IN ANY WAY RELIEVE THE SUPPLIER FROM COMPLIANCE. DEVIATIONS FROM ANY SPECIFICATION OR DOCUMENT SHALL REQUIRE THE WRITTEN APPROVAL OF ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION.

2.1.1 AMERICAN NATIONAL STANDARDS INSTITUTE CODE FOR PRESSURE PIPING, ANSI B31.1 AND STEEL PIPE FLANGES AND FLANGED FITTINGS B16.5.

2.1.2 HYDRAULIC INSTITUTE STANDARDS, 1975 EDITION, 13.

2.1.3 CALIFORNIA ADMINISTRATIVE CODE, TITLE 8, CHAPTER 4, SUBCHAPTER 4, CONSTRUCTION SAFETY ORDERS, AND SUBCHAPTER 7, GENERAL INDUSTRY SAFETY ORDERS.

2.1.4 OCCUPATIONAL SAFETY AND HEALTH STANDARDS, PART 1910.

2.1.5 LATEST REVISION OF THE NATIONAL ELECTRICAL CODE, NFPA 70.

2.1.6 UNDERWRITERS LABORATORY OR FACTORY MUTUAL ELECTRICAL TEST PROCEDURES FOR LISTED ELECTRICAL EQUIPMENT.

3.0 DOCUMENT SUBMITTALS

3.1 ONE REPRODUCIBLE COPY OF THE FOLLOWING DATA SHALL BE SUBMITTED WITH THE BIDS.

3.1.1 OVER-ALL DRAWINGS OF THE PUMP SHOWING ENVELOPE DIMENSIONS AND ALL INTERFACE DIMENSIONS IS REQUIRED.

3.1.2 PROPOSED MATERIAL SPECIFICATIONS.

3.1.3 SECTIONAL DRAWING OF COMPLETE PUMP WITH PART IDENTIFICATION.

3.1.4 CENTRIFUGAL PUMP PERFORMANCE CURVE AT RATED RPM, INCLUDING NPSH, EFFICIENCY, TOTAL HEAD AND HP FOR CALORIA HT-43 AT 580F.

3.1.5 FURNISH A LIST OF RECOMMENDED SPARE PARTS AND TOOLS, WITH INSTRUCTIONS FOR PUMP DISASSEMBLY.

3.1.6 ONE SET OF REPRODUCIBLE DRAWINGS OF OUTLINE AND BASE DIMENSIONS OF THE POWER SUPPLY AND MOTOR SHALL BE SUBMITTED TO ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION, WITH THE BID.

3.2 CERTIFIED COPY OF THE AFOREMENTIONED DATA, PARAGRAPHS 3.1.1 THROUGH 3.1.6 INCLUSIVE, SHALL BE SUBMITTED TO ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION WITHIN (14) DAYS AFTER THE RECEIPT OF ORDER.

3.3 THREE COPIES OF COMPLETE PARTS LIST, INSTALLATION MAINTENANCE AND OPERATING INSTRUCTIONS SHALL BE DELIVERED TO ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION AT THE TIME OF PUMP DELIVERY.

3.4 ONE SET OF REPRODUCIBLE ELECTRICAL SCHEMATICS, WIRING DIAGRAMS, INTERCONNECTION DIAGRAMS, AND COMPONENT SCHEMATICS SHALL BE SUPPLIED AT THE TIME OF DELIVERY.

3.5 CERTIFIED PUMP TEST REPORTS, INCLUDING DATA LISTED IN PARAGRAPH 3.1.4, SHALL BE SUBMITTED PRIOR TO SHIPMENT.

4.0 DESIGN AND CONSTRUCTION

4.1 THE PUMP SHALL BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS SETFORTH BY THE 13TH EDITION OF THE HYDRAULIC INSTITUTE STANDARDS.

4.2 THE PUMP SHALL BE DESIGNED AND CONSTRUCTED SO THAT THERMAL EXPANSION WILL NOT DISTURB ALIGNMENT OF SHAFT BEARINGS, SHAFT PACKING, SHAFT COUPLINGS, OR SEALS.

4.3 THE PUMP SHALL BE CENTERLINE MOUNTED, END SUCTION, VERTICAL DISCHARGE, FURNISHED ON A RIGID PUMP/MOTOR BASEPLATE WITH PROVISION FOR OIL SPILL DRAINAGE TO A SINGLE POINT.

4.4 THE ELEVATION OF THE SUCTION FLANGE CENTERLINE ABOVE THE BOTTOM OF THE BASEPLATE SHALL NOT EXCEED ONE FOOT TWO INCHES.

4.5 PUMP CASTINGS AND BEARING HOUSINGS SHALL BE MACHINED WITH A DEEP GROOVE OR DOWELLING TO MAINTAIN RIGID ALIGNMENT OF THE TOTAL ASSEMBLY.

4.6 PUMP SUPPORTS AND BEARING HOUSINGS SHALL BE STRESS RELIEVED.

4.7 COOLING OF PUMP BEARINGS AND SEALS, IF REQUIRED, SHALL BE ACCOMPLISHED IN A MANNER THAT SHALL MINIMIZE THE LOSS OF HEAT FROM THE OIL.

4.8 TO ENSURE COMPATIBILITY OF THE EXXON CALORIA HT-43 HEAT TRANSFER FLUID WITH THE MATERIALS USED FOR THE CONSTRUCTION OF THE PUMP, NO COPPER OR ALLOYS CONTAINING A SIGNIFICANT AMOUNT OF COPPER SHALL BE USED.

4.9 MECHANICAL SEALS

4.9.1 THE PUMPS SHALL BE PROVIDED WITH A JOHN CRANE TYPE 15 WT MECHANICAL SEAL WITH THE TUNGSTEN CARBIDE VERSUS TUNGSTEN CARBIDE FACES.

4.9.2 THE PUMPS SHALL BE PROVIDED WITH A SEAL FLUSHING SYSTEM.

4.10 COOLING WATER PIPING

4.10.1 THE PUMPS SHALL BE PROVIDED WITH COOLING WATER PIPING WHICH SHALL INCLUDE THE FOLLOWING.

4.10.1.1 AN INLET AND OUTLET 3/4" GLOBE VALVE AT THE PUMP BASE PLATE.

4.10.1.2 A 3/4" SOLENOID VALVE.

4.10.1.3 A PADDLE-TYPE FLOW SWITCH.

4.10.1.4 ALL PIPING FOR THE COOLING WATER FLOW BETWEEN THE INLET AND OUTLET VALVES AND THE PUMP INCLUDING A 1/4" LINE TO THE STUFFING BOX WITH A COIL WOUND AROUND THE PUMP CASING TO PROVIDE STEAM FOR THE FLUSHING OF THE STUFFING BOX.

4.10.1.5 A 1/4" NEEDLE VALVE IN THE 1/4" FLUSHING LINE.

4.10.1.6 A THERMAL SWITCH AT THE OUTLET OF THE SEAL FLUSHING SYSTEM DRAIN FOR THE DETECTION OF OIL LEAKS.

5.0 PERFORMANCE REQUIREMENTS

THE PUMP SHALL BE DESIGNED TO PROVIDE EXTRACTION, AND WARM UP SERVICE ACCORDING TO THE FOLLOWING REQUIREMENTS.

5.1 EXTRACTION SERVICE

THE PUMP SHALL PRODUCE AN OPERATING PRESSURE OF 13.7 PSID OR MORE OVER THE FLOW RANGE OF 266 GPM TO 307 GPM. OPERATION AT 307 GPM SHALL BE CONSIDERED CONTINUOUS DUTY.

THE PUMP SHALL OPERATE OVER THE REQUIRED FLOW RANGE WITHIN THE TEMPERATURE RANGE OF 350F TO 580F. PUMP HEAD AS GIVEN SHALL BE DEVELOPED OVER THE REQUIRED FLOW RANGE WITH FLUID INLET TEMPERATURES FROM 560F TO 580F.

5.2 WARM UP SERVICE (60F TO 350F)

THE PUMP SHALL BE CAPABLE OF CONTINUOUS OPERATION AND MEET THE HEAD REQUIREMENTS UP TO A FLOW RATE OF 135 GPM WITH FLUID TEMPERATURE DOWN TO 60F. IF THE PUMP CANNOT MEET THE REQUIRED FLOW FOR THE WARM UP SERVICE, THE MANUFACTURER SHALL IDENTIFY THE FLOW FOR THE WARM UP SERVICE THAT THE PUMP IS CAPABLE OF DELIVERING. A FLOW CONTROL VALVE DOWNSTREAM OF THE PUMP WILL CONTROL THE FLOW.

5.3 POWER CONSUMPTION

PUMP SHAFT POWER SHALL NOT EXCEED 10 HORSEPOWER.

5.4 NPSH

A NPSH OF AT LEAST 25 FEET IS AVAILABLE UNDER ALL OPERATING CONDITIONS. (BASED ON OIL.)

5.5 OPERATING ENVIRONMENT

5.5.1 FLUID TEMPERATURE OPERATING RANGE WILL BE 60 F TO 580F.

5.5.2 AMBIENT TEMPERATURE RANGE WILL BE 16F TO 113F.

5.5.3 PUMP SHALL BE LOCATED IN THE OUTSIDE ATMOSPHERE AT A SITE ELEVATION OF 1950 FEET (13.72 PSIA)

5.5.4 INLET PRESSURE

STATIC PRESSURE AT THE PUMP INLET WILL COVER THE RANGE OF -5 PSIG WHEN OPERATING AND A MAXIMUM OF 13 PSIG DURING NON-OPERATION. NEGATIVE VALUES ARE ASSOCIATED WITH OPERATION OF THE FLUID BELOW 100F.

5.6 LOADS

5.6.1 PIPING

IT IS DESIRABLE THAT THE PUMP ASSEMBLY BE CAPABLE OF SUPPORTING THE FOLLOWING LOADS:

PUMP SUCTION FLANGE

	Fx	Fy	Fz	Fr	Mx	My	Mz
ALLOWABLE LOADS	800	435	640	770	725	295	600

PUMP DISCHARGE FLANGE

	Fx	Fy	Fz	Fr	Mx	My	Mz
ALLOWABLE LOADS	480	600	300	566	725	295	600

FORCE UNITS = LBS MOMENT UNITS = LB. FT

).0 PROPERTIES OF EXXON CALORIA HT-43 HEAT TRANSFER FLUID

6.1 THE FLUID IS A COMMERCIAL PRODUCT MANUFACTURED BY EXXON CORPORATION, AND IS DESCRIBED BY THEM AS "A PETROLEUM FRACTION SIMILAR TO LIGHT LUBE OIL". PROPERTY VALUES FOR DENSITY, HEAT CAPACITY, THERMAL CONDUCTIVITY, AND VISCOSITY ARE GIVEN AS FUNCTIONS OF TEMPERATURE IN TABLE 1. OTHER PROPERTY DATA IS SUMMARIZED BELOW:

MAXIMUM RECOMMENDED BULK TEMPERATURE: 600F

MAXIMUM RECOMMENDED FILM TEMPERATURE: 680F

POUR POINT: 15F (-9C)

FLASH POINT: 400F (204C)

AUTOIGNITION TEMPERATURE: 759F (404C)

VAPOR PRESSURE:

TEMP.	FRESH FLUID	WEATHERED FLUID
400 F	0.57 PSIA	0.09 PSIA
450 F	1.8 PSIA	0.3 PSIA
500 F	3.7 PSIA	0.8 PSIA
575 F	9.0 PSIA	2.7 PSIA
600 F	11.3 PSIA	3.7 PSIA

TABLE 1, PROPERTIES OF EXXON CALORIA HT-43 AT SELECTED TEMPERATURES

TEMPER-ATURES	DENSITY			SPECIFIC HEAT	THERMAL CONDUCTIVTY	VISCOSITY	
	GR/CC	LB/FT3	LB/GAL	BTU/LB-F	BTU/FT-HR-F	CENTI-POISE	LBm/HR-FT
40F	0.863	53.9	7.20	0.42	0.073	240	580
77F	0.850	53.1	7.09	0.44	0.070	57.9	140
100F	0.841	52.5	7.02	0.45	0.069	27.7	67
200F	0.805	50.3	6.72	0.50	0.064	4.96	12.0
300F	0.768	48.0	6.41	0.55	0.060	1.98	4.80
400F	0.730	45.6	6.09	0.60	0.056	1.03	2.50
425F	0.719	44.9	6.00	0.61	0.055	0.91	2.20
450F	0.709	44.3	5.92	0.63	0.053	0.79	1.92
500F	0.689	43.0	5.75	0.65	0.051	0.64	1.54
575F	0.657	41.0	5.48	0.69	0.048	0.47	1.13
600F	0.645	40.3	5.38	0.70	0.047	0.43	1.03

7.0 ELECTRICAL

7.1 GENERAL

7.1.1 THE POWER SOURCE FOR THE PUMP MOTOR WILL BE 480V, 3 PHASE 60HZ, PROVIDED FROM A HIGH RESISTANCE GROUNDED WYE TRANSFORMER.

7.1.2 THE PUMP MOTOR SHALL BE FOR INSTALLATION OUTDOORS IN A CLASS I, DIVISION 2, GROUP D HAZARDOUS LOCATION AS DEFINED BY THE NATIONAL ELECTRICAL CODE. THE PUMP, FLOW SWITCH AND THE THERMAL SWITCH SHALL MEET THIS REQUIREMENT.

7.1.3 THE PUMP MOTOR STARTER SHALL BE A SIZE 1 CIRCUIT BREAKER TYPE MAGNETIC STARTER HAVING THE FOLLOWING FEATURES OF DESIGN:

7.1.3.1 30 AMPERE, 600 VAC, 25000 AMPERE RMS INTERRUPTING CAPACITY THERMAL MAGNETIC CIRCUIT BREAKER.

7.1.3.2 NEMA 12 DUST TIGHT AND DRIP TIGHT ENCLOSURE.

7.1.3.3 3 POSITION "HAND-OFF-AUTO" SELECTOR SWITCH AND RED PILOT LIGHT IN COVER.

7.1.3.4 A TOTAL OF ONE NORMALLY OPEN AND ONE NORMALLY CLOSED ELECTRICAL INTERLOCK ON MAGNETIC CONTACTOR.

7.1.3.5 THREE MELTING ALLOY OVERLOAD RELAYS WITH THERMAL UNITS TO SUIT THE MOTOR NAMEPLATE FULL LOAD CURRENT.

7.1.3.6 120 VOLT CONTROL CIRCUIT TRANSFORMER HAVING 100 VA ADDITIONAL CAPACITY AND ONE FUSE IN SECONDARY.

7.1.3.7 STARTER SHALL BE WIRED IN ACCORDANCE WITH WIRING SCHEMATIC SKETCH "B".

7.1.4 A CUSTOMER FURNISHED "START-STOP" TWO WIRE 5 TO 10 VDC CONTROL VOLTAGE WILL BE USED TO CONTROL THE MOTOR STARTER. THE START SIGNAL WILL BE MAINTAINED WHILE THE MOTOR IS RUNNING AND REMOVAL OF THE SIGNAL SHALL CAUSE THE MOTOR TO STOP.

7.1.5 AS SHOWN BY THE WIRING SCHEMATIC, SKETCH "B", THE PUMP SHALL ALSO STOP IF THE "WATER FLOW SWITCH" OPENS OR THE "PUMP THERMAL SWITCH" OPENS.

7.2 ANNUNCIATOR PANEL DESCRIPTION

.2.1 THE ANNUNCIATOR PANEL SHALL BE FURNISHED AS SHOWN ON SKETCH "A" AND WIRING OF ANNUNCIATOR PANEL AND EXTERNAL

CONNECTIONS SHALL BE AS SHOWN ON SKETCH "B".

7.2.2 THE PURPOSE OF THE ANNUNCIATOR PANEL IS TO IDENTIFY WHICH FAILURE MODE HAS CAUSED AN AUTOMATIC SHUTDOWN OF THE PUMP. THREE POSSIBLE FAILURE MODES CAN BE IDENTIFIED AS FOLLOWS: "MOTOR OVERLOAD", "SEAL LEAKAGE" AND "WATER FLOW".

7.2.3 THE CONTROL SEQUENCE SHOWN BY THE SCHEMATIC SKETCH "B" ALSO WILL CAUSE THE PUMP COOLING WATER TO CONTINUE TO FLOW FOR UP TO 10 MINUTES AFTER PUMP SHUTDOWN.

7.2.4 ALL INTERCONNECTIONS BETWEEN MOTOR STARTER AND ANNUNCIATOR PANEL AS WELL AS ALL OTHER INSTALLATION WIRING WILL BE BY CUSTOMER.

8.0 TESTING

8.1 SHOP TESTS

8.1.1 THE PUMP AND MOTOR DRIVE SHALL BE FACTORY TESTED. THE TESTS SHALL BE IN ACCORDANCE WITH THE "HYDRAULIC INSTITUTE STANDARDS". CERTIFIED TEST CURVES AND CERTIFIED TEST REPORTS SHALL BE SUBMITTED FOR APPROVAL, PRIOR TO SHIPMENT IN ACCORDANCE WITH SPECIFIED DOCUMENTATION REQUIREMENTS.

8.1.2 ALL NECESSARY PERFORMANCE TESTS SHALL BE CONDUCTED TO VERIFY CURVES PREVIOUSLY SUBMITTED AS PART OF THE BIDDER'S PROPOSAL.

9.0 CLEANING

9.1 ALL INTERNAL AND EXTERNAL SURFACES OF EQUIPMENT SHALL BE CLEANED OF ALL MILL SCALE, LOOSE METAL PARTICLES, WELD SPATTER, SLAG, DIRT, GREASE, OIL AND OTHER FOREIGN MATTER. ALL EXTERNAL FERROUS SURFACES SHALL BE CLEANED, IN ACCORDANCE WITH SSPC SURFACE PREPARATION SPECIFICATION SSPC-SP 3, "POWER TOOL CLEANING." ALL BURRS AND FLASHING SHALL BE REMOVED AND ALL SHARP EDGES SHALL BE EASED.

9.2 A REPRESENTATIVE OF THE BUYER MAY VISUALLY INSPECT THE EQUIPMENT AFTER CLEANING. ANY EVIDENCE OF FOREIGN MATTER WILL BE CAUSE FOR REJECTION AND RE-CLEANING.

10.0 SEALING AND MARKING

10.1 ALL OPENINGS SHALL BE SEALED AGAINST CONTAMINATION

IMMEDIATELY AFTER CLEANING.

10.2 FLANGE OPENINGS SHALL BE PROTECTED BY BLIND FLANGES AND GASKETS, OR BY POLYETHYLENE SHEETING (MINIMUM 0.008 INCH THICK), BACKED WITH CLEAN METAL, CLEAN PLYWOOD, OR HEAVY CARDBOARD, AND BOLTED OR SECURELY TAPED IN PLACE. POLYETHYLENE SHEETING SHALL BE SEALED TO PREVENT DUST INFILTRATION THROUGH FLANGE BOLT HOLES.

10.3 SCREWED PIPE PORTS SHALL BE SEALED WITH PIPE PLUGS.

10.4 THE PUMP AND MOTOR SHALL BE PERMANENTLY IDENTIFIED BY STAMPING OR ELECTORETCHING A METAL NAMEPLATE WITH ALL PERTINENT INFORMATION CLEARLY INSCRIBED THEREON. THE NAMEPLATE SHALL BE PERMANENTLY ATTACHED TO EQUIPMENT IN A CONSPICUOUS PLACE.

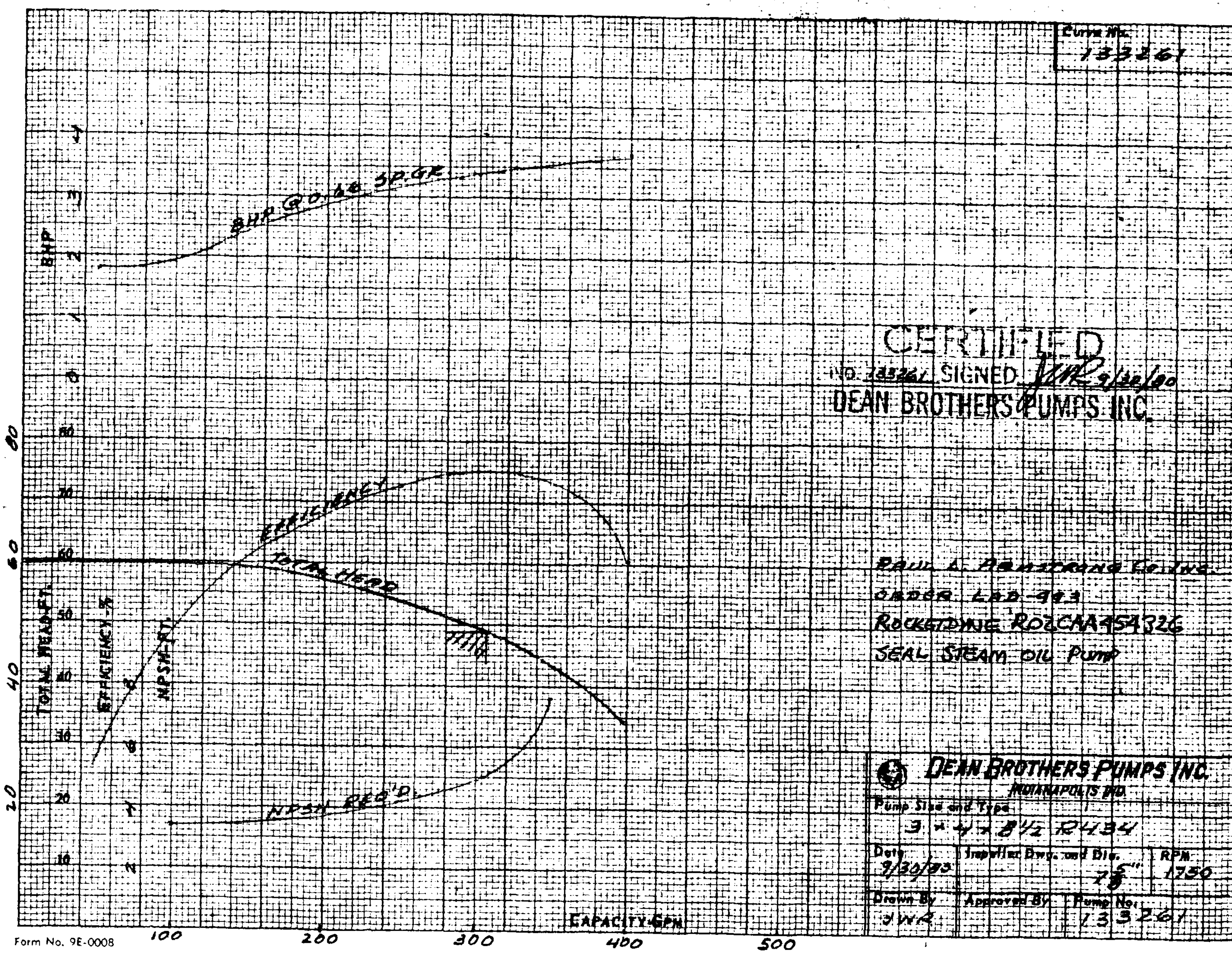
11.0 PAINTING

11.1 ALL EXPOSED SURFACES OF THE EQUIPMENT, EXCLUDING NAME AND DATA PLATES, TAGS, AND MACHINED MATING SURFACES, SHALL BE GIVEN ONE (1) SHOP COAT EACH OF RUST INHIBITIVE PRIMER AND FINISH PAINT THAT ARE COMPATIBLE WITH THE MAXIMUM OPERATING CONDITIONS THAT WILL BE ENCOUNTERED IN THE OUTSIDE ATMOSPHERE.

11.2 NAMEPLATES, DATA PLATES, TAGS, AND MACHINED MATING SURFACES SHALL BE COATED WITH A SLUSHING COMPOUND.

12.0 PREPARATION FOR SHIPMENT

12.1 EQUIPMENT SHALL BE BOXED, CRATED AND/OR SKID MOUNTED, AND COVERED TO SUCH AN EXTENT TO PREVENT DAMAGE DURING SHIPMENT AND TO FACILITATE HANDLING.



Form No. 9E-0008

1.2.3 Fluid Make Up Pump

1.2.3.1 Identification

Tag Number	Description
P-306	Fluid Make Up Pump

1.2.3.2 Description

Manufacturer: Worthington Group
McGraw-Edison Co.
East Orange, NJ 07017

Part Number: Type GR, Size 3" GRW Frame Size 215

1.2.3.3 Vendor

Worthington

1.2.3.4 Specification

DOE Spec No. 40M7006S

1.2.3.5 Piping Connections

DOE Drawing No. 40P3005132027

1.2.3.6 Operation/Maintenance

See Following Worthington Manual 2066-E4E

INSTRUCTIONS FOR INSTALLATION, OPERATION, MAINTENANCE AND LIST OF PARTS

DOUBLE HELICAL

ROTARY PUMPS

Types GR, GRM, GRMI, GRJ, GRL, GRJL, GRW, GRWM, GRWMI, GRWL, GRH, GRHM, GRHMI, GRHJ, GRHL, GRHJL

TYPE GR
3'GRW FRAME
SIZE 215
FILTER
PF-70-1-1

☑ REVIEWED/NO COMMENTS
☐ REVIEWED/SEE COMMENTS
☐ REVISE PER COMMENTS & RESUBMIT FOR REVIEW
☐ SEE LETTER OF TRANSMITTAL

ENG. DEPT. BY JAMM DATE MAR 27 1981

NEITHER REVIEW, COMMENT, NOR REVISION RELIEVES MANUFACTURER OR CONTRACTOR FROM RESPONSIBILITY FOR COMPLIANCE WITH SPECIFICATIONS OR WITH ALL OTHER CONTRACT REQUIREMENTS.

RETURN TO
Stearns-Roger
INCORPORATED
ON OR BEFORE

RECEIVED
MAR 17 1981
TOWNSEND & BOTTUM INC.

~~Solar Pilot Power~~ Plant, Daggett, CA.
P.O.#CM-0100-965, ~~Spec.~~ Section No. A4-8, A4-9, A4-10
Tag: P-306, ~~P-710~~

Clarify manual application.
Applicable only for Pump P-306

Stearns-Roger
C21700 MAR 20 '81
No. CP-9 File No. 237

MEMBER
HYDRAULIC INSTITUTE U.S.A.

1.2.3-2

Worthington Group
McGraw-Edison Company
14 Fourth Avenue
East Orange, NJ 07017

2066-E4E

INTRODUCTION

This booklet gives instructions which apply to Worthington's type GR Rotary Pumps.* The GR pump is a gear type rotary pump designed for handling viscous liquids at moderate pressures. As such it depends upon accuracy of assembly and close internal clearances for efficient operation. Pumping action is achieved by liquid being carried around in the space between the gear teeth and the pump body and being forced out as the teeth mesh on the discharge side. It is the close clearances around the gear that prevent liquid from leaking back to the suction side. This enables the pump to build up pressure needed to force liquid thru the discharge pipe. Double helical impeller gears provide smooth, pulsation-free flow and heavy duty bearings support the loads which discharge pressure imposes on the impeller gears.

These instructions will answer most of your questions about operation and maintenance of your GR rotary pump. Since these pumps are standardized for application to a wide range of services, it would not be practical to include perfomance data for all pumps in this instruction booklet. If performance characteristics and ratings have not been furnished for your installation, your Worthington Representative can provide you with necessary information.

When requesting information or ordering replacement parts be sure to give pump serial number and size as shown on nameplate. When requesting information on pump performance or bearing life full conditions of service (pressures, type of liquid, speed etc.) should be known.

*SOME NOTES ON NOMENCLATURE

Worthington standard heavy duty gear type rotary pumps from sizes 1 ½ thru 6 are designated as type GR rotary pumps. Additional letters in the model name serve to define the standard versions of the type GR pump. These versions are illustrated on pages 9, 10 and 11.

The number which precedes the letter designation is an indication of size of suction and discharge connections (except size 5 which uses 6" standard connections).

A letter "S" anywhere in the model name indicates that the pump has one or more non-standard features.

GR pump casings are normally cast iron. Cast steel or nodular iron casings are made for specialized applications. There is no letter designation for these optional materials.

There are occasional exceptions to these nomenclature rules. For this reason, pump serial numbers should be included whenever referring to a specific pump.

This booklet does not apply to smaller Worthington Rotary pumps of types GA, GAR or GB or obsolete types GI, GS, GE, GRV or GEC.

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SECTION I
INSTALLATION

CHECKING EQUIPMENT

Inspect and check shipping manifest immediately on receipt of shipment and report any damage or shortage to transportation company's local agent.

STORAGE

If the pumping unit is to be placed in storage, it should be inspected, re-crated, and stored in a dry location. Parts subject to attack from moisture should be coated with a protective material.

CLEANING

All parts must be cleaned prior to installation. Use solvent to remove slushing compounds which have been used to protect parts in transit.

PRODUCT CONTAMINATION

All pumps are shipped with a small amount of preservative oil inside to protect the internal mechanism against corrosion. If this oil will be detrimental to the system, it will be necessary to disassemble the pump, clean all parts thoroughly and fill the pump with the liquid to be pumped.

LOCATION

The pump should be installed in a light, clean, dry location and so placed that it is easily accessible for inspection and maintenance. Suction piping should be full size, short and direct. Motor driven units should not be located in damp or moist places unless provisions have been made for this condition. Check motor rotation against rotation arrow on pump nameplate. If necessary pump may be adjusted for reverse rotation. See page 6.

FOUNDATION

The foundation should afford permanent rigid support for the entire unit. Concrete foundations built up from solid ground will prove the most satisfactory. Ample allowance should be provided for grout in building the foundation.

Foundation bolts of the specified size should be accurately located according to drawings. Each bolt should be surrounded by a pipe sleeve three or four diameters larger than the bolt. After the concrete is poured the pipe is held solidly, while the bolts may be moved to conform to the holes in the bedplate.

When a unit is mounted on steel work or other structure, it should be set directly over, or as close as possible to the supporting beams or walls, and should be so supported that the baseplate cannot be distorted by yielding or springing of the structure.*

MOUNTING AND ALIGNMENT

Shaft alignment is the most important consideration in pump installation. Pump-driver combinations are aligned at the factory, but baseplates can be sprung in shipment or distorted by unequal tightening of foundation bolts, so they must be checked before they are put in service.

Pumps are generally shipped mounted, and it is usually unnecessary with units of moderate size to remove the pump or driver from its baseplate when leveling. The unit should be placed over the foundation supported by short strips of steel plate and wedges close to the foundation bolts, allowing for grouting from three quarters to two inches space between the bottom of the baseplate and the top of the foundation.

Remove coupling bolts before proceeding with leveling of unit and alignment of coupling halves.

Employing a small spirit level, the projecting edges of pads supporting pump and motor feet when scraped clean can be used for leveling the baseplate. Adjust the wedges under baseplate till pump shaft is level and flanges of suction and discharge nozzles are vertical; at the same time observe that the pump is at the specified height, and location.

While proceeding with the leveling of pump and base, maintain at the same time accurate alignment of the unbolted coupling halves between pump and driver shafts.

Alignment—The procedure followed when checking driver and driver shaft alignment is as follows: Place a straight edge across the top and side of the coupling, and at the same time check the faces of the coupling halves for parallelism by means of a tapered thickness gauge or feeler gauges, as shown in Fig. 1 and 2.

When the peripheries of the coupling halves are true circles and of same diameter and the faces flat, exact alignment exists when the distance between the faces is the same at all points and a straight-edge will lie

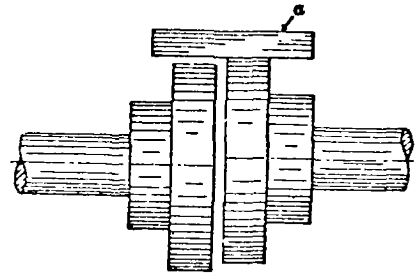


Fig. 1—Method of Checking Coupling Alignment.

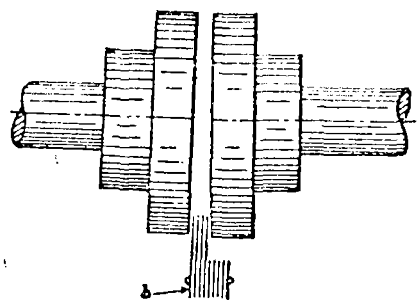


Fig. 2—Method of Checking Coupling Alignment.

squarely across the rims at any point. If the faces are not parallel, the thickness gauge or feelers will show a variation at different points. If one coupling is higher than the other, the amount may be determined by the straight-edge and feeler gauges.

Maximum coupling life with a minimum of maintenance may be obtained if the coupling is aligned properly at installation. Generally, permissible angular and parallel misalignment is .005″ for motors up to 75 hp and .010″ for motors above 75 hp.

*Worthington Bulletin 20RP-1355 "Mounting and Grouting for Pumps" gives valuable additional information on this subject.

Space between faces of couplings—The clearance between the faces of couplings and the ends of shafts should be set so that they cannot touch, rub or exert a pull on either pump or driver. The amount of this clearance may vary with the size and type of coupling used. The best rule to follow is to allow sufficient clearance for unhampered endwise movement of the shafts of the driving element to the limit of its bearing clearance. On sleeve bearing motor driven units, the magnetic center of the motor will determine the running position of the motor half coupling. It is recommended that this position be checked by operating the motor while disconnected. At this time, check also direction of rotation of motor. If current is not available, move motor shaft in both directions as far as bearings will permit, then adjust shaft centrally between these limits, thereafter assembling the unit with the correct gap between coupling halves.

When the unit is accurately levelled and aligned, the holding down bolts should be gently and evenly tightened previous to grouting.

High Temperature Alignment: In applications where pumps and drivers are operated at elevated temperatures, final alignment should be made with unit heated to operating temperature.

Where this is not possible at the time of alignment, proper allowance should be made for the increase in pump shaft height due to thermal expansion. As a "rule of thumb" for cast iron or cast steel pumps, with 70 degrees Fahrenheit as ambient, use an expansion of .0006 in. per 100 F. per inch of shaft height. This is the height the driver should be set above the pump.

(Example: 2 GR, 370 F pumping temperature. $8\frac{1}{2}$-in. pump shaft height. 3 x .0006 x $8\frac{1}{2}$ equals .015 allowance for expansion.

MULTI-V-DRIVES

Slide rails for driver should be located so that it is not necessary to roll the belts on or to force them over the grooves. Use of these methods will result in permanent injury to the V-belts.

Pump and driver sheaves must be carefully aligned so that the shafts are parallel and the grooves in both sheaves are in perfect alignment.

Before tightening a newly applied set of belts, the slack should all be on one side.

Good belt wear is dependent on proper tension. The correct operating tension is just beyond the point of slippage when the drive is operating at full load and speed. Slippage can be detected by belt squeal or by overheating of the small groove sheave.

It may be necessary to apply slight additional belt tension during the first 36 hours operation due to initial stretch and wearing in of the belts.

Excessive tightening will result in reduced belt life and cause overheating and possible failure of bearings.

GROUTING

The purpose of grouting is to prevent lateral shifting of the baseplate, not to take up irregularities in the foundation. We recommend the following procedure:

The typical mixture for grouting-in a pump base is composed of one part pure portland cement and two parts building sand with sufficient water to cause the mixture to flow freely under the base.

The top of the rough concrete foundation should be well saturated with water before grouting. A wooden form should be built around the outside of the baseplate to contain the grout. In some cases this form is placed tightly against the lower edge of the base, and in other cases it is placed a slight distance from the edge of the baseplate. Grout is added until the entire space under the base is filled. A stiff wire should be used to work the grout and release any air pockets.

After the grout is poured, the exposed surfaces should be covered with wet burlap to effect slow drying to prevent cracking. When the grout is set (about 48 hours) remove the forms and smooth the exposed surfaces, if desired. The grout should be hard in approximately 72 hours.

SUCTION PIPING

One of the largest sources of rotary pump problems is faulty suction lines. The suction pipe should be clean, short, air tight, no smaller than the pump suction opening and have a minimum of valves and fittings. Where economically practical the pipe should be one size larger than the suction opening and should have a continuous rise or fall from the source to eliminate air pockets. Gate valves on suction and discharge lines are recommended to facilitate future inspection and repairs. Figure 3 serves to illustrate some of the important features in a rotary pump piping layout.

A strainer is recommended if the liquid contains large foreign objects which might clog suction lines or jam the impeller gears. It is generally impractical to filter out any fine abrasives which can cause rapid wear of bearings or close clearances. A strainer should have a net area of from three to four times the suction pipe area and should permit easy cleaning.

A new GR pump will generally prime itself with a static suction lift of less than 28 feet (22″ vacuum) providing there is sufficient liquid remaining in the discharge line to fill clearances around the pump gears. However, if the combination of static suction lift and suction pipe friction loss is greater than 10 to 25 feet (8″-19″ vacuum) (depending on pump speed and viscosity), the pump will be noisy and will not produce full capacity. This condition will be aggravated by entrained or dissolved air in the liquid.

When pumping highly volatile liquids such as hot oils there should be sufficient static head to prevent vaporization of the liquid in the pump. Extremely viscous liquids (over 50,000 SSU) generally require a positive suction head in addition to slow speeds of rotation.

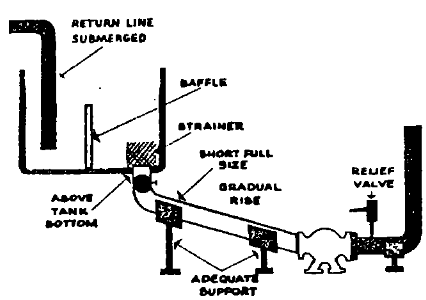


Fig. 3

DISCHARGE PIPING

Always carry the discharge piping up through a riser approximately five times the diameter, as shown in Fig. 3. This prevents gas or air pockets in the pump and will act as a seal in high vacuum service. A valve on the top of the riser may be used as a vent when starting the pump.

To protect the pump against excessive pressures caused by increased pipe friction in cold weather or accidental closing of valve in discharge line, a by-pass line with a relief valve may be installed. This relief valve should be set slightly higher than the maximum pump discharge pressure but not more than 10%.

JACKET PIPING

If steam jackets are supplied, the inlet is located on the top and outlet on the bottom. On water jackets the inlet is at the bottom and the outlet at the top. Valves should be installed in the inlet lines to regulate the quantity of jacket supply.

DRIVERS

For all driver information, reference should be made to the manufacturer's instruction tag or booklet attached to the unit. On *motor driven units*, check electrical characteristics on the nameplate and connect the wiring in accordance with the attached instruction sheet.

DIRECTION OF ROTATION

Before a pump is run it must be set up for proper direction of rotation. If a change is required the following procedure should be followed:

Check the prime mover for correct rotation against the arrow on the pump nameplate.

Standard direction of rotation is counter-clockwise when standing at and facing the shaft extension end. This is indicated by an arrow on the nameplate.

Remove stuffing box bolts and slide stuffing box back a few inches. (See Fig. 5)

Remove bearing cover. (See Fig. 6) Remove the small plug in each sideplate and place them on the new discharge side. (See Fig. 7)

These plugs (one in each sideplate) should be on the discharge side to induce circulation through the bearings to the suction and to maintain *suction pressure on the stuffing box* and end of the drive shaft.

On some larger pumps there are ½ or ¾ in. pipe plugs located on the outside of the stuffing box and bearing cover. Removal of these plugs allows access to the plugs in the sideplate, thereby allowing the direction of rotation to be changed without removal of the stuffing box and bearing cover.

If this change is not made, unbalanced discharge pressure acting on the end of the driving shaft will cause premature wear of inboard sideplate and gears.

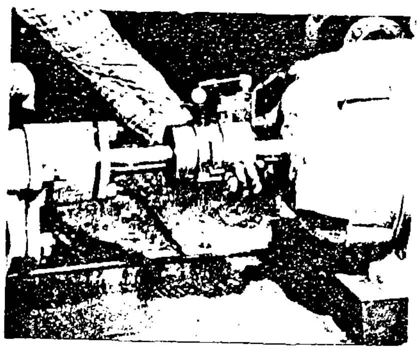


Fig. 4

FINAL ALIGNMENT CHECK

Alignment must be rechecked, after suction and discharge piping have been bolted to pump, to test the effect of piping strains. When handling hot liquids, the nozzle flanges, after the unit has been in service, should be disconnected to check in which direction the expansion of the piping is acting, correct for the effect of the strains as required.

An approved method for finally putting the coupling halves in alignment is by the use of a dial test indicator. See Fig. 4.

(1) Move the driver as required, including shimming front or back till the coupling faces are parallel.

(2) Bolt the indicator to the pump half of the coupling. With the button resting on the other coupling periphery, set the dial to zero and chalk mark the coupling half at the point where the button rests. For any check, top or bottom or sides, rotate both shafts by the same amount, i.e., all readings on the dial must be made with its button on the chalk mark.

The dial readings will indicate whether the driver has to be raised or lowered or moved to either side. After any movement, check that the coupling faces remain parallel to one another.

EXAMPLE: If the dial reading at the starting point is set to zero and the diametrically opposite reading at the bottom or sides shows a plus or minus .020-in. the driver has to be raised or lowered by shimming or moved to one side or the other by half of this reading.

NOTE: For all checks including that *for parallelism of coupling faces*, keep both shafts pressed hard over to one side when taking the readings.

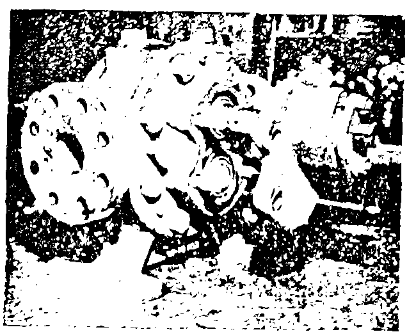


Fig. 5 20F-12103

Fig. 6 20F-12104

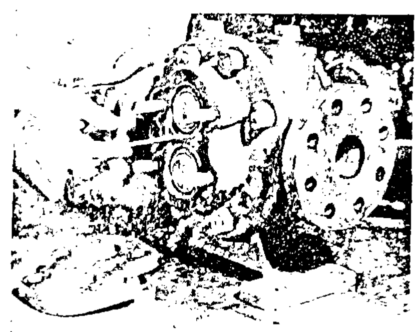


Fig. 7 20F-12105

SECTION II
OPERATION

STARTING

Start up of a new pump should be preceded by several final checks:

1. Make sure any valves in the suction or discharge lines are open. Starting any rotary pump against a closed discharge line can result in extreme pressures which may damage equipment and result in injury to personnel.

2. Close all drain lines.

3. Fill the pump with liquid to seal the clearances and lubricate the internal parts during initial starting.

REMEMBER — Starting or running a pump DRY will inevitably cause Galling, Seizing or Destructive Wear between Gears, Sideplates and Pump Body.

Touch the starter button for a preliminary start. During this brief period a check should be made for extreme noise, vibration or excessive pressure. If none of these are noticeable start the driver and if the system permits, run the pump at reduced load. Check for localized heating in the bearing housings, casing and stuffing box. Check power consumption. See if the pump is delivering liquid. If the pump is pulling a lift a few seconds may elapse before the air is evacuated from the suction line. When the liquid is finally drawn into the impeller gears there will be a distinct change in the sound of the pump. If anything seems wrong or questionable shut the unit down immediately. Refer to Section IV page 14 for a guide to locating the source of trouble.

ELEVATED TEMPERATURES

Start up and operation of pumps used for elevated temperature service requires some additional precautions. Sudden introduction of hot liquid into a cold pump will cause uneven expansion of internal parts with resultant pump wear or failure. If the system in which the pump is used does not allow a gradual increase in liquid temperature, then an auxiliary means of heating is required. Type GRJ pumps incorporate an integral system jacket in the pump body. This can be used to preheat the pump and melt any liquids such as tars and asphalt which might solidify in the pump during shut down. The GRJ steam jacket is designed for 150 PSI maximum pressure and may be used with steam or heat transfer oils. Maximum temperature for steam is 350°F. and for heat transfer oils, 500°F. Steam jackets are normally used for start up only. Once the pump is running the liquid moves thru too fast for the steam jacket to heat it any significant amount.

LUBRICATION

The roller bearings in the GR type pump are lubricated by the liquid being handled and consequently require no additional lubrication.

The adapter type inboard ball bearing in types GRMI and GRWMI should be lubricated with a good grade of No. 2 consistency ball bearing grease. The frequency of lubrication depends on the operating conditions. As a guide, under conditions of normal duty, 8 hours daily, bearings should be re-lubricated approximately every 1000 hours.

SECTION III
MAINTENANCE

GENERAL

Most type GR Rotary Pumps are similar as regards arrangement and maintenance of impeller gears, bearings and other internal parts. The main differences are in stuffing box or mechanical seal configurations. Maintenance of these are covered in the first three parts of this section.

Throughout this section the word "Outboard" refers to the end of the pump furthest away from the driver or sheave. The "Inboard" end of the pump is the end opposite the outboard end.

When reassembling any pumps with cast steel casings it is recommended that impeller gears and sideplates be coated with a Molybdenum disulphide based lubricant to prevent any tendency toward galling failure on initial start up.

TYPES GR, GRW, GRJ, GRL, GRWL, GRJL, GRH, GRHJ, GRHL, GRHJL

Disassembly: To open pump for inspection, back off outboard sideplate (1212) with jack screws provided for this purpose. Be sure to remove coupling or sheave from driving shaft. Both rotation assemblies can now be removed from the outboard side.

Assembly: Reverse the above procedure. Care should be exercised to obtain good alignment of parts. Dowel pins have been provided to insure this. The metal to metal joint between the pump body and sideplates should be made up with a thin coat of locktite anti-seize compound with molysulfide.

Packing Procedure: Before packing, rotate shaft by hand to be certain there is no binding.

Clean the stuffing box.

Insert the rings one at a time. Each ring should be firmly seated, by tamping as it is applied. Ring joints should be staggered at least ninety degrees. When it is not possible to slide the packing over the end of the shaft, twist each ring sideways to avoid damaging the packing.

When the stuffing box is full, the gland should be tightened with a wrench to seat the packing firmly, then back off the nuts and run them up finger tight.

Do not tighten the glands too tightly as a slight leakage is required to lubricate the packing.

In repacking stuffing boxes equipped with lantern glands, be sure that the lantern gland lines up with the inlet hole in the stuffing box.

TYPE GRD

Type GRD Pumps have two stuffing boxes. That is, in place of bearing cover (1216) there is another stuffing box (701), packing and extension of the driving shaft (1271).

This type of pump, which is used for certain special applications, is subject to the same maintenance procedures as type GR except that there are two stuffing boxes which require attention.

TYPES GRM, GRWM

General: The stuffing box for the GR or GRM, GRW or GRWM is identical. Therefore, it is possible to equip a new GR or GRW pump with mechanical seal.

Disassembly: Remove 1/4 in. pipe

STUFFING BOX DIMENSIONS (in inches)*

PUMP SIZE	SHAFT DIA.	STFG. BOX BORE DIA.	STFG. BOX DEPTH - ALL EXCEPT TYPE GRL, GRJL	STFG. BOX DEPTH TYPE GRL-GRJL
1 1/2 GR GRH 2 GRW	.938	1.562	2.000	4.000
2 GR, 2 1/2 GRW 2 1/2 GR 3 GRW	1.250	1.875	2.250	4.750
3 GR-4 GRW	1.875	2.625	3.250	5.125
4 GRH, 4 GR 5 GRW	2.000	3.000	3.750	6.250
5 GR	2.750	3.750	3.750	6.250
6 GRH, 6 GR	3.500	4.750	4.500	7.250

*Type GRMI, GRWMI, GRHMI does not have a conventional stuffing box (see sectional)

Fig. 8

TYPE GR NO. 1 1/2, 2, 2 1/2, 3, 4, 5, 6 †
TYPE GRW NO. 2, 2 1/2, 3, 4, 5 †

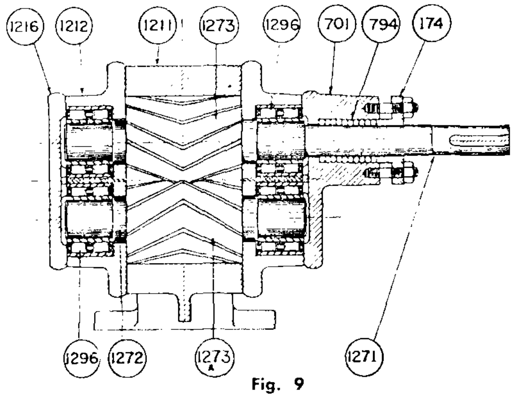


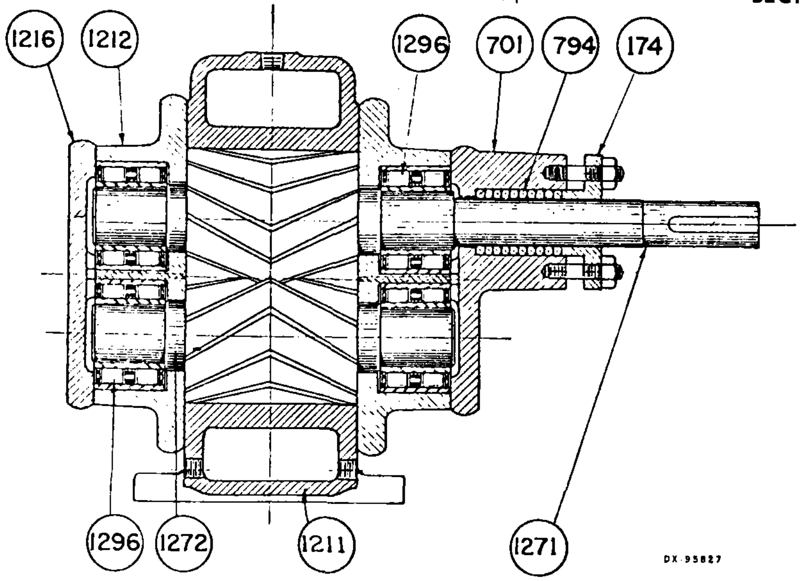
Fig. 9

REFERENCE PART NUMBERS

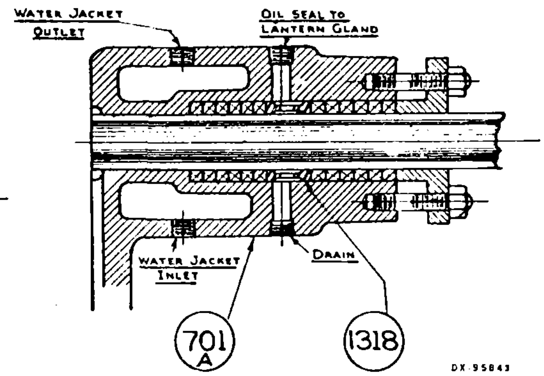
174	STUFFING BOX GLAND
701-701A	STUFFING BOX
794	STUFFING BOX PACKING
1211	PUMP BODY
1212	SIDE PLATES
1216	BEARING COVER
1271	DRIVING SHAFT
1272	DRIVEN SHAFT
1273	IMPELLER GEARS—DRIVING
1273A	IMPELLER GEARS—DRIVEN
1296	ROLLER BEARINGS—COMPLETE
1318	LANTERN GLAND

†Sizes 1 1/2, 2, 2 1/2 (Early Types) have Single-Row Bearings.
Sizes 1 1/2, 2, 2 1/2 (Late Types) 3-6 Double-Row Bearings.

TYPE GRJ NO. 1½ - 6†



TYPE GRL, GRWL, GRHL, GRHJL,
GRJL NO. 1½ - 6†
SECTION THROUGH JACKETED STUFFING BOX



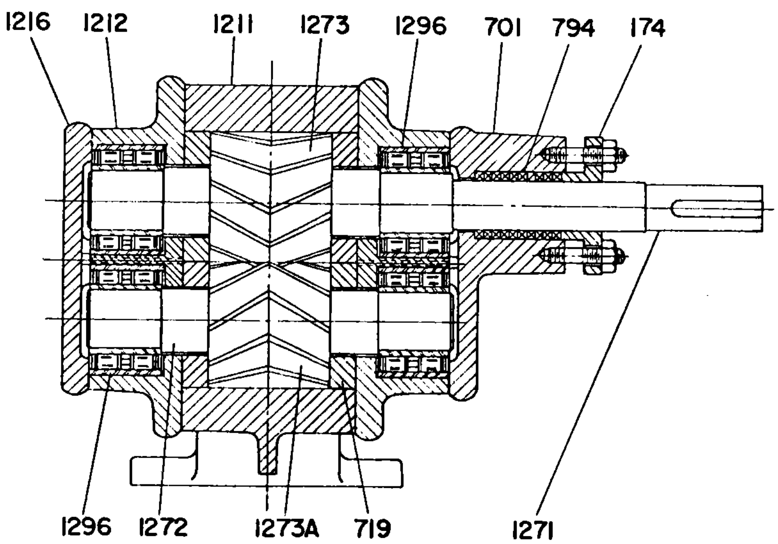
†Sizes 1½, 2, 2½ (Early Types) have Single-Row Bearings. Sizes 1½, 2, 2½ (Late Types) 3-6 have Double-Row Bearings.

Fig. 10

REFERENCE PART NUMBERS

174	STUFFING BOX GLAND	1271	DRIVING SHAFT
701-701A	STUFFING BOX	1272	DRIVEN SHAFT
719	FILLER PLATE	1273	IMPELLER GEARS—DRIVING
794	STUFFING BOX PACKING	1273A	IMPELLER GEARS—DRIVEN
1211	PUMP BODY	1296	ROLLER BEARINGS—COMPLETE
1212	SIDE PLATE	1318	LANTERN GLAND
1216	BEARING COVER		

TYPE GRH NO. 1½, 4, 6



plug on top of stuffing box casting. Loosen set screw holding seal collar (422) to shaft. (Fig. 14)

Remove stuffing box gland (174) and floating seat.

Carefully slide mechanical seal assembly and spring (729) off shaft (1271).

Back off outboard sideplate (1212) with jack screws provided for this purpose.

Remove coupling from driving shaft. Both rotating assemblies can now be removed from the outboard side.

Assembly: The pump can be assembled by reversing the above procedure. Successful operation is dependent upon proper installation of the mechanical seal. The following is a guide for installing seals:

1. Keep all parts clean. Do not use dirty rags for wiping surfaces.

2. Examine driving shaft (1271) carefully and remove any sharp corners or burrs.

3. If stuffing box has not been drilled and tapped for collar set screw wrench, drill and tap per tabulation shown in Fig. 12 and 13.

4. Assemble floating seat to stuffing box gland as shown in Fig. 12. Make sure that the synthetic rubber ring is tight against the shoulder of the floating seat, with rounded outer edge at the rear to facilitate insertion. The ring is assembled this way when shipped. Oil the outer surface of the seat ring and push the assembly into the gland cavity, seating it firmly and squarely. A brass or bakelite sleeve which will contact the outer edge of the floating seal, not on the lapped face should be used.

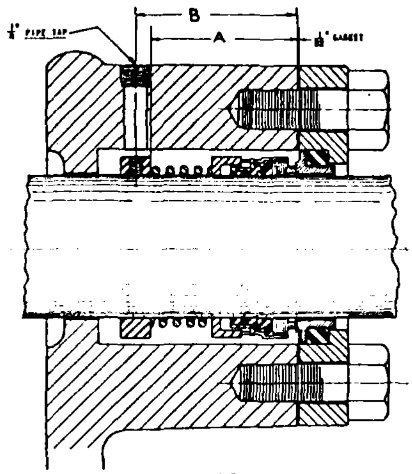


Fig. 12 DY-102209

The sleeve diameters required for the various size pumps are listed in the table (Fig. 16) under GRMI and GRWMI pumps.

5. Assemble the seal collar (422) to the driving shaft (1271) as indicated in the tabulation. After tightening the set screw, plug the opening with a ¼ in. pipe plug.

6. Assemble seal (729) to driving shaft (1271). Put spring on shaft as shown on seal sectional drawing. Oil shaft and slide the bellows and washer assembly on the shaft just far enough to center on the spring.

7. Assemble gland to stuffing box. Before doing this, clean and oil both sealing faces. With gasket (42) in place, slide gland into place and pull in evenly with gland bolts.

PUMP SIZE	A	B
1½ GRM	1-21/32	1-51/64
2 GRWM	1-21/32	1-51/64
2 & 2½ GRM	1-9/16	1-3/4
2½ & 3 GRWM	1-9/16	1-3/4
3 GRM	2-9/32	2-15/32
4 GRWM	2-9/32	2-15/32
4 GRM & 5 GRWM	2-9/32	2-15/32
5 GRM	2-25/32	3-1/32
6 GRM	3-7/32	3-1/2

Fig. 13

TYPES GRMI, GRWMI

General: The mechanical seal, inboard bearing head and shaft of the type GRMI and GRWMI pumps are interchangeable with the type GR and GRW stuffing boxes and shafts. Therefore, it is possible to disassemble a GR or GRW pump and rebuild it as a GRMI pump or GRWMI pump with a new driving shaft.

Disassembly: Back off the lock nut on the adapter type bearing (728). (Fig. 15)

Remove the nuts which hold the inboard bearing head (730) to the sideplate (1212).

Tap off the inboard bearing head.

TYPE GRM NO. 1½ - 6*
TYPE GRWM NO. 2 - 5*

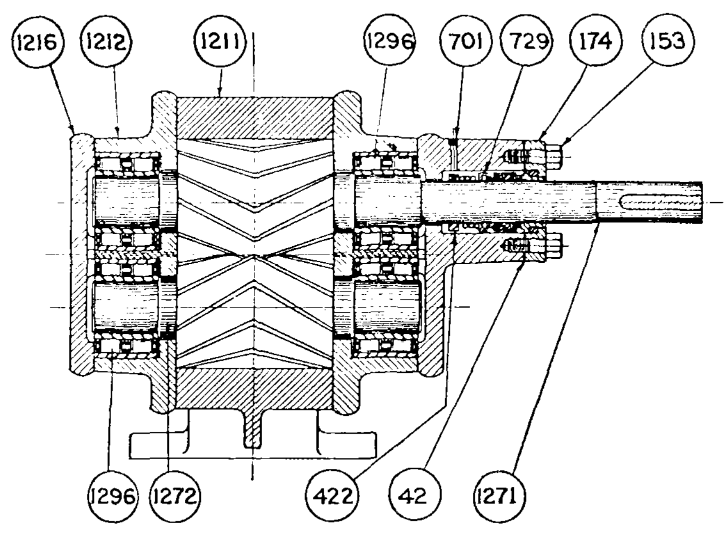


Fig. 14 DX-102238

REFERENCE PART NUMBERS

42	GASKET 1/32 THICK
153	GLAND BOLT
174	STUFFING BOX GLAND
422	SEAL COLLAR
701	STUFFING BOX
729	JOHN CRANE BELLOWS SHAFT SEAL
1211	PUMP BODY
1212	SIDE PLATES
1216	BEARING COVER
1271	DRIVING SHAFT
1272	DRIVEN SHAFT
1273	DRIVING IMPELLER GEAR
1273A	DRIVEN IMPELLER GEAR
1296	ROLLER BEARINGS—COMPLETE

The adapter type bearing and tapered sleeve will come off with the head.

Carefully remove seal parts from the shaft.

Back off the outboard sideplate (1212) with jack screws provided for this purpose.

Remove sheave or pulley from driving shaft.

Both rotating assemblies can now be removed from the outboard side.

Assembly: To assemble pump, reverse the above procedure. Successful operation is dependent upon proper installation. The following is a guide for installing seals and adapter type bearings:

1. Keep all parts clean. Do not use dirty rags for wiping surfaces.
2. Remove any burrs on the finished surfaces of the inboard bearing head (730).
3. Examine shaft (1271) carefully and remove any sharp corners or burrs.
4. Assemble floating seat to inboard bearing head. Make sure that the synthetic rubber ring is tight against the shoulder of the floating seat, with rounded outer edge at the rear to facilitate insertion. The ring is assembled this way when shipped. Oil the outer surface of the seat ring and push the assembly into the inboard bearing head cavity, seating it firmly and squarely. This cavity is rather deep, therefore, it is not possible to insert the floating seat with the fingers. It is necessary to use a brass or bakelite sleeve which will make contact on the outer edge of the floating seat, **not** on the lapped face. Table (Fig. 16) lists the sleeve diameters required for the different size pumps.
5. Assemble seal (729) to shaft (1271). Put spring holder and spring on shaft as shown in seal sectional drawing (Fig. 17). Spring must be centered in the holder. (The No. 1½ GRMI requires a 1 in. I.D. x 1¼ in. O.D. x ⅛ in. thick spacer ring behind the spring holder). Oil shaft and slide the bellows and washer assembly along the shaft just far enough to center on the spring. Do not compress the spring.
6. Assemble inboard bearing head to pump sideplate (1212). Before doing this, thoroughly clean and oil both sealing faces. With gasket (734) between sideplate and inboard bearing head in place, slide the inboard bearing head on the shaft and press it in as far as it will go. With the bearing head in this position, line up the dowel pin holes and drive in the dowel pins. Run up and tighten the holding nuts. This operation will insure correct spring pressure on the seal.
7. Assemble adapter type ball bearing (728) to shaft and inboard bearing head. The bearing must be a sliding fit in the housing. Before

PUMP SIZE	SHAFT SIZE	SEAL SIZE	SLEEVE I. D.	SLEEVE O. D.
1½ GRMI	15/16	S-937	1-3/8	1-5/8
2 GRWMI	15/16	S-937	1-3/8	1-5/8
2 & 2½ GRMI	1-1/4	S-1250	1-11/16	1-15/16
2½ & 3 GRWMI	1-1/4	S-1250	1-11/16	1-15/16
3 GRMI	1-7/8	S-1875	2-3/8	2-5/8
4 GRWMI	1-7/8	S-1875	2-3/8	2-5/8
4 GRMI	2	S-2000	2-1/2	2-7/8
5 GRWMI	2	S-2000	2-1/2	2-7/8
5 GRMI	2-3/4	S-2750	3-3/8	3-7/8
6 GRMI	3-1/2	S-3500	4-3/16	5

Fig. 16

TYPE GRMI NO. 1½ - 6*

TYPE GRWMI NO. 2 - 5*

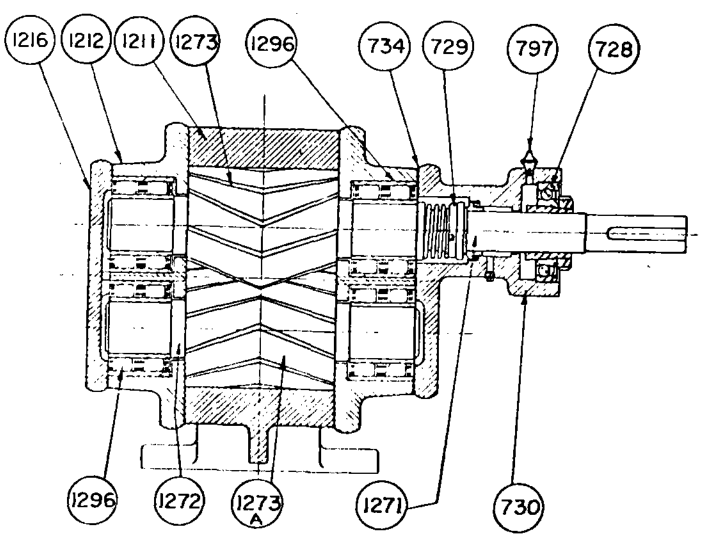


Fig. 15

REFERENCE PART NUMBERS

728	MRC ADAPTER TYPE BEARING
729	JOHN CRANE BELLOWS SHAFT SEAL
730	INBOARD BEARING HEAD
734	INBOARD BEARING HEAD GASKET
1211	PUMP BODY
1212	SIDE PLATES
1216	BEARING COVER
1271	DRIVING SHAFT
1272	DRIVEN SHAFT
1273	DRIVING IMPELLER GEAR
1273A	DRIVEN IMPELLER GEAR
1296	ROLLER BEARINGS—COMPLETE

assembly the bearing should be slipped into the housing bore to check that the fit is correct. If necessary buff out the bore to insure a sliding fit. Avoid all dirt and other foreign matter between the bearing and adapter sleeve, and between the sleeve and shaft during application. The bearing should be slid along the shaft into the housing. Since the bearing fit has been lined up with the shaft and dowelled into position, the bearing should slip in freely. The shielded side of the bearing should line up approximately with the end of the housing. When the bearing has been placed in this position, tighten the bearing lock nut by hand or with a spanner wrench until it is just up against the inner ring of the bearing. Further tightening is accomplished by tapping the end of the spanner wrench with a hammer. If a spanner wrench is not available a hammer and drift pin can be used. The nut should not be drawn up too tightly since this expands the inner race of the bearing and will cause the bearing to bind. Turning the shaft by hand will detect any undue binding. After the bearing has been drawn up tight enough, one tang on the lockwasher should be bent over into a corresponding slot in the lock nut.

8. Lubricate MRC adapter type bearing through alemite fitting (797) with a good grade of #2 consistency ball bearing grease.

RELIEF VALVES

A relief valve and bypass piping is an optional extra available on all type GR pumps size 1½-3 and GRW size 2-4 with exception of steam jacketed type GRJ pumps.

The relief valve is set by removing the cap and adjusting the compression screw. Plus or minus 20% of original specified pressure is the normal range of adjustment of these valves. Beyond this the spring should be changed. Maximum operating pressure for relief valves is 300 PSI.

These relief valves are safety valves and are not recommended for continuous bypass service. Prolonged bypassing with a closed discharge line can result in excessive heating and possible pump failure.

MECHANICAL SEALS

General: Mechanical seals are precision products. Great care must be used in assembling the seal parts. In handling, do not let the carbon sealing face drop; and take particular care not to scratch the faces of the seal face or stationary seat.

When a seal has been dismantled for examination it is practically impossible to reassemble the parts into their original position. Seal face and stationary seat must be relapped or replaced before reassembly.

Seals must never be run dry. In some instances a short period of operation is required to clear up slight leakage.

RECONDITIONING SEAL FACES

Carbon Seal Face: This part as received from the factory should be a perfectly lapped face. If the seal face is slightly marred it is possible to recondition it. The materials needed are: a flat plate such as a lapping plate or a piece of plate glass and fine lapping paper such as No. 600 Minnesota Mfg. Co. grinding paper. The lapping paper should be held flat against the lapping plate, making sure that no foreign material is under it.

Lapping of the seal face is accomplished as follows:

1. Press the seal face very lightly but firmly against the lapping paper and describe a series of about five figure eights. During the lapping process maintain an even pressure, keep the seat flat and avoid rocking.

2. Rotate the seal face 90 deg. and describe five more figure eights.

3. Repeat this procedure at 90 deg. intervals until the face is cleaned up.

4. Wipe off with a clean cloth saturated in solvent.

SECTION OF TYPE GRMI-GRWMI MECHANICAL SEAL

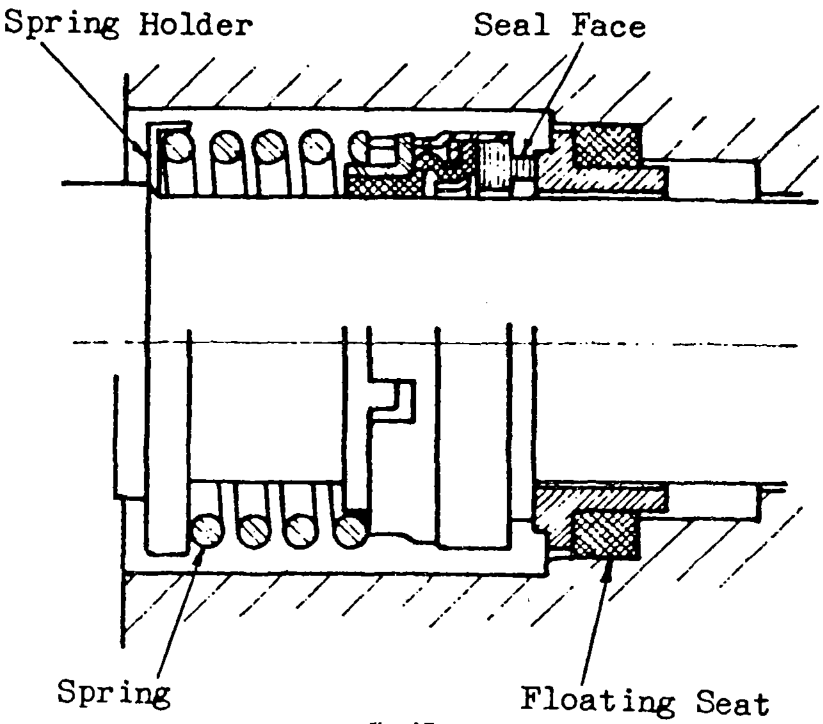


Fig. 17

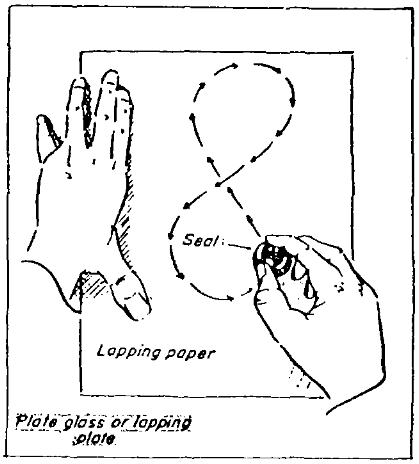


Fig. 18

Since the carbon ring is quite soft it should not be necessary to make very many strokes to obtain a lapped face. After this operation the carbon face will have a dull appearance, but a short run in the pump will produce a highly polished surface.

Stationary Floating Seat: The same procedure applies for this surface.

Since the material is cast iron, more strokes will be required to obtain a lapped face.

BEARINGS

Life of GR pump bearings depends primarily upon discharge pressure, liquid viscosity, proper installation of the pump and to a lesser extent upon speed and temperature. On most applications conditions are such that bearing life is many years. Where high discharge pressures and other factors combine to produce bearing life of only a few thousand hours a regular preventive maintenance program should be followed. Your Worthington Representative can provide bearing life information which will serve as a guide for regular bearing inspection and replacement.

Bearing clearances and the physical appearance of the bearings are a guide to their condition. Assembled internal clearance in a new bearing will vary from an average of .0005 in. in a 1½ GR to an average of .0035 in a 6 GR. When a pump bearing fails due to fatigue the first stage is pitting of some of the rollers. This is followed by pitting of inner and outer races and a slight increase in clearance (on the order of .001″-.002″). This internal clearance can be measured with a feeler gauge between the O.D. of the inner race and a roller on the slack side of the bearing. At this point the bearings should be replaced. If bearings continue to deteriorate, wear of gears, body and sideplate will follow.

With poor lubricants or abrasives bearing life is shorter than with good lubricants and is quite unpredictable. In this situation wear of races and rollers will progress at a steady rate and there may be no fatigue pitting at all. Under such conditions, any development of poor performance or increased pump noise may be a sign of bearing failure. The individual user's experience in such situations should be a guide to future preventive maintenance.

SERVICE TO BEARINGS

Bearing clearances can be checked with a feeler gauge by removing stuffing box (701) or inboard bearing head (730) and bearing cover (1216). Visual examination of bearing races and rollers requires removal of sideplates (1212). The bearing outer race and roller assembly is a "Tap" fit in the sideplate. The

ROTARY PUMP BEARINGS

MAIN ROLLER BEARINGS		INBOARD ADAPTER BEARING	
TYPE & SIZE PUMP	HYATT ROLLER BEARING NO.	TYPE & SIZE PUMP	MRC ADAPTER BEARING NO.
1½ GR, GRM, GRJ, GRMI— Early Type* 2 GRW, GRWM, GRWMI— Early Type*	A5205 TS	1½ GRMI 2 GRWMI	206 SFXY
1½ GR, GRM, GRJ, GRMI, 1½ GRH Late Type* 2 GRW, GRWM, GRWMI— Late Type*	A6205 TS		
2 GR, GRM, GRJ, GRMI— Early Type* 2½ GRW, GRWM, GRWMI— Early Type* 2½ GR, GRM, GRJ, GRMI— Early Type* 3 GRW, GRWM, GRWMI— Early Type*	A5207 TS	2 GRMI 2½ GRWMI 2½ GRMI 3 GRWMI	208 SFXY
2 GR, GRM, GRJ, GRMI— Late Type* 2½ GRW, GRWM, GRWMI— Late Type* 2½ GRW, GRWM, GRWMI— Late Type* 2½ GR, GRM, GRJ, GRMI— Late Type* 3 GRW, GRWM, GRWMI— Late Type*	A6207 TS		
3 GR, GRM, GRJ, GRMI 4 GRW, GRWM, GRWMI	A6210 TS	3 GRMI 4 GRWMI	211 SFXY
4 GR, GRM, GRJ, GRMI, GRH 5 GRW, GRWM, GRWMI	A6212 TS	4 GRMI 5 GRWMI	211 SFXY
5 GR, GRM, GRJ, GRMI	A6214 TS	5 GRMI	216 SFXY
6 GR, GRM, GRJ, GRMI, GRH	A6219 TS	6 GRMI	220 SFXY

*Early type are serial numbers below and late type are serial numbers above the following: 1½GR-A195282; 1½GRM-A198216; 1½GRMI-A199150; 1½GRJ-A206200; 2GR-A196830; 2GRM-A199317; 2GRMI-A198340; 2GRJ-A199475; 2½GR-A10990; 2½GRM-A12193; 2½GRMI-A12199; 2½GRJ-A10994; 2GRW-A199450; 2GRWM-A199120; 2GRWMI-A192170; 2½GRW-A199848; 2½GRWM-A208400; 2½GRWMI-A208410; 3GRW-A6858; 3GRWM-A12260; 3GRWMI-A12263.

Fig. 19

inner races may be removed by pressing the impeller gears off the shafts with a hydraulic press. Because the gear I.D. is smaller than the bearing race O.D., the race is pushed ahead of the gear. Races may also be removed by grinding. This latter method is the only way to remove inner races from 1½ GR and 2 GRW shafts, since the races are smaller than the gear bores on these sizes.

New bearing inner races are installed on shafts by preheating to 300-350° F. A press may be used for size 6205 and 6207 bearings, but this method is not recommended for larger sizes. Roller bearing outer races are a tap fit in the sideplates. During installation, be careful not to dent the roller retainers.

Carbon sleeve bearings sometimes used in place of roller bearings can be pressed into the sideplates cold. However, it is better to heat the sideplate in an oven to 350° before pressing. This will reduce the possibility of bearing misalignment due to shaving material off one side of the bearing O.D.

IMPELLER GEARS AND OTHER INTERNAL PARTS

In a new pump adequate clearance is provided to prevent contact between impeller gears and casing. In advanced stages of bearing failure, however, the impeller gears will contact and wear the suction side of the body and, if bearing wear is uneven, one or both sideplates. Wear of gears and sideplates will be accelerated, and may precede bearing failure when liquid pumped is abrasive or a poor lubricant or when drive or piping misalignments exist. Wear of these internal surfaces will be reflected in reduced pump capacity, failure to produce desired pressure in system, excessive priming time and in some cases an increase in noise level of pump.

Service to internal parts of a GR pump consists of renewal of clearances and wearing surfaces of gears, sideplates and body. Fig. 20 gives maximum new pump clearances and minimum gear dimensions for each size pump. This will serve as a guide. A pump may be quite satisfactory with greater clearances if pressures are moderate.

Impeller gears and bodies generally must be replaced when worn excessively. Remachining to new clearances is beyond the capability of most shops. Reversing the gears and running on the unworn side of the teeth will not provide any improvement in performance, but may temporarily forestall deteriorating performance. Reversing a worn body may provide a slight improvement.

Sideplate wear many be corrected by resurfacing up to .060", however, the average machine shop is not equipped to do this economically with the required degree of accuracy (within .0002" per inch of sideplate diameter). If resurfacing is attempted it will be necessary to restore the six small radial oil grooves surrounding each shaft bore to their original proportions, including the radiused edges, unless wear plates or filler plates are to be fitted.

Replaceable wear plates of a self-lubricating phenolic laminate material are an option available for all pumps except type GRH and pumps operating over 250° F. These sandwich between the pump body (1211) and both sideplates (1212) and present an excellent wearing surface to the face of the impeller gears. These are easily replaced when worn and can be installed in a pump in the field not originally so equipped. Since these wear plates will flex under pressure, they must have a solid backing and should not be used over a worn sideplate or reversed when worn themselves.

RECOMMENDED SPARES

The type and quantity of spare parts will naturally vary with each application dependent upon the type of liquid being pumped, operating conditions, isolated locations, etc. In general, however, a set of bearings and stuffing box packing or a mechanical seal assembly is adequate. Where service is severe, a complete rotating assembly, consisting of impeller gears, shafts, bearings and packing is recommended.

ORDERING REPLACEMENT PARTS

When ordering replacement parts or writing for any information not given in the foregoing instructions, always give the pump serial number and size as shown on the nameplate. Itemize each part required using the reference No. and the name of part in the sectional drawing that applies to your pump. Be sure to state the number of pieces desired.

INTERNAL DIMENSIONS

PUMP SIZE	MAX. END CLEARANCE	MAX. DIAM. CLEARANCE AROUND GEARS	MINIMUM GEAR WIDTH	MINIMUM GEAR DIA. *
1½ GRH (1)	.0045	.009	1.924	2.771
1½ GR	.0035	.009	2.748	2.771
2 GRW	.0035	.009	3.498	2.771
2 GR	.0035	.011	2.748	3.465
2½ GRW	.0035	.011	3.498	3.465
2½ GR	.005	.011	4.247	3.465
3 GRW	.006	.011	5.997	3.465
3 GR	.006	.012	4.996	4.621
4 GRW	.006	.012	7.621	4.621
4 GRH (2)	.0085	.0125	4.897	5.556
4 GR	.0065	.0125	6.996	5.556
5 GRW	.0075	.0125	10.495	5.556
5 GR	.0085	.018	9.994	6.947
6 GRH (3)	.0105	.018	7.197	9.259
6 GR	.0085	.018	11.994	9.259

* Diameter cannot be measured with micrometer due to odd number of gear teeth.

(1) Includes two .4115" min. filler plates

(2) Includes two 1.049" min. filler plates

(3) Includes two 2.398" min. filler plates

Fig. 20

SECTION IV

LOCATING TROUBLES

We list below the most frequent causes of trouble with Rotary Pumps. The operator can often avoid unnecessary expense by careful consideration of the points outlined.

1. THE PUMP FAILS TO DISCHARGE

a. Stop pump immediately.

b. Not properly primed. Reprime from discharge side. Keep discharge air vent open until liquid begins to discharge.

c. Wrong direction of rotation. Reverse wiring at motor.

d. Speed too low. Entire pump capacity slips through clearances. Change drive to increase speed. Check driver to see that it is up to rated speed.

e. Valves closed or an obstruction in suction or discharge pipe. Open all valves. See that flange gaskets have the center cut out and that no obstruction is across end of suction pipe.

f. Strainer clogged. Remove basket, clean and be sure it has ample area.

g. Suction pipe end not submerged in liquid. Increase length of suction pipe or raise liquid level in supply tank.

h. Foot valve stuck. Check to see that suction pipe has not been screwed into foot valve far enough to hold it closed.

i. Suction lift too high. Check with vacuum gauge.

j. Bypass open. Examine all bypass and return lines for open valves. Close them if open. A relief valve stuck open may bypass entire pump capacity.

k. Air leaks in suction. Paint and tighten all suction pipe gaskets and threaded joints. Check stuffing box packing.

l. Check valve and pressure backed up by hydraulic pressure Install an air-release valve between check valve and pump.

m. Pump badly worn. Replace parts. Excessive clearances will cause slip equal to pump displacement.

2. PUMP IS NOISY

a. Insufficient liquid supply. Increase suction pipe size and reduce its length. Lower position of pump to prevent cavitation.

b. Air leaks in suction. Paint all pipe joints, replace faulty flange gaskets, repack stuffing box to stop crackling noise due to air in pump.

c. Pump out of alignment. Align drive with pump. Release pipe flanges to determine if they strain pump casing causing metallic contact between rotating elements and casing.

d. High spots on rotating elements. File or scrape high spots that cause rotating elements to bind and produce a noise synchronized with each revolution.

e. Bent drive shaft. Replace shaft as it causes rotating elements to operate unevenly with consequent noise.

f. Excessive pressure. Check pressure. Install a relief valve.

g. Coupling out of balance or alignment. Align driver and pump to prevent coupling cover from slapping.

h. Relief valve chatters. Change pressure adjustment or check size and type of relief valve.

i. Excessive entrained or dissolved air in liquid.

3. PUMP WEARS RAPIDLY

a. Abrasives in liquid.

b. Pipe strain on pump casing. Release piping and align it in independent supports before connecting to pump.

c. Pump operating against excessive pressure. Install relief valve to protect pump, or use a heavier duty pump.

d. Corrosion that roughens rubbing surfaces.

e. Pump runs dry. Provide ample supply of liquid at all times. Do not allow pump to operate under conditions where liquid supply may fail.

f. Severe belt drive or coupling misalignment.

g. Excessive end thrust on driving shaft either from driver or coupling or from improper positioning of sideplate plugs. (See "Direction of Rotation" Page 6.)

4. PUMP NOT UP TO CAPACITY

a. Suction lift too high. Bubbles form to usurp part of pump displacement. Check with vacuum gauge.

b. Suction strainer partly clogged or of insufficient area. Clean the screen. If all danger of foreign material has passed and screen has insufficient area, move screen.

c. Suction pipe ends insufficiently submerged so liquid eddies and allows air to be drawn into pump. Increase suction-pipe length to obtain greater submergencies.

d. Suction pipe too small, too long, or has many fittings to increase pipe friction abnormally and cause liquid to vaporize. Simplify the suction line and increase its size to reduce pipe friction.

e. Stuffing box improperly packed so that air is drawn in. Repack box, tighten gland. **Caution: Don't tighten enough to cause excessive packing wear and heating.**

f. Air leaks in suction piping. Paint all pipe joints. Replace gaskets where necessary.

g. Speed too low. Check driver for speed and overload. Change drive speed ratio.

h. Hand bypass or return line partly open. Close all bypass valves and see that they seat properly.

i. Relief valve improperly seated or incorrectly set. Regrind valve on its seat. Be sure valve does not open until desired pressure is reached.

j. Pump parts worn. Replace parts and adjust clearances to eliminate excessive slip.

5. STARTS, THEN LOSES ITS SUCTION

a. Suction-line end not immersed deep enough. Increase suction-pipe length so liquid is not drawn down too near the end of pipe.

b. Liquid vaporizes in suction line. Reduce suction lift so, as liquid approaches tank bottom, it will not vaporize.

c. Air or gas pockets in system. Reduce size of pockets in suction system, or provide a partly open bypass to maintain pump prime.

d. Air leaks in suction line. Check for air leakage into pump suction.

e. Liquid supply exhausted. Check suction tank.

6. PUMP TAKES TOO MUCH POWER

a. Speed too high or liquid heavier or more viscous than specified for pump. Reduce speed or heat liquid to reduce viscosity.

b. Obstruction in discharge line causes pump to operate above rated pressure. If new installation, recalculate what the heads should be.

Include head due to friction losses in pipe and fittings. Check this head against rated pump head. Check head developed by pump with pressure gauge. An obstruction in discharge line or partly closed valve may increase head above normal. If head cannot be reduced to give safe load on motor, reduce pump speed or install larger motor.

c. Stuffing box packing too tight. Check packing. If too tight, make necessary adjustment or replace packing with correct type properly installed.

d. Shaft bent or out of alignment. Check shaft, pump and motor alignment. If shaft is bent, straighten it or install a new one. Properly align pump and motor.

e. Rotating element binds and wears excessively. Pipe connection out of line distorts the pump casing. Disconnect suction and discharge piping to see if they are in alignment. Flange faces should be parallel and aligned axially without being forced. Support pipe separate from pump. Check fit of rotating parts to make sure they do not bind, or have not worked endwise on shaft to rub casing.

1.2.4 Flash Tank Drain Pump

1.2.4.1 Identification

Tag Number	Description
P307	Flash Tank Drain Pump

1.2.4.2 Description

Manufacturer: Worthington Group, McGraw-Edison Co.
14 Fourth Avenue
East Orange, NJ 07017

Part Number: 8H 38-2 Stage Vertical Pump

1.2.4.3 Vendor

Worthington

1.2.4.4 Procurement Specification

DOE Specification Number 40M700-6S, CP9

1.2.4.5 Piping Connections

DOE Dwg. N-. 40P7005133249, CP9

1.2.6 Operation/Maintenance

See following Worthington manuals:

2400-E8C Instructions for Installation, Operation, Maintenance, and list of parts for Can Pumps

2400-E2D Instructions for Disassembly, Assembly, Maintenance, and List of part for pump bowl assemblies

2950-GL Instruction Leaflet, Medium AC Motors Vertical, High Thrust, P-Base

INSTRUCTIONS FOR
INSTALLATION, OPERATION,
AND MAINTENANCE,
AND LIST OF PARTS

CAN PUMPS

For Use With UHF Vertical Turbine Pumps

NC
Q S-R Denver
9/9/81

S-R #

CPQ #336

RECEIVED
MAY 12 1981
TOWNSEND & BOTTUM INC.

Our new name,
effective January 1, 1981,
is Worthington Group,
McGraw-Edison Company.

WORTHINGTON

2400—E8C

1.2.4-2

FOREWORD

Worthington products are the result of more than a century of progressive study and development. Advanced design, proper selection of materials, and precision construction reflect this wide experience. Worthington products will give trouble-free efficient operation with minimum maintenance and repair.

This instruction book will familiarize management and operating personnel with pertinent details and proper procedures for the installation, operation, and maintenance of one of these products.

Designate below your identification of the equipment for which this book applies.

UNIT SIZE	IDENTIFICATION NO.

STUDY THIS INSTRUCTION BOOK

The descriptions and instructions included in this book cover the standard design of the equipment and any common deviations when possible. This book does not cover all design details and variations nor does it provide for every possible contingency which may be encountered. When information cannot be found in this book, contact the nearest Worthington District Office.

Do not operate this equipment in excess of its rated speed, pressure and temperature, nor otherwise than in accordance with the instructions contained in this Manual. This equipment (or a prototype) has been shop tested and found satisfactory for the conditions for which it was sold, but its operation in excess of these conditions will subject it to stresses and strains which it was not designed to withstand.

Failure to heed this warning may result in an accident causing personal injury.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION I
INTRODUCTION AND GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. The Worthington Vertical Turbine Can Pumps are designed for those services where the available energy, Net Positive Suction Head, is limited. By installation in a suction can of sufficient depth, part or all of the Net Positive Suction Head required for satisfactory operation is built into the unit. Vertical construction of this equipment requires a minimum of floor space. This book contains instructions for pre-installation, installation, operation and maintenance, and list of parts for the pump.

1-3. GENERAL DESCRIPTION.

1-4. Basic components of the vertical can pump unit (figure 1-1) are the driver, the discharge head, the column pipe, the pump bowl assembly and the suction can. The pump components are normally assembled at the factory and shipped ready for installation. The drivers are shipped separately to prevent damage to the pump top shaft and driver bearings. The suction can is also shipped separately.

1-5. DRIVER UNIT.

1-6. Driver units are supplied in a variety of types and sizes to meet a wide range of operating requirements. Electric motors, of the vertical solid shaft type, are most commonly used. Flanged couplings are used with solid shaft drivers.

1-7. PUMP HEAD.

1-8. The pump head is a sturdy fabricated steel structure which supports the pump and driver on the foundation. Two types of pump heads are available, T type and L type. The T type provides a discharge port which couples to the discharge piping and a suction port which couples to the suction piping, receives the liquid to be pumped and directs it to the suction can. The L type provides a discharge port only. The suction port is located below ground on the suction can. Sealing of the shaft in the pump head is accomplished by either a stuffing box with packing or a mechanical seal.

1-9. STUFFING BOX.

1-10. A pump with shaft sealed by packing usually employs a stuffing box sleeve and a stuffing box which houses the rings of packing, seal cage and stuffing box bearing. A gland bolted to the stuffing box is adjustable to compress the packing to the desired tightness about the shaft. Stuffing box may, on special

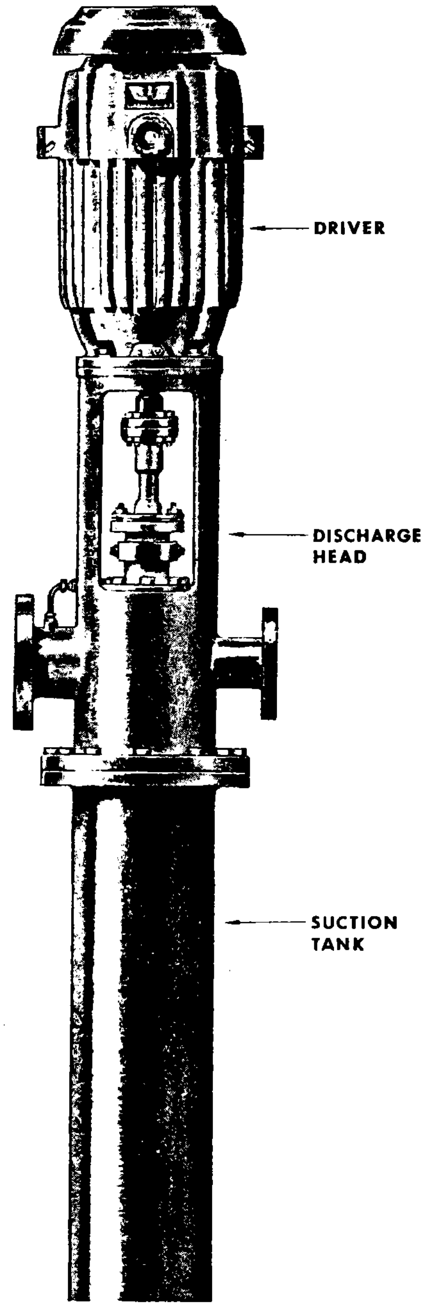


Figure 1-1. Can Pump

occasions, be supplied with a water cooled jacket. Connections to the seal cage and water jacket (if the latter is used) and packing maintenance are described in Sections III and V. Stuffing box bearing replacement is described in Section III.

1-11. MECHANICAL SEAL ADAPTOR.

1-12. A pump with shaft sealed mechanically employs a mechanical seal adaptor of cast construction which houses the mechanical seal and mechanical seal bearing. Details of the seal and its maintenance are described in Sections III and V.

1-13. BOWL ASSEMBLIES.

1-14. Bowl assemblies are designed to operate completely submerged in the suction can. A suction bell is usually provided to reduce suction losses. Special bearing material may be used dependent on the liquid being pumped. For details on bowl assemblies, refer to the applicable instructions book listed below: Construction may differ slightly due to design and material requirements.

a. 6" - 8" BOWL ASSEMBLIES
Handbook No.2400-E2B

b. 10" - 15" BOWL ASSEMBLIES
Handbook No.2400-E3B

c. 16" and LARGER BOWL ASSEMBLIES
Handbook No.2400-E4B.

SECTION II
PRE-INSTALLATION

2-1. INSPECTION OF EQUIPMENT.

2-2. All parts should be inspected upon receipt for damaged or missing components. Any deficiency should be reported to the local agent of the company responsible for transporting the equipment.

NOTE

Components, parts and accessory parts are sometimes placed in shipping containers in individual packages. Thoroughly inspect all wrappings and crates for attached parts before discarding.

2-3. STORAGE.

2-4. The unit is shipped in condition for immediate installation. If interim storage of the unit is required, carefully select storage space so that the unit is not subject to excessive moisture, extreme weather conditions, corrosive fumes, or other harmful storage conditions. If the duration of storage is expected to be extensive, the unit should be examined from time to time and cleaned when required.

2-5. CLEANING PRIOR TO INSTALLATION.

2-6. Flush the pump thoroughly with clean water before installing. Remove any rust spots from machined surfaces with fine grade of emery cloth. Clean all threaded surfaces and attaching hardware of dirt or grease.

SECTION III
INSTALLATION

3-1. LOCATION OF EQUIPMENT.

3-2. Place the pump where it is easily connected to a simple discharge piping arrangement, and is accessible for periodic inspection. There should be ample head room to allow the use of an overhead crane or other lifting device with sufficient capacity to handle the assembled pump and the pump motor individually.

3-3. FOUNDATION.

3-4. The foundation may consist of any material that will afford permanent, rigid support to the full area of the pump supporting member and will absorb expected stresses and shocks that may be encountered in service.

3-5. Concrete foundations should be level and built on solid ground. Foundation bolts of the specified size should be located according to the pump can flange template drawing. Each bolt should be surrounded by a rigidly held pipe.

3-6. When the pump unit is mounted directly on structural steel framing, it should be located directly over or as near as possible to the main building members, beams, or walls. The baseplate should be bolted to the steel supports to avoid distortion, prevent vibration, and retain proper alignment.

3-7. EQUIPMENT REQUIRED FOR INSTALLATION.

3-8. Equipment required for installation includes:

a. Dial indicator with clamp.
b. Foundation nuts and bolts, when necessary.
c. Leveling apparatus such as wedges or shims.
d. Suitable derrick, tripod, or crane with chain hoist or similar equipment having a hook and swivel.

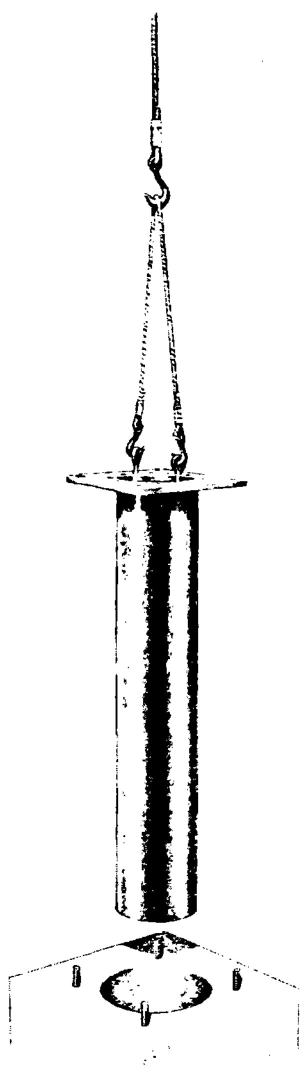


Figure 3-1. Suction Can Installation

3-9. INSTALLATION.

3-10. Before commencing with the installation, it is recommended that a qualified electrical contractor be engaged to arrange connection of electrical controls and protective devices for the motor and to make electrical connections to the motor after it is installed.

3-11. INSTALLATION OF SUCTION CAN.

3-12. Lower the suction can onto the foundation or supporting structure (figure 3-1) and mount in a true vertical position with the top of the foundation plate absolutely level. Care must be taken to avoid bending the foundation bolts during this operation. Use wedges and shims under the support plate to level. Secure by tightening the foundation bolts.

3-13. GROUTING.

3-14. Grouting prevents lateral shifting of the pump discharge head. Foundation irregularities are taken up by proper shimming before pulling down on the foundation bolts. Grout the pump as follows:

a. Construct a wood form around pump discharge head to contain grout.
b. Mix grout by using one part portland cement and two parts building sand with sufficient water to form a thin paste.
c. Wet foundation thoroughly with water and pour grout into a wood form, making certain the mixture flows freely under the pump discharge head.
d. Using a stiff wire, work the grout to release any air pockets.
e. Cover exposed grout surface with wet burlap to effect slow drying.
f. After grout has set 48 hours, remove wood forms and smooth exposed surface.
g. Remove wedges and shims.
h. Fill up cavities left by wedges and shims.
i. Allow grout to set a total of 72 hours before starting pump.

3-15. PUMPS.

a. Cover the can opening with a sheet of plywood or other material to avoid dropping anything into the can.
b. Position lifting device with hook and swivel centered over foundation opening.
c. Attach a sling to pump head.
d. Attach sling to the lifting device hook.
e. Lift pump until lower end is free of ground or floor (figure 3-2).
f. Remove cover from foundation opening.
g. Slowly lower pump, guiding lower end through can opening.
h. Hand guide pump column pipe as it passes through foundation opening to make certain that it

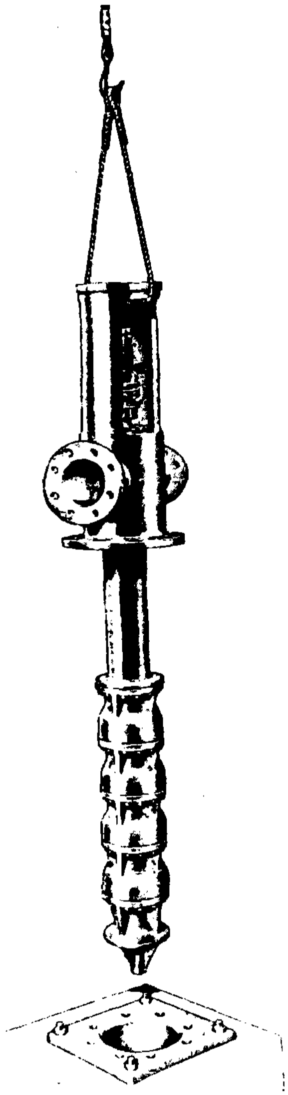


Figure 3-2. Pump Installation

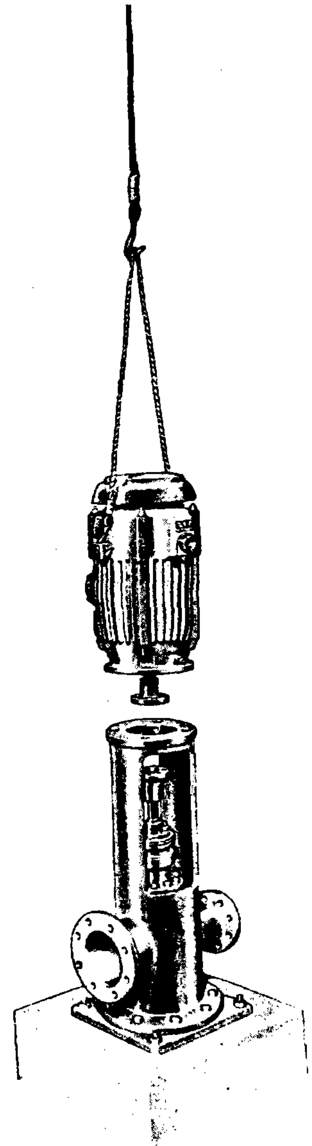


Figure 3-3. Driver Installation

meets with no obstruction. Any obstruction the pump may strike can be felt in this manner.

i. Rotate pump until discharge head faces proper direction to mate with discharge piping, or suction and discharge piping for T type heads, and pump mounting holes align with foundation mounting holes.

j. Remove sling from pump.

3-16. SOLID SHAFT MOTORS.

a.* Remove packing and gland and insert centering gage in stuffing box (figure 3-5).

b. Install the driven half of motor coupling on pump top shaft.

c. Install the driver half of motor coupling on motor shaft.

*Omit these steps when heads are furnished with rabbit fit.

d. Attach sling to motor.

e. Lift motor and center over pump shaft.

f. Slowly lower motor onto pump head, making certain that mounting holes in motor and pump head are aligned.

g. Using a straight edge, check that two halves of coupling are aligned.

h. Bolt motor loosely to pump head.

i. Clamp dial indicator to spacer or driver half of coupling.

j. Indicate to driven half of coupling.

k. Rotate motor shaft by hand.

l. Tighten motor mounting bolts if shaft alignment is within 0.001 inch. If shafts are not aligned, reposition motor and align shafts then tighten mounting bolts.

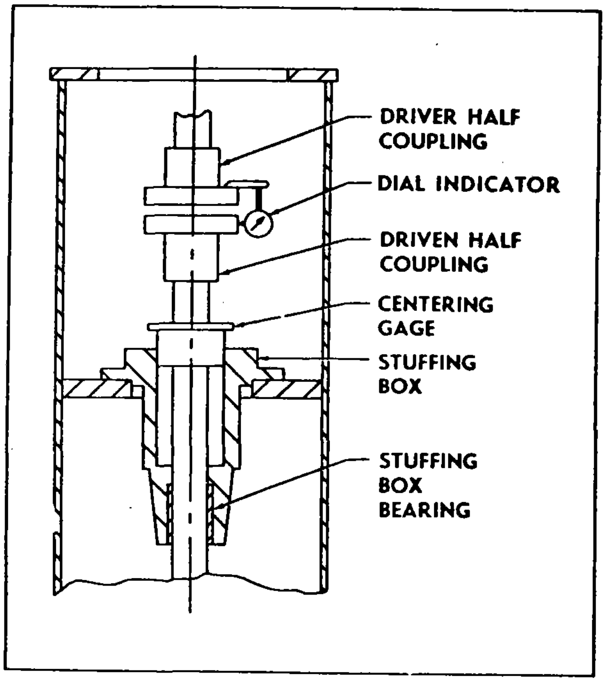


Figure 3-4. Centering Gage

m.* For positive location of motor, drill and ream lower motor base flange and top pump discharge head flange for two taper dowel pins.

n. Remove sling from motor and remove hoisting equipment.

o.* Remove driven half of motor coupling on pump top shaft. Remove centering gauge and reinstall packing and gland.

p.* Insert dowel pins.

q. Rotate adjusting nut on pump shaft until space between coupling halves is 1/8 in. to 1/4 in. Check that motor rotates in proper direction by momentarily starting motor.

r. Tighten socket head cap screw in adjusting not. Make certain that screw engages pin hole in adjusting nut.

s. Securely tighten all coupling bolts.

3-17. VENT LINE AND AUXILIARY PIPING TO DISCHARGE HEAD AND SHAFT SEAL.

3-18. Install a vent line from the vent tap in the pump to the supply reservoir. Slope this line continually upward away from the pump to prevent vapor binding. Refer to the pump elevation drawing for location of other piping possibly required, such as sealing water, cooling water, and stuffing box drainage connections.

3-19. STUFFING BOX.

3-20. Connect the pipe which connects the stuffing box to the suction chamber of the pump discharge head to provide re-circulation through the stuffing box bearing and reduce the pressure on the packing. An orifice is usually in this line to control the rate of circulation and maintain above atmospheric pressure on the packing.

***Omit these steps when heads are furnished with rabbit fit.**

3-21. The stuffing box, packing, seal cage, and gland are assembled in accordance with cross section drawing provided with the pump. Packing is selected for the particular service of the pump involved. Only pre-formed, molded rings of packing are used, and the joints of the packing rings are staggered 180° apart. Tighten the nuts on the gland studs finger tight. This will allow profuse leakage during packing "break-in time".

3-22. Normally two sealing connections are provided on all packed stuffing box pumps, and are located 180° apart. A sealing liquid can be used to:

a. Seal the packing against the entrance of air into the pump.
b. Provide lubrication for the packing.
c. Prevent the escape of valuable, corrosive, highly volatile, hazardous or injurious liquids.
d. Provide a cooling medium for the stuffing box.

3-23. An idle pump handling steam condensate with suction pressure less than atmospheric is vulnerable to the entrance of air through the stuffing box packing. The piping arrangement shown in figure 3-5 is suggested to provide above atmospheric pressure to one of the seal cage connections. The outlet connection is plugged.

3-24. When pumping liquids with low specific gravity, the liquids have little if any lubricating qualities. Consequently, the packing must be self-lubricating or an external supply of lubricant must be furnished at the seal cage at a pressure slightly higher than that at the bottom of the stuffing box. For the above, only one connection is required and the outlet is plugged.

3-25. When a sealing and/or lubricating liquid is used that will contaminate the liquid being pumped or where it is desirable not to have the pumped liquid escape, in and out seal cage connections should be

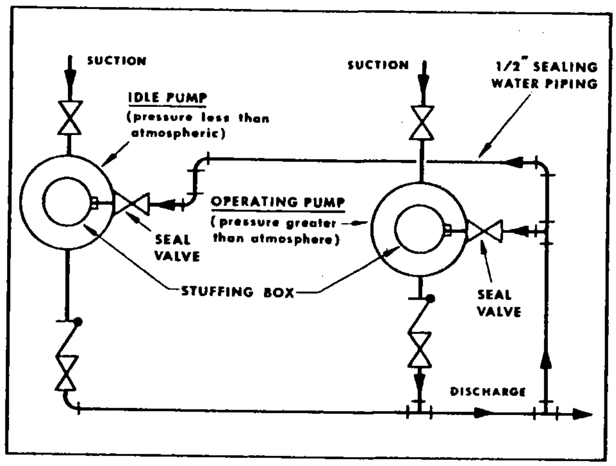


Figure 3-5. Piping Arrangement

used. The sealing liquid should be introduced at a slightly higher pressure than at the bottom of the stuffing box. Control valves on both the inlet and outlet seal connections are recommended to regulate the volumn and pressure of the sealing liquid.

3-26. MECHANICAL SEAL.

3-27. The mechanical shaft seal is installed in accordance with the cross section drawing provided with the pump. Refer to the drawings supplied by the seal manufacturer for specific instructions. After the pump has been adjusted vertically, tighten set screws in seal drive collar, locking seal sleeve to the pump shaft. Remove the seal positioning device. After slight initial leakage, the mechanical seal should operate with no visible leakage.

3-28. There should always be circulation of the liquid pumped through the seal bearing and by the seal faces. The pipe which connects the mechanical seal and the suction chamber of the pump discharge head is furnished for this purpose. An orifice is usually in this line to control the rate of re-circulation and maintain above vaporization pressure in the seal.

SECTION IV
OPERATION

4-1. PRE-STARTING.

4-2. Before starting the pump, check that:

a. The discharge valve is partially open and the discharge piping is properly connected.
b. The impellers have been properly adjusted during installation and the motor shaft and pump rotate freely.
c. All bolts are tight.

4-3. STARTING.

4-4. Start the pump as follows:

a. Close the starting switch.
b. Observe that the pump starts easily and runs without excessive vibration. If there is starting difficulty or excessive vibration, stop the pump immediately and refer to Section V to determine the probable cause.
c. Slowly open the discharge valve until the discharge pressure reaches the desired value or the valve is fully open.

4-5. FINAL ADJUSTMENT.

4-6. After the pump has run long enough to tighten the lineshaft couplings and clear the pumped liquid of abrasives, the impellers position should be checked and readjusted for 1/8 in. clearance between couplings on solid shaft motors, and one turn of the adjusting nut on hollow shaft motors.

4-7. STOPPING.

4-8. Close the discharge valve slowly then shut off the motor. This will prevent surges in the system and avoid liquid backflow through the pump.

SECTION V
MAINTENANCE

5-1. PREVENTIVE MAINTENANCE.

5-2. INSPECTION.

5-3. The Worthington can pumps are designed for long trouble-free service with a minimum amount of attention. Periodically inspect the stuffing box for proper leakage, and the pumps for loose bolts, excessive vibration, dirt and corrosion.

5-4. CLEANING.

5-5. Remove rust or corrosion with a fine wire brush and rags. If necessary, clean all parts, except electrical contacts, by moistening the cloth or brush with a suitable solvent.

5-6. PUMPS PROVIDED WITH A MECHANICAL SEAL.

5-7. A pump of this arrangement is furnished with a mechanical seal on a sleeve that may be removed as a unit. See paragraph 5-21. No attention or adjustment is required and except for slight initial leakage, the seal should operate with no visible leakage.

5-8. PUMPS PROVIDED WITH A STUFFING BOX.

5-9. A pump of this arrangement is usually furnished with a stuffing box shaft sleeve, seal cage, packing, and gland. No attention or adjustment is required beyond ordinary stuffing box care. Under no circumstances is the packing gland to be drawn so tight as to stop all leakage. This practice would result in short packing life and scored sleeve on shaft. The best practice is to loosen packing gland until the nuts are finger tight and allow to leak profusely for the starting period or after box has been replaced. Reduce leakage gradually by tightening the gland nuts a few turns at a time allowing the packing to set. Continue until leakage is normal (40 to 60 drops per minute).

5-10. CORRECTIVE MAINTENANCE.

5-11. TROUBLESHOOTING.

5-12. PUMP DOES NOT START. Failure of the pump to start may be caused by:

a. Low voltage supplied to the pump motor.
b. Electrical circuit open or not completed.
c. Defective motor.
d. Impellers binding against pump bowl because of maladjustment or bearing wear.

5-13. PUMP DOES NOT DELIVER LIQUID. Failure of the pump to deliver liquid may be caused by:

a. Low pump speed caused by low line voltage or frequency.
b. Incorrect direction of rotation.
c. Total pumping head may exceed pump design head.
d. Foreign material caught in fluid way.
e. Insufficient NPSH.
f. Lineshaft broken.

5-14. INSUFFICIENT CAPACITY. The capacity may not be sufficient because:

a. Low pump speed caused by low line voltage or frequency.
b. Total pumping head may exceed pump design head.
c. Liquid lines may be partially clogged.
d. Loose impeller.
e. Air or vapor entering the suction head.
f. Insufficient NPSH.

5-15. PUMP LOSES PRIME AFTER STARTING. The pump may lose its prime after starting if the liquid level falls below the pump suction. This may occur when the quantity of liquid supplied for pumping is less than the capacity of the pump.

5-16. PUMP OVERLOADS MOTOR. The pump may overload the motor because:

a. Operation at point on curve other than design.
b. Liquid pumped is not of the specific gravity for which the pump was designed.
c. Low line voltage or defective motor.
d. Impellers rubbing on top or bottom.

5-17. PUMP VIBRATES. Pump vibration may be caused by:

a. Worn bearings.
b. Misaligned or bent lineshaft.
c. Loose mounting bolts or foundation not rigid.
d. Impeller corroded or partially clogged causing unbalance.
e. Air or vapor entering suction head.
f. Stress due to piping misalignment.

5-18. EXCESSIVE WEAR. Excessive wear may be caused by:

a. Sand or other abrasive in liquid pumped.
b. Vibration if not remedied immediately.

5-19. CORROSION. Corrosion may be caused by impurities in the water, or by the type of liquid pumped. Corrosion can be minimized by using stainless steel, bronze or monel metal parts which can be furnished to suit special needs.

5-20. REPAIR

5-21. MECHANICAL SEAL. Repair the mechanical seal, if used, as follows:

a. Insert the sleeve positioning device under the seal sleeve locking collar; then loosen sleeve locking collar.
b. Remove all coupling bolts and withdraw the coupling spacer from between the motor and motor couplings. Loosen set screw locking adjustment nut and slide the motor coupling downward.
c. Unscrew the coupling adjuster and remove it.
d. Remove motor coupling and key.
e. Remove any piping connected to the seal end plate.
f. Remove the bolts holding the seal end plate in position, and slip the sleeve complete with seal and end plate from the shaft.

5-22. Disassemble, inspect, repair and reassemble seal in accordance with seal manufacturers instructions.

a. Reassemble sleeve complete with seal and end plate over shaft.
b. Bolt seal and plate in position.
c. Reassemble the coupling and adjust the shaft to the desired position as instructed in Section III.
d. Lock the sleeve to the pump shaft and remove the positioning device.
e. Refer to the seal manufacturers special additional instructions.

5-23. STUFFING BOX. When repacking the stuffing box, it will be found that die molded packing rings will give the best results. However, where rings must be formed from coil stock, cut all ends with a butt joint carefully fitted to prevent buckling of the ends. Each new ring should be inserted as far as possible into the stuffing box by means of the gland. Joints are to be staggered 180° from the previous ring. The sleeve is held in place by set screws or a key and snap rings. To prevent air or liquid leakage under the shaft sleeve, a seal "O" ring is provided. If there is leakage under the sleeve, the seal "O" ring should be replaced.

5-24. PUMPS. Repair of pumps consists of removal of the pump and disassembly to the point necessary for replacement of defective parts. Hoisting equipment such as that described for installation, is required to pull the pump from the casing. Remove and disassemble the pump as follows:

a. Remove electrical power from motor and disconnect and tag electrical leads at the motor. This should be done by a qualified electrician.
b. Remove bolts from motor coupling.
c. Remove bolts that secure motor to pump head.
d. Attach a sling to motor lifting eyes and lift motor vertically until the driver portion of the coupling clears the pump head.
e. Provide a suitable support and lower motor on to it.
f. Disconnect discharge piping from pump.
g. Remove bolts that secure pump to can.
h. Attach a sling to pump lifting hooks and lift pump vertically until lower end of suction case is clear of can.
i. Position pump horizontally on a suitable support for disassembly.

NOTE

Be sure to provide a clean area with sufficient room to lay parts out in the order in which they are removed.

j. Remove water slinger (6).
k. If equipped with a mechanical seal, remove as per paragraph 5-21.
l. Remove stuffing box piping.
m. Remove suffing box gland (9) by removing securing bolts (456).
n. Remove stuffing box (17) by removing the securing bolts (8).
o. Remove and discard stuffing box packing (15).
p. Disconnect top column pipe (21) from pump head (7) by removing top column bolts (461).
q. Slip pump head off top shaft (19).
r. Disconnect top shaft (19), from lineshaft if present, (32) at coupling by holding coupling and turning shaft clockwise. The threads are left hand.
s. Disconnect column pipe at first coupling, if present, below pump head and remove from shaft.
t. Disconnect column pipe from bowl assembly.
u. Slip column pipe away from bowl assembly until lineshaft coupling is exposed.
v. Disconnect lineshaft at coupling.
w. Remove lineshaft from column pipe.
x. Position bowl assembly in a suitable work area and disassemble as described in Handbook No. 2400-E2B, No. 2400-E3B, or No. 2400-E4B.

5-25. Clean all parts thoroughly with a suitable solvent, wipe the lineshaft with an oily cloth, and reassemble the pump in the reverse order of disassembly as described in paragraph 5-21. Re-install the pump as described in Section III.

SECTION VI
LIST OF PARTS

6-1. GENERAL

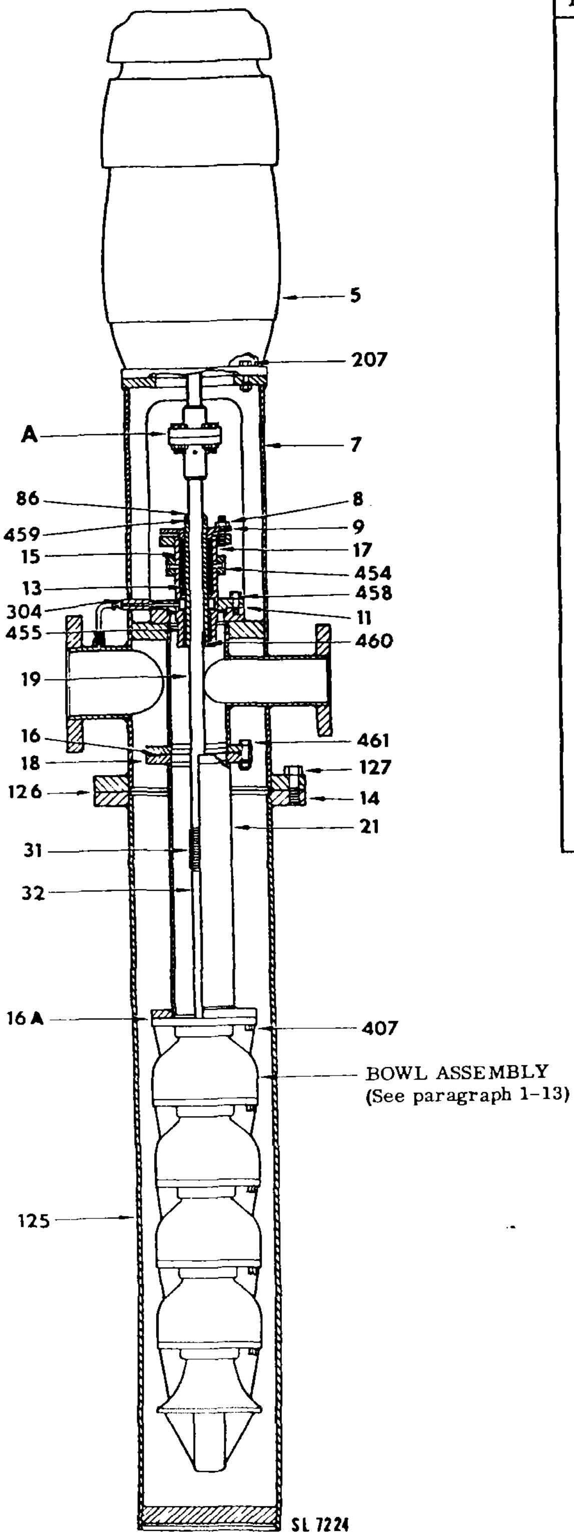
6-2. The requirement for a stock of spare.parts will vary with the severity of conditions of service, the extent of field maintenance anticipated, and the number of units installed. A minimum of one spare of each moving part should be stocked, as well as a complete set of bearings and seals.

6-3. ORDERING PARTS

6-4. When ordering spare and replacement parts the pump serial number, size and type of pumps must be given. Refer to the nameplate. This information is essential in order that the Worthington Corporation may identify the pump and furnish the correct repair parts. Give the name and number of the part as listed in the parts list of the sectional drawing applicable to the pump (figures 6-1 and 6-2), the quantity required and where possible, the complete symbols stamped on the old part. Orders for replacement parts should be sent to the nearest Worthington District Office.

6-5. RETURN PARTS

6-6. All materials returned to the factory must have prior approval and a DRM number assigned. Unnecessary delays are avoided when parts or equipment are returned to the proper factory using the correct procedure.
a. Contact your nearest District Office or Regional Engineering and Service Office, listing the material to be returned and the reasons for return.
b. They will consult the factory using Form DO-657. A copy of this form with shipping instructions will be sent to you if approval is given to return the material. If approval is not given, you will be notified the reason by the office.
c. Articles being returned should be carefully packed to prevent damage from handling or from exposure to weather, and marked with the DRM number provided with the approval.



REF. NO.	NAME OF PART
5	MOTOR
7	DISCHARGE HEAD
8	STUDS AND NUTS
9	STUFFING BOX GLAND
11	STUFFING BOX GASKET
13	TOPSHAFT SLEEVE
14	FOUNDATION PLATE
15	PACKING
16	TOP COLUMN FLANGE GASKET
16A	TOP BOWL GASKET
17	STUFFING BOX
18	TOP COLUMN PIPE FLANGE
19	TOP SHAFT
21	TOP COLUMN PIPE
31	PUMP SHAFT COUPLING
32	PUMP SHAFT
86	SNAP RING
88	SET SCREW
101	DRIVER HALF COUPLING
102	DRIVEN HALF COUPLING
103	COUPLING ADJUSTER
107	COUPLING BOLT
112	DRIVER HALF COUPLING KEY
112A	DRIVEN HALF COUPLING KEY
113	SPLIT RING
125	SUCTION TANK
126	SUCTION TANK FLANGE GASKET
127	SUCTION TANK BOLTS
207	MOTOR BOLTS AND NUTS
304	ORIFICE
407	BOWL BOLTS
454	SEAL CAGE
455	STUFFING BOX BEARING
458	STUFFING BOX BOLT
459	SLEEVE "O" RING
460	SLEEVE KEY
461	TOP COLUMN BOLT

NOTE: WHEN ORDERING PARTS USE DRAWING NUMBER SL-7224 WITH REF. NO.

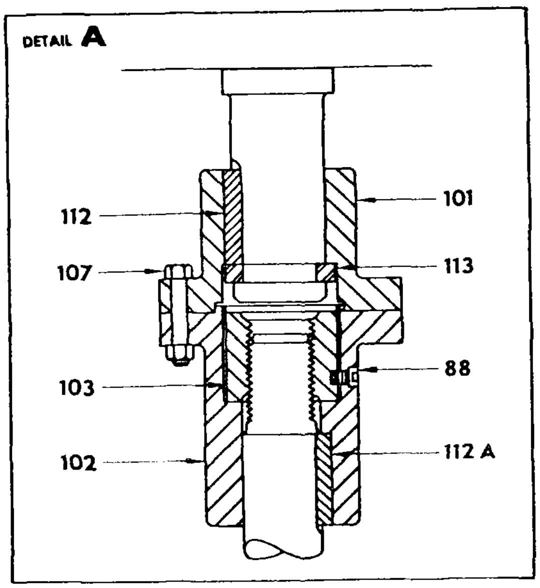
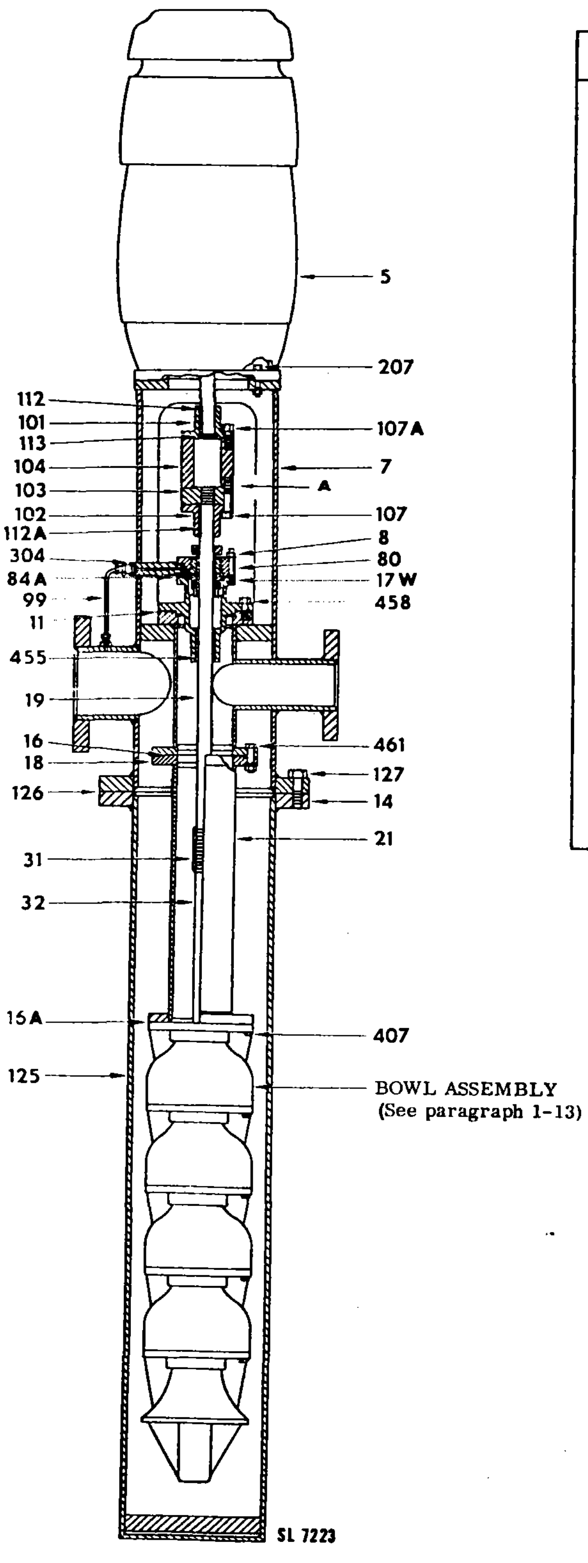


Figure 6-2. Can Pump With Stuffing Box And List of Parts



REF. NO.	NAME OF PART
5	MOTOR
7	DISCHARGE HEAD
8	STUDS AND NUTS
11	STUFFING BOX GASKET
14	FOUNDATION PLATE
16	TOP COLUMN FLANGE GASKET
16A	TOP BOWL GASKET
17W	STUFFING BOX
18	TOP COLUMN PIPE FLANGE
19	TOP SHAFT
21	TOP COLUMN PIPE
31	PUMP SHAFT COUPLING
32	PUMP SHAFT
80	MECHANICAL SEAL
84A	MECHANICAL SEAL GASKET
99	BYPASS TUBING
101	DRIVER HALF COUPLING
102	DRIVEN HALF COUPLING
103	COUPLING ADJUSTER
104	COUPLING SPACER
107	COUPLING BOLT - DRIVEN HALF
107A	COUPLING BOLT - DRIVER HALF
112	DRIVER HALF COUPLING KEY
112A	DRIVEN HALF COUPLING KEY
113	SPLIT RING
125	SUCTION TANK
126	SUCTION TANK FLANGE GASKET
127	SUCTION TANK BOLTS
207	MOTOR BOLTS AND NUTS
304	ORIFICE
407	BOWL BOLTS
455	STUFFING BOX BEARING
458	STUFFING BOX BOLTS
461	TOP COLUMN BOLTS

NOTE: WHEN ORDERING PARTS USE DRAWING NUMBER SL-7223 WITH REF. NO.

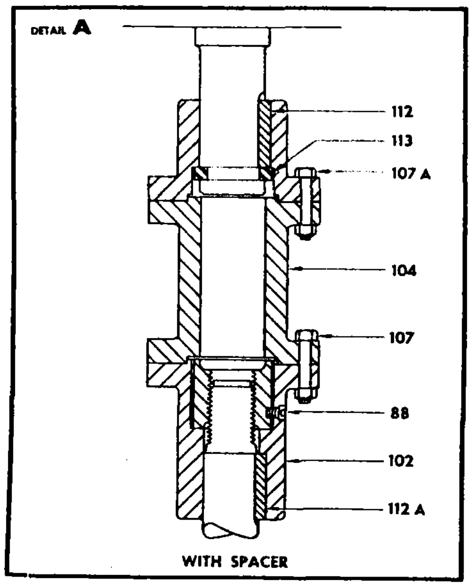


Figure 6-3. Can Pump With Mechanical Seal and List of Parts

WORTHINGTON

Worthington Pump Corporation (U.S.A.)
Shawnee, Oklahoma
A subsidiary of Worthington Corporation

WORTHINGTON

2400-E8C
Supersedes 2400 E8B

Litho in U.S.A

INSTRUCTIONS FOR

DISASSEMBLY, ASSEMBLY

AND MAINTENANCE,

AND LIST OF PARTS

PUMP BOWL ASSEMBLIES

(OPEN AND ENCLOSED TYPES)

For Use With Vertical Turbine Pumps
6" UHF And 8" UHF
(15cm and 20cm)

NC
by S-R Denver
9/9/81

SR #
CP9-335

Our new name,
effective January 1, 1981,
is Worthington Group,
McGraw-Edison Company.

WORTHINGTON

1.2.4-18

FOREWORD

Worthington products are the result of more than a century of progressive study and development. Advanced design, proper selection of materials, and precision construction reflect this wide experience. Worthington products will give trouble-free efficient operation with minimum maintenance and repair.

This instruction book will familiarize management and operating personnel with pertinent details and proper procedures for the installation, operation, and maintenance of one of these products.

Designate below your identification of the equipment for which this book applies.

UNIT SIZE	IDENTIFICATION NO.

NOTE

BOWL SERIAL NUMBER IS STAMPED ON DISCHARGE CASE FLANGE AS SHOWN IN FIGURE 3-1.

STUDY THIS INSTRUCTION BOOK

The descriptions and instructions included in this book cover the standard design of the equipment and any common deviations when possible. This book does not cover all design details and variations nor does it provide for every possible contingency which may be encountered. When information cannot be found in this book, contact the nearest Worthington District Office.

Do not operate this equipment in excess of its rated speed, pressure and temperature, nor otherwise than in accordance with the instructions contained in this Manual. This equipment (or a prototype) has been shop tested and found satisfactory for the conditions for which it was sold, but its operation in excess of these conditions will subject it to stresses and strains which it was not designed to withstand.

Failure to heed this warning may result in an accident causing personal injury.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION I
INTRODUCTION AND GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. This instruction book contains a description and instructions for open and enclosed type bowl assemblies used in the Worthington vertical turbine pumps, manufactured by the Vertical Pump Division of the Worthington Corporation. Special maintenance tools are listed in Section II. Instructions for disassembly, maintenance, and reassembly are given in Section III. A list of parts, covering all models of the bowl assembly, and instructions for ordering parts is given in Section IV.

1-3. GENERAL DESCRIPTION.

1-4. Worthington UHF vertical turbine pumps are normally designed to operate in wells or sumps. The bowl assembly (see figure 1-1), consists primarily of a suction case, one or more pump bowls, and a discharge case. The number of stages (bowls) employed is determined by the head requirements of the installation. The pump bowl assembly is positioned in the sump or well at a depth to provide the proper submergence. A pump shaft, common to all moving parts in the bowl assembly, provides mechanical linkage to the pump driver unit.

1-5. Two basic configurations of the bowl assembly are the open type and the enclosed type. Functional differences in the two types are in the methods employed to lubricate the line shaft. In the enclosed type, a tube is placed over the line shaft and lubricants are supplied to the bearings through the shaft tube. In the open type no lubricants are used other than the fluid being pumped.

1-6. SUCTION CASE.

1-7. The suction case serves as the input port to the pump bowls. Internal guides or vanes perform the dual functions of directing fluids into the eye of the first stage impeller, and supporting the housing for the suction case bearing. In some installations, a suction column may be used to extend the inlet of the suction case. The lower end of the standard suction case is threaded to mate with the upper end of the column.

1-8. PUMP BOWLS.

1-9. Two types of pump bowls, top and intermediate, are available for the vertical turbine pump. Operation of the bowls is identical with the exception that the top bowl discharges fluids into the discharge case and the intermediate bowl or bowls discharge fluids into the eye of the impeller of the next stage. Each

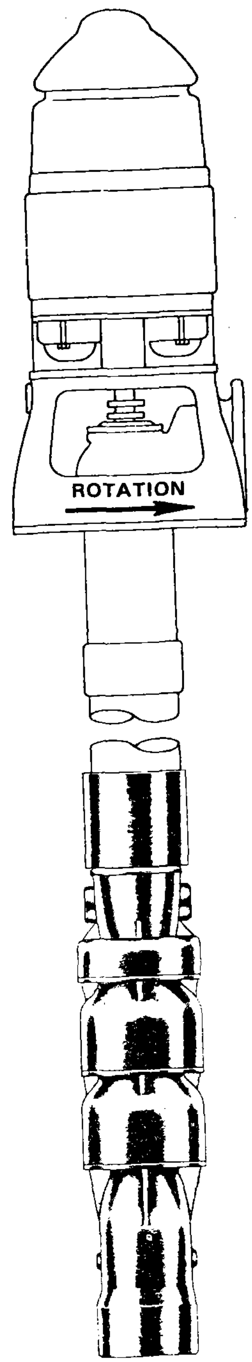


Figure 1-1. UHF Vertical Turbine Pump Installation

type of bowl contains an impeller, mechanically connected to the pump shaft by a cone shaped, split lock collet. Liquid flow in the impeller is both axial and radial. The upper portion of the bowls contain vanes that direct the fluids from the impeller out of the bowl. The vanes also support the housing for the bowl bearings. Intermediate bowls contain a bronze bearing press fitted into the housing. Top bowls contain a single bronze bearing that extends up into the discharge case. Bearing materials may be varied to suit specific application. A multiple stage assembly contains a top bowl and one or more intermediate bowls. A single stage assembly contains only a top bowl.

1-10. IMPELLER.

1-11. Impellers used in Worthington UHF Turbine Pumps are of the enclosed centrifugal or mixed flow type. Sealing of interstage leakage is accomplished by close radial fitting between the bowl and impeller sealing surface.

1-12. DISCHARGE CASE.

1-13. The discharge case receives the fluid from the top bowl and directs it to the column pipe, if one is used, or directly into the discharge head. Vanes that guide the fluid also act as a support for the pump shaft bearing. When the discharge case is used with enclosed shaft pumps, the tapped holes in the external boss of the discharge case provide venting of the pump discharge pressure, and permits correct flow of lubricants down the enclosing tube. When the discha‑ case is used with an open type pump, threaded plugs are screwed into the holes to prevent by-passing of liquids through the vent ports.

SECTION II
SPECIAL SERVICE TOOLS

2-1. GENERAL.

2-2. Worthington vertical pumps are designed to operate for long periods of time with a minimum of maintenance requirements. When maintenance becomes necessary, common hand tools are sufficient for the most part to dismantle the bowl assembly. To prevent damage to certain parts of the pump during disassembly and assembly, special tools, each designed for a specific function, are available. These tools will be supplied with the pump, if ordered, or may be purchased from the nearest Worthington Dealer.

2-3. SPECIAL TOOLS.

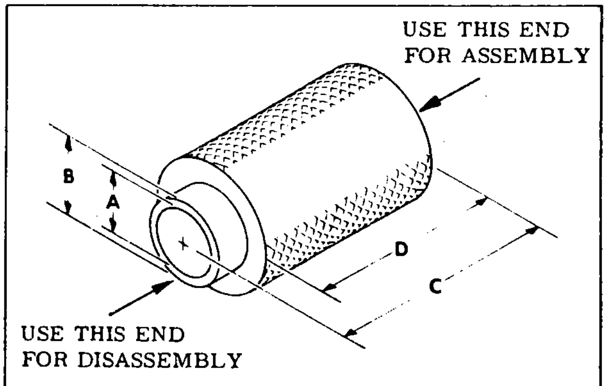
2-4. Two types of special tools are provided for maintenance of the bowl assemblies covered by this handbook: An Impeller-Lock Collet Driver, and a Positioning Plug. Tools are supplied in a variety of sizes to service all models of the pump.

2-5. IMPELLER LOCK COLLET DRIVER.

2-6. The Impeller Lock Collet Driver (figure 2-1), is used to wedge the lock collet between the impeller and the pump shaft. The driver has a knurled handle portion to allow a firm hold when in use and is case hardened for added strength. To use the driver, place it over the pump shaft with the proper facing towards the impeller, and seat or unseat the collet by striking it sharply with the driver.

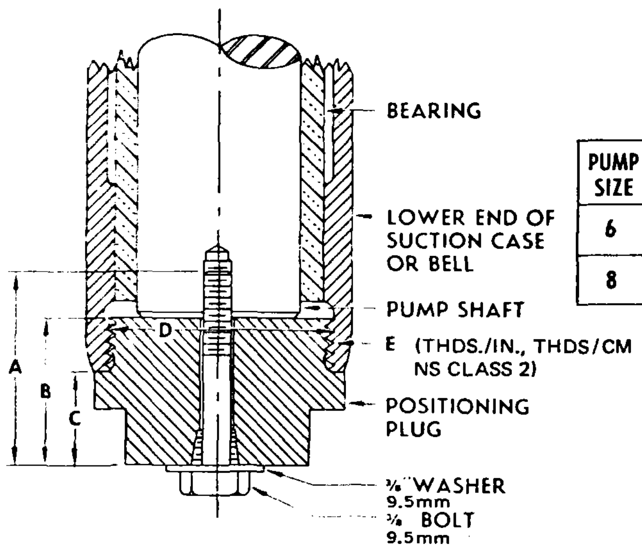
2-7. POSITIONING PLUG.

2-8. The Positioning Plug (figure 2-2), is designed to simplify establishment of proper clearance between moving and stationary parts of the bowl assembly after assembly.



TYPE PUMP	SHAFT DIA.	A	B	C	D
6	1 25mm	1-1/32 26.2mm	1.190 30.2mm	5 127mm	4-1/4 108mm
8	1-1/4 32mm	1-9/32 32.5mm	1.485 37.7mm	5 127mm	4-1/4 108mm

Figure 2-1. Impeller Lock Collet Driver



PUMP SIZE	SHAFT DIA.	A	B	C	D	E
6	1 25mm	2-3/8 60mm	1-25/32 45.2mm	1-1/4 32mm	1.452 36.88mm	14 36
8	1-1/4 32mm	2-3/8 60mm	1-25/32 45.2mm	1-1/4 32mm	1.765 44.83mm	14 36

Figure 2-2. Positioning Plug

SECTION III
MAINTENANCE INSTRUCTIONS

3-1. GENERAL.

3-2. Frequency of complete overhauls on bowl assemblies is dependent upon the number of accumulated hours of operation, severity of conditions of service, and the care given to the pump during operation. The bowl assembly should not normally be opened for inspection unless there is a definite indication of an internal malfunction. Evidence of internal malfunctions generally takes the form of a reduction in capacity or pressure, or a significant change in the vibration or the sound of a running pump.

3-3. DISASSEMBLY.

3-4. Disassembly of bowl assemblies should be performed in a clean area with sufficient space to lay parts in the order in which they were removed. Special tools required to disassemble the bowl assembly are listed in Section II. Figure 3-1 illustrates the components of the bowl assembly, indexed in the order that they are to be removed during disassembly. Proceed as follows:

CAUTION

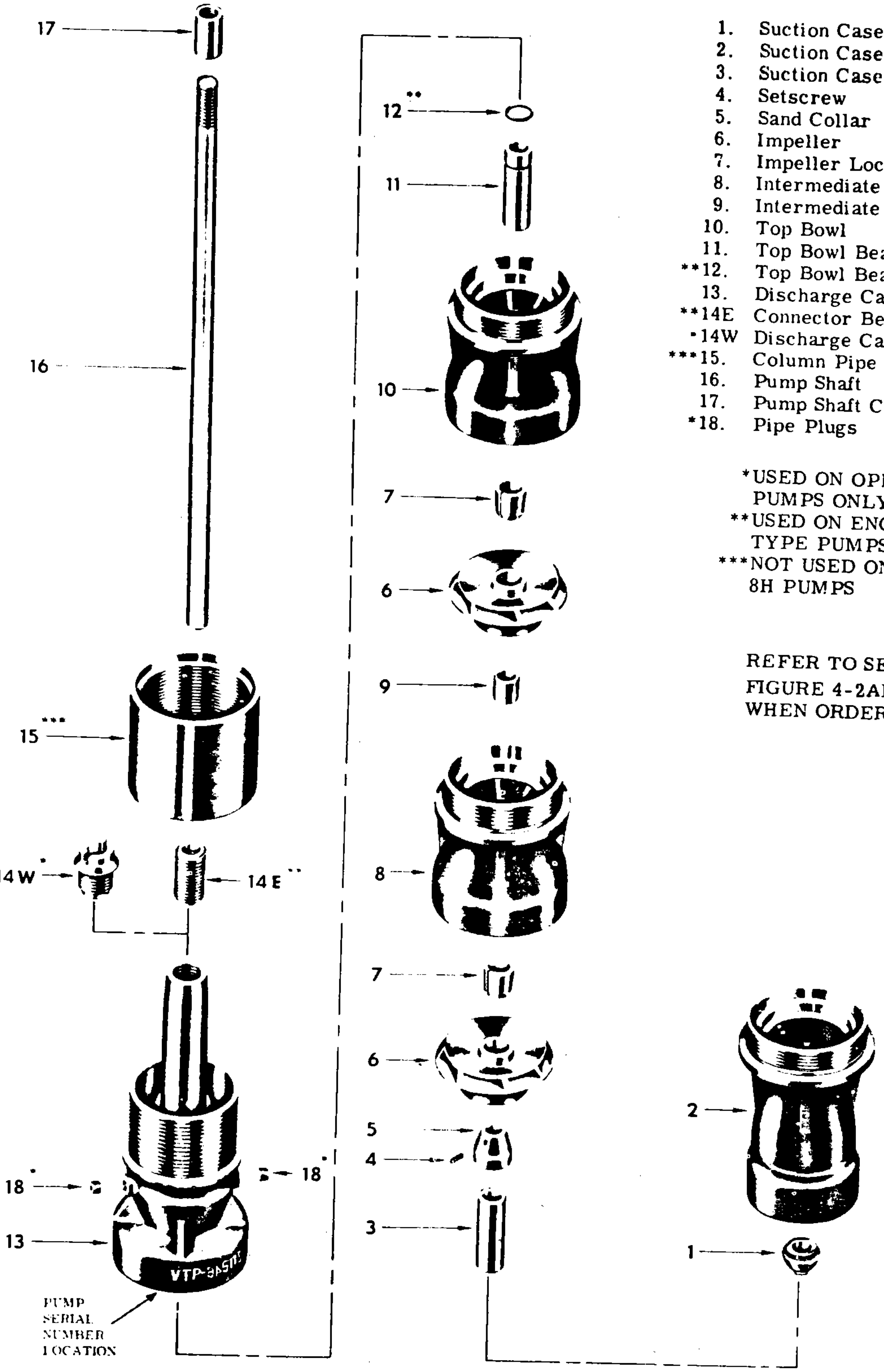
During disassembly and when assemblies are undergoing repair, protect machined and threaded surfaces from metal to metal contact.

a. Lay bowl assembly in a horizontal position with a block under the first bowl above the suction case.

NOTE

Before proceeding with the disassembly of the bowl assembly, measure and record the end play of the shaft.

b. Remove suction case plug (1) from bottom of suction case.
c. Loosen suction case (2) with chain tong, then turn off until case is clear of pump bowl and slide case over lower end of pump shaft. Suction case bearing (3) will slide off with suction case.
d. Loosen setscrew (4) on sand collar (5) and slide collar over lower end of pump shaft.
e. Use driver tool (figure 2-1) to drive impeller lock collet (7) toward top of bowl assembly.
f. Slide impeller (6) over lower end of pump shaft.
g. Place blade of screwdriver in split on the collet (7) and slide the collet over lower end of pump shaft.
h. Loosen pump bowl (8) with chain tong, then turn off until bowl is clear of next stage and slide bowl over lower end of pump shaft. Pump bowl bearing (9) will slide off with pump bowl.
i. Repeat steps e through h to remove remainder of bowls. When top bowl (10) is removed, top bowl bearing (11) and seal (12) will slide off with top bowl.
j. Slide discharge case (13) over lower end of shaft.



1. Suction Case Plug
2. Suction Case
3. Suction Case Bearing
4. Setscrew
5. Sand Collar
6. Impeller
7. Impeller Lock Collet
8. Intermediate Bowl
9. Intermediate Bowl Bearing
10. Top Bowl
11. Top Bowl Bearing

**12. Top Bowl Bearing Seal Ring

13. Discharge Case

**14E Connector Bearing

*14W Discharge Case Cap

***15. Column Pipe Coupling

16. Pump Shaft
17. Pump Shaft Coupling

*18. Pipe Plugs

*USED ON OPEN TYPE PUMPS ONLY

**USED ON ENCLOSED TYPE PUMPS ONLY

***NOT USED ON 8M AND 8H PUMPS

REFER TO SECTIONALS, FIGURE 4-2AND 4-3 WHEN ORDERING PARTS

Figure 3-1. Pump Bowl Assembly Exploded View

IN. (mm)

PUMP SIZE		6	8
Pump Shaft O. D.	MIN	.997 (25.32)	1.247 (31.67)
	MAX	1.000 (25.40)	1.250 (31.75)
Suction Case Bearing I. D. (Before Pressing Into Case)	MIN	1.0085 (25.62)	1.2585 (31.97)
	MAX	1.0105 (25.67)	1.2605 (32.02)
Top and Intermediate Bowl Bearing I. D. (Before Pressing Into Bowl)	MIN	1.0085 (25.62)	1.2585 (31.97)
	MAX	1.0105 (25.67)	1.2605 (32.02)
Pump Shaft End Play "L"		.250 (63)	.4375 (11.1)
Pump Shaft End Play "M"		.375 (9.5)	.4375 (11.1)
Pump Shaft End Play "H"		.3125 (7.9)	.375 (9.5)
Impeller Seal Ring Diameter "L"	MIN	2.455 (62.36)	3.236 (82.19)
	MAX	2.475 (62.41)	3.238 (82.25)
Impeller Seal Ring Diameter "M"	MIN	2.924 (74.27)	3.861 (98.07)
	MAX	2.926 (74.32)	3.863 (98.12)
Impeller Seal Ring Diameter "H"	MIN	3.424 (86.97)	4.609 (117.07)
	MAX	3.426 (87.02)	4.611 (117.12)
Bowl or Wear Ring Diameter "L"	MIN	2.469 (62.71)	3.250 (82.55)
	MAX	2.471 (62.76)	3.252 (82.60)
Bowl or Wear Ring Diameter "M"	MIN	2.938 (74.63)	3.875 (98.42)
	MAX	2.940 (74.68)	3.877 (98.48)
Bowl or Wear Ring Diameter "H"	MIN	3.438 (87.33)	4.625 (117.48)
	MAX	3.440 (87.38)	4.627 (117.53)

Figure 3-2. Table of Nominal Dimensions and Tolerances

Discharge case bearing (14E) or discharge case cap (14W) and column pipe coupling (15) will slide off with discharge case. Coupling (15) not used on 8M and 8H pumps.

3-5. INSPECTION AND CLEANING.

3-6. After disassembly, all components of the bowl assembly should be thoroughly cleaned and examined for physical defects. Examine impellers for signs of rubbing or chipping. Check dimensions listed in table 3-2 and verify that parts checked are within the tolerances listed in table 3-2.

3-7. REPLACEMENT.

3-8. Parts showing cracks, breaks, or signs of excessive wear should be replaced. Only genuine Worthington parts should be used to replace worn or damaged parts. If shafts, impellers, or castings appear to be subject to excessive corrosion due to impurities or chemical action in the fluids being pumped, a consultation with Worthington's staff of competent engineers is recommended. After a complete analysis of conditions peculiar to your area, it may be found that pumps manufactured of special materials would afford you better service. A cost quotation along with any special instructions for installation and operation will be supplied to you at the end of the investigation.

3-9. BEARINGS.

3-10. Bearings in the suction case and pump bowls are press fitted into their respective housings with .001-.003 inch (.025-.076mm) interfernce fit. Worn bearings may be pressed out of housings, or machined on the inside diameter until the wall is thin enough to collapse and remove by hand. Replacement bearings must be pressed into place. Bearings mounted in the discharge case are threaded (left hand) and may be turned in or out of their housings.

3-11. Before installation check the I. D. dimension of the bearings and O. D. dimension of the pump shaft (see figure 3-2). If the clearance is not within tolerance, the I. D. of the bearing must be machined.

NOTE

Replacement suction case and bowls come equipped with bearings of standard dimensions and require no machining.

3-12. LUBRICATION.

3-13. Lubricate all metallic bearings with a clean grease or oil while the bowl is in a dismantled condition. Wipe off excess lubricant and paint all mating and threaded surfaces with a good anti-corrosive compound.

3-14. ASSEMBLY.

3-15. Assembly of the unit is essentially a reversal of disassembly. See figure 3-1 and proceed as follows:

a. Screw the positioning plug (figure 2-2) into the lower end of the suction case (2) and lay in a horizontal position.
b. Insert shaft fully into suction case and lock against positioning plug (figure 2-2) by tightening 3/8" (9.5mm) bolt on the positioning plug.
c. Slide the sand collar (5) down the shaft and turn it back and forth until it fits fully down over the suction case bearing housing, then tighten setscrew (4).
d. Slide impeller (6) down pump shaft until it rests in the recess at the top of the suction case.
e. Place screwdriver blade in split in impeller collet (7) and slide collet down shaft until it rests in the impeller. Work the collet by hand as far into the impeller as possible.
f. Use the impeller lock collet driver (figure 2-1) to drive the collet securely between the impeller and pump shaft.
g. Remove collet driver from shaft and slide bowl (8) down shaft until it mates with the top of the suction case. Thread bowl on to the suction case and use chain tong for final tightening.

h. Repeat steps d through g until all bowls are in place.

i. Slide the discharge case (13) down the shaft slowly until it mates with the top bowl. Thread discharge case onto the top bowl and use chain tongs for final tightening.

CAUTION

Do not allow the discharge case to drop heavily onto the top bowl. Damage to the top bowl bearing may result.

j. Remove 3 8" bolt from bottom of positioning plug and screw grease fitting into the hole and inject a good grade of insoluble grease.

k. Work shaft up and down several times to remove excess grease.

l. Remove the positioning plug and insert the suction case plug (1).

NOTE

After bowl assembly is completely reassembled, measure end play of shaft and compare against reading obtained in note after step a, paragraph 3-4. Nominal end play dimensions are listed in table 3-2.

CAUTION

Discharge case plugs (18, figure 3-1) are used only on open shaft pumps and special high pressure lube enclosed shaft pumps.

DO NOT USE PLUGS ON STANDARD ENCLOSED SHAFT PUMPS

SECTION IV
LIST OF PARTS

4-1. GENERAL

4-2. The requirement for a stock of spare parts will vary with the severity of conditions of service, the extent of field maintenance anticipated, and the number of units installed. A minimum of one spare of each moving part should be stocked, as well as a complete set of bearings and seals.

4-3. ORDERING PARTS

4-4. When ordering spare and replacement parts the pump serial number, size and type of pumps must be given. Refer to nameplate. This information is essential in order that the Worthington Pump Corporation may identify the pump and furnish the correct repair parts. Give the name and number of the part as listed in the parts list of the sectional drawing applicable to the pump (figures 6-1 and 6-2), the quantity required and where possible, the complete symbols stamped on the old part. Orders for replacement parts should be sent to the nearest Worthington District Office.

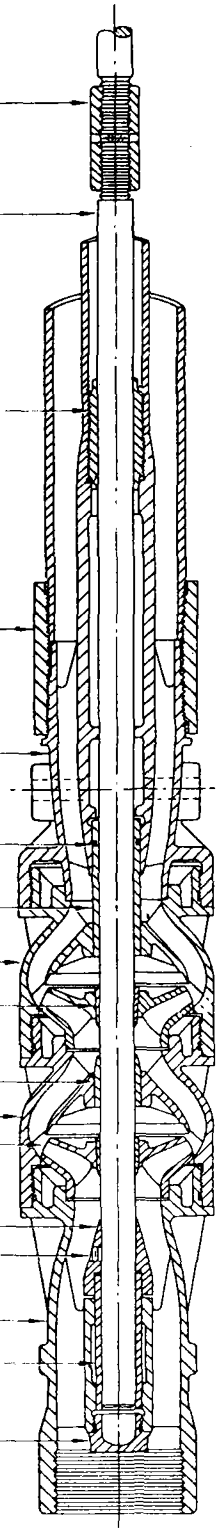
4-5. RETURNING PARTS

4-6. All materials returned to the factory must have prior approval and a DRM number assigned. Unnecessary delays are avoided when parts or equipment are returned to the proper factory using the correct procedure.

a. Contact your nearest District Office listing the material to be returned and the reasons for return.

b. They will consult the factory using Form DO-657. A copy of this form with shipping instructions will be sent to you if approval is given to return the material. If approval is not given, you will be notified the reason by the office.

c. Articles being returned should be carefully packed to prevent damage from handling or from exposure to weather, and marked with the DRM number provided with the approval.



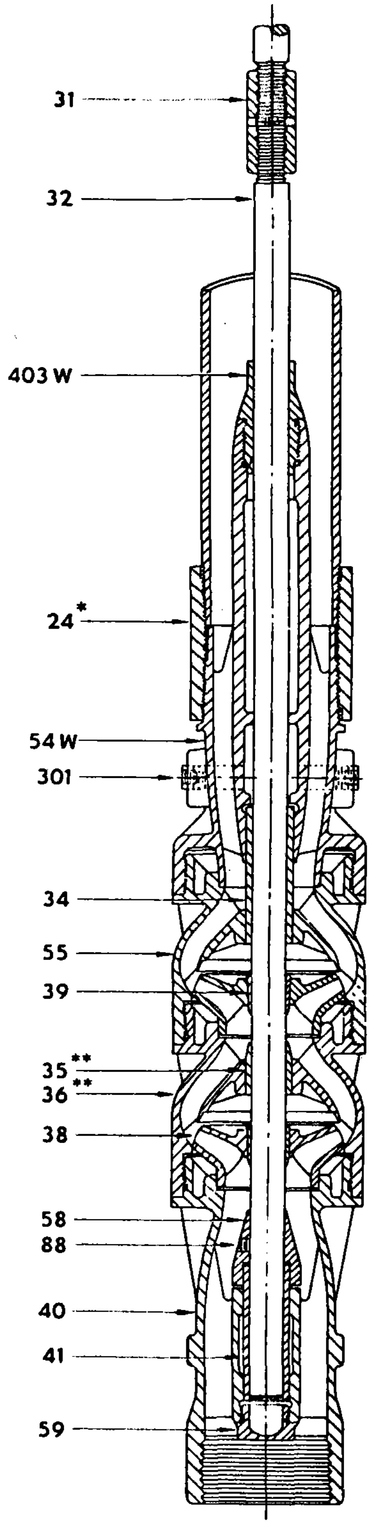
REF. NO.	LIST OF PARTS
24*	COLUMN PIPE COUPLING
31	PUMP SHAFT COUPLING
32	PUMP SHAFT
34	TOP BOWL BEARING
35**	INTERMEDIATE BOWL BEARING
36**	INTERMEDIATE BOWL
38	IMPELLER
39	IMPELLER LOCK COLLET
40	SUCTION CASE
41	SUCTION CASE BEARING
54E	DISCHARGE CASE
55	TOP BOWL
58	SUCTION CASE SAND COLLAR
59	SUCTION CASE PLUG
67E	CONNECTOR BEARING
88	SET SCREW
414	TOP BOWL BEARING SEAL RING

NOTE: WHEN ORDERING PARTS USE DRAWING NUMBER VL-5601 WITH REF. NO.

* NOT USED ON 8M AND 8H PUMPS

**NOT USED ON SINGLE-STAGE PUMPS

Figure 4-2. Enclosed Pump Bowl Assembly and List of Parts



REF. NO.	LIST OF PARTS
301	PIPE PLUGS
24*	COLUMN PIPE COUPLING
31	PUMP SHAFT COUPLING
32	PUMP SHAFT
34	TOP BOWL BEARING
35**	INTERMEDIATE BOWL BEARING
36**	INTERMEDIATE BOWL
38	IMPELLER
39	IMPELLER LOCK COLLET
40	SUCTION CASE
41	SUCTION CASE BEARING
54W	DISCHARGE CASE
55	TOP BOWL
58	SUCTION CASE SAND COLLAR
59	SUCTION CASE PLUG
88	SET SCREW
403W	DISCHARGE CASE CAP

NOTE: WHEN ORDERING PARTS USE DRAWING NUMBER VL-5600 WITH REF. NO.

* NOT USED ON 8M AND 8H PUMPS

**NOT USED ON SINGLE-STAGE PUMPS

Figure 4-3. Open Pump Bowl Assembly and List of Parts

WORTHINGTON

Worthington Pump Corporation
A McGraw-Edison Company
Shawnee, Oklahoma 74801

WORTHINGTON

2400-E2D
Supersedes 2400-E2C

Litho in U.S.A.

Westinghouse Electric Corporation
Medium Motor and Gearing Division
Buffalo, New York, U.S.A. 14240

Instruction Leaflet
2950-CL
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January, 1978
Supersedes I.L. 3030-11TA
dated February, 1971

Grease Lubricated, Lifeline T and Type G Models

Hollow Shaft, Frames 210TP thru 449TP
Solid Shaft, Frames 210VP thru 449VP

Medium Ac Motors Vertical, High Thrust, P-Base

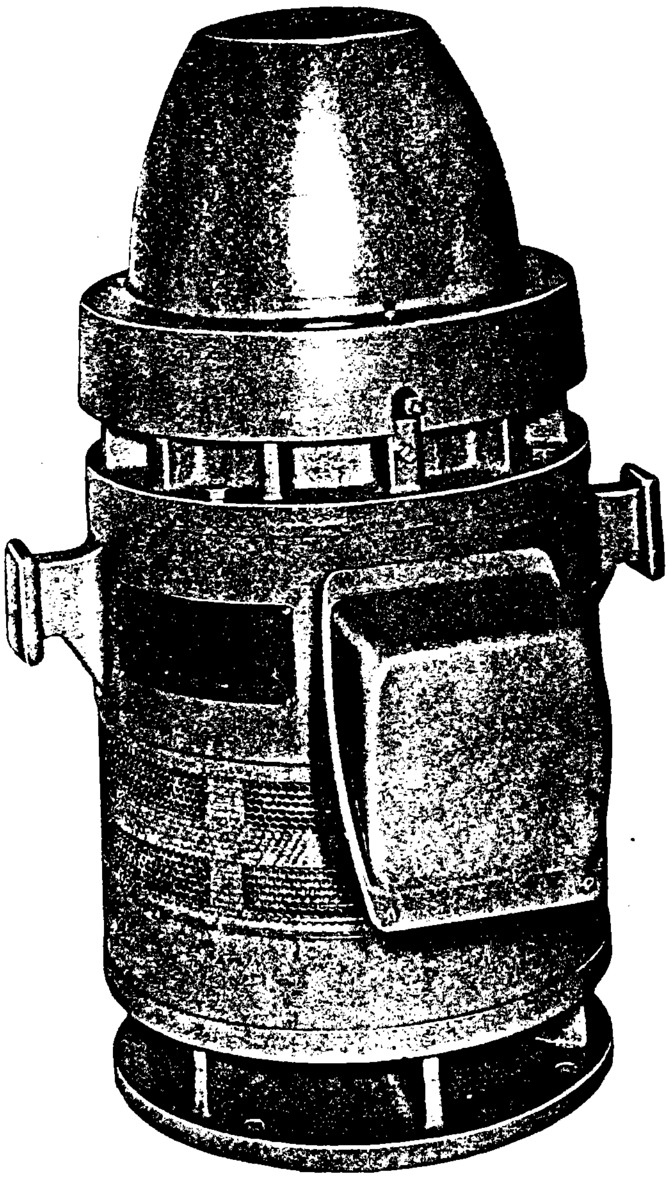


Fig. 1 Typical High Thrust - WPI (Open Dripproof) Vertical Motor Frames 210T-449T

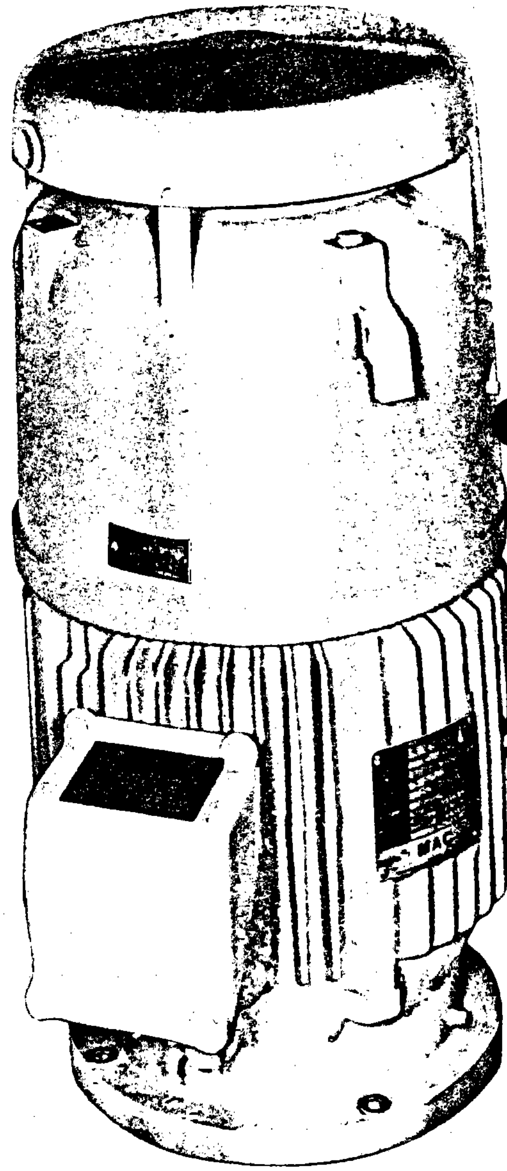


Fig. 2 Typical High Thrust (Fan Cooled) Vertical Motor Frames 210T-28

Note: These instructions do not cover all details or modifications in equipment nor provide for all contingencies of installation, operation, or maintenance. Should additional information be required, contact Westinghouse.

Life-Line T vertical hollow and solid shaft motors are designed for use on deep well or high thrust pump applications. Sturdy cast iron construction is employed throughout with the stator core encased in a cast iron frame. The brackets register directly in accurately machined fits in the frame. The lower bracket provides a housing for the greasable guide bearing as well as a register fit and mounting holes to mate with the pump head. The upper bracket provides a housing for grease lubricated thrust bearings.

Explosionproof assemblies are so identified by an Underwriters' label installed on the motor. Underwriters' labels can be mounted only at point of manufacture.

The presence of the Underwriters' label on the motor is certification that it has been built to rigidly controlled standards to assure utmost safety of operation in hazardous locations.

Warning:
The use of electric motors is potentially hazardous. Installation and service of the motor are to be performed only by trained personnel and in accordance with the national electrical code, all local codes, NEMA Safety Standard MG2 and after reading the nameplate and instructions for that motor.

To prevent possible accidents, locate the motor in an enclosure to keep out children and other unauthorized personnel. This is essential for motors on automatic controls which may restart unexpectedly.

Receiving and Storage

Carefully inspect the motor upon arrival, record and report any damage promptly to the carrier and to the nearest office of the Westinghouse Electric Corporation.

Motor rating and identification data are furnished on the nameplate for checking purposes. The motor should be stored in a dry area with factory packaging intact, unless appearance of package indicates possibility of motor damage during shipment. During long-term storage protect the motor's windings from absorption of moisture. Use space heaters, if present. Periodically inspect, rotate the shaft, megger the winding and record conditions. Investigate any significant changes. (If desired, request detailed long-term storage procedure for Medium Ac Motors from Westinghouse.)

Just prior to actual use, unpack motor – remove shipping braces and packing material from the coupling. Rotate shaft by hand to see that it turns freely. Remove rust preventative paper or slushing compound from shaft extension.

Handling

You should handle the motor in a vertical position. It has lifting lugs on opposite sides for placing the motor on a pump base.

Caution:
To make a proper lift, use a spreader bar; chains vertical. Don't squeeze the top hood; lift gently, slowly. With care, and if necessary, the motor's lifting lugs can safely handle additionally, up to 2 times the motor's weight. This might include a pump base of the approximate weight as the bottom part of the motor.

Installation

Mounting

Locate the motor in a place that is clean and well ventilated. The motor enclosure is such that dripping, wind-blown and splashing water will not damage the motor. Under conditions of extreme weather and moisture, additional protection, such as a pump house, is recommended; however, the free flow of air around the motor must not be obstructed. The external air temperature should not exceed 40°C or 104°F, unless the motor has been specially designed or otherwise cleared for use in a higher ambient temperature.

Bolt the motor to the pump head or rigid foundation using bolts of the largest size permitted by the holes in the motor bracket.

Accurate alignment between motor and pump is of extreme importance. The fits are accurately machined. The mating surfaces must be free of dirt or burrs and solidly engaged. The assembly should turn freely without stress to the shaft and bearings from misalignment. Misalignment will result in bearing troubles.

Vertical Hollow Shaft Motors (VHS)

When mounting VHS motors, remove the hood and coupling. Lower the motor onto the pump head before installing the pump head shaft through the hollow shaft. The motor bracket should bolt home square with the pump head and at right angles with the pump head shaft. The pump head shaft should be centered within the motor hollow shaft. Fit the top drive coupling over the threaded end of the pump head shaft and key it to the pump using a gib head key. Put on the adjusting nut supplied with the pump and draw up on the impellers. Lock the adjusting nut in place with a screw through the nut into a tapped hole in the coupling.

Thrust

The axial thrust load imposed upon the motor by the pump shaft and impellers plus the hydraulic load should not exceed the value for which the motor was ordered. Basically the vertical high thrust motor is designed to withstand momentary up-thrust of 30% of the standard down-thrust rating. For an application having continuous up-thrust or momentary up-thrust in excess of 30%, check that the motor was so ordered.

Method of Drive

Open Dripproof Vertical Hollow Shaft motors (Fig. 1) may be equipped with either a non-reverse coupling or a self-release coupling, as specified by the purchaser.

Non-Reverse Coupling

Prevents motor and pump from rotating to possibly damaging speeds in the reverse direction when the motor is switched off.

These motors are equipped with a non-reverse ratchet that permits CCW rotation (looking downward at the motor) only. The ratchet assembly (Fig. 3) consists of a stationary plate with teeth cast into it, and a rotating drive hub or runner with pins operating in slots. When the motor starts in the forward or CCW direction, the inclined faces of the ratchet track lift the pins where they are held by centrifugal force. When the motor stops, the pins move down and prevent CW or reverse rotation by locking against the vertical faces of the teeth. The pins and pin holes must be clean and free of oil or grease. Oiling or greasing pins will attract dirt which can cause pins to stick and result in ratchet failure.

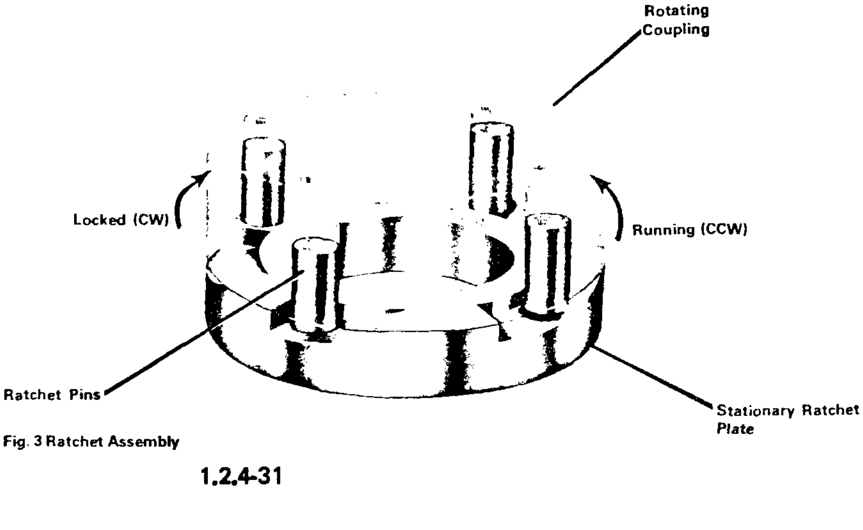


Fig. 3 Ratchet Assembly

A non-reverse ratchet protects against **accidental** reverse rotation due to phase reversals or from backspins at shutdown.

A non-reverse ratchet should not be used indiscriminately or unnecessarily. This type of ratchet is inherently subject to wear in **normal** usage and under certain conditions may fail with consequent damage to the pump/motor system. The non-reverse ratchet is not recommended for settings greater than 375 feet, since pump torque developed is greater than motor torque which results in destruction of ratchet, coupling drive hub, etc.

In addition, the non-reverse ratchet is not recommended for pressure systems where **frequent** starts and stops are common. Frequent being defined as 5 starts and stops per 24 hour period. This type of service would require a check valve or similar device. Although a non-reverse ratchet does protect against reverse rotation, it is **not intended and will not perform** like a check valve.

Self-Release Coupling
Prevents pump line-shaft joints from unscrewing if, occasionally, the motor accidentally runs in the reverse direction.

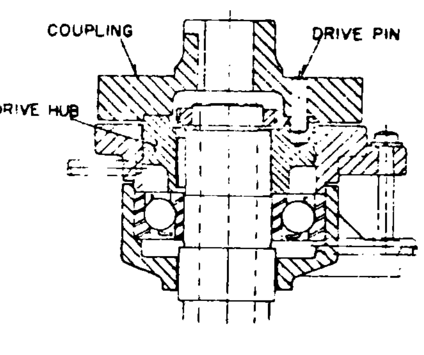


Fig. 4 Self-Release Coupling Assembly in Hollow-Shaft Motors – Open Dripproof Only

These motors (Fig. 4) are equipped with a unique coupling and drive hub. The drive hub is keyed to the motor shaft, and the coupling is keyed to the pump shaft and attached with a screw to the pump shaft adjusting nut. The coupling centers on the drive hub by means of a machined fit. The coupling is driven by two pins attached to the coupling hub and engaging corresponding holes in the drive hub. Disengagement is caused by a lifting of the pump shaft which in turn lifts the coupling off the two drive pins. This feature applies to dripproof motors only.

Bolted Coupling
The bolted down coupling allows the motor bearings to take momentary up-thrust from the pump and limits lifting of the pump head shaft to the amount of motor end play.

Totally Enclosed Fan Cooled and TEFC – Explosionproof Vertical Hollow Shaft motors are equipped only with a bolted-down coupling, which may have the non-reverse feature, if so ordered (Fig. 2).

Solid Shaft Vertical Motors
These motors are provided with a shaft extension suitable for coupled service, and are either straight or tapered as selected by the purchaser.

Note:
Coupling halves should have a close sliding fit on the shaft extension and must be securely locked to avoid hammering out in operation. Be sure to tighten coupling bolts per good mechanical practice. If it is necessary to drive the coupling in position, it is important that the end of the shaft opposite the extension be backed up so that the force of the blow is not taken in the bearings. Use a pinion puller for removing tight couplings.

Electrical Connections
Be sure the motor is connected as shown on the nameplate diagram, and that your power supply (voltage, frequency, and number of phases) corresponds with the nameplate data.

Employ trained personnel to install all wiring, fusing and grounding in accordance with National Electrical Code, local requirements and NEMA Safety Standard MG-2.

Carefully identify motor auxiliary devices before connecting. These might be space heaters, winding thermostats, thermocouples, thermistors, or other temperature sensors. Be sure they are connected only in circuits for which they are designed and that their connections are carefully insulated from the motor power cables.

Connect to the power supply through a suitable starter and overload protection.

Conduit Box
The conduit box may be rotated 360 degrees in 90 degree steps.

Warning:
When servicing, all power sources to the motor and to accessory devices should be disconnected and de-energized; all rotating parts should be at standstill.

Operation
1. Disconnect load and start motor. Check direction of rotation. If rotation must be changed, ALLOW THE MOTOR TO STOP COMPLETELY. Interchange any two leads of a three phase motor. Reconnect a single phase motor per nameplate instructions; interchange the leads of either phase of a two phase motor. Fans on fan cooled motors that have directional rotation nameplates must be reversed on shaft if rotation is changed.

2. Connect load. The motor should start quickly and run smoothly. If not, shut power off at once. Recheck the assembly including all connections before restarting. For single phase motors, also examine capacitor wiring and mechanism for switching between starting and running.

3. If excessive vibration is noted, check for loose mounting bolts, too flexible motor support structure or transmitted vibration from adjacent machinery. Periodic vibration checks should be made; foundations often settle.

4. Operate under load for short period of time; check operating current against nameplate.

The motor will operate satisfactorily with a 10 percent variation in voltage; a 5 percent variation in frequency or a combined voltage and frequency variation of 10 percent, but not necessarily in accordance with the standard of performance established for operation at normal ratings.

Maintenance

Inspection
Although LIFE-LINE motors require a minimum of attention in service, they should be inspected at regular intervals to check for (1) dirt, (2) moisture, (3) friction, and (4) vibration, which account for 90 percent of all motor failures.

1. Guard Against Dirt
Keep the insulation and mechanical parts of the motor clean. Dust that is free from oil or grease may be removed by wiping with a clean, dry cloth, or preferably, by suction. Dust may be blown from inaccessible parts with clean, dry air, using not more than 30 to 50 pounds pressure. Use care to prevent personal injury from the air hose; use goggles to avoid eye injury from flying particles.

When grease or oil is present, wipe with a cloth moistened (but not dripping) with a petroleum solvent of a "safety type" such as Stoddard solvent or similar materials available under various trade names. When a material is difficult to remove, carbon tetrachloride is more effective than petroleum solvents. Wear neoprene gloves to prevent skin irritation when using either petroleum solvents or carbon tetrachloride.

Petroleum solvents are flammable, but comparatively nontoxic.

Carbon tetrachloride is non-flammable, but is highly toxic. Suitable ventilation should be provided to avoid breathing vapors. When ventilation is not sufficient to prevent a distinct odor of carbon tetrachloride, a chemical cartridge respirator or gas mask must be used.

2. Guard Against Moisture
The motor should not be subject to extreme moisture conditions such as high humidity during shut down periods, exposure to water under pressure such as hosing down, or severe weather conditions.

During prolonged periods of idleness, the motor should be run at least once a week, or should be provided with heaters to guard against moisture condensation.

The insulation resistance of motors not in regular use should be checked with a megger, and, if necesary, their windings should be dried by appropriate means before energizing.

Before blowing motor windings out with air, make sure the air line is free of condensation.

3. Guard Against Friction and Vibration
Excessive friction or overheating of bearings is usually traced to one of the following causes:
a) Poor alignment causing excessive vibration or binding.
b) Bent shaft.
c) Excessive thrust.
d) Overgreasing.

To avoid failures due to vibration, a few simple checks should be made regularly:
a) Check for misalignment such as may be caused by foundation settling.
b) Check to see if any pump vibration is being transmitted to the motor.
c) Check the motor mounting bolts and bracket bolts to be sure they are tight.
d) Check transmission from adjacent machinery or too flexible motor support structure, as well as by motor unbalance itself.

Note:
If vibration of 5 mils or more is experienced under running conditions after above checks have been made, then it is certain that there is some resonance in the system.

Coils
Revarnishing the windings when motors are overhauled will lengthen their life. Suitable varnish may be obtained from the nearest Westinghouse Sales Office.

Guide Bearing
The guide bearings are vacuum degassed single row width conrad type greasable ball bearings, with single shields on each side.

Thrust Bearing
The thrust bearings are angular contact ball bearings.

① Not applicable to 3600 rpm motors on frame 210TP or 210VP. For information regarding these ratings, contact Westinghouse.

Caution:
The thrust capacity of these bearings vary with supplier and care should be taken to insure that replacement bearings are equivalent to the original.

Lubrication
Grease lubricated bearings as furnished are adequate for a long period of operation without relubrication. A good maintenance schedule for regreasing will vary widely depending on motor size, speed, duty and environment.

Warning:
When servicing, disconnect all power sources; all rotating parts should be at standstill. Make sure any accessory re-start device is de-energized.

Frequency of Regreasing
The following table suggests relubrication intervals for motors on normal duty, steady running, in relatively clean atmosphere at 40°C ambient (104°F) temperature or less.

See motor nameplate for insulation class, frame and identity of bearings.

Enclosure	Ins.	Frame 210	Frames 250 & 280	Frames 320 to 440
WPI Dripproof	B	2 yrs	18 mos	1 yr
Enclosed-Fan Cooled / WPI Dripproof	B / F	18 mos	1 yr	9 mos
Enclosed-Fan Cooled / WPI Dripproof	F / H	1 yr	9 mos	6 mos
Enclosed-Fan Cooled	H	9 mos	6 mos	3 mos

NOTE:
For motors over 1800 rpm – grease twice as frequently
For heavy duty – dusty locations – grease twice as frequently

Type of Grease
Use Westinghouse 53701RY grease unless a special grease is specified on the nameplate. Some equivalent greases are:
Chevron SRI-2 — Standard Oil of California
Premium RB — Texaco Inc.
Unirex N2 — Exxon
Dolium R — Shell Oil Company
Rykon Premium — American Oil

Caution:
Overgreasing is a major cause of bearing and motor failure. Make sure dirt and contaminants are not introduced when adding grease.

Procedure for Regreasing
When regreasing, stop motor, remove inlet and outlet plugs, and add grease with hand lever operated gun only. Add quantity of grease per chart below. **Do not** expect grease to appear at the outlet, but if it does, discontinue greasing at once. Run motor for about ten minutes before replacing outlet plug.

Reference Table for Guide and Thrust Bearings

Shaft Diameter (At Face of Bracket)	Amount of Grease to Add
Lower Guide Bearings	
¾ to 1¼	⅛ cu. in. or 0.1 oz.
1¼ to 1⅞	¼ cu. in. or 0.2 oz.
1⅞ to 2⅜	¾ cu. in. or 0.6 oz.
2⅜ to 3⅜	2 cu. in. or 1.6 oz.
Upper Thrust Bearing	Frames 210-280 3.6 cu. in. or 2 oz. Frames 320-440 5.4 cu. in. or 3 oz. per Brg.

1 oz. = 1.8 cu. in. by Weight

End-Play Adjustment①
All vertical high thrust motors are designed for momentary up-thrust. This up-thrust is taken by the lower guide bearing which is restricted in movement by the drive hub locknut. This adjustment is made at the factory for new motors and need not be readjusted.

If the motor should be disassembled for any reason, the end-play adjustment must be made to avoid bearing damage.

The procedure for end-play adjustment is as follows:

1. Assemble motor with lower inner bearing cap pulled down tight.

2. Assemble upper bearing, drive hub, drive hub lockwasher and locknut onto shaft. Tighten drive hub locknut until bearings are just starting to pre-load. When slight pre-load is experienced, there is no end-play and the rotor will not turn as freely by hand.

3. After slightly pre-loading the bearings, back off the drive hub locknut ⅛ turn for frames 210 through 280 and ¼ turn for frames 320 and larger.

4. Check end-play. End-play should be .005 to .010 inches.

5. If equipment is available, it is desirable that shaft end-play be checked using a dial indicator to measure movement as rotor and shaft is raised and lowered.

6. When end-play is established, lock the nut in place with the lockwasher.

For motors that are supplied to withstand continuous up-thrust, end-play adjustment is not required. Drive hub locknut should be secured tight and locked with the lockwasher.

Repair and Renewal Parts
Repair and renewal parts information may be obtained from the nearest Westinghouse Sales Office. Be sure to use title and number from Figs. 5, 6 and 7 which describe the part or parts required, and give the complete nameplate reading on the motor for positive identification.

Repairs on explosion-proof motors, that alter in any way the explosion resisting character of the motor, void the Underwriters' label.

Note:
Bearings - AFBMA number is on the motor nameplate.

To obtain Westinghouse No. 53701RY grease in small containers, order:
S# 773A773G35 - 35 lb. can

Returning Apparatus
Authorization and shipping instructions for the return of any apparatus must be obtained by the purchaser from Westinghouse Sales Office or distribution outlet before returning apparatus. In no event will Westinghouse be responsible for apparatus returned without proper authorization and identification.

Warranty
Contact nearest Westinghouse Apparatus Sales Office for details of warranty coverage. Generally, Westinghouse will correct by repair or replacement any defect in workmanship or material which develops in this motor, when properly used, for one year after installation or 18 months after shipment, whichever comes first.

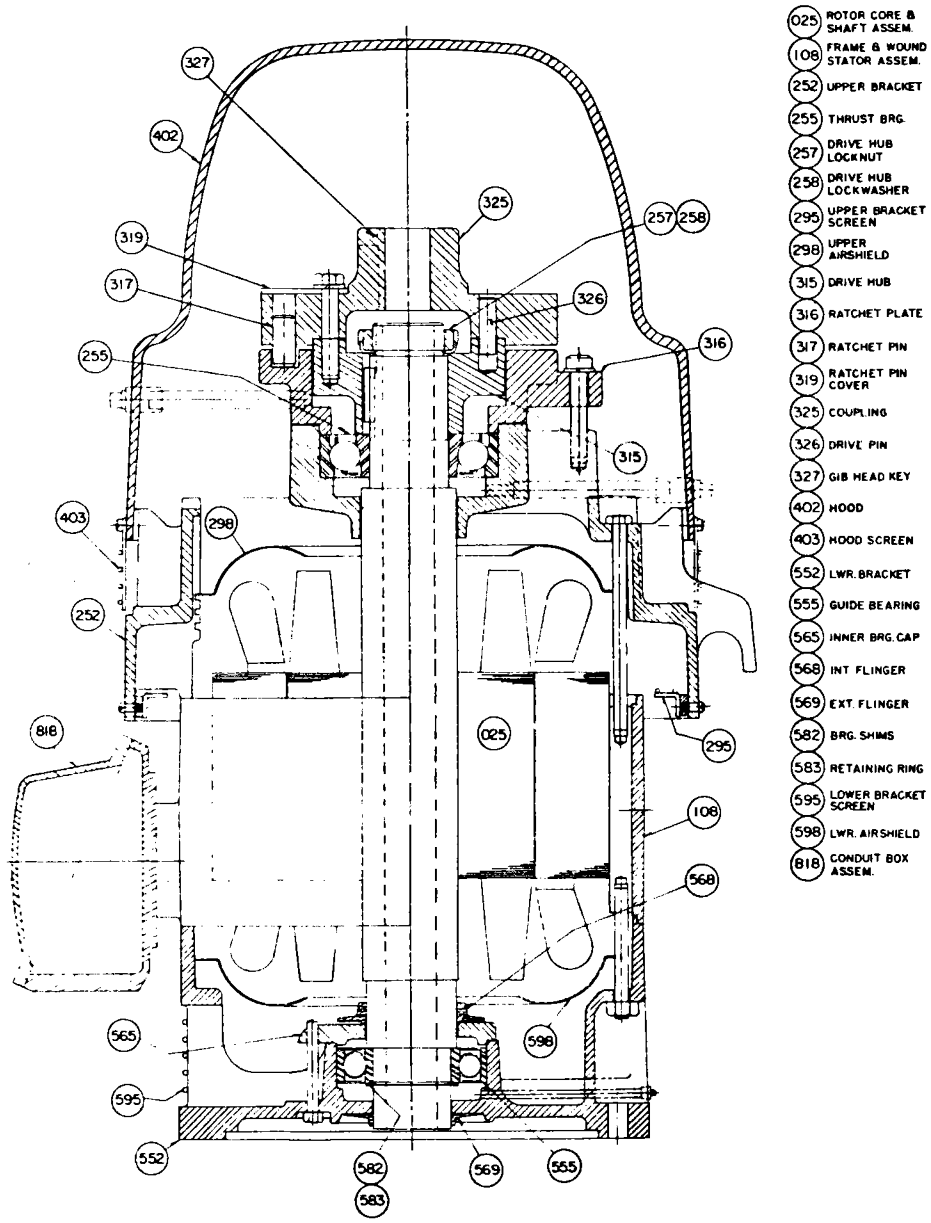


Fig. 5 Arrangement of Parts, Vertical Hollow Shaft Dripproof Type T Life-Line Motors, Frames 210TP-280TP (Solid Shaft Motors use same Construction except Top Coupling and Ratchet Pins are Omitted.)

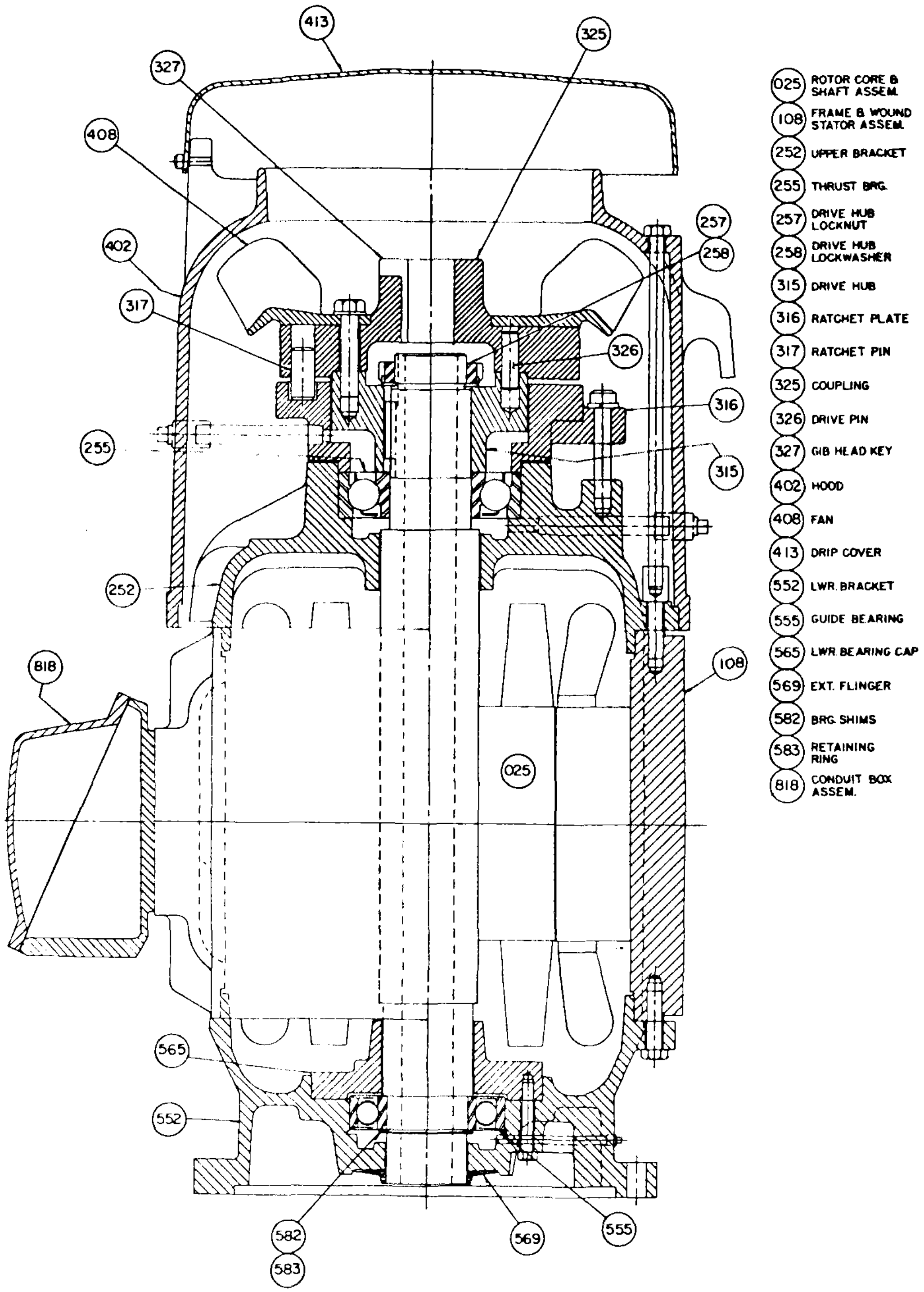
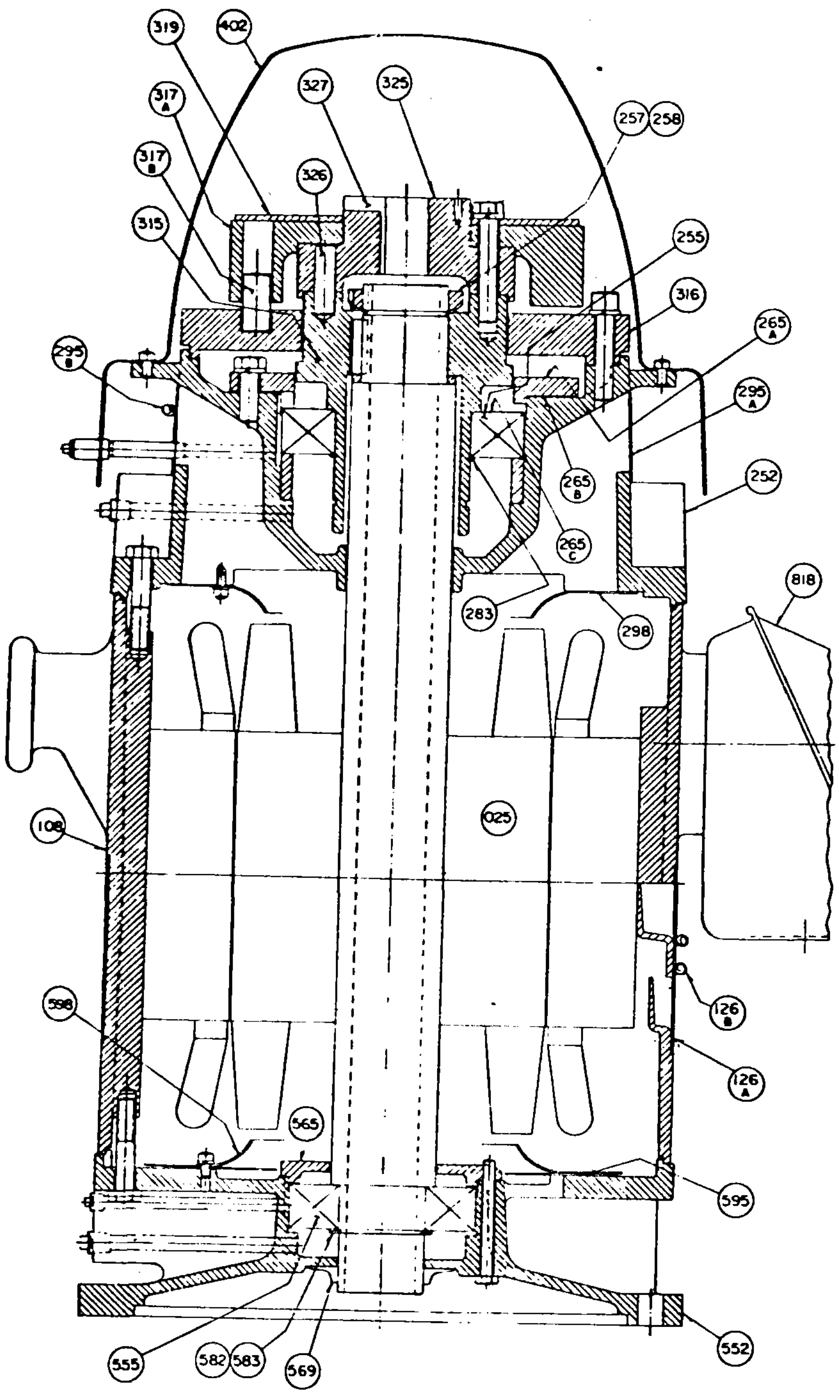


Fig 6 Arrangement of Parts, Vertical Hollow Shaft Fan-Cooled or Type T Life-Line Explosionproof Motor, Frames 210TP-280TP (Solid Shaft Motors use same Construction except Ratchet Pins are Omitted.)



025 ROTOR CORE & SHAFT ASSEM.
108 FRAME & WOUND STATOR ASSY
126 A LOWER FRAME SCREEN
126 B SCREEN SPRING
252 UPPER BRACKET
255 THRUST BRG.
257 DRIVE HUB LOCKNUT
258 DRIVE HUB LOCKWASHER
265 A UPPER BRG. CAP
265 B UPPER BRG. CAP GASKET
265 C GREASE METERING PLATE
283 RETAINING RING
295 A UPPER BRACKET SCREEN
295 B SCREEN SPRING
298 UPPER AIRSHIELD
315 DRIVE HUB
316 RATCHET PLATE
317 A RATCHET PIN RING
317 B RATCHET PIN
319 RATCHET PIN COVER
325 COUPLING
326 DRIVE PIN
327 GIB HEAD KEY
402 HOOD
552 LWR. BRACKET
555 GUIDE BRG.
565 INNER BEARING CAP
569 EXT. FLINGER
582 BRG SHIMS
583 RETAINING RING
595 LWR BRACKET SCREEN
598 LWR AIRSHIELD
818 CONDUIT BOX ASSEM.

Fig. 7 Arrangement of Parts, Vertical Hollow Shaft Dripproof Life Line Motor, Type G Frames 320TP-440TP
(Solid Shaft Motors use same Construction except Top Coupling and Ratchet Pins are Omitted.)

1. 2. 5 ULLAGE PUMP

1. 2. 5.1 Identification

Tag Number	Description
P-308	Ullage Pump

1. 2. 5.2 Description

Manufacturer : Aurora Pump, 800 Airport Rd., North Aurora, Illinois 60542

Part Number : Model 134, Size C04

Specification No. : None

Material :

Weight : 62 lb.

1. 2. 5.3 Prescribed Service

Thermal Storage Liquid Hydrocarbon Return

1. 2. 5.4 Vendor

Hirt Combustion Engineers, 931 So. Maple Ave., Montebello, CA 90640

1. 2. 5.5 Special Cautions

See Aurora Bulletin 130E

1. 2. 5.6 Periodic Service

None

1. 2. 5.7 Parts List

None

1. 2. 5.8 Special Tools

None

1. 2. 5.9 Maintenance Instructions

None

1. 2. 5.10 Acceptance Tests

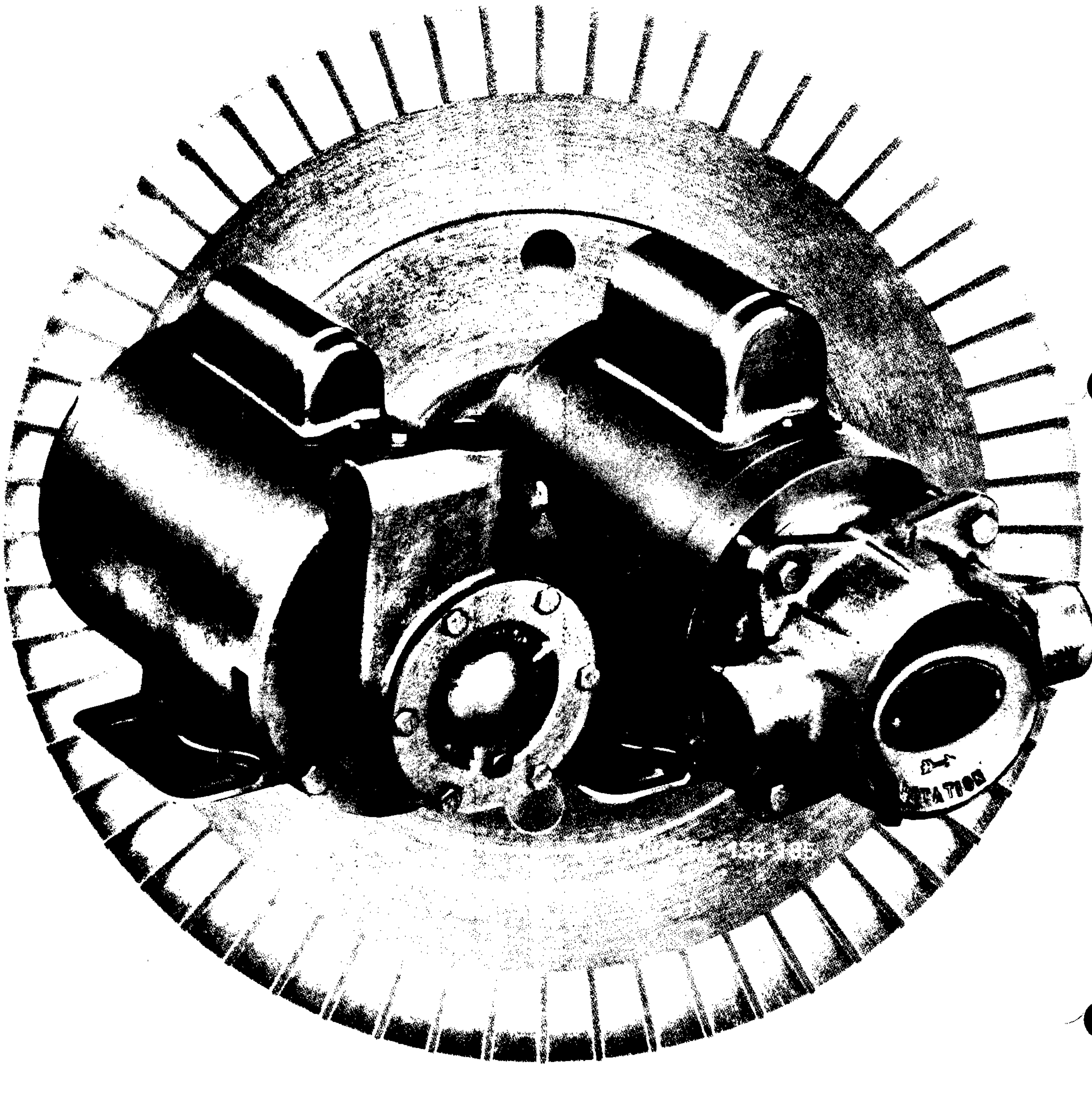
None

AURORA® PUMPS

BULLETIN 130E

130 SERIES SINGLE STAGE TURBINE TYPE PUMPS—"O"

CAPACITIES TO 50 G.P.M.
HEADS TO 700 FEET
TEMPERATURES TO 212° F



A.I.A. FILE NO. 29-D-5

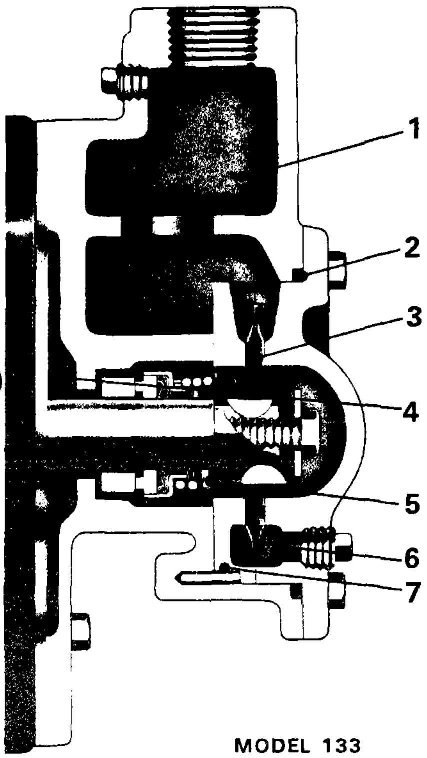
AURORA PUMP, a pioneer in turbine pump design, has long been the leader in the turbine pump industry. AURORA's leadership consistently offers the ultimate in turbine pump design.

The regenerative turbine pump offers many advantages in the area of low flow and moderate to high pressure. A turbine pump is efficient under low flow — high pressure conditions and delivers a steady stream of liquid free from pressure pulsations. There is no metal to metal contact existing within the operating parts of a turbine pump channel.

Turbine pumps have solved many liquid handling problems. Because of this versatility, thousands of turbine pump units have been in use for over 50 years.

The following pages explain the reasons why AURORA PUMP is able to offer you a modern, efficient, economical and customer proven turbine pump.

PUMP FEATURES



MODEL 133

1 SELF-PRIMING feature is provided on Model 133.

2 "O" RING GASKETS prevent leakage.

3 SELF-CENTERING IMPELLER minimizes wear.

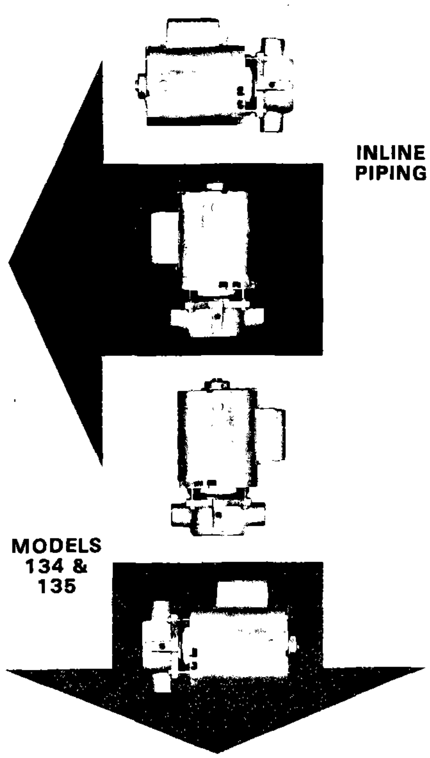
4 WATER SLINGERS protect bearings.

5 MECHANICAL SEAL has carbon against Ni-Resist face for optimum hot water performance. Long life is also assured with 303 stainless steel metal parts and "Buna-N" elastomers.

6 DOUBLE SUCTION IMPELLER minimizes axial thrust.

7 REPLACEABLE CHANNEL RINGS and impellers reduce maintenance costs.

8 STRAIGHT THROUGH IN LINE PIPING is provided on Models 134 and 135 for simple installation.



STANDARD

Bronze fitted construction

Hydraulically balanced bronze impeller

300# case working pressure

416 stainless steel shaft

Internal sealing water passages

Removable channel rings

VIP TEST — Every pump is hydrostatically tested and given a running check with data consisting of head, capacity and horsepower readings at your specified operating conditions.

OPTIONAL

All iron, bronze ring, all bronze construction

Ductile iron or stain. steel impeller

316 stainless steel or monel shaft

Vertical ASA Flanged suction casing (See Bulletin 680, Models 134 and 135 only)

Bypass with manual shut-off valves

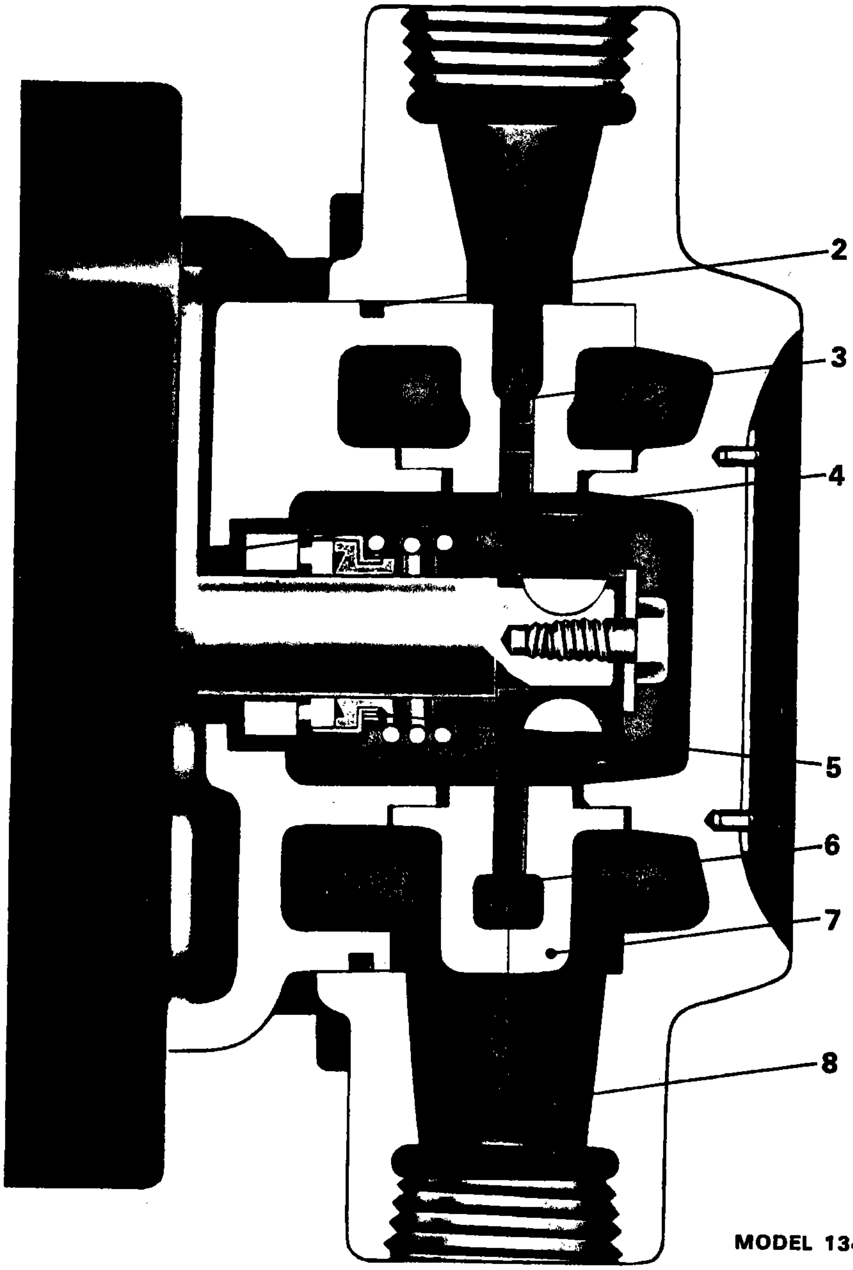
Bypass with relief valve

Certified performance test data consisting of head capacity and horsepower readings taken over the full operating range of the pump.

THEY'RE ECONOMICAL
End-mounted, close-coupled design with single mechanical seal and choice of 3500 RPM or 1750 RPM operating speeds means you get greater capacity and pressure—dollar for dollar. In fact, these close-coupled pumps are so economical, it's practical to have a spare unit ready for immediate replacement when maintenance is required.

THEY CAN'T "VAPOR LOCK"
Turbine impeller handles gases and vapors (up to 20%) along with the liquid . . . eliminating any possibility of vapor lock within the pump.

THEY'RE VERSATILE
Steep head curves with near-constant capacity over wide head variations means you can specify 130 Series Pumps for an extremely wide range of operating conditions. And, if it's necessary, Model 134 and 135 Pumps can be easily field converted to right- or left-hand operation by rotating the casing 180° after removing only 4 mounting bolts. Need a self-priming pump? Specify Model 133 with the self-priming feature. This feature has made Model 133 a popular pump selection.



MODEL 134

THEY SAVE SPACE AND ARE EASY TO INSTALL
Close-coupled design gives you substantial space savings compared to conventional bearing frame pumps. Installation is quick and easy, too. Straight-through piping (Model 134 and 135) also means you can locate the pump almost anywhere within the piping system — without using elbows at the pump.

AND, THEY'RE RELIABLE
It takes quality materials and careful production methods to make reliable pumps. Standard construction 130 Series Turbine Pumps are bronze-fitted with bronze impellers, (chrome-plated channel rings are standard on Models 133 and 134), cast iron casings, and stainless steel motor shafts. (They're also available in All-Bronze or All-Cast Iron construction to meet your most demanding application. Then, after 130 Series Pumps are assembled with these quality materials, each pump is tested on dynamic test stands which duplicate operating conditions and measure precisely each pump's head, capacity, and power requirement — not to mention hydrostatic and mechanical function tests. After a 130 Series Pump passes these tests it's VIP-rated (Verified Individual Performance) and one you can apply with full confidence that the rating you specify will be attained.

WHAT'S SO SPECIAL ABOUT OUR TURBINE PUMPS?

They have steep head-capacity characteristics. They have excellent vapor handling properties. They have unusually high suction lift properties. And, they're economical.

THE STEEPER THE BETTER

Take head-capacity characteristics, for example. Figure 1 shows a performance curve for a typical Aurora turbine pump. As you can probably tell at a glance, the steep head characteristics make it possible for an Aurora turbine to go on pumping about the same amount of liquid even though there are relatively wide variations in head pressure. Pressure variations can occur for a number of reasons, but the most common designed-in variations are the result of automatic pop-off valves and similar control devices. The important point is this: you can design your system using Aurora turbine pumps, knowing that you can always count on about the same capacity despite some unavoidable variations in pressure.

VAPOR LOCK! WHAT'S THAT?

The second feature that makes Aurora turbine pumps somewhat special is the way they handle vapor without any serious effect on pumping capacity. Even though bubbles form in the suction nozzle, the pump will carry them along with the liquid, discharging the vapors. This makes Aurora turbine pumps ideal not only for handling hot water but also for pumping refrigerants and liquids that may vaporize at normal temperatures. Aurora turbines can also handle steam and air along with hot water, without vapor lock or bind.

BIG LIFTS, TOO

As for high suction lift properties, just take a look at Figure 2. Here you'll find that the maximum suction lift of an Aurora turbine pump is only 5½ feet less than the theoretical maximum for any type of pump. (No wonder Aurora turbines are specified, over and over, for "lifting" operations . . . especially hot water and liquids that vaporize at normal temperatures.)

BUDGET WATCHERS

How about economy? More good news. Turbine pumps, by their very design, are the most economical solution to general lift applications. What's more, we think we know how to design and build a very economical turbine pump without sacrificing quality or performance.

We ought to. We've been at it more than 50 years.

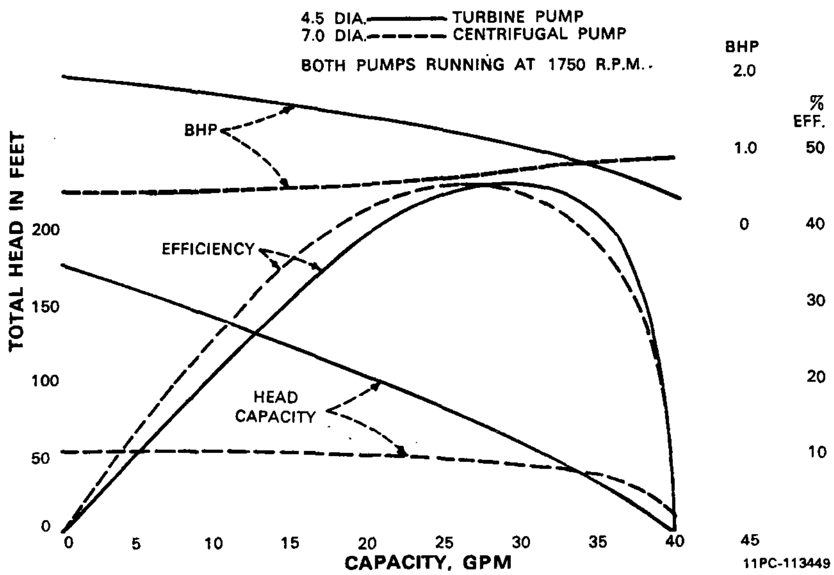


Fig. 1

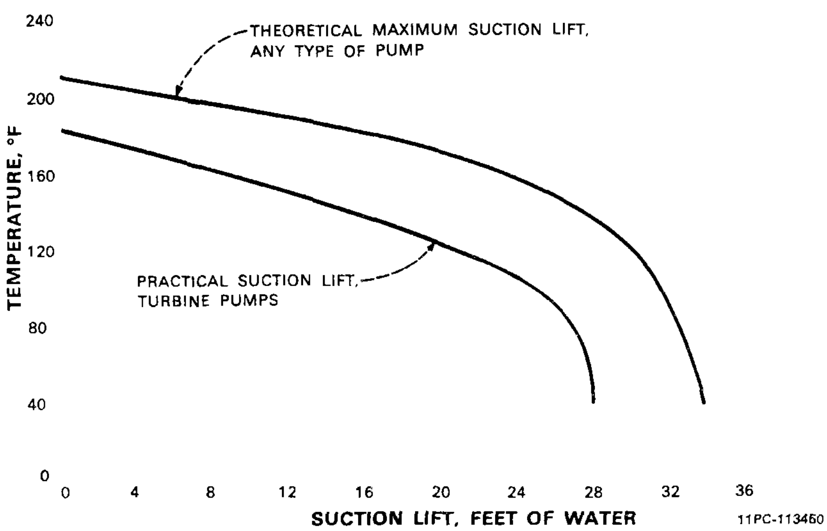


Fig. 2

TURBINE PUMPS ARE UNIQUE PERFORMERS

Turbine pumps derive their name from the many buckets machined into the periphery of the rotating impeller. They have long since been recognized for their effectiveness in the areas of low flow, high head application. The turbine pump offers higher heads than centrifugal pumps.

Because the head capacity curve is steep in a turbine pump, a greater degree of flexibility is available to the engineer.

Turbine pumps having top center line discharge are self-venting and have the ability to handle vapors without vapor lock. This characteristic allows handling of boiling liquids and liquified gases at suction heads slightly over the vapor pressure. The turbine pump also has higher efficiencies at low flows than a centrifugal pump.

Turbine pumps utilize close running clearances and are normally utilized on clean liquid applications. Viscous materials up to 500 S.S.U. can be pumped.

Turbine pumps are unique in operation. The pumped liquid is directed by the liquid passage so that the liquid circulates in and out of the impeller buckets many times on its way from the pump inlet to the pump outlet. Both centrifugal and shearing action combine to impart additional energy to the liquid each time it passes through the buckets.

Heads over 900 feet are successfully developed in a single stage.

The impeller runs at very close axial clearances with the pump channel rings to minimize recirculation losses. The channel rings provide a circular channel around the blade area of the impeller, from the inlet to the outlet.

Liquid entering the channel from the inlet is picked up immediately by the buckets on both sides of the impeller and pumped through the channel (Figure 3) by a shearing action. The flow of the liquid within the impeller buckets is illustrated in Figure 4. This process is repeated over and over, each cycle imparting more energy until the liquid is discharged. This flow is smooth and continous.

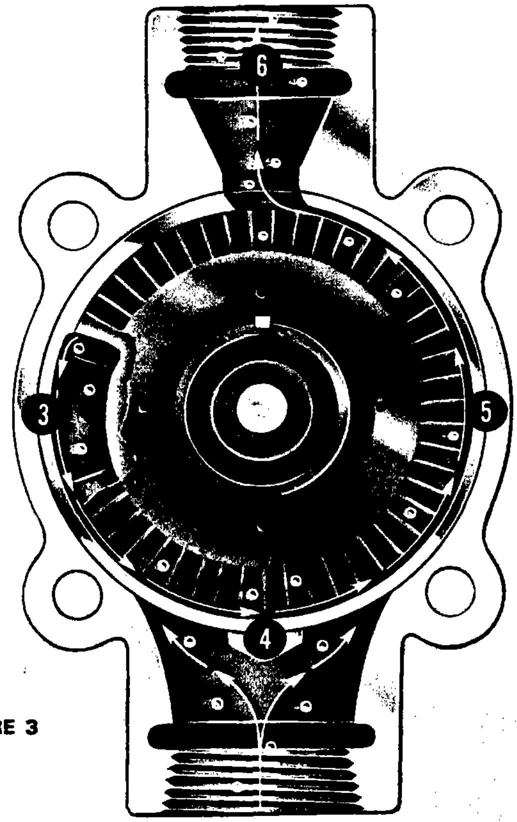


FIGURE 3

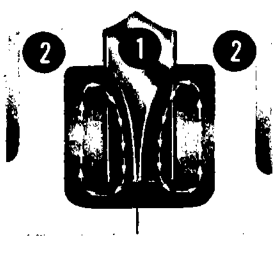


FIGURE 4

1 TURBINE IMPELLER

2 CHANNEL RINGS

3 25% OF DISCHARGE PRESSURE

4 50% OF DISCHARGE PRESSURE

5 75% OF DISCHARGE PRESSURE

6 100% OF DISCHARGE PRESSURE

Determine the pump capacity and discharge head. Find the nearest charted head under the Total Dynamic Head listing, select the desired motor speed, and read down to the next larger capacity closest to the calculated requirement. The figures and numbers identify the size of the pump and the motor horsepower.

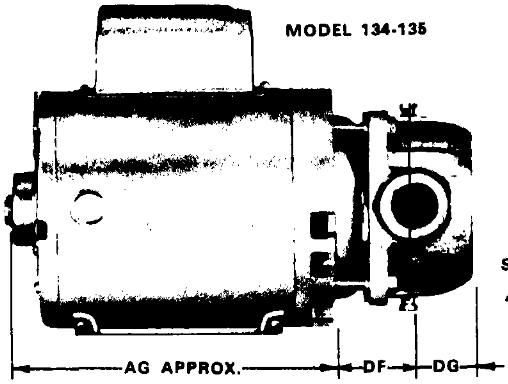
Horsepowers shown may not be non-overloading. Check performance curve for actual B.H.P.

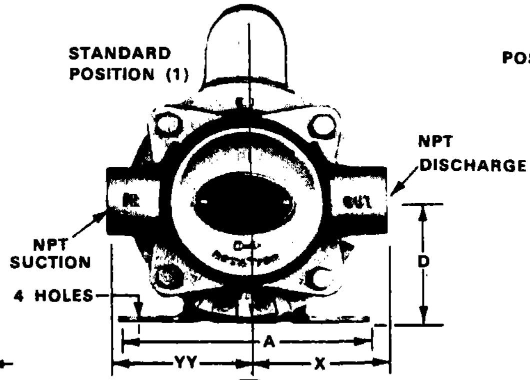
Selections are based on cold water with specific gravity of 1.0 . . . for final selection refer to performance curves.

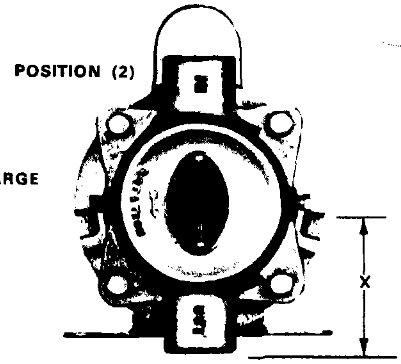
If fluctuation or increase in head is anticipated, the specific pump performance curve should be checked for final selection.

TOTAL DYNAMIC HEAD IN FEET

PUMP SIZE	R.P.M.		10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	450	500	550	600	650
D03	3500	GPM	7.2	6.9	6.6	6.3	5.9	5.6	5.2	4.7	4.3	3.9	2.3	1.0									
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	½	¾									
E03	3500	GPM	10.8	10.1	9.7	9.2	8.8	8.4	8.0	7.6	7.2	6.9	5.2	3.7	2.1								
		HP	⅓	⅓	⅓	⅓	⅓	½	½	½	½	½	¾	1	1								
F03	3500	GPM	12.0	11.5	11.0	10.4	9.9	9.5	9.1	8.6	8.3	7.9	6.1	4.4	2.7								
		HP	⅓	⅓	⅓	⅓	½	½	½	½	¾	¾	¾	1	1½								
G03	3500	GPM	15.8	15.3	14.7	14.2	13.7	13.2	12.7	12.2	11.7	11.3	9.1	6.9	4.5	2.0							
		HP	½	½	½	½	¾	¾	¾	¾	¾	1	1	1½	2	2							
A04	1750	GPM	2.9	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.1											
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓											
	3500	GPM	5.8	5.6	5.5	5.2	5.1	4.9	4.8	4.6	4.5	4.3	3.7	3.1	2.6	2.0	1.6	1.1					
		HP	½	½	½	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1½	1½	1½					
B04	1750	GPM	3.8	3.5	3.2	2.8	2.5	2.2	1.8	1.5	1.1	0.7											
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓											
	3500	GPM	8.5	8.2	7.8	7.6	7.3	7.0	6.8	6.6	6.3	6.1	5.1	4.2	3.3	2.4	1.4						
		HP	⅓	⅓	⅓	⅓	⅓	⅓	½	½	½	½	¾	¾	1	1	1½						
C04	1750	GPM	5.0	4.4	3.9	3.6	3.2	2.9	2.6	2.3	2.0	1.7											
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓											
	3500	GPM	10.6	10.2	9.9	9.6	9.4	9.1	8.8	8.5	8.3	8.1	6.9	5.8	4.8	3.8	2.8	1.9					
		HP	⅓	⅓	½	½	½	½	½	½	½	½	¾	¾	1	1	1½	1½					
D04	1750	GPM	6.6	6.2	5.7	5.2	4.7	4.2	3.6	3.0	2.4	1.8											
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓											
	3500	GPM	12.3	12.2	12.1	12.0	11.9	11.8	11.7	11.6	11.5	11.3	10.4	9.0	7.1	5.5	4.0	2.6					
		HP	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1½	1½	2	2					
F05	1750	GPM	8.2	7.6	7.1	6.6	6.3	6.0	5.6	5.4	5.1	4.8	3.4	2.0									
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	⅓	½	½	½	¾									
	3500	GPM	16.5	16.3	16.0	15.7	15.5	15.3	15.0	14.7	14.4	14.2	13.0	11.9	10.8	9.8	9.0	8.0	7.1	6.3	5.5	4.6	3.8
		HP	¾	¾	¾	¾	¾	1	1	1	1	1	1½	1½	2	2	3	3	3	3	5	5	5
G05	1750	GPM	12.3	10.7	9.9	9.2	8.4	7.8	7.2	6.6	6.0	5.4	2.6										
		HP	⅓	⅓	⅓	⅓	⅓	⅓	⅓	½	½	½	¾										
	3500	GPM	24.9	24.6	24.1	23.8	23.6	23.0	22.7	22.3	22.0	21.5	20.0	18.2	16.6	15.0	13.5	12.0	10.5	9.0	7.7	6.4	5.1
		HP	2	2	2	2	2	2	2	2	3	3	3	3	5	5	5	5	5	5	7½	10	10
H05	1750	GPM	14.0	13.1	12.4	11.8	11.2	10.7	10.2	9.7	9.2	8.8	6.7	4.7	3.0								
		HP	⅓	⅓	⅓	⅓	½	½	½	¾	¾	¾	1	1	1½								
	3500	GPM	25.0	24.9	24.7	24.5	24.4	24.2	24.1	24.0	23.8	23.7	22.8	21.7	20.5	19.2	17.8	16.0	14.4	12.9	11.3	10.0	8.5
		HP	1½	1½	1½	1½	1½	1½	1½	1½	2	2	2	3	3	5	5	5	5	7½	10	10	10
I05	1750	GPM	18.0	17.2	16.5	15.6	15.0	14.2	13.5	12.8	12.2	11.5	8.5	5.7	3.0								
		HP	⅓	⅓	½	½	½	¾	¾	¾	¾	¾	1	1½	2								
	3500	GPM	31.3	31.2	31.1	31.1	31.0	30.9	30.8	30.7	30.6	30.5	29.8	28.5	26.8	25.0	23.2	21.5	19.8	18.1	16.5	14.9	13.2
		HP	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	7½	10	10	10	10	10
J05	1750	GPM	24.4	23.7	22.6	21.5	20.3	19.2	18.1	17.0	15.6	14.5	8.4	2.2									
		HP	½	½	½	½	¾	¾	¾	¾	¾	1	1½	1½									
	3500	GPM	38.4	38.3	38.2	38.1	38.1	38.0	38.0	37.9	37.8	37.8	37.2	36.5	35.0	32.8	30.3	27.5	24.5	21.3	18.0	14.5	11.0
		HP	3	3	3	3	3	3	3	3	5	5	5	5	5	7½	7½	10	10	10	10	10	15
K05	1750	GPM	30.1	29.0	28.0	26.9	25.8	24.6	23.5	22.2	21.0	19.8	12.7	5.0									
		HP	⅓	⅓	½	½	¾	¾	¾	1	1	1	1½	2									
	3500	GPM	43.7	43.6	43.6	43.5	43.5	43.4	43.4	43.3	43.3	43.2	42.9	42.3	41.7	40.9	39.0	36.0	32.7	29.1	25.7	22.0	18.0
		HP	7½	7½	7½	7½	7½	7½	7½	7½	7½	7½	7½	7½	7½	7½	10	10	10	10	15	15	15



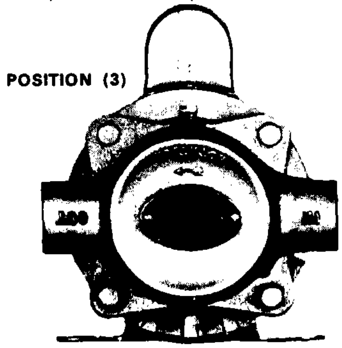


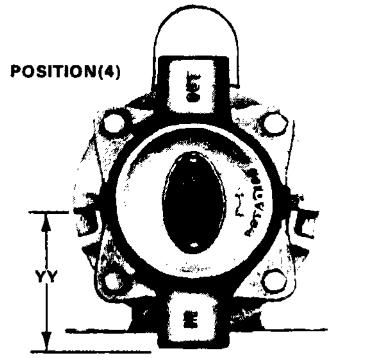


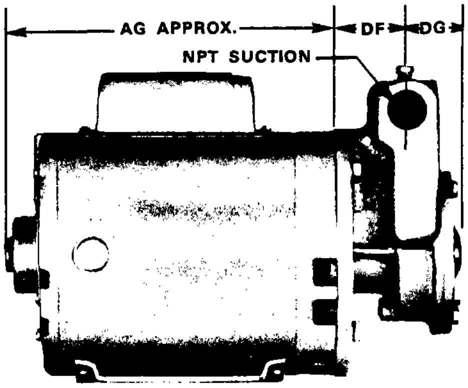
NOTES

1. Dimensions and weights are approximate.
2. All dimensions are in inches and may vary ±⅛".
3. Frame sizes, "AG" dimension and motor weight are for open drip proof motors only.
4. Conduit box is shown in approximate position. Dimensions are not specified as they vary with each motor manufacturer.
5. Add pump and motor weight for unit weight.
6. Not for construction purposes unless certified.
7. Aurora Pump reserves the right to make revisions to its products and their specifications, and to this bulletin and related information, without notice.

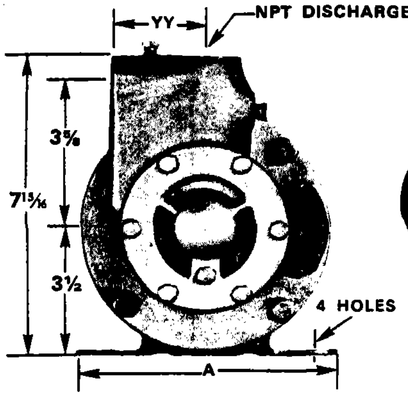
*Single phase only. **Three phase only.

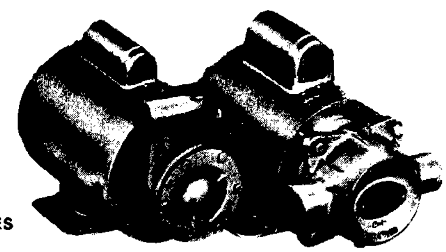






MODEL 133





MODEL 133 MODEL 134-135

Frame	Horsepower 3500 RPM	Horsepower 1750 RPM	Motor Weight (Lbs.)	A	D	AG	Model
56	⅓	⅓	29	[illegible]	[illegible]	[illegible]	133 134 135
	½	½	46				
	¾	¾	56				
	1	1	56				
	1½	1½**	65				
	2	—	80				
145T	—	1½*	42	7	[illegible]	[illegible]	134 135
	3**	2**	48				
182T	3*	2*	65	9	[illegible]	[illegible]	
	5**	3**	69				
184T	7½**	3*	79	9	[illegible]	12	
	—	5**	83				
213T	10	—	105	10½	5¼	14	135
215T	15	—	125	10½	5¼	15	
254T	20	—	200	12½	6¼	17	

Model	133	134	135
Suction	[illegible]	1	2
Disch.	[illegible]	1	1½
DF	[illegible]	2	2¼
DG	1½	[illegible]	2¼
X	NA	3¾	4½
YY	2½	3¾	4½
Pump Wt. (Lbs.)	13	16	30

The Vendor shall furnish an Aurora 130 Series Close-Coupled Turbine Type Pump size . . . . . (bronze fitted) (all iron) (all bronze) when operating against a total discharge head of construction. Each pump shall have a capacity of . . . . G.P.M. at . . . . . feet. Suction pressure will be . . . . feet. Pumping temperature is . . . . . ° F. Specific gravity is . . . . The fluid to be pumped is (describe). . . . . Pump is to be furnished with mechanical seal, replaceable channel rings with in-line suction and discharge openings in casing. The pump shall be close-coupled to a . . . . H.P., ... phase, ... cycle, ... voltage, ... R.P.M. (drip proof) (totally enclosed) (explosion proof) motor for (continuous) (intermittent) operation in a . . . . ° F. maximum and . . . . ° F. minimum atmosphere. Installed per Hydraulic Institute standards.

LIMITATIONS

Pump Series	Pump Size	Max. Suct. Pressure P.S.I.	Max. Diff. Pressure P.S.I.	Max. Casing Pressure P.S.I.	Max. Temp. °F.	Min. Suct. Pressure Vac. in Hg	Motor Frame
133	D03 thru G03	100	150	175	225	26	
134	A04 B04 C04 D04	100	225 225 190 180	300	225	26	56 145T 182T 184T
135	F05 G05 H05 I05 J05 K05	100	280 250 220 175 150 130	300	225	26	
135	F05 thru K05	100	300	300	225	26	213T 215T 254T

MATERIALS OF CONSTRUCTION

PUMP PART	BRONZE FITTED	ALL IRON	ALL BRONZE
CASING	CAST IRON ASTM A48-64	CAST IRON ASTM A48-64	BRONZE ASTM B62-63
COVER (153)	CAST IRON ASTM A48-64	CAST IRON ASTM A48-64	BRONZE ASTM B62-63
IMPELLER	BRONZE ASTM B62-63	DUCTILE IRON ASTM A395-61	BRONZE ASTM B62-63
IMPELLER SLEEVE	BRONZE ASTM B62-63	STAIN. STEEL AISI 316	BRONZE ASTM B62-63
INNER RING	CAST IRON ASTM A48-64	CAST IRON ASTM A48-64	BRONZE ASTM B62-63
OUTER RING (154-155)	CAST IRON ASTM A48-64	CAST IRON ASTM A48-64	BRONZE ASTM B62-63
MECHANICAL SEAL	316 stainless steel metal parts, "Buna-N" elastomer parts, Ni-resist seat and carbon washer.		

NOTES

1 Maximum differential pressure based on allowable shaft deflection for standard shafts.

2 Maximum casing pressure based on laboratory tests at twice the pressure shown.

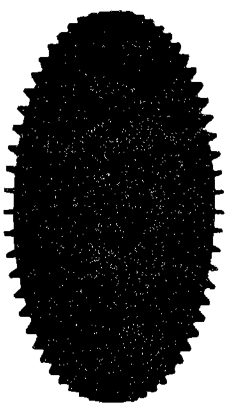
3 All pressure limitations on this chart are based on standard pumps constructed of standard materials and handling water at normal temperatures.

4 For temperatures below −32° F., consult factory.

5 Maximum suction pressure based on limitations of mechanical seal furnished as standard.

6 Pumps should not be used when any one of the above limitations is exceeded.

MODEL 133-134-135 IMPELLER



A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD • NORTH AURORA, ILLINOIS • 60542
SALES OFFICES IN ALL MAJOR CITIES AND COUNTRIES
Refer to "Pumps" in the yellow pages of your phone directory
MANUFACTURING FACILITIES LOCATED IN: NORTH AURORA, ILLINOIS • CITY OF INDUSTRY (GREATER LOS ANGELES), CALIFORNIA • REXDALE (TORONTO), ONTARIO
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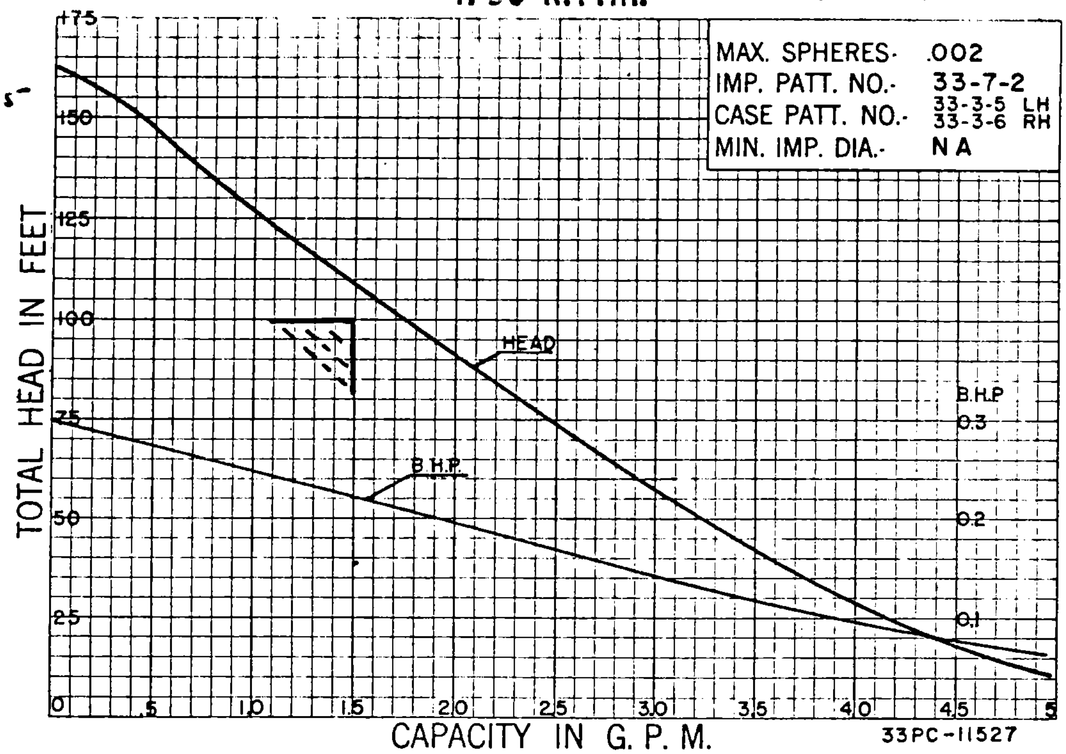
1750 R.P.M.

P-308



AURORA PUMP
A UNIT OF GENERAL SIGNAL CORPORATION
AURORA · ILLINOIS

CURVES

1.2.6 Raw/Service Water Pumps

1.2.6.1 Identification

Tag Number	Description
P-703	Raw/service water pump
P-704	Raw/service water pump

1.2.6.2 Description

1.2.6.2.1 Raw/service water pump P-703

Manufacturer: Goulds Pumps, Inc.
Seneca Falls, N.Y. 13148

Part Number:

1.2.6.2.2 Raw/service water pump P-704

Manufacturer: Goulds Pumps, Inc.
Seneca, N.Y. 13148

Part Number:

1.2.6.2.3 Vendor

Goulds Pumps, Inc.

1.2.6.2.4 Specification

DOE Drawing spec no. 40M7006S

1.2.6.2.5 Piping Connections

DOE Drawing no. 40P7005133155, CP 9

1.2.6.2.6 Operation/Maintenance

See following Goulds Pumps Installation, Operation and Maintenance Instructions

GOULDS PUMPS

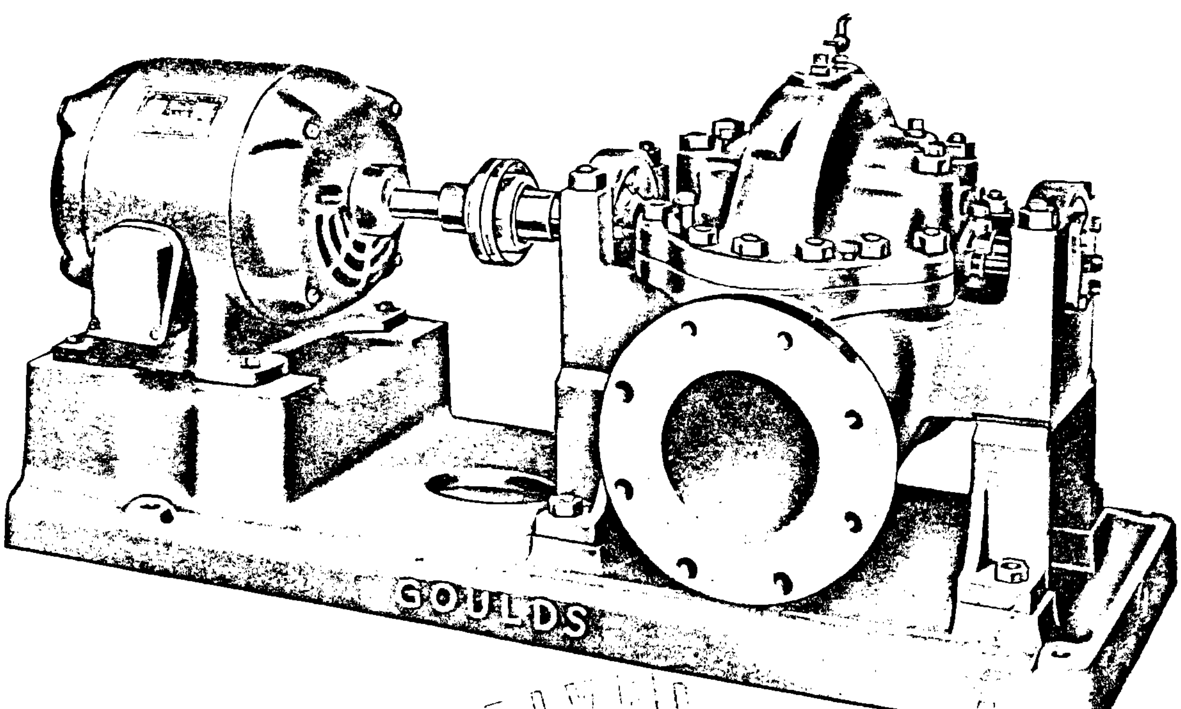
NC by S-R Denver 6/9/81

S-R Dr-# CP-9-#328

Raw/Service Water P-703 & 704

Installation, Operation and Maintenance Instructions

DOUBLE SUCTION CENTRIFUGAL PUMPS



MODELS 3405, 3406, 3416

FOREWORD

The design, material and workmanship incorporated in the construction of Goulds Model 3405, 3406 and 3416 Double Suction Centrifugal Pumps makes them capable of giving long, trouble-free service. The life and satisfactory service of any mechanical unit, however, is enhanced and extended by correct application, proper installation, periodic inspection and maintenance. This instruction book was prepared so operators will understand the construction and the correct methods for installing, operating and maintaining these pumps.

Read thoroughly Sections I, II, III and IV and be sure to follow the instructions for installation and operation. Sections V and VI are answers to trouble and maintenance questions. Keep this instruction book handy for reference. Kindly direct any questions or suggestions to the attention of the Engineering Application Div., Goulds Pumps, Inc., Seneca Falls, New York.

Remember . . . the experience and recommendation of a Goulds representative are always available on any pump application problem.

TABLE OF CONTENTS

SECTION I — INSTALLATION

I—A. LOCATION.

Pumping unit should be placed as close as practical to the source of supply. Always allow sufficient head room to remove the upper half casing of the pump and the rotating element. Floor space allotted to the pumping unit should be sufficient for inspection and maintenance.

I—B. FOUNDATION.

1. The foundation should be substantial in order to absorb any vibration and to form a permanent rigid support for the bedplate. A concrete foundation poured on a solid footing, using a one-three-five mix, of a liberal thickness to support the pumping unit is satisfactory.
2. Foundation Bolts:
   (a) The location and size of the foundation bolts is shown on the outline assembly drawing supplied for the pumping unit.
   (b) Each bolt should be installed with a pipe sleeve around it — to allow for adjustment. The inside sleeve diameter should be 2½ to 3 times the diameter of the bolt. Place a washer between bolt head and sleeve to hold bolt in position. Stuff waste around foundation bolts to prevent concrete from entering between the bolt and pipe sleeve. See Fig. 1.
   (c) The foundation bolts should be of sufficient length so that they project through the nut approximately ¼" after allowance has been made for grouting (¾" to 1½"), the thickness of the bedplate, and the thickness of the foundation bolt nut. See Fig. 1.

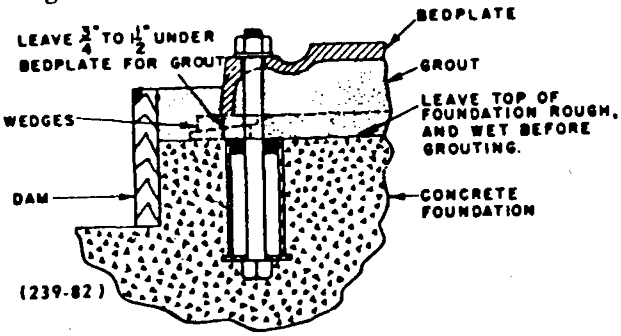


Fig. 1

3. Preparing Foundation for Mounting:
   Prior to setting unit upon the foundation, clean the top surface of concrete.
4. Mounting Unit on Foundation:
   (a) Put the pumping unit in place on the wedges furnished. The wedges should be placed at four points, two below the approximate center of the pump and two below the approximate center of the driver. (See Fig. 2). Some installations may require additional wedges near the middle of the bedplate.
   (b) Be sure that coupling is disconnected between pump and driver.
   (c) By adjustment of the wedges, bring the unit to an approximate level and provide for the proper distance above the foundation for grouting (¾" to 1½"). Plumb the suction and discharge flanges. By further adjustment of the wedges, bring the coupling halves into reasonable alignment. Check by method described in Section I—C 4-6.
   (d) After the wedges have been adjusted, tighten foundation bolts evenly but only finger tight.
   NOTE: Final tightening of foundation bolts is done after grout has set 48 hours.

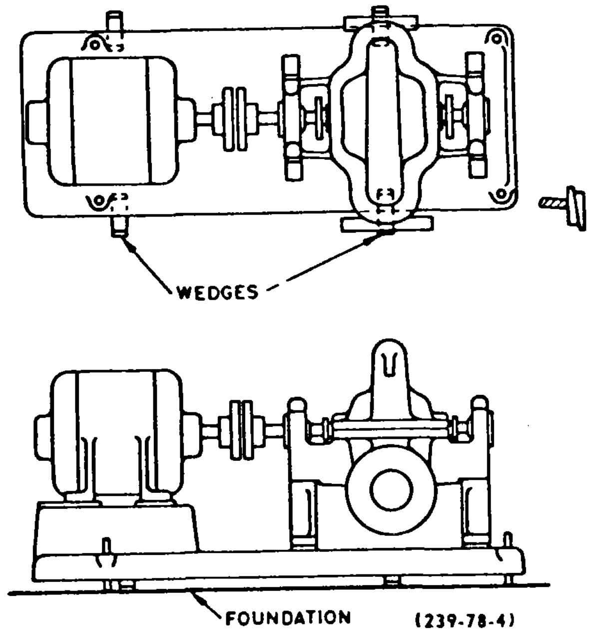


Fig. 2

5. Grouting Unit on Foundation:
   (a) Build wood dam around foundation as shown in Fig. 1. Wet top surface of concrete foundation thoroughly.
   (b) Pour grout in hole provided in the top of the bedplate. Use of a non-shrink grout is recommended. The grout should be thin enough to flow out under the bedplate. A mixture of one part Portland cement to three parts sharp sand may also be used. Cement grout should not be so thin that the cement will separate from the sand.
   (c) The grout should be puddled continuously as it is poured to expel the air and completely fill the space under the bedplate, to the level of the grout hole in the top of the bedplate.
   (d) With a trowel, strike along the top of the wood dam to give a neat, finished appearance at this point.
   (e) Allow grout to harden at least 48 hours.

I—C. ALIGNMENT—INITIAL.

Alignment of the pump and driver through the flexible coupling is of extreme importance for trouble-free mechanical operation.

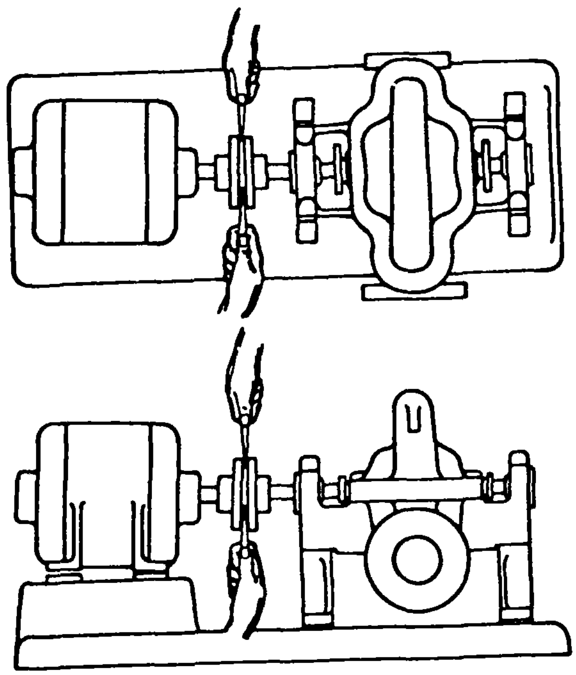
If the driver was mounted at the factory, the unit was in alignment before it left our assembly department. However, in transit and subsequent handling, this factory alignment was probably destroyed; and, it is now necessary to reestablish the alignment. As directed in Section I—B 4 (c) only *approximate* alignment was obtained by wedging under bedplate before grouting.

The following are suggested steps to establish the initial alignment of the pumping unit:

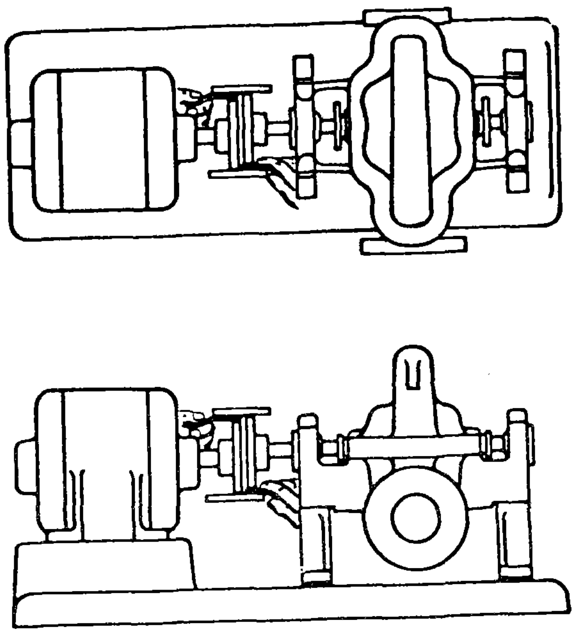
(NOTE THAT THIS IS AN INITIAL ALIGNMENT. THE FINAL ALIGNMENT IS DONE AFTER THE UNIT HAS BEEN RUN UNDER ACTUAL OPERATING CONDITIONS. THE FINAL ALIGNMENT PROCEDURE IS OUTLINED IN SECTION III-D AND MUST BE FOLLOWED).

1. Be sure coupling halves are disconnected as instructed in Section I—B (b).
2. Tighten foundation bolts.
3. Tighten pump and driver hold-down bolts.
4. Any coupling manufacturer's instruction sheets sent with the pump should be studied and used when installing, aligning, or servicing coupling. Align coupling, following manufacturer's instructions. If instructions are not available, the following procedure (steps 5 and 6) may be used.
5. Check angular misalignment — shaft axes concentric but not parallel — by inserting a taper gauge or feeler at four points on the circumference of coupling halves at 90° intervals. See Fig. 3. The unit will be in angular alignment when the measurements show the coupling faces are the same distance apart at all points. The "gap" between the coupling halves should be checked at this time. This depends on the type of coupling used and this information will be found in the instructions for the specific make of coupling furnished. It is normally 1/8-1/4" for most applications. Adjust angular alignment and "gap" by loosening the driver hold-down bolts and shifting or shimming driver as required. Tighten driver hold-down bolts after angular alignment and correct "gap" are secured.

   NOTE — Pumps and drivers are bedplated so that when coupling faces are positioned in accordance with the manufacturer's recommended gap, there is an overhang of approximately 1/8" from shaft ends to coupling hub faces.
6. Check parallel misalignment — shaft axes parallel but not concentric — by laying straight edge across both coupling rims at top, bottom and both sides. See Fig. 4.



(239-81-6) Fig. 3



(239-81-7) Fig. 4

The unit will be in horizontal parallel alignment when the straight edge rests evenly on both halves of the coupling at each side.

In order to secure vertical parallel alignment under actual operating conditions, the driver shaft must be set higher or lower than the pump shaft to compensate for vertical expansion. A suggested approximate cold setting for motor driven pumps is outlined below:

(a) When pumping cold liquids, set the motor shaft .006" below the pump shaft.

(b) When pumping hot liquids (200° F and over) set the motor and pump shafts at the same height. Thin shim stock should be used under the driver feet to establish parallel alignment. (In some instances, shims may be required under the pump feet).

7. Bear in mind always that alignment in one direction may alter the alignment in another. Check through each alignment procedure after making any alignment alteration.

I—D. PIPING—GENERAL.

1. All piping must be supported independently of the pump. The piping should always "line-up" naturally with the pump flanges. NEVER DRAW THE PIPING INTO PLACE BY USE OF FORCE AT THE FLANGED SUCTION AND DISCHARGE CONNECTIONS OF THE PUMP!
2. The piping, both suction and discharge, should be as short and direct as possible. Avoid all unnecessary elbows, bends and fittings, as they increase the friction losses in the piping. The size of pipe and fittings should be carefully selected and of sufficient size to keep the friction losses as low as practical.
3. Piping must not be connected to the pump until the grout has thoroughly hardened and the foundation bolts as well as driver and pump hold-down bolts have been tightened. See Section I—G.
4. When handling liquids at elevated temperatures, arrangements must be made for expansion loops or expansion joints so that the linear expansion of the pipe will not cause the pumping unit to be drawn out of alignment.

I—E. PIPING—SUCTION.

1. General — Properly installed suction piping is of extreme importance for trouble-free centrifugal pump operation.
   (a) The suction pipe should be as large or larger than the pump suction.
   (b) Increasers, if used, should be eccentric and preferably at the pump suction flange, sloping side down.
   (c) A centrifugal pump should *never* be throttled on the suction side for capacity adjustment.
   (d) When more than one pump is operating from the same source of supply, separate suction lines, if possible, should be used. If not possible for separate lines, piping arrangement as shown in Fig. 7 is recommended.
2. Installations With Pump Above Source of Supply—Suction Lift:
   (a) Keep suction pipe free from air pockets. See Fig. 5.
      1. Piping should slope upwards from source of supply.
      2. No portion of piping should extend above the pump suction nozzle.

   (b) All joints must be air tight.
   (c) The suction pipe should always be submerged into the source of supply as shown in Fig. 6.
   (d) A foot valve should only be used if necessary for priming, or, if the pump is to be used on intermittent service and is required to hold its prime.
   (e) Suction strainers when used should have a net free area of at least three times the suction pipe area.
3. Installations With Pump Below Source of Supply—Suction Head or Flooded Suction:
   (a) A gate valve should be installed in the suction line to permit closing the line for pump inspection and maintenance.
   (b) Keep suction pipe free from air pockets.
      1. Piping should be level or slope gradually downward from the source of supply.

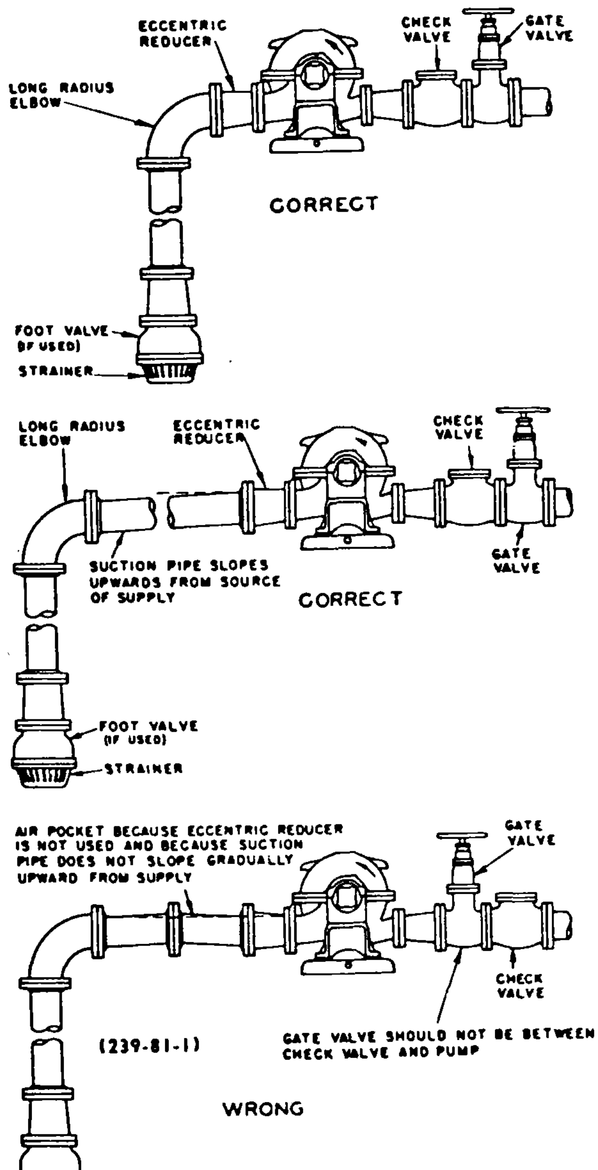


Fig. 5

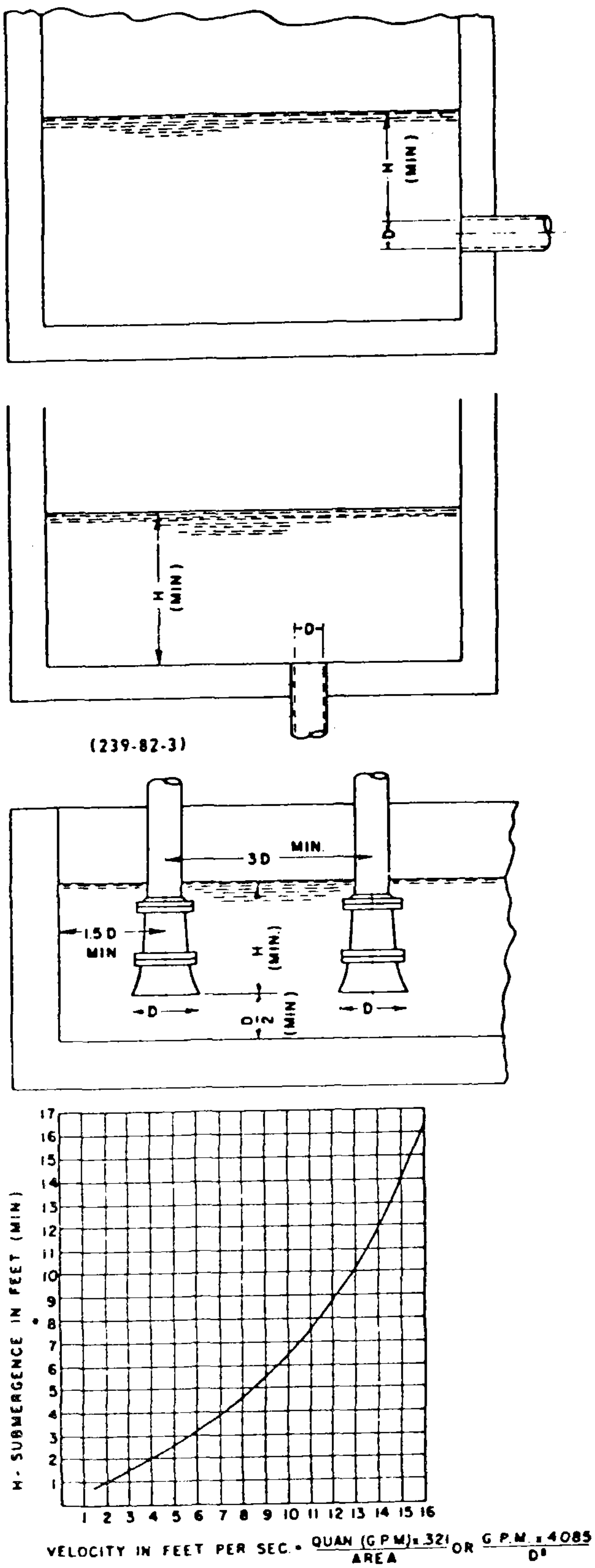


Fig. 6

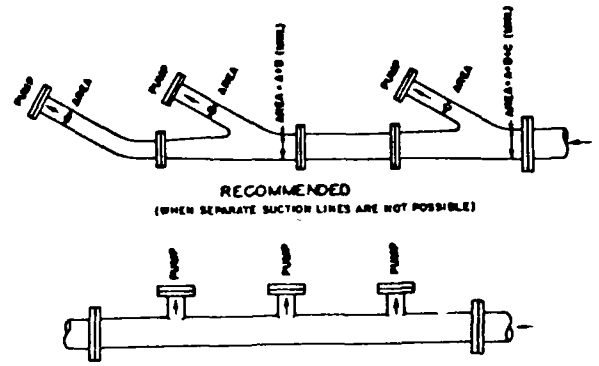


Fig. 7

2. No portion of the piping should extend below the pump suction flange.

(c) The size of entrance from the supply should be no smaller than the suction pipe.

(d) The suction pipe should be below the liquid surface at the source of supply as shown in Fig. 6.

I—F. PIPING—DISCHARGE.

1. A gate valve and a check valve should be installed in the discharge line. The check valve should be located between the gate valve and pump to permit inspection of the check valve. The gate valve is required for priming, regulation of flow capacity and for inspection and maintenance of the pump. See Fig. 5.
2. Increasers, if used in discharge line, should be placed between the check valve and the pump.

I—G. CONNECTION OF PIPING.

Connect suction and discharge piping. Rotate the pump shaft by hand several complete revolutions to be sure that there is no binding and that all parts are free. Recheck alignment as described in Section I—C. If the connection of the piping causes unit to be out of alignment, correct piping to relieve strain on the pump.

I—H. CHECK OF ROTATION.

The direction of rotation is marked on the pump casing. Make sure that driver rotates in the same direction. On electric motors, *jog* starting switch to be sure wiring is connected for correct rotation. Be sure that coupling is disconnected.

I—J. CONNECTION OF COUPLING.

Connect coupling, following instructions for the particular make of coupling furnished. This data is supplied separately, giving complete instructions for connection, lubrication, alignment and maintenance.

NOTE—Pumps and drivers are bedplated so that when coupling faces are positioned in accordance with the manufacturer's recommended gap, there is an overhang of approixmately 1/8″ from shaft ends to coupling hub faces.

SECTION II — PREPARATION FOR OPERATION

II—A. PUMP BEARINGS.

1. Model 3405 pump bearings are grease lubricated and sufficient lubricant is inserted at the factory for 2000 hours of operation.
2. Model 3406 pump bearings are ring oil lubricated, and are not lubricated before leaving the factory.
3. Model 3416 pump bearings are flood oil lubricated and are not lubricated before leaving the factory.

A high quality turbine type oil, with rust and oxidation inhibitors, should be used. For the great majority of operation conditions, oil temperature will run between 50 and 180° F. In this range an oil of 300 SSU viscosity at 100° F. (approximately SAE 20) should be used.

If oil temperature exceeds 180° F. (Models 3405 and 3406) or 250° F. (Model 3416) for extended periods of time, use of cooling water as outlined in Section II — E & B and/or use of a special high temperature oil should be considered. For extreme conditions, refer to factory or a lubrication expert for a recommendation.

The constant level oilers are found in the box of fittings which accompany the pump. Oiler manufacturer's instructions accompany the oiler. Oiler was adjusted to maintain proper oil level before leaving factory. If adjustment is lost, reset as directed in Figure 8.

On the Model 3406 install the constant level oilers in the bearing housing at each end of the pump. The oiler piping must rest on top of the cap screw which projects from the casing. This screw keeps the oiler piping level. (See Figure 9).

On the Model 3416 install the constant level oilers in the bearing end covers at each end of the pump, as shown in Figure 10. Do not install the oiler in the opening for the optional cooling coils, which are directly below the oiler.

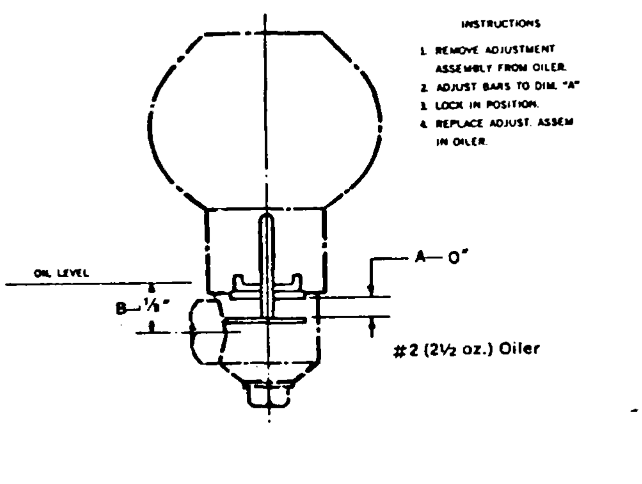


Fig. 8

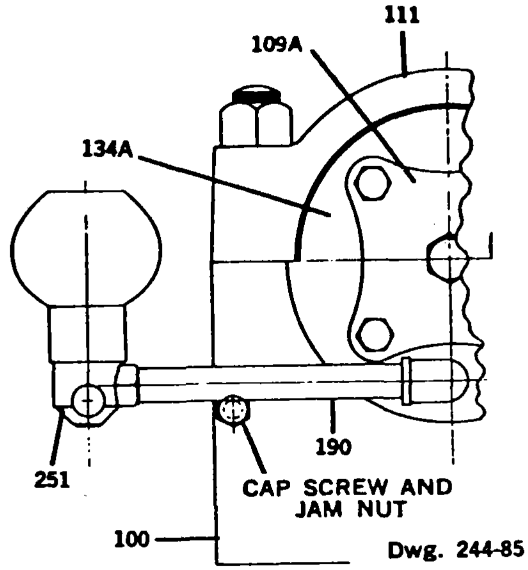


Fig. 9

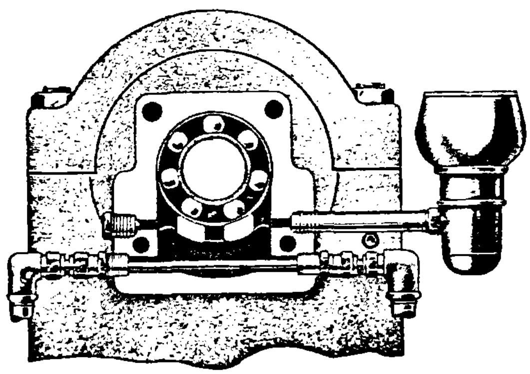


Fig. 10

II—B. DRIVER BEARINGS AND COUPLING.

Check to be sure the driver bearings and coupling are properly lubricated.

II—C. STUFFING BOXES

Pumps are furnished with packed type stuffing boxes as standard. However, mechanical seals, either of single or double type, can be furnished on order.

1. Stuffing Boxes with Packing Rings:

In the box of fittings accompanying the pump will be found the stuffing box packing. The standard packing is John Crane "Super Seal" No. 1 and is a general purpose plastic type packing composed of special long fibre pure asbestos, suitable antifriction metal particles, fine lubricating graphite, and binder. It contains no volatile oils. The packing is die-formed to facilitate installation. "Super Seal" No. 1 is recommended for water, ammonia, mild chemicals and all general services, and is good for the maximum temperatures for which the pumps are rated.

It is suggested that the packing rings be allowed to soak in #10 SAE oil for 15 minutes to one hour prior to installation.

When installing the packing and the Teflon lantern ring, twist the rings sideways just enough to get them around the shaft sleeves. DO NOT ATTEMPT TO PULL RINGS STRAIGHT OUT TO GET THEM OVER SHAFT AND SHAFT SLEEVE. (See Fig. 11.)

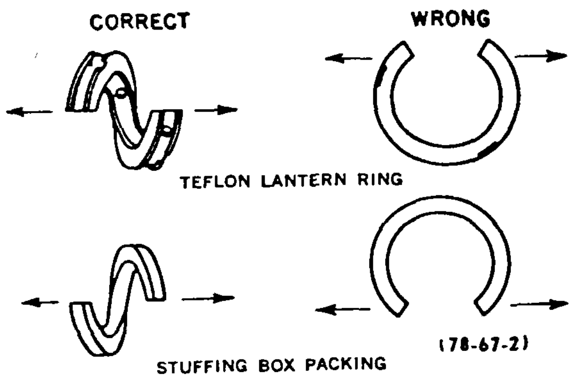


Fig. 11

Insert two rings of packing for Group "S" & "M" pumps and three rings for Group "L" pumps against the stuffing box bushings (125), staggering the joints. See Section Assembly, Section VI—C (page 16). The lantern ring (105) should then be inserted in the stuffing box. When it is in its proper position, it will be directly opposite the sealing inlet connection.

After the lantern ring is in place, insert three more rings of packing, staggering the joints. Two extra rings of packing are furnished in each set of packing. The extra ring for each side may be added as required.

Insert gland packing (210) into recess in each gland half and trim off excess flush with face of each gland half.

Now, insert lower half gland (107) into stuffing box. Run ½"—20 SAE nuts (355) about three-fourths the length of the threaded part of bolts (353) and place cupped washers (354) on gland bolts.

Insert round, flattened end of gland bolts into recesses of bearing housing (134 or 166) on Model 3405, or into recesses of bearing housing cover (160) on Model 3406. Threaded portion of gland bolts lays on gland half.

Insert upper half gland into stuffing box. Place cupped washers over the bosses on the gland to hold the gland halves together.

Draw the gland nuts up evenly but not tight.

2. Stuffing Boxes With Mechanical Seals:

When mechanical seals are furnished they are install- at the factory and no further adjustments are required.

When single mechanical seals are used, the water seal piping must be connected as explained in II—D.

When double mechanical seals are used, the water seal piping is omitted and the four holes in stuffing box and casing must be plugged. Cooling liquid from an outside source must be piped to the gland openings at a pressure slightly more than the suction pressure of the pump. The two gland openings are tapped for ⅛" pipe.

II—D. CONNECTION OF WATER SEAL PIPING.

Water seal piping is required only when pump is operating under suction lift or when single mechanical seal is used. It is not necessary when pump is operating under suction head or when double mechanical seal is furnished, in which cases the four openings in the stuffing box and casing must be plugged.

On all iron pumps or when the pump is handling hydro-carbons, solvents and similar liquids, a grease lubricator, using a non-solvent grease, should be fitted into the tapped opening in stuffing boxes (Fig. 12).

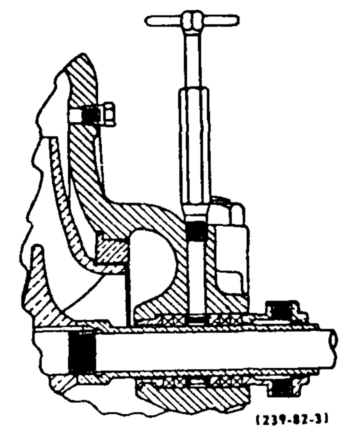


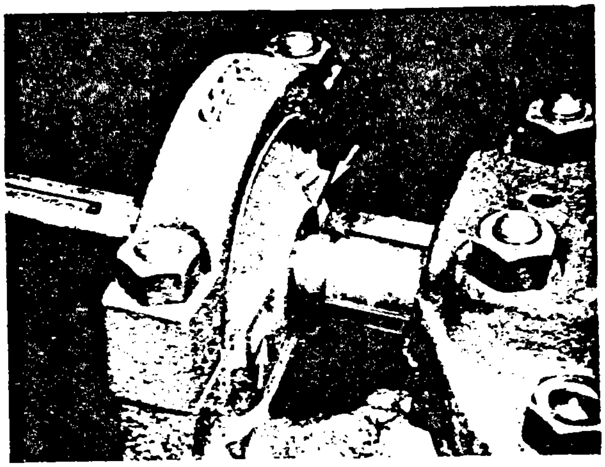
Fig. 12

If the liquid contains abrasives or paper stock particles (white water applications) or is gritty, omit the water seal piping and plug the tapped openings in the casing. Pipe a clean water supply with a shut-off valve to each of the openings at the top of stuffing boxes at a pressure slightly higher than the suction pressure on the pump.

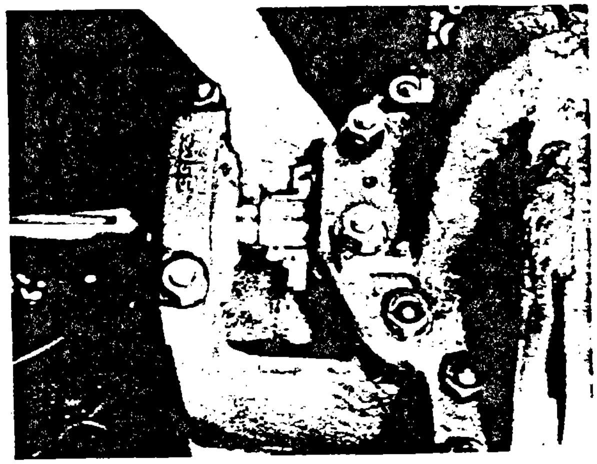
The water seal piping, when required, is shipped separately in the box of fittings accompanying the pump. When this piping is used, one end is attached to the tapped opening in the casing and the other end to the tapped opening on the top of the stuffing box with connectors furnished. See Sectional Assembly, Section VI—C.

II—E. CONNECTION OF PIPING TO QUENCHING GLAND.

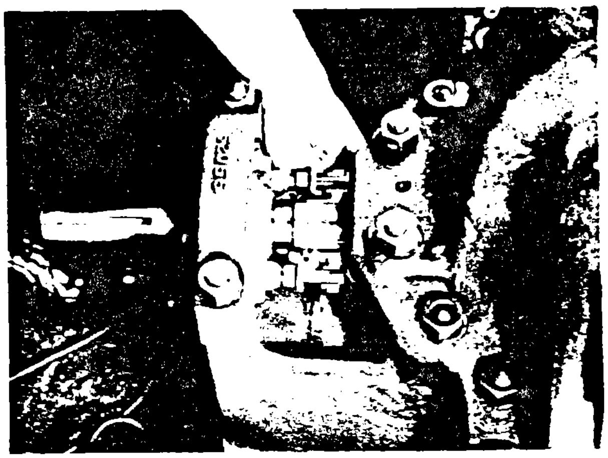
The stuffing box gland can be operated with or without quenching water. Quenching is recommended on applications where the liquid pumped is:



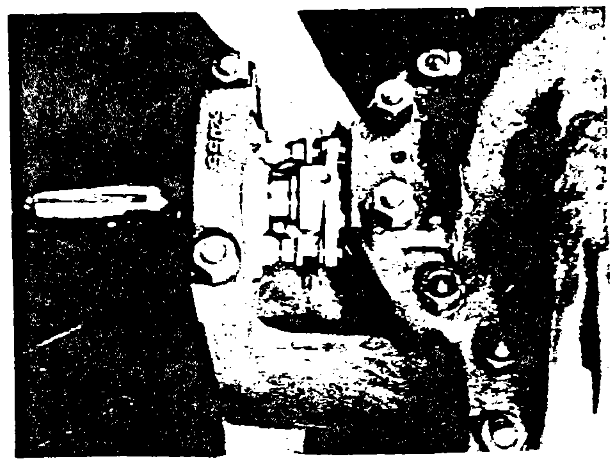
(a) Bearing Housing Showing Slots for Gland Bolt Heads.



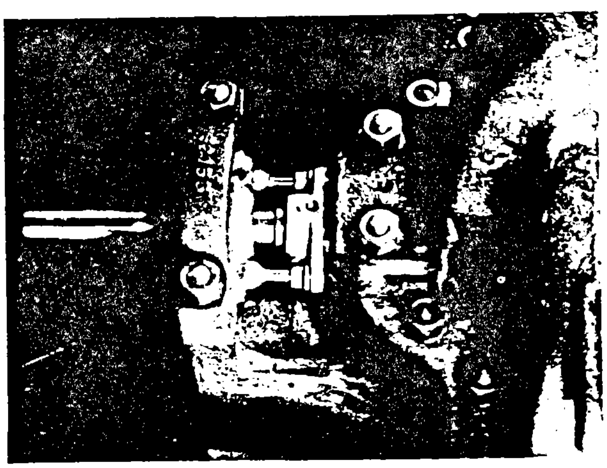
(b) First Half of Stuffing Box Gland Installed.



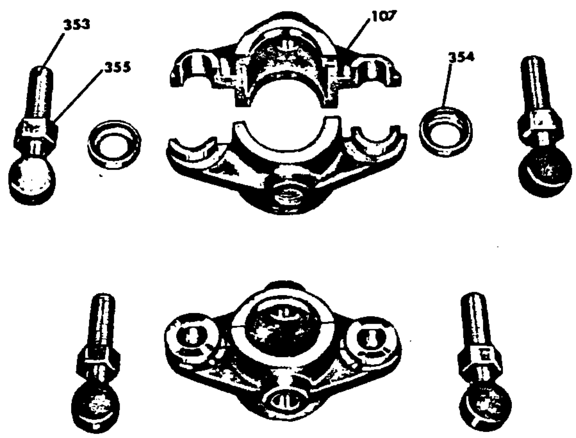
(c) Lay Gland Bolts on bottom half of Gland with bolt heads in bearing housing slots. Nuts and special cup washers should be all the way back on the bolts, toward the bolt heads as shown.



(d) Install top half of stuffing box gland over gland bolts and bottom half of gland.



(e) Slide cup washers over shoulders of gland flanges and tighten nuts evenly to provide proper pressure against stuffing box packing. Gland bolts do not screw into tapped holes in casing. Tapped holes in casing are for mechanical seal gland only when pumps are furnished with seals.



Stuffing Box Gland

1. Model 3405 — Between 180° F. and 250° F. when bearing housings are not cooled and between 250° F. and 350° F., in addition to bearing housing cooling.

2. Model 3406 — Between 180° and 250° F.

3. Model 3416 — Between 250° and 350° F. when bearing housings are not cooled and between 350° and 400° F., in addition to bearing housing cooling.

4. Volatile or toxic, in order to smother the gland leakage, which then can be piped away.

The quenching liquid must be from an outside source and should be piped with a flexible pipe, into the opening in the upper gland half and allowed to drain into chamber or pocket in lower half casing. When used for cooling, the flow should be regulated as shown in Section III—B. The openings in the gland halves should be installed in each quenching line.

II—F. CONNECTION OF BEARING COOLING WATER PIPING.

Water cooled bearing housings are furnished when ordered (Models 3405 and 3416 only). Bearing cooling should be used when the liquid pumped is:

1. Model 3405 between 180° and 250° F. when gland quenching is not used and between 250° and 350° F., in addition to gland quenching.

2. Model 3416 between 250° and 350° F. when gland quenching is not used and between 350° and 400° F., in addition to gland quenching.

On the Model 3405 — cooling water lines should be connected to the 3/8" pipe tap openings in the bearing housing, as shown in the sectional assembly, Section VI—C. The inlet line should be at the bottom, and should have a shut-off valve installed to regulate flow. See Section III—B for instructions for regulating cooling water flow.

On the Model 3416 — the cooling coils are installed as follows:

1. Refer to Figure 3, which shows the installed cooling coil.

2. Special fittings and tubing are in the box of fittings sent with the pump.

3. Remove four — 1/4" plugs from bearing end covers (109 and 119) — one plug from each side of each cover. The plugged openings are those below the openings for the constant level oilers.

4. Screw 1/4" pipe x 1/4" O.D. tube compression fittings into each of the four openings.

5. Push each 1/4" O.D. x 9" long copper tube through one fitting until it comes out the fitting on the other side. Center tubing so that equal lengths project from each side. Tighten nuts on compression fittings.

6. Connect the 1/4" pipe x 1/4" O.D. tubing elbow to each end of the copper tube. This provides a 1/4" pipe connection for cooling water piping.

7. Connect cooling water. The inlet line should have a shutoff valve to regulate flow.

II—G. CONNECTION OF DRAIN PIPING.

Connect overflow outlets from stuffing boxes (located in casing near pump feet) to drain, and connect overflow from bedplate (located at pump end of bedplate) to drain. All of the above overflow openings are tapped for 3/4" pipe.

SECTION III — STARTING PUMP

III—A. PRIMING.

The pump must always be fully primed and the suction pipe full of liquid before pump is started.

If pump is run dry, the rotating parts within the pump may seize to the stationary parts as they depend on the liquid being pumped for lubrication.

Several different methods of priming can be used, depending on the type of installation and service involved.

Note: If the pump is being used to pump potable or drinking water, the priming line should be protected against back-siphonage by the installation of a check valve and an approved type vacuum breaker.

1. Suction Supply Above Pump:

When pump is installed as shown in Fig. 13, pump will prime itself. Open gate valve on suction and close discharge gate valve. *Open air vent valves until all air is expelled and water flows through openings.* Close air vent valves, start pump, open discharge gate valve, and pump will continue to be primed for any future starting.

This method is the simplest and, particularly for automatic operation, the safest. A float switch in the suction reservoir can be arranged to stop pump, should there be failure of liquid supply.

2. Priming With Foot Valve:

With pump installed on suction lift, with foot valve at end of suction line, priming can be done any of the following three ways:

(a) *From Some Outside Supply* (*See Fig. 14*). Close discharge gate valve, open air vent valves and open valve in primary supply line until all air is expelled and water issues from vent openings. Close valve in priming supply line, close air vent valves and start pump; then open discharge gate valve.

(b) *By Separate Hand or Manually Controlled Priming Pump* (*See Fig. 15*). Close discharge gate valve (keep air vent valves closed) and open valve in line to priming pump. Exhaust air from pump and suction piping until water flows from priming pump. Close valve in priming

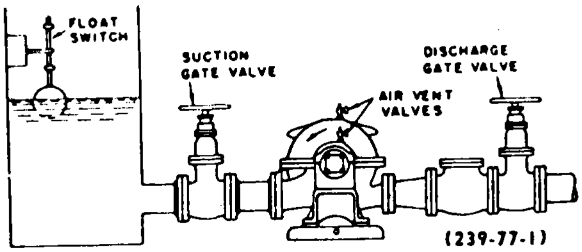


Fig. 13

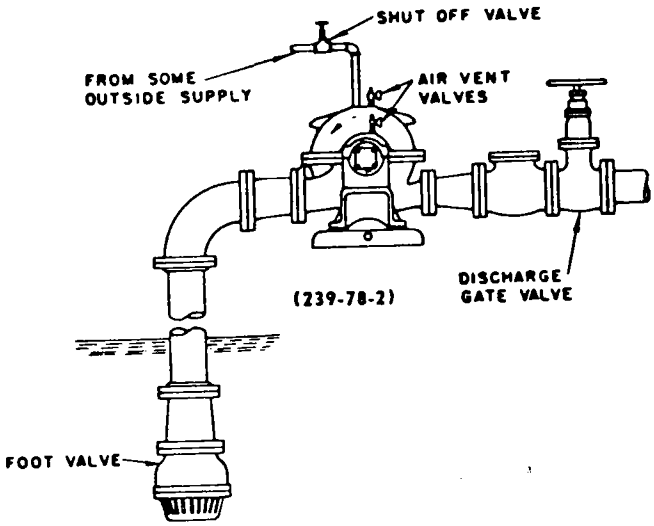


Fig. 14

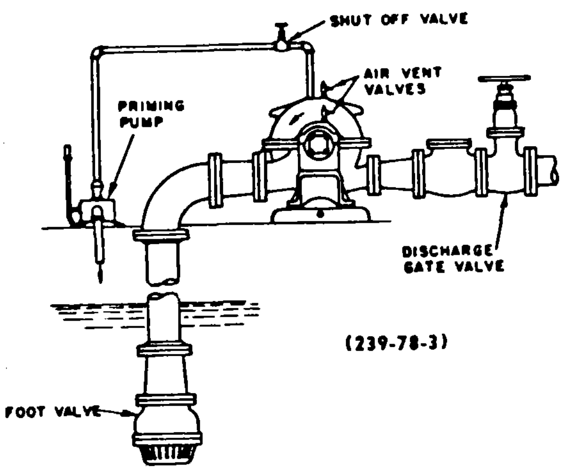


Fig. 15

line, start pump and open discharge gate valve. Or, by reversing connections on priming pump and extending priming pump suction to source of liquid supply, centrifugal pump may be primed by pumping liquid into casing until liquid comes out of the open air vent valves. As in Section III—A2 (a) (page 10). In either of these methods (a) and (b), the pump will remain primed, provided foot valve is tight. Any failure, however, of foot valve when pump is standing idle, will permit the pump to lose its prime. During long idle periods, the pump can also lose its prime through leakage from stuffing boxes.

(c) *Bypassing Around Discharge Check Valve (See Fig. 16).*

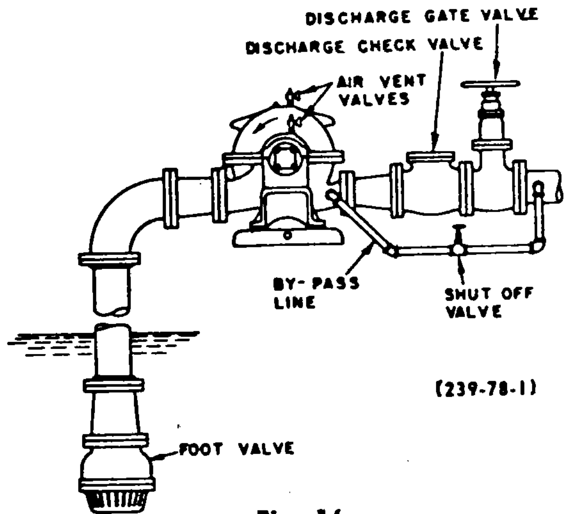


Fig. 16

This method can be used only when there is liquid under some pressure in the discharge line. The original prime must be effected from some outside source. After subsequent idle periods, open air vent valves and open valve in bypass line around discharge check and gate valves until liquid flows from air vent openings. Close air vent valves and bypass valve, start pump and open discharge gate valve.

The valve in bypass can be left open, in which event, during idle periods, loss through foot valve is constantly replenished from discharge line. This system is used for automatic operation where idle periods are of short duration and there is no danger of exhausting all liquid from discharge line, due to a leaky foot valve. If the valve in the bypass is left open, as described above, the foot valve must be capable of withstanding static head pressure of the system.

3. **Priming by Ejector (see Fig. 17):**

On suction lift installations, an ejector, operated by steam, compressed air, or water under pressure, and connected to tapped opening in top of casing can be used to remove air from casing and suction line, thus priming the pump.

Close discharge gate valve, open valve "E" in steam, air or water pressure supply line. Open valve "S" in suction pipe of ejector connected to pump casing. Air will be evacuated and liquid will be drawn up into suction

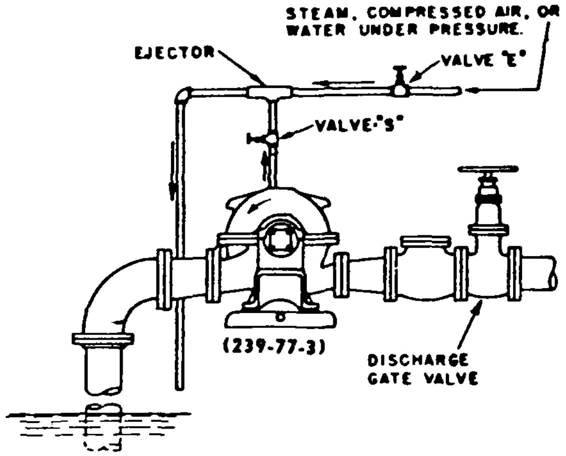


Fig. 17

pipe and pump casing. When all air is evacuated, start pump, close valve "S" and valve "E", and open discharge gate valve.

4. Priming by Automatic Primer Pump (see Fig. 18):

Where there is a fluctuating suction lift that occasionally might drop below the normal limits of the pump or for installations where there is any quantity of air entrained with the liquid being pumped, the system shown in Fig. 18 is very well adapted.

A vacuum tank and a vacuum gauge can be installed near the primer pump and the vacuum switch set to automatically start or stop the primer pump according to the vacuum required to keep the system primed.

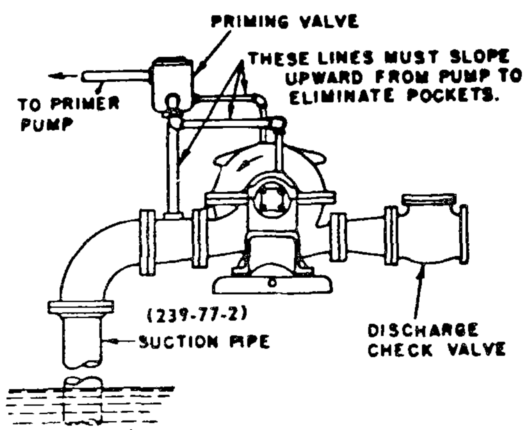


Fig. 18

III—B. REGULATION OF COOLING WATER FLOW.

The supply of liquid to the water-cooled bearings and quenching glands should be regulated by valves in the supply line. Approximately ½ G.P.M. to each gland and 1 G.P.M. to each bearing cooling coil is sufficient. The cooling lines should be checked periodically to see that they have not become clogged.

III—C. ADJUSTMENT OF STUFFING BOX GLAND.

With pump running at rated speed, stuffing box glands can be adjusted. Draw gland nuts up evenly and only one-sixth of a turn at a time, allowing sufficient time between adjustments for the packing to adjust itself and the effect on the leakage to be observed. If any sign of heating is evident, shut off the pump and allow the boxes to cool. Several starts may be necessary before the boxes run cool. Do not back off the gland nuts on a hot box as this will usually result in liquid leaking between the outer edge of the packing and the stuffing box bore. It must be borne in mind that it takes newly-installed packing some time to "run in" and that during this period, frequent attention and careful adjustments are necessary. See IV—A (page 13) for final adjustments of gland.

III—D. ALIGNMENT — FINAL.

Final alignment can only be accomplished after unit has been run under actual operating conditions for a sufficient length of time to bring the unit up to operating temperatures.

After this warm-up period has elapsed, stop the unit and immediately disconnect the coupling and check the alignment.

Follow the alignment procedure as outlined in I—C (page 4), with the exception of Paragraph I—C 5 (page 4), which allows for "growth" of the parts due to temperature difference between the driver and the pump. However, at the operating temperature, the unit will be in correct horizontal and vertical parallel alignment when a straight edge rests evenly on both halves of coupling rims at four points 90° apart.

As cautioned in I—C 6 (page 4), changing alignment in one direction may alter the alignment in another. Check thru each alignment procedure after making any alignment change.

III—E. DOWELING.

Doweling is not required in Group "S" and "M" pumps. On these pumps, patented lock washers are furnished which hold the pump and driver feet securely in place.

On Group "L" pumps, the pump and driver should be doweled after installation is complete and the unit is in correct final alignment. Four #6 taper dowel pins are included in the box of fittings accompanying the pump. These pins have a taper of ¼" to the foot. The diameter at large end is .341" (approximately 11/32") and the recommended drill size is 9/32".

Drill through two diagonally opposite feet of the pump and driver into the bedplate. Use a reamer with a taper of ¼" to the foot. Ream out the drilled holes so that dowels extend well into the bedplate but project above the pump and driver feet.

If the operator so desires, the same size pins and method of doweling can be used on Series "S" and "M" pumps in addition to the patented lock washers.

To determine the group of a particular size pump, see interchangeability list, Section VI—C (page 16).

SECTION IV — OPERATION

IV—A. STUFFING BOX.

1. Stuffing Boxes With Packing Rings — Less Quenching Gland and Grease Lubricator:

Periodically inspect stuffing box to see that there is sufficient leakage to lubricate the packing and maintain a cool box. Never draw up packing so that the stuffing box heats, as this will cause damage to both packing and sleeve. Always draw up gland nuts evenly and when pump is running.

After pump has been in operation for some time and the packing has been completely run in, at least 40 to 60 drops per minute of the liquid should be allowed to trickle from the stuffing box at all times for cooling and lubricating the packing and shaft sleeve.

2. Stuffing Boxes With Packing Rings — With Quenching Gland:

The same precautions as described above apply. However, the amount of leakage through the packing cannot be so readily ascertained, due to the quenching liquid. In most cases, the valve on the quenching liquid supply line can be shut off for a short period and the amount of leakage determined as in IV—A 1. In no instance should the gland be drawn up tight.

3. Stuffing Boxes With Packing Rings — With Grease Lubricator:

Operation is the same as directed in IV—A 1 with the addition that the handle on the lubricator should be given a turn or two about every 100 hours off operation.

4. Stuffing Boxes With Mechanical Seal:

This type of box requires no attention other than to make sure that the circulating lines do not become clogged.

IV—B. OPERATING AT REDUCED CAPACITIES.

Do not operate a centrifugal pump at greatly reduced capacities or with discharge gate valve closed, because the energy required to drive the pump is converted into heat. If this condition exists over a long period, the temperature of the liquid in the pump may increase until the boiling point is reached. If this occurs, the rotating parts are exposed to vapor with no lubrication and they may score or even seize to the stationary parts; and furthermore, if running clearances have enlarged due to wear, seizure may not take place. Continued operation under these conditions may create an explosive hazard due to the confined vapor under high pressure and temperature.

To guard against possible damage, protective devices are available, such as:

1. Liquid temperature relay or thermostat which will shut off the unit if the liquid temperature in the pump exceeds a predetermined maximum. This device guards against possible damage due to running the pump against a closed valve.

2. Constant open by-pass orifice between the pump discharge and any check or regulating valve in the discharge line. The liquid through the orifice is returned to the suction source. The amount of liquid by-passed is a function of input horsepower and the allowable temperature rise. This device also is insurance against damage due to running the pump against a closed discharge valve or very low flow conditions.

3. Bearing temperature relay which will shut the unit down if the bearing temperature exceeds a predetermined maximum.

4. Low suction pressure control which will shut off the unit should the suction pressure drop below a pre-established minimum.

A centrifugal pump should *never* be throttled for capacity adjustment on the suction side.

IV—C. OPERATING AT REDUCED HEAD.

On motor driven pumps, when discharge head or pressure is allowed to drop considerably below the rated point for any length of time, the motor should be watched for heating because the pump capacity increases rapidly with reduced head, as does horsepower consumption. If this condition is likely to persist, arrangements should be made either to manually or automatically throttle the discharge valve to build up head to a safe point.

IV—D. OPERATING WITH SURGE CONDITIONS IN LINE.

If pump is installed with a quick closing valve in discharge line that closes when pump is running, dangerous pressure surges may be built up that can cause damage to the pump or line. In services of this kind, some cushioning arrangement must be provided to protect the pumping equipment.

IV—E. OPERATING UNDER FREEZING CONDITIONS.

When exposed to freezing conditions and pump is standing idle, liquid inside the pump should be drained by removing drain plugs in bottom of casing and opening air cocks at top. Cooling water should also be drained from the water-cooled bearing (if water-cooled bearings are used).

SECTION V — TROUBLE CHECK LIST

V—A. NO WATER DELIVERED.

1. Priming — casing and suction pipe not completely filled with liquid.
*2. Speed too low.
3. Discharge head too high. Check total head (particularly friction loss).
4. Suction lift too high (suction pipe may be too small or long, causing excessive friction loss), Check with gauge.
5. Impeller or suction pipe or opening completely plugged.
6. Wrong direction of rotation.
7. Air pocket in suction line.
8. Stuffing box packing worn or water seal plugged allowing leakage of air into pump casing.
9. Air leak in suction line.
10. Not enough suction head for hot water or volatile liquids. Check carefully as this is a frequent cause of trouble on such service.

V—B. NOT ENOUGH WATER DELIVERED.

1. Priming — casing and suction pipe not completely filled with liquid.
*2. Speed too low.
3. Discharge head higher than anticipated. Check total head (particularly friction loss).
4. Suction lift too high (suction pipe may be too small or long, causing excessive friction loss). Check with gauge.
5. Impeller or suction pipe or opening partially plugged.
6. Wrong direction of rotation.
7. Air pocket in suction line.
8. Stuffing box packing worn — or water seal plugged — allowing leakage of air into pump casing.
9. Air leak in suction line.
10. Not enough suction head for hot water or volatile liquids. Check carefully as this is a frequent cause of trouble on such service.
11. Foot valve too small.
12. Foot valve not immersed deeply enough (see Fig. 8, page 7).
13. Mechanical defects:
    Wearing rings worn.
    Impeller damaged.
    Casing gasket defective.

V—C. NOT ENOUGH PRESSURE.

*1. Speed too low.
2. Air in water.
3. Impeller diameter may be too small.
4. Mechanical defects:
    Wearing rings worn.
    Impeller damaged.
    Casing gasket defective.
5. Wrong direction of rotation.
6. Be sure pressure gauge is in correct place on discharge nozzle of pump and not on top of casing.

V—D. PUMP WORKS AWHILE AND THEN QUITS.

1. Leaky suction line.
2. Stuffing box packing worn — or water seal plugged — allowing leakage of air into pump casing.
3. Air pocket in suction line.
4. Not enough suction head for hot water or volatile liquids. Check carefully as this is a frequent cause of trouble on such service.
5. Air or gases in liquid.
6. Suction lift too high (suction pipe may be too small or long, causing excessive friction loss). Check with gauge.
7. Impeller plugged.

V—E. PUMP TAKES TOO MUCH POWER.

*1. Speed too high.
2. Head lower than rating, pumps too much water.
3. Liquid heavier than water. Check viscosity and specific gravity.
4. Mechanical defects:
    Shaft bent.
    Rotating element binds.
    Stuffing boxes too tight.
    Pump and driving unit misaligned.
*5. Wrong direction of rotation.

V—F. PUMP LEAKS EXCESSIVELY AT STUFFING BOX.

1. Packing is worn or not properly lubricated.
2. Packing is incorrectly inserted or not properly run in.
3. Packing is not right kind for liquid handled.
4. Sleeves scored.

V—G. PUMP IS NOISY.

1. Hydraulic noise — cavitation, suction lift too high. Check with gauge.
2. Mechanical defects:

Shaft bent.

Rotating parts bind, are loose or broken.

Bearings worn out.

Pump and driving unit misaligned.

*When connected to electric motors, check whether motor wiring is correct and receives full voltage.

When connected to steam turbines, make sure that turbine receives full steam pressure.

SECTION VI — CARE AND MAINTENANCE

VI—A. LUBRICATION — BEARINGS.

Grease Lubricated Bearings

1. As specified in Section II—A, Model 3405 pumps with grease lubricated bearings are lubricated at the factory for 2000 hours or three months service. DO NOT ADD GREASE AT TOO FREQUENT INTERVALS. It is suggested that additional or replacement lubricant be added only after 2000 hours operation or three month intervals. While shaft is revolving, insert grease through "Alemite" fittings (193) into bearing housing until grease appears through relief fitting (113), DO NOT ADD ADDITIONAL LUBRICANT AFTER GREASE APPEARS THROUGH RELIEF FITTING.
2. The grease should be renewed in the Model 3405 housings at least once annually.

   (a) Following an overhaul operation and when bearing housings contain no lubricant, proceed to grease the bearings as follows: Insert grease through "Alemite" fittings (193) into bearing housing until grease comes out the relief fitting. Turn shaft by hand several revolutions in both directions during the greasing operation. DO NOT ADD ADDITIONAL LUBRICANT AFTER GREASE APPEARS THROUGH THE RELIEF FITTING.

   (b) Grease may be renewed in housings without removing rotating element as follows: Remove bearing end covers (109-119) and clean old grease from housing and covers using clean cloths soaked in kerosene. Insert grease through "Alemite" fittings (193) until new grease appears through the bearings. Wipe bearing housings clean again to remove all old grease displaced through the bearing. Replace end covers and add grease through the "Alemite" fittings as described previously.
3. The ball bearing grease should be of a sodium or lithium base, NGLI No. 2 consistency. DO NOT USE GRAPHITE.
4. The following is the approximate grease capacity for each bearing housing in fluid ounces:

   Group "S" — 2 ounces.
   Group "M" — 3 ounces.
   Group "L" — 4½ ounces.

Oil Lubricated Bearings

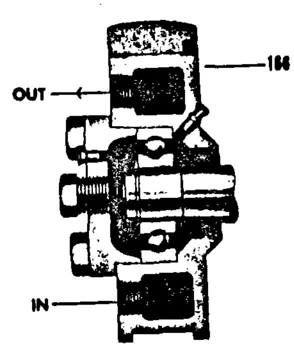
1. On Model 3406 and 3416 pumps, keep oiler bottle filled with correct grade of oil. Oiler will maintain constant oil level in bearing housings.
2. Under normal operating conditions, a good grade of oil will be suitable for 6 months to one year between changes, as long as it is free from contaminants. A small sample of oil should be drained from the bearing frame periodically. Any cloudiness, turbidity, discoloration or presence of solids is evidence of contamination, and the oil should be changed immediately.

VI—B. REPACKING STUFFING BOXES.

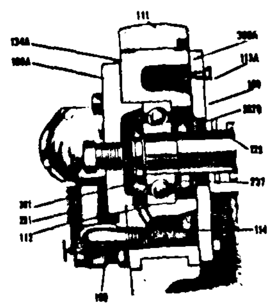
1. To remove stuffing box gland assembly: Back off nuts (355). Slip the cupped washers (354) from bosses on gland, lift the upper gland half out of stuffing box and remove the gland bolts and lower gland half. This now affords unobstructed access to the stuffing box for repacking.
2. Remove the three outer rings of packing with the aid of a packing hook.
3. Remove split lantern ring by inserting a wire hook in the slots in the outer edge of the ring and pulling ring from box.
4. Remove the remaining rings of packing with the aid of a packing hook.
5. Remove all foreign matter from stuffing box.
6. An alternate method of removing the packing and lantern ring is as follows: Remove the upper half casing. See VI—D 1, 2, 4, 5. Remove the packing and lantern ring from the stuffing box. This method permits the inspection of the shaft sleeve and the stuffing box bushing. If the shaft sleeves are found to be deeply grooved in the packing area, they should be replaced as it is only possible for the packing to do an efficient job when the sleeve surface is relatively smooth.

SECTION VI-C

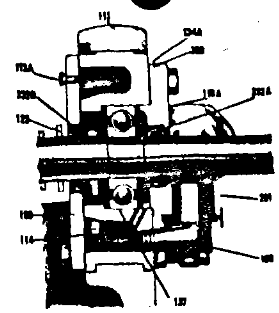
SECTIONAL VIEW



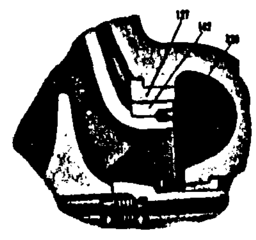
Liquid cooled bearing housing. Model 3405 only.



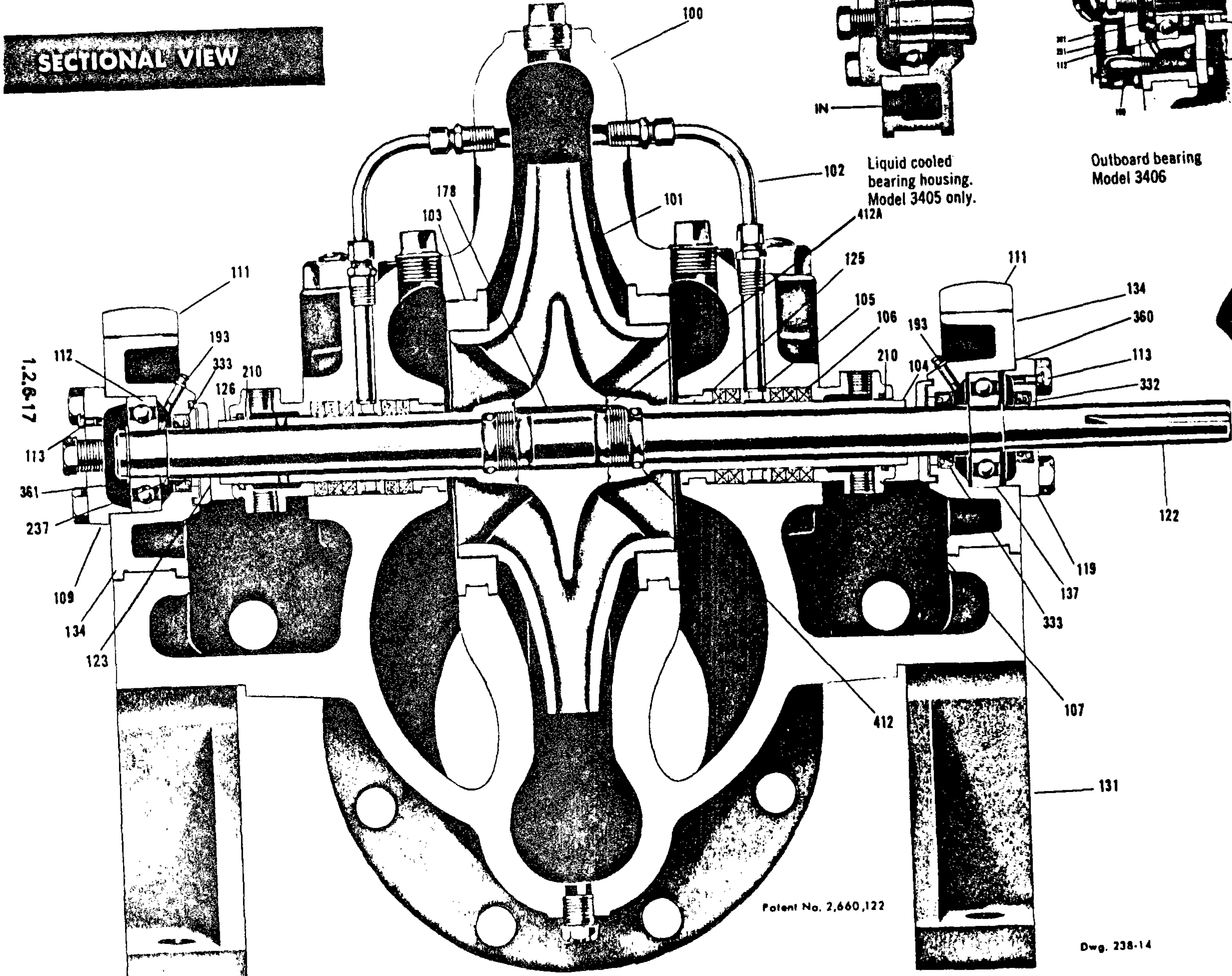
Outboard bearing Model 3406



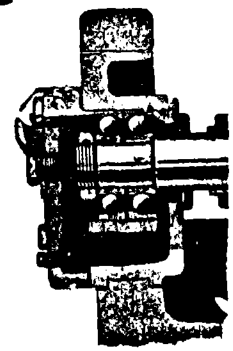
Coupling end bearing Model 3406



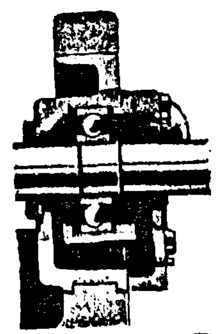
Impeller Wearing Ring Models 3405-3406



SECTIONAL VIEW — MODEL 3405 — BRONZE FITTED CONSTRUCTION



Outboard bearing Model 3416



Coupling end bearing Model 3416

Materials of Construction Parts List and Chart of Parts Interchangeability

ITEM No.	Reqd. per Pump	PART NAME	MATERIAL: BRZ. FTD.	MATERIAL: ALL IRON	MATERIAL: ALL BRZ.	MATERIAL: AI/316 R.E.	MATERIAL: ALL 316
100 100	1-Up. 1-Low.	CASING	1003	1003	1103	1000	316
101	1	IMPELLER	1103	1000	1103	316	316
102	2	WATER SEAL PIPE	BRASS TUBING	USE GREASE LUBRICATOR	BRASS TUBING	USE GREASE LUBRICATOR	316 TUBING
⊙103	2	WEARING RING—CASING	1106	1000	1106	316	316
104	1	SHAFT SLEEVE—LOCKING	1106	AISI-420▲	1106	316	316
105	2	LANTERN RING	GLASS FILLED TEFLON				
106	1 Set	STUFFING BOX PACKING	*DIE FORMED				
107	2	STUFF. BOX SPLIT GLAND	1106	1000	1106	316	316
●109	1	BRG. END COVER—THRUST END	1000				
△109A	1	BRG. END COVER—THRUST END	1000				
111	2	BEARING CAP	1000				
112	1	BALL BEARING—THRUST END	STEEL				
●113	2	GREASE RELIEF FITTING	STEEL				
△113A	2	OIL BREATHER FITTING	STEEL				
△114	2	OIL RING	BRASS				
●119	1	BRG. END COVER—CPLG. END	1000				
△119A	1	BRG. END COVER CPLG. END	1000				
122	1	SHAFT	SAE 4340		AISI-303	316	316
123	2	DEFLECTOR	MICARTA				
125	2	STUFFING BOX BUSHING	1102	1000	1102	316	316
126	1	SHAFT SLEEVE—WITH SET SCREW	1106	AISI-420▲	1106	316	316
×127	2	WEAR. RING—CASING	1106	1000	1106	316	316
131	2	PEDESTAL	1000				
●134	2	BEARING HOUSING	1000				
△134A	2	BEARING HOUSING	1000				
137	1	BALL BEARING—CPLG. END	STEEL				
142	2	WEARING RING—IMPELLER	1103	1000	1103	316	316
△160	2	BRG. HOUSING COVER	1000				
●166	2	BRG. HOUSING—LIQUID COOLED	1000				
178	1	IMPELLER KEY	AISI 303			316	316
△190	2	OIL PIPE	STEEL				
●193	2	GREASE FITTING	ALEMITE				
210	1 Set	GLAND PACKING	½" x ½" ASBESTOS				
237	1	BALL BEARING COLLAR	STEEL				
△251	2	CONSTANT LEVEL OILER	STEEL AND GLASS				
320	6	SET SCREW (IMP. WRG. RINGS)	303 STAINLESS				
331	4	SHIM—BRG. CAP (NOT ILLUS.)	1/64" ASBESTOS				
●332	1	GREASE SEAL—BRG. END COVER					
△332A	1	OIL SEAL BRG. END COVER CPLG. END					
△332B	2	OIL SEAL BRG. HOUSING COVER					
●333	2	GREASE SEAL—BRG. HOUSING					
351	1	GASKET—CASING PARTING (NOT ILLUS.)	1/64" ASBESTOS				
●353	4	GLAND BOLT (ILLUS. PG. 3)	1109	STEEL	1109	316	316
△353A	4	GLAND BOLT (NOT ILLUS.)	1109	STEEL	1109	316	316
354	4	GLAND HOLDING WASHER (ILLUS. PG. 3)	AISI 416				
355	4	GLAND BOLT NUT (ILLUS. PG. 3)	AISI 303				
360	2	GASKET—BRG. END COVER	.0145 DUPLEX PAPER				
△360A	2	GASKET BRG. HOUSING COVER	MANILA PAPER				
361	1	SNAP RING	STEEL				
412	2	"O" RING SHAFT	BUNA RUBBER				
412A	2	"O" RING (IMPELLER HUB)	TEFLON				

INTERCHANGEABILITY BY GROUP AND CASING CLASS

GROUP S

ITEM No.	▽ 2x3-11	▽ 3x4-8 / 3x4-8G	▽ 3x4-8H	▽ 3x4-12	▽ 3x4-12G	▽ 3x4-14	▽ 4x6-8	▽ 4x6-8G	+ 4x6-12	▽ 4x6-12G
⊙103	‡2	‡3	†	‡3	3B	‡3	4	†	4	4B
104	S	S		S		S	S		S	
105	S	S		S		S	S		S	
106	S	S		S		S	S		S	
107	S	S		S		S	S		S	
●109	S	S		S		S	S		S	
△109A	S	S		S		S	S		S	
111	S	S		S		S	S		S	
112	S	S		S		S	S		S	
●113	L	L		L		L	L		L	
△113A	L	L		L		L	L		L	
△114	S	S		S		S	S		S	
●119	S	S		S		S	S		S	
△119A	S	S		S		S	S		S	
122	S	S		S		S	S		S	
123	S	S		S		S	S		S	
125	S	S		S		S	S		S	
126	S	S		S		S	S		S	
×127	‡2A	‡3A	‡3	‡3	3C	‡3A	4A	4	4A	4C
131	S	S		S		S	S		S	
●134	S	S		S		S	S		S	
△134A	S	S		S		S	S		S	
137	S	S		S		S	S		S	
142	‡2	‡3	3A	‡3	‡2	‡3	4	‡3	4	‡3
△160	S	S		S		S	S		S	
●166	S	S		S		S	S		S	
178	S	S		S		S	S		S	
△190	S	S		S		S	S		S	
●193	L	L		L		L	L		L	
210	L	L		L		L	L		L	
237	S	S		S		S	S		S	
△251	L	L		L		L	L		L	
320	L	L		L		L	L		L	
331	M	M		M		M	M		M	
●332	S	S		S		S	S		S	
△332A	S	S		S		S	S		S	
△332B	S	S		S		S	S		S	
●333	S	S		S		S	S		S	
351	—	—		—		—	—		—	
●353	M	M		M		M	M		M	
△353A	M	M		M		M	M		M	
354	L	L		L		L	L		L	
355	S	S		S		S	S		S	
360	S	S		S		S	S		S	
△360A	S	S		S		S	S		S	
361	S	S		S		S	S		S	
412	S	S		S		S	S		S	
412A	S	S		S		S	S		S	

GROUP M

ITEM No.	▽ 3x4-17	4x6-11	+ 4x6-14	4x6-17	▽ 4x6-17G	5x8-12DV	5x8-14DV	▽ 6x8-8	▽ 6x8-8G	6x8-12	6x8-12G	+ 6x8-14	+ 6x8-14G	6x8-17DV	6x8-17G DV	8x10-12DV	8x10-12G DV
⊙103	‡3	‡5	4	4	4B	7	7	‡6	†	6	†	7	7B	7	7B	‡8	8B
104	M	M	M	M		M	M	M		M		M		M		M	
105	M	M	M	M		M	M	M		M		M		M		M	
106	M	M	M	M		M	M	M		M		M		M		M	
107	M	M	M	M		M	M	M		M		M		M		M	
●109	M	M	M	M		M	M	M		M		M		M		M	
△109A	M	M	M	M		M	M	M		M		M		M		M	
111	M	M	M	M		M	M	M		M		M		M		M	
112	M	M	M	M		M	M	M		M		M		M		M	
●113	L	L	L	L		L	L	L		L		L		L		L	
△113A	L	L	L	L		L	L	L		L		L		L		L	
△114	M	M	M	M		M	M	M		M		M		M		M	
●119	M	M	M	M		M	M	M		M		M		M		M	
△119A	M	M	M	M		M	M	M		M		M		M		M	
122	M	M	M	M		M	M	M		M		M		M		M	
123	M	M	M	M		M	M	M		M		M		M		M	
125	M	M	M	M		M	M	M		M		M		M		M	
126	M	M	M	M		M	M	M		M		M		M		M	
×127	‡3A	‡5A	4A	4A	4C	7A	7A	‡6A	‡6	‡6A	‡6	7A	7C	7A	7C	‡8A	8C
131	M	M	M	M		M	M	M		M		M		M		M	
●134	M	M	M	M		M	M	M		M		M		M		M	
△134A	M	M	M	M		M	M	M		M		M		M		M	
137	M	M	M	M		M	M	M		M		M		M		M	
142	‡3	‡5	4	4	‡3	7	7	‡6	6A	‡6	6B	7	4	7	4	‡8	‡6
△160	M	M	M	M		M	M	M		M		M		M		M	
●166	M	M	M	M		M	M	M		M		M		M		M	
178	M	M	M	M		M	M	M		M		M		M		M	
△190	M	M	M	M		M	M	M		M		M		M		M	
●193	L	L	L	L		L	L	L		L		L		L		L	
210	L	L	L	L		L	L	L		L		L		L		L	
237	M	M	M	M		M	M	M		M		M		M		M	
△251	L	L	L	L		L	L	L		L		L		L		L	
320	L	L	L	L		L	L	L		L		L		L		L	
331	M	M	M	M		M	M	M		M		M		M		M	
●332	M	M	M	M		M	M	M		M		M		M		M	
△332A	M	M	M	M		M	M	M		M		M		M		M	
△332B	M	M	M	M		M	M	M		M		M		M		M	
●333	M	M	M	M		M	M	M		M		M		M		M	
351	—	—	—	—		—	—	—		—		—		—		—	
●353	M	M	M	M		M	M	M		M		M		M		M	
△353A	M	M	M	M		M	M	M		M		M		M		M	
354	L	L	L	L		L	L	L		L		L		L		L	
355	M	M	M	M		M	M	M		M		M		M		M	
360	M	M	M	M		M	M	M		M		M		M		M	
△360A	M	M	M	M		M	M	M		M		M		M		M	
361	M	M	M	M		M	M	M		M		M		M		M	
412	M	M	M	M		M	M	M		M		M		M		M	
412A	M	M	M	M		M	M	M		M		M		M		M	

GROUP L

ITEM No.	6x8-22DV	+ 8x10-14 / 8x10-14G	8x10-17 / 8x10-17G	10x12-12	+ 10x12-14	+ 10x12-14G	10x12-17	10x12-17G	12x14-12DV	12x14-14DV
⊙103	6C	10	10	10	12	12B	12	13	12B	12
104	L	L	L	L	L		L		L	L
105	L	L	L	L	L		L		L	L
106	L	L	L	L	L		L		L	L
107	L	L	L	L	L		L		L	L
●109	L	L	L	L	L		L		L	L
△109A	L	L	L	L	L		L		L	L
111	L	L	L	L	L		L		L	L
112	L	L	L	L	L		L		L	L
●113	L	L	L	L	L		L		L	L
△113A	L	L	L	L	L		L		L	L
△114	L	L	L	L	L		L		L	L
●119	L	L	L	L	L		L		L	L
△119A	L	L	L	L	L		L		L	L
122	L	L	L	L	L		L		L	L
123	L	L	L	L	L		L		L	L
125	L	L	L	L	L		L		L	L
126	L	L	L	L	L		L		L	L
×127	6D	10A	10A	10A	12A	12C	12A	13A	12C	12A
131	L	L	L	L	L		L		L	L
●134	L	L	L	L	L		L		L	L
△134A	L	L	L	L	L		L		L	L
137	L	L	L	L	L		L		L	L
142	6C	10	10	10	12	10	10	10	12	12
△160	L	L	L	L	L		L		L	L
●166	L	L	L	L	L		L		L	L
178	L	L	L	L	L		L		L	L
△190	L	L	L	L	L		L		L	L
●193	L	L	L	L	L		L		L	L
210	L	L	L	L	L		L		L	L
237	L	L	L	L	L		L		L	L
△251	L	L	L	L	L		L		L	L
320	L	L	L	L	L		L		L	L
331	L	L	L	L	L		L		L	L
●332	L	L	L	L	L		L		L	L
△332A	L	L	L	L	L		L		L	L
△332B	L	L	L	L	L		L		L	L
●333	L	L	L	L	L		L		L	L
351	—	—	—	—	—		—		—	—
●353	L	L	L	L	L		L		L	L
△353A	L	L	L	L	L		L		L	L
354	L	L	L	L	L		L		L	L
355	L	L	L	L	L		L		L	L
360	L	L	L	L	L		L		L	L
△360A	L	L	L	L	L		L		L	L
361	L	L	L	L	L		L		L	L
412	L	L	L	L	L		L		L	L
412A	L	L	L	L	L		L		L	L

NOTE: ALL PARTS S, M AND L EXCEPT NO. 131 PEDESTAL INTERCHANGEABLE WITH GOULDS MODEL 3316 MULTI-STAGE PUMPS.
†ON THESE SIZES IMPELLER WEARING RINGS ARE STANDARD.
*WHITE METAL, GRAPHITE, LONG FIBRE ASBESTOS.
▲FLAME HARDENED.

△MODEL 3406 ONLY.
●MODEL 3405 ONLY.
‡INTERCHANGEABLE WITH GOULDS MODEL 3316 MULTI-STAGE PUMPS.
⊙USED WITH IMPELLER WITHOUT WEARING RINGS.
×USED WITH IMPELLER WITH WEARING RINGS.
DV SUFFIX DESIGNATES DOUBLE VOLUTE CASINGS.

▽ NOT AVAILABLE WITH 316 ROTATING ELEMENT OR IN ALL 316 CONSTRUCTION.
+ AVAILABLE WITH 316 ROTATING ELEMENT BUT NOT IN ALL 316 CONSTRUCTION.

CONSTRUCTION DETAILS

GROUP S

		2x3—11	3x4—8G	3x4—8	3x4—8H	3x4—12	3x4—12G	3x4—14	4x6—8	4x6—8G	4x6—12	4x6—12G
PUMP	WEIGHT — BRONZE FITTED BARE PUMP	320	300			390		455	365		470	
	CASING THICKNESS — VOLUTE	3/8"	3/8"			11/16"		3/4"	3/8"		11/16"	
	CASING THICKNESS — SIDE WALLS	1/2"	1/2"			3/8"		3/8"	7/16"		3/8"	
	MAXIMUM DIAMETER SPHERICAL SOLIDS	5/16"	1/2"		3/8"	7/16"		7/16"	1/2"		5/8"	3/8"
	CASING CAPACITY — GALLONS	1.5	2			2.6		3.6	3.75		4.25	
STUFFING BOX	STUFFING BOX BORE	2"										
	STUFF. BOX DEPTH (To Stuff. Box Bush.)	2 5/16"										
	STUFFING BOX PACKING SIZE	5/16" x 5/16"										
	STUFF. BOX — NO. OF PACKING RINGS	5										
	WIDTH OF LANTERN RING	5/8"										
SHAFT	SHAFT DIA. AT IMPELLER	1 5/16"										
	SHAFT DIA. IN SHAFT SLEEVE	1 5/16"										
	SHAFT DIA. AT COUPLING END	15/16"										
	OUTSIDE DIA. OF SHAFT SLEEVE	1 3/8"										
GENERAL	BALL BEARING — BOTH ENDS	305-S										
	†MAXIMUM TOTAL WORKING PRESSURE	250 PSI										
	MAXIMUM TEST PRESSURE	375 PSI										
	BEARING CENTERS	18 3/8"										
	MAX. SHAFT H.P. PER 100 R.P.M.	2.57										

GROUP M

		3x4—17	4x6—11	4x6—14	4x6—17	4x6—17G	5x8—120V	5x8—140V	6x8—8	6x8—8G	6x8—12	6x8—12G	6x8—14	6x8—14G	6x8—17DV	6x8—17G DV	8x10—12DV	8x10—12G DV
PUMP	WEIGHT — BRONZE FITTED BARE PUMP	650	640	660	720		680	750	585		725		795		895		905	
	CASING THICKNESS — VOLUTE	3/4"	3/8"	3/8"	3/8"		3/8"	11/16"	3/4"		13/16"		7/8"		7/8"		7/8"	
	CASING THICKNESS — SIDE WALLS	5/8"	3/8"	3/8"	3/8"		5/8"	11/16"	5/8"		11/16"		3/4"		3/4"		3/4"	
	MAXIMUM DIAMETER SPHERICAL SOLIDS	7/16"	7/16"	7/16"	7/16"	7/16"	11/16"	11/16"	1"	3/4"	11/16"	5/8"	3/4"	7/16"	5/8"	7/16"	1"	11/16"
	CASING CAPACITY — GALLONS	3.9	5.0	5.3	5.4		8.3	8.5	7.6		9.1		9.4		11.6		16.5	
STUFFING BOX	STUFFING BOX BORE	2 1/2"																
	STUFF. BOX DEPTH (To Stuff. Box Bush.)	2 13/16"																
	STUFFING BOX PACKING SIZE	3/8" x 3/8"																
	STUFF. BOX — NO. OF PACKING RINGS	5																
	WIDTH OF LANTERN RING	3/4"																
SHAFT	SHAFT DIA. AT IMPELLER	1 9/16"																
	SHAFT DIA. IN SHAFT SLEEVE	1 11/16"																
	SHAFT DIA. AT COUPLING END	1 3/8"																
	OUTSIDE DIA. OF SHAFT SLEEVE	1 3/4"																
GENERAL	BALL BEARING — BOTH ENDS	307-S																
	†MAXIMUM TOTAL WORKING PRESSURE	250 PSI																
	MAXIMUM TEST PRESSURE	375 PSI																
	BEARING CENTERS	22 1/2"																
	MAX. SHAFT H.P. PER 100 R.P.M.	8.7																

GROUP L

		6x8—22DV	8x10—14	8x10—14G	8x10—17	8x10—17G	10x12—12	10x12—14 / 10x12—14G	10x12—17	10x12—17G	12x14—120V	12x14—140V
PUMP	WEIGHT — BRONZE FITTED BARE PUMP		1285		1330		1300	1385	1555		1600	1620
	CASING THICKNESS — VOLUTE	15/16"	7/8"		7/8"		7/8"	7/8"	1"		7/8"	15/16"
	CASING THICKNESS — SIDE WALLS	13/16"	3/4"		3/4"		3/4"	3/4"	3/4"		3/4"	3/4"
	MAXIMUM DIAMETER SPHERICAL SOLIDS	15/16"	1"	7/8"	3/4"	7/8"	1 1/4"	1"	1 11/16"	3/4"	1 1/2"	1 3/4"
	CASING CAPACITY — GALLONS		21.0		19.5		24.9	25.0	29.3		33.0	35.5
STUFFING BOX	STUFFING BOX BORE	3 1/4"										
	STUFF. BOX DEPTH (To Stuff. Box Bush.)	3 3/8"										
	STUFFING BOX PACKING SIZE	1/2" x 1/2"										
	STUFF. BOX — NO. OF PACKING RINGS	6										
	WIDTH OF LANTERN RING	7/8"										
SHAFT	SHAFT DIA. AT IMPELLER	2 3/16"										
	SHAFT DIA. IN SHAFT SLEEVE	2 1/16"										
	SHAFT DIA. AT COUPLING END	1 15/16"										
	OUTSIDE DIA. OF SHAFT SLEEVE	2 1/2"										
GENERAL	BALL BEARING — BOTH ENDS	310-S										
	†MAXIMUM TOTAL WORKING PRESSURE	250 PSI										
	MAXIMUM TEST PRESSURE	375 PSI										
	BEARING CENTERS	28"										
	MAX. SHAFT H.P. PER 100 R.P.M.	27.1										

		ALL GROUPS
TEMP. LIMITS	MAX. LIQUID TEMPERATURE WITHOUT COOLING OR QUENCHING	180°F
	MAX. LIQUID TEMP. WITH QUENCHING GLAND	250°F
	MAX. LIQUID TEMPERATURE WITH BEARING COOLING (GREASE LUB.)*	250°F
	MAX. LIQUID TEMP. W/QUENCH. GLAND & BEAR. COOLING (GREASE LUB.)*	350°F

†Any Part of Which May Be Suction Pressure. *Water Cooled Bearings Available for Model 3405 Only.

TYPICAL BRONZE ANALYSIS

No.	Cu. %	Sn. %	Pb. %	Zn. %	P. %	Ni. %
1102	84-86	4-6	4-6	4-6	—	—
1103	87	6	4.5	1.75	.05-.15	0.75
1106	84	8	8	—	.10-.15	—
1109	88	8	.3	4.	—	—

Symbol 1000—Cast Iron—Corresponds to ASTM A278-59T Class 25
1003—Cast Iron—Corresponds to ASTM A278-59T Class 30

REPLACEMENT SNAP RINGS (PART 361) (WALDES TYPE 5102 OR EQUAL)

GROUP	RING NO.	PLIERS NO.
S	100	2, 22, 4 OR 24
M	137	4 OR 24
L	196	4, 24, 6, OR 26

REPLACEMENT GREASE & OIL SEALS (VICTOR OR EQUAL)

Part No.	GROUP S	GROUP M	GROUP L
332	H 60222	K 60454	K 60771
332A	H 60222	K 60454	K 60771
332B	K3 64284	K3 63290	K 60810
333	H 60284	K 60478	K 60810

VI—D. DISMANTLING OF PUMP.

The basic instructions are for a Model 3405 pump. Where dismantling of the Model 3406 or 3416 pumps differ, the necessary supplementary instructions are included.

1. Drain liquid from pump.
2. Shut off and disconnect any auxiliary piping.
3. Disconnect coupling.
4. Remove gland assembly from stuffing boxes. See VI—B (page 15).
5. Jack and remove dowel pins from upper half casing by use of hex nut provided on top of pins. Remove nuts from casing parting studs and loosen upper half casing (100) by screwing two bolts (1/2"-13 threads) in holes provided in the flange. Lift off upper half casing, being careful not to injure the parting gasket. Use the lugs provided for lifting the upper half casing. DO NOT USE THESE LUGS FOR LIFTING ENTIRE PUMP.
6. Remove nuts from bearing cap studs and lift bearing cap (III) from unit. NOTE: THESE CAPS MUST BE REPLACED ON THE SAME END OF PUMP FROM WHICH THEY WERE REMOVED. They should be marked for identification before disassembly. The shims under the bearing caps should be preserved and reused at reassembly. If lost or damaged, they must be replaced by shims 1/64" thick.
7. Carefully lift rotating assembly from unit and place on padded supports which will not injure the shaft sleeves.
8. Note the distance from the end of the shaft to the face of the pump half coupling so that the coupling half can be correctly positioned when reassembled. Pull the coupling half from pump shaft.
9. Remove coupling key.
10. Remove cap screws on each end cover and remove end covers (109 and 119) from bearing housing (134 or 166). Preserve end cover gaskets (360). On the Model 3406 and 3416 the constant level oilers (251) must first be removed from both thrust and coupling end and the oil drained from the bearing housings.
11. Remove snap ring (361) from shaft. Use No. 4 Waldes pliers. The Model 3416 has a shaft nut rather than a snap ring.
12. Remove ball bearings (112 and 137) from shaft seat by the use of a bearing puller. Details of a recommended puller, capable of removing bearings from all three groups of pumps, are shown in Figure 19. Care must be used. Puller bar must be

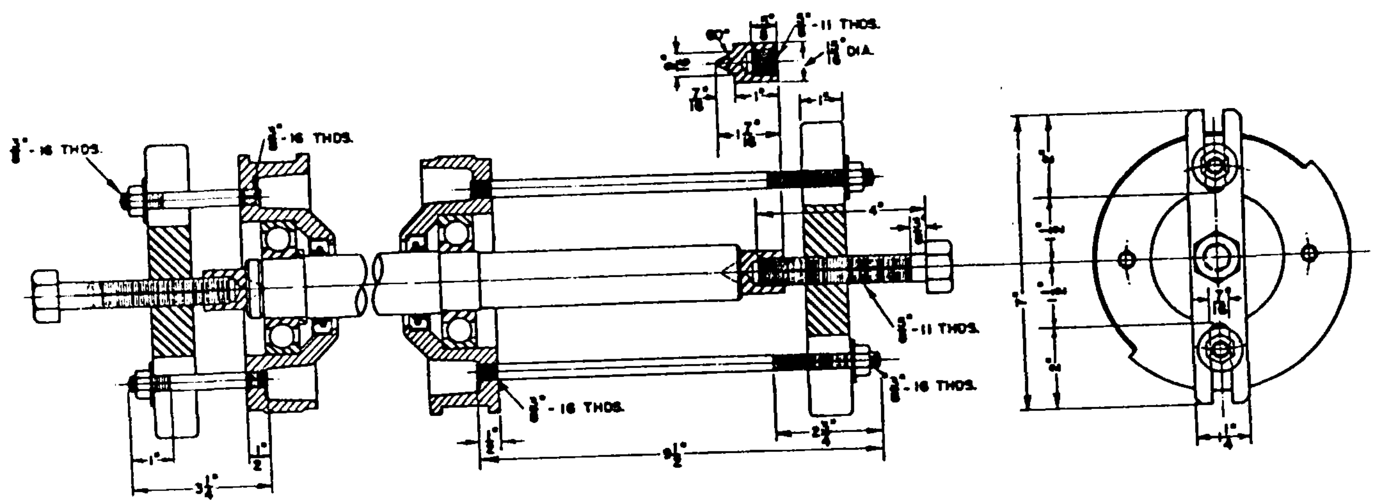


Fig. 19

square with shaft so that equal pressure is applied evenly to the circumference of the outer race of the bearing. A steady pressure must be applied to the puller screw.

NEVER USE HAMMER BLOWS TO DRIVE SHAFT THROUGH BEARINGS. Protect bearings from dirt or other contamination.

13. Slide ball bearing collar (237 off of shaft) (122).
14. Slide bearing housings from shaft. Remove deflectors (123) from both ends of shaft. On the Model 3406, remove cap screws from bearing housing covers (160) on both bearing housings and lift out oil rings (114). Preserve bearing housing cover gaskets (360A).
15. Slip casing wearing rings (103 or 127) from impeller and off rotating element.
16. Slide packing, lantern rings (105) and stuffing box bushings (125) off ends of shaft.
17. Smooth the exposed portions of the shaft at the ends of the sleeves with fine emery cloth so that sleeves will not bind while being removed.
18. The shaft sleeve (1266) must be removed first. This is the sleeve with the spanner holes. Loosen set screw in sleeve (if supplied) — previous design did not have set screws). Unscrew sleeve from shaft with a pin spanner or a strap wrench. Shaft to sleeve threads are right hand. DO NOT USE PIPE WRENCH! NEVER ATTEMPT TO REMOVE THE SLEEVE (104) WHICH HAS NO SPANNER HOLES UNTIL IMPELLER AND IMPELLER KEY ARE REMOVED FROM SHAFT.
19. Tap the impeller (101) from shaft with a lead mall. Tap evenly around the impeller as near as possible to the shaft. DO NOT DRIVE AGAINST THE SEALING SURFACE ON END OF HUB. Do not let the key "ride up" on the exposed curved portion of the sled runner keyway.

    Should the impeller key start to "ride" as the impeller is being removed, the key can be driven back by a drift pin or piece of keystock a size smaller than the impeller key.
20. Remove key from keyway.
21. Unscrew and remove the remaining sleeve from shaft by hand or with a strap wrench. Shaft to sleeve threads are right hand. This completes the disassembly of the pump.

VI—E. REASSEMBLY OF PUMP.

The following directions are for use when the pump is completely dismantled and it is desired to reassemble. Figs. 21 and 22 illustrate the steps described in the following. The basic instructions are for a Model 3405 pump. Where reassembly of the Model 3406 or 3416 pumps differ the necessary supplementary instructions are included.

1. Check shaft to see that it is not bent or otherwise damaged, and that it is also smooth and clean. Inspect "O" Rings (412 and 412A). Replace if damaged. Position "O" Rings (412) inside shaft sleeves as shown in the sectional assembly, page 16.
2. Determine the correct setting of the impeller and sleeves on the shaft in relation to the rotation of the pump. To do this, face the discharge flange of the pump. The locking shaft sleeve must be on the right as shown in Fig. 20 and the impeller must rotate in correct relation to the casing as shown in the end views in Fig. 20.
3. Mark the location of the keyway on the outside of both the impeller hub and the locking sleeve (104) at points "A" and "B" in Fig. 21 and 22 (pages 22 and 23). These marks will be used later to indicate that the keyways are in line.
4. Assemble the shaft sleeve (104) that has a keyway in the threaded end but does not have spanner wrench holes. Turn sleeve in a clockwise direction on shaft until the dimension from the threaded end of the sleeve to the shaft shoulder at thrust bearing or outboard seat agrees with the dimension on Fig. 22 for right hand or Fig. 21 for left hand rotation.

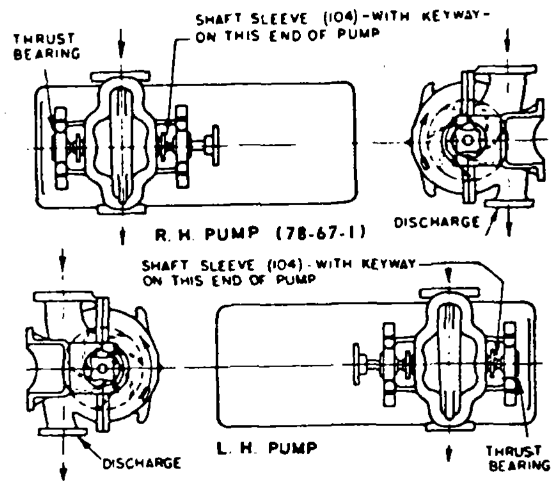


Fig. 20

This dimension must be held as near as possible with the keyways in the shaft and sleeve in alignment.

For the Model 3416 substitute the following B dimensions for those shown on Fig. 21 and 22.

	Figure 21	Figure 22
Group "S"	7-13/16″	9-13/16″
Group "M"	9-1/32″	12-17/32″
Group "L"	10-3/4″	16″

5. If it is necessary to replace the impeller wearing rings on pumps so equipped, proceed as follows:

(a) Remove old rings. Rings are held by press fit and also by 3 set screws in edge of impeller and ring.

(b) Clean wearing ring seats and press on new rings.

(c) Drill 3 holes ("F" drill, 11/16″ deep, 120° apart), so that holes are half in impeller and half in ring. Tap holes (5/16″-18 tap, 3/8″ deep). Screw set screws in hole, and lightly upset first thread to keep screw from backing out.

(d) The impeller wearing rings are supplied 0.020-0.030 inch oversize on the O.D. They should be turned to size after they are mounted on the impeller. Turning to size after mounting is the procedure used in the factory, and has the following advantages:

(1) Eliminates possibility of runout.

(2) Eliminates distortion and expansion due to the press fit.

(3) Permits the user to compensate for wear of the casing wearing rings, so that the casing wearing rings need not be replaced to restore original clearances.

(4) Permits the user to select a special clearance for unusual operating conditions.

The table of original clearances in section VI—G may be used as a guide in setting the final dimension of the impeller rings. If rings are 300 series stainless steel, or if extremely viscous liquids are being handled, the suggested clearance should be increased 0.005 inch.

6. Insert impeller key (178) in shaft keyway. Turn sleeve (104) about a quarter turn, either way, so that key cannot enter keyway in this sleeve until after impeller is checked for correct setting in casing.

7. If the impeller diameter has been cut in the field, the impeller should be statically balanced and, if possible, dynamically balanced. Balancing can be effected by grinding on the outside of the shrouds near the periphery.

8. Place "O"-Ring (412A) in groove in end of shaft sleeve (104). "O"-Ring may have to be slightly stretched to fit.

Note: Model 3405 pumps were previously supplied without "O"-rings (412A) in the ends of the shaft sleeves. On these pumps, coat the large ends of the shaft sleeves and the ends of the impeller hub with plastic thread compound, gasoila varnish, or white lead. Old and new style sleeves are interchangeable. "O"-rings (412) must be used between shaft sleeve and shaft whether "O"-rings (412A) are used or not. (This applies to step 10 below also.)

9. Slide impeller on shaft and tap in place against the sleeve with a lead mall. Tap evenly around the impeller near the wearing ring surface. DO NOT TAP AGAINST THE SEALING SURFACE ON END OF HUB.

10. Place "O" Ring (412A) in groove in end of shaft sleeve (126). Screw shaft sleeve on shaft up to key.

11. Slip wearing rings (103 or 127) on impeller, being sure that the single lock on the upper half of ring is toward the center of the impeller.

12. Place stuffing box bushings (125) on shaft and slide over shaft sleeves toward impeller. The single lock on the upper half of bushings must be toward the outside, away from impeller.

13. If grease or oil seals (322, 333, 332A, or 332B) are being replaced, make sure that the seals are installed so that the lips of the grease seals face outward, away from the bearings, and the lips of the oil seals face inward, toward the bearings.

14. Make sure that all parts that are assembled inside the bearing housings, including the shaft, snap ring, bearing end covers, bearings and oil rings, are entirely free from dust and dirt.

This is extremely important, as the life of a ball bearing can be drastically reduced if contaminated with even a small amount of dirt. All bearing assembly operations should be done in as dust-free an atmosphere as possible. All tools, as well as the hands, should be kept clean.

If new ball bearings are being used, they should not be unwrapped until ready for installation and should not be cleaned or washed unless the protective wrapper has been broken and dirt allowed to enter the bearing.

If old bearings, or new ones that have been allowed to become dirty, are being used, clean thoroughly before installing as follows: Use a clean pail or receptacle. Pour into it one or two quarts of clean, water-free kerosene. Dip the bearing into the kerosene and spin slowly. Repeat until all traces of grease have been removed. Now blow dry with clean filtered compressed air, holding the two races together so that they do not rotate but allowing the inner race to rotate a few turns now and then to dislodge the kerosene from the retainer pockets. If the bearing is very dirty, it is advisable to rinse it in a second bath of clean kerosene. When the bearing has been blown dry, oil it immediately with a good grade of clean machine oil; especially the race grooves and balls to prevent corrosion or rust.

15. Place deflectors (123) on shaft. On the Model 3406 — Wipe a small amount of grease on oil seal lips (332B) and slide bearing housing covers (160) carefully over shaft and place oil rings (114) on shaft against bearing housing covers (160).

16. Wipe a small amount of grease on the grease seal lips in bearing housing (134 or 166). Place bearing housings on shaft and slide them along until they contact the shaft sleeves. Care must be taken not to injure the lips of the grease seals during this operation. A thin piece of shim stock, wrapped inside the grease seal before sliding over the shaft will protect the seal lips and can readily be removed after the seal is past the shaft shoulder.

17. Slide ball bearing collar (237) over thrust end of shaft (122) and push up against shaft shoulder.

18. The thrust and coupling end ball bearings are the the same and can be installed on either end of shaft. Both bearings are installed in a like manner as follows: Apply a film of oil to the bearing seat on the shaft. Start bearing "square" and drive on about 1/8", keeping bearing square at all times. Use a driving sleeve as shown in Figs. 21 and 22. Note that the outside diameter of this sleeve should never be larger than the outside diameter of the inner race of bearing. Next slip the bearing housing over the ball bearing toward the end of the shaft to eliminate any possibility of binding between the outside of the bearing and the bearing housing bore. Now continue to drive the bearing solidly against the shaft shoulder.

    On the Model 3416 coupling end bearing is single row. Thrust bearing is a duplex bearing (two angular contact bearings, specially matched) and must be mounted in "back-to-back" position. This is done on the bearing originally sent with the pump by having the stamped faces of the outer rings against each other.

    Both bearings are installed in same manner as the 3405.

    Model 3416 uses the following bearings:

	Group "S"	Group "M"	Group "L"
Coupling End	305S	307S	310S
Thrust End	7304PD-DB	7306PD-DB	7308PD-DB

19. Place snap ring (361) in groove in shaft on thrust bearing end. Be sure that groove is clean and that snap ring seats in bottom of groove. Snap ring is flat on one side, tapered on other side. Flat side of ring must be against bearing.

    In the Model 3406 slide oil rings (114) toward bearing to the proper position in the bearing housings. Bolt the bearing housing covers to the bearing housing, making sure that the oil breather fitting (113A) in the bearing cover is up when the double locks of the bearing housing are in the lowermost position. This fitting is used as a pressure release for the bearing housing. It must be in the vertical position or the bearing will not be properly oiled. (Thrust end bearing end cover is not installed until Step No. 22.)

20. Oil shaft extension and slide coupling end bearing end cover (119) with gasket (360) in place, being careful not to injure grease seal (332). Turn end cover so that the small oil cup is in line horizontally with center of shaft when the double lock of the bearing housing are in the lowermost position (see Figs. 21 and 22). This oil cup is used as a pressure relief for the bearing housing. It must be in the horizontal position to facilitate the correct filling of the grease chamber. (Note that the location of this relief fitting is shown at the top in the sectional assembly, Section VI—C (page 16), only to show construction details.) Bolt the bearing end cover securely in place.

    On the Model 3406 — Turn end cover so that oil drain notch is at the bottom when the double locks of the bearing housing are in the lowermost position. This notch permits oil to drain from between the bearing and the end cover, maintaining proper oil circulation.

    On the Model 3416 turn the end cover so that the small oil cup is up when the double locks at the bearing housing are in the lowermost position. Be sure gasket (360) is in place. Bolt bearing end cover to bearing housing.

    Install oil pipe (190) and constant level oiler (251) on the coupling end only. Be sure the oiler rests on cap screw, which projects from casing as shown in Figure 9,

21. Assemble the pump half coupling on Group "S" pumps as follows: Put oil or white lead on shaft extension and in the coupling bore. Insert pump half coupling key in shaft. Place the complete pump half coupling over end of shaft and align key with keyway. Place a solid object, such as a portion of a 2" diameter bar, against the end of the shaft opposite the coupling end and drive coupling half on shaft with a lead mall. Note: — If a bearing puller, similar to that shown in Fig. 19 (page 19) is available, it can be used on thrust bearing end to hold shaft when driving on coupling half. When using the puller for this purpose, draw the puller screw

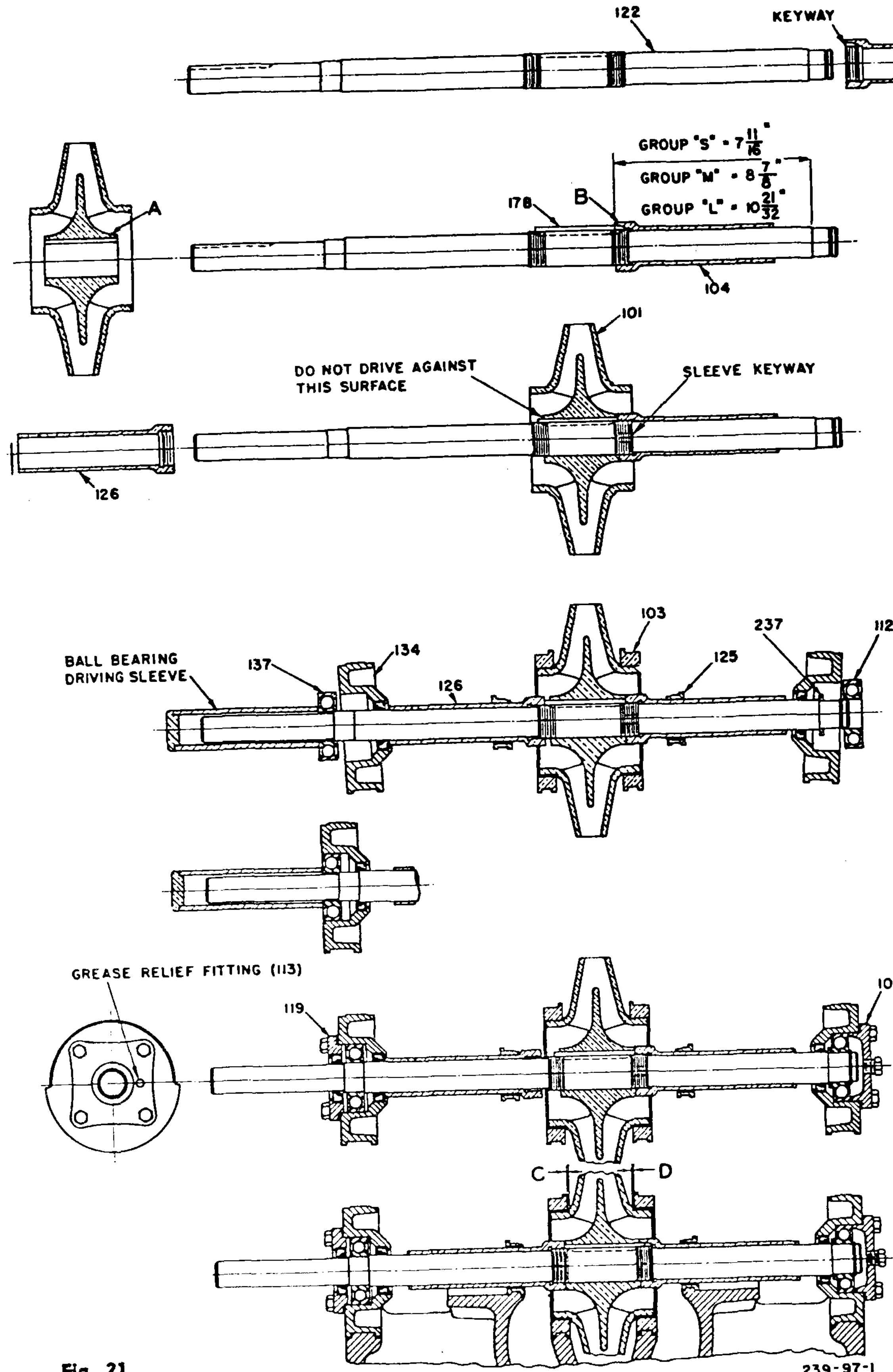
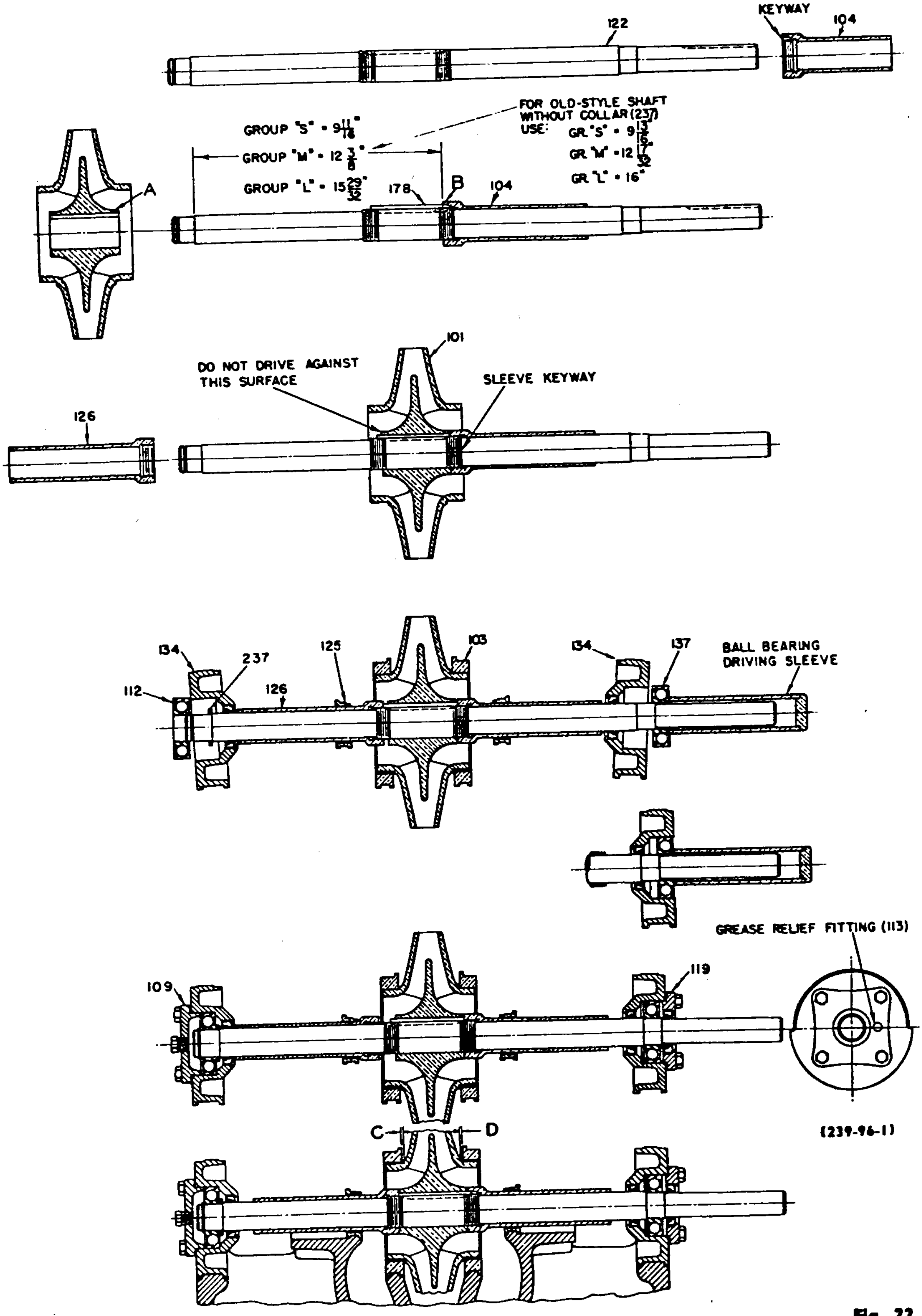


Fig. 21

LEFT HAND PUMP



RIGHT HAND PUMP

Fig. 22

up only finger tight so as not to injure snap ring. Locate the coupling half in the same location on shaft as it was when removed. Never drive the coupling on shafft with the bearing end cover (109) in place as this may injure the ball bearing.

21A. Assemble the pump half coupling on Groups "M" and "L" pumps as follows: Screw a 1/2" stud, approximately 1¼" longer than the length of the coupling hub, into the end of the shaft. Insert the coupling key in shaft. Put oil or white lead on shaft and in the coupling bore. Place the complete pump half coupling in position over the stud and align the key and keyway.

Place washers over the stud against the coupling hub and pull coupling on with a nut placed on the stud. Locate the coupling in the same location on the shaft as it was when removed.

22. Bolt the thrust end bearing end cover (109 or 190A) to the bearing housing. Be sure gasket (360) is in place. On Model 3405 pumps, be sure grease relief fitting is in a horizontal position as indicated in VI—E Step 20. On Model 3406 pumps, be sure oil drain notch is at bottom as indicated in VI—E Step 20A. Install oil pipe (190) and constant level oiler (251) on thrust end. Be sure oiler piping rests on cap screw which projects from casing as shown in Fig. 9, pg. 7.

23. Smooth up and clean casing wearing ring, stuffing box bushing and bearing housing seats in upper and lower half casing. The casing and bearing caps are precision bored so that hand scraping and fitting of the casing wearing rings, stuffing box bushings or bearing housings are not required.

Inspect parting gasket and if torn or otherwise damaged, cut a new gasket of 1/64" sheet asbestos (Johns-Manville service sheet #60 or equivalent). The gasket should be removed while assembling rotating element.

To cut a new gasket, lay the gasket sheet on the upper half casing parting flange, which will serve as a template. Strike the sheet with a ball peen hammer. This will cut the gasket against the edges of the casting, and around the parting stud holes. The gasket must cover the entire surface of the parting flange, especially around the casing wearing ring locks, or internal leakage from high to low pressure zones in the pump may occur.

Lower carefully the entire rotating element into the lower half casing. Be sure that the wearing ring, stuffing box bushing and bearing housing "locks" line up with the recesses in the lower half casing. The single "lock" on each of these parts must be on top so that when the upper half casing and the bearing caps, having only one recess each, are bolted in place, these parts are locked against rotation.

With "locks" properly aligned, the rotating element should settle easily into place. If there is interference, the impeller may have to be tapped along the shaft until it lines up correctly. The sleeves may have to be backed off to do this.

After the element has been properly seated in the lower half casing, tap impeller along shaft until the shoulders on the impeller are in the center of the space between the two casing wearing rings (103). In other words, dimension "C" and "D" — Figs. 21 and 22 (pages 22 and 23) will be equal.

Now tighten shaft sleeve (104) against impeller until the marks which were made previously line up, indicating that the keyways are in line. Check again the distance between the wearing rings and the impeller shoulders. If rubbing occurs, turn the shaft sleeve (104) one complete turn ahead or back as required.

With the locating marks together, tap the key (178) from the opposite end of impeller into the shaft sleeve (104) until the end of the key is flush with the end of the impeller (on end opposite sleeve 104).

Tighten the shaft sleeve (126) securely against the impeller with a spanner or a strap wrench. Tighten set screw in sleeve (126) (if supplied — previous design did not have set screw). Be sure fiber insert is under set screw so that set screw will not burr shaft.

Check the rotating elements for free turning by rotating slowly in one direction and then the other. The casing wearing rings and the stuffing box bushings should be seated in the lower half casing, and should remain stationary when the shaft is rotated. If they ride on the impeller or sleeves, it may indicate that the bearing housings, wearing rings or bushing surfaces in the lower half casing have not been properly cleaned of scale or other foreign matter, or that there is too much eccentricity in the element, due to a bent shaft or other causes. If any of the above are evident, correct the cause and continue to assemble as follows.

26. Replace shims (1/64" thick) over bearing cap studs.

27. Assemble bearing caps (111) and tighten the nuts evenly, being sure that the bearing caps are replaced on the same end from which they were removed.

28. Check again for free turning of the rotating element.

29. Place the parting gasket in position over the studs on the lower half casing with the edges flush with the stuffing box bores and tight against the wearing rings and stuffing box bushings.

30. Be sure that the "locks" on the stuffing box bushing and wearing rings are in their correct position with the single "lock" on top.

Lower carefully the upper half casing, which should settle into position without resistance and then slip the dowel pins in place.

Check the rotating element for free turning and, if no binding is apparent, tighten casing parting nuts alternately on each side of the pump starting from the center. The shaft should turn freely after all nuts are tightened.

31. Repack stuffing boxes and replace gland assemblies as outlined in II—C.

32. Check coupling alignment as outlined in I—C (page 4). If the direction of rotation has been changed, see VI—F.

33. Connect coupling as outlined in I—J (page 6).

34. Grease or oil pump bearings as outlined in VI—A (page 15).

35. Connect auxiliary piping, if used.

36. Follow directions in Section III for initial operating condition and for starting pump.

VI—F. CHANGING ROTATION OF PUMP IN FIELD.

The rotation of these pumps can be changed without using additional parts. The following steps should be followed:

1. Disassemble pump as outlined in VI—D (page 18).
2. Loosen dowel pins, if used, in pump feet and remove hold-down bolts. Lift lower half casing from bedplate.
3. Turn lower half casing 180° so that suction and discharge flanges are reversed from previous position or turn bedplate 180° and leave pump casing in original position. See Fig. 22 (page 23), showing right and left hand pump.
4. Replace lower half casing in this new position on bedplate and bolt in place. Do not dowel.
5. Reassemble pump as outlined in VI—E (page 19).
6. Be sure that pump bearings are greased. See Section VI—A (page 15).
7. Check alignment as outlined in Section I—C (pg. 4).
8. Connect coupling as shown in Section I—J (page 6).
9. Follow directions in Section III (page 10), for initial operating conditions and for starting pump.

VI—G. OVERHAUL OF PUMP.

The pump should be opened and the interior inspected for wear and excessive clearances approximately once each year. The period, however, may vary, depending on operating conditions and severity of service. See Section VI—D (page 18) for disassembly and Section VI—E (page 19), for reassembly of pump.

The following items should be checked:

1. Wearing Ring Clearance:

The original diametric clearance between the wearing rings and the impeller is .010″ to .014″.

The following is suggested as guide for allowable wear of wearing rings before replacement for 6″ pump and smaller:

(a) Pumps of 50 feet or less T.D.H. (total dynamic head) — .030″ to .035″ total diametric clearance.

(b) Pumps of between 51 and 100 feet T.D.H. — .025″ to .030″ total diametric clearance.

(c) Pumps of more than 100 feet T.D.H. — .020″ to .025″ total diametric clearance.

For 8″ pumps or larger, the following is suggested:

(a) Pumps of 50 feet or less T.D.H. — .045″ to .050″ total diametric clearance.

(b) Pumps of between 51 and 100 feet T.D.H. — .035″ to .040″ total diametric clearance.

(c) Pumps of more than 100 feet T.D.H. — .025″ to .030″ total diametric clearance.

2. **Fit of Impeller on Shaft:**

These parts are machined for a push fit. (The shaft is made .000″ to .0015″ smaller than the impeller hub bore) and the impeller should tap easily on the shaft. If the impeller does not tap on readily, the bore and shaft should be inspected to see that they are free from foreign matter or burrs. The fit of the key in the keyways should also be checked to see that it is not causing binding. The key should have a sliding fit on the sides and should have .004″ to .016″ clearance at the top.

3. Clearance Between Shaft Sleeve (104 or 126) and Stuffing Box Bushing (125):

The original diametric clearance is .008″ to .012″. If this clearance has increased to more than .030″, the shaft sleeve, and at times, the stuffing box bushing should be replaced.

4. Condition of Shaft Sleeves:

If the outer surface of the shaft sleeve at the packing area is deeply grooved, the sleeve should be replacd.

5. Condition of Shaft:

Check shaft for straightness. If bent, it should be straightened. If otherwise damaged, it should be replaced.

6. Condition of Impeller:

Check the impeller and replace if any of the following conditions exist:

(a) Excessive erosion, especially on the inlet of vanes.

(b) Excessive wear on wearing ring surface.

7. Condition of Ball Bearings:

If the bearings are worn or damaged so that they have become loose or are noisy or rough when rotated they should be replaced.

VI—H. EMERGENCY BALL BEARING REPLACEMENT.

If the thrust end ball bearing (112) has become worn and needs replacing and it is not desirable to overhaul the entire pump, the bearing can be replaced as follows:

Note — This cannot be done on the coupling end unless the pump or the driver is removed from the bedplate.

1. On Model 3406 pumps, remove oil pipe (190) and constant level oiler from thrust end bearing housing (134A). Drain oil from housing.

2. Remove thrust bearing end cover (109 or 109A).
3. Remove snap ring (361).
4. Remove bearing cap (111).
5. Rotate bearing housing (134, 134A, or 166) 180° so that the two locks are on the top.
6. Remove ball bearing as directed in VI—D 12 through 14 (pages 18 and 19).
7. Thoroughly flush bearing housing, bearing end cover, snap ring, ball bearing collar, and end of shaft with clean kerosene. The slightest trace of dirt or grit may drastically reduce the life of a ball bearing. Examine the ball bearing collar. If the edges of the collar are rounded over, or if the collar is otherwise damaged, replace the collar.

   Examine the shoulder on the shaft against which the ball bearing collar bears. Shoulder must be square, and not rounded over.
8. Assemble new ball bearing as follows:

   (a) Wipe a small amount of grease on the grease seal lips in the bearing housing.

   (b) Place bearing housing on shaft, with the double locks up, and slide it along to approximately its correct location.

   (c) Slide ball bearing collar (237) over shaft end and push up to shaft shoulder.

   (d) Apply a film of oil to the bearing seat on the shaft. Start bearing "square" and tap on shaft up to the shaft shoulder. Use a driving sleeve as shown in Figs. 21 and 22.

   (e) Place snap ring (361) in shaft groove. Be sure that the groove is clean and that the snap ring seats properly.

   (f) Bolt bearing end cover (109 or 109A) to bearing housing. Be sure gasket (360) is in place. Position end cover as directed in Section VI—E Step 20 so that grease relief fitting or oil drain notch is in correct location.

   (g) Align locks on bearing end cover with the grooves in lower half casing and rotate bearing end cover 180° so that the locks are at the bottom.

   (h) Assemble bearing cap (111) being sure that the 1/64" shims are in place, and that the prick punch marks on the cap and the casing are on the same side. Now tighten the nuts evenly.

   (i) Refill with grease or oil as outlined in VI—A (page 15).

VI—I. SPARE PARTS.

To insure against possible long and costly "downtime" periods, especially on critical services, it is advisable to have spare parts on hand.

1. The most desirable parts to have on hand are the following:

   (a) "Rotating element." This is a group of assembled parts, including bearing housings, bearings, bearing end covers, grease seals, wearing rings, stuffing box bushings and all rotating parts, except coupling.

   (b) Stuffing box packing (106) — one set for two stuffing boxes.

   (c) Stuffing box gland packing (210) — one set for four gland halves.

   (d) Stuffing box gland halves (107) — four required.

   With these parts on hand, pump can be easily and quickly reconditioned by replacing the worn parts.
2. An alternate, though not as desirable as that stated above, is to have on hand parts that are most likely to wear and which can be used as needed.

   Following is a list of these suggested parts:

   (a) Stuffing box packing (106) — one set for two stuffing boxes.

   (b) Stuffing box gland packing (210) one set for four gland halves.

   (c) Shaft sleeve (104 and 126) — one each.

   (d) Ball bearings (112 and 137) — two required (both bearings being the same).

   (e) Snap ring (361) — one required.

   (f) Wearing rings (103) — two required; or (127 and 142 — two of each.

   (g) Shaft (122) — one required.

   (h) Impeller key (178) — one required.

   (i) Stuffing box bushings (125) — two required.

   (j) Stuffing box gland halves (107) — four required.

   (k) Ball bearing collar (237) — one required.
3. If it is not convenient or desirable to carrry the spare parts listed in items 1 or 2, the following list is suggested as a minimum for servicing the pump under ordinary conditions of wear:

   (a) Stuffing box packing (106) — one set for two stuffing boxes.

   (b) Stuffing box gland packing (210) — one set for four gland halves.

   (c) Shaft sleeves (104 and 126) — one each.

   (d) Ball bearings (112 and 137) — two required (both bearings being the same).

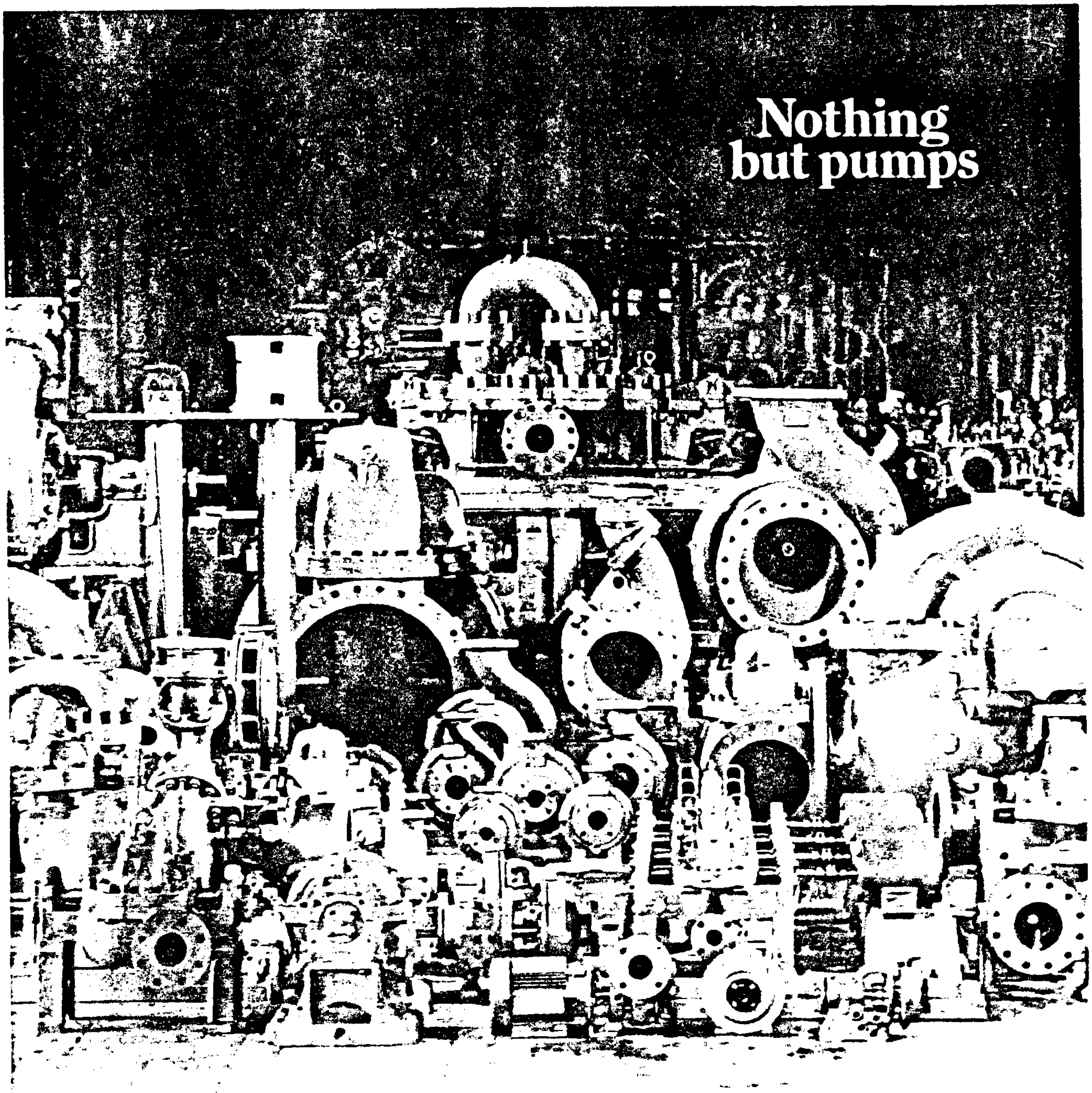
   (e) Snap rings (361) — one required.

   (f) Ball bearing collar (237) — one required.

VI—J. INSTRUCTIONS FOR ORDERING SPARE PARTS.

Repair orders will be handled with the minimum of delay if the following directions are followed:

1. Give the Model No., size of the pump and serial number. These can all be obtained from the name plate.
2. Write plainly the names, part numbers and material of the parts required. These names and numbers should agree with those on the sectional assembly (Section VI—C) (page 16).
3. Give the number of parts required.
4. Give complete shipping instructions.



Branch Sales Offices

*Atlanta—Atlanta GA (404) 455-4800
Baltimore—Hunt Valley MD (301) 666 7900
Baton Rouge—Baton Rouge LA (504) 827-3870
Beaumont—Beaumont TX (713) 832-3447
Birmingham—Birmingham AL (205) 939-0533
Boston—Wellesley Hills MA (617) 235-3636
Buffalo—Cheektowaga NY (716) 634-3114
Charleston—St. Albans WV (304) 722-4241
Charlotte—Charlotte NC (704) 527-2177
*Chicago—Lisle IL (312) 960-3400
Cincinnati—Cincinnati OH (513) 731-4862
Cleveland—Westlake OH (216) 835-2350
Dallas—Richardson TX (214) 234 3868
Denver—Englewood CO (303) 761-4984
Detroit—Southfield MI (313) 557-4070
*Houston—Houston TX (713) 785-8880
Jacksonville—Jacksonville FL (904) 396-3530
Kansas City—Kansas City MO (816) 942-4450
Los Angeles—Whittier CA (213) 692-4801
Memphis—Memphis TN (901) 767-2380
Mobile—Mobile AL (205) 342-0868
Monroe—Monroe LA (318) 387-0864
*New York—Fairfield NJ (201) 575-1222
Philadelphia—Bala Cynwyd PA (215) 667-4870
Pittsburgh—Pittsburgh PA (412) 922-9180
*Portland—Beaverton OR (503) 644 7867
Seattle—Lynnwood WA (206) 775-4247
St. Louis—St. Louis MO (314) 821-4050
San Francisco—Lafayette CA (415) 283-6144
Tampa—Tampa FL (813) 885-7351
Tulsa—Tulsa OK (918) 622 2400
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International Sales Offices

Goulds Pumps, Inc.—Headquarters Seneca Falls NY (315) 568 2811 (TLX 93 7280)
Goulds Pumps Southeast Asia Office—Singapore Republic of Singapore 236-5715 (TLX 26126)
Goulds Pumps European Office—Luzerne Switzerland (041) 23-12-35 (TLX 72-482)
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Manufacturing Plants

Engineered Products Division—Seneca Falls NY (315) 568-2811 (TLX 93-7280)
Vertical Pump Division—City of Industry California (213) 692-0211 (TLX 67-0458)
Texas Division—Lubbock Texas (806) 763-2381 (TLX 744411)
Bombas Goulds de Mexico, S.A. de C.V.—Mexico City Mexico 593-6730
Goulds Bombas e Equipamentos LTDA—Sao Paulo S.P. Brazil (11) 483-2911 (TLX 68239)
Goulds Pumps (Phil.) Inc.—Manila Philippines 85-74-71 (TLX 3663)
Goulds Pumps Europe AG—Zofingen Switzerland (41-62) 52-19 91 (TLX 68-246)

Manufacturing Licensees

Allen Gwynnes Pumps LTD—Bedford England 67400 (TLX 82486)
Belort Canada Ltee Ltd—Goulds Pumps Division—Pointe Claire Quebec Canada (514) 695-8520 (TLX 05-821528)
Goulds-Hidraven, Hidraven Commercial C.A.—Caracas Venezuela 36-33-06 (TLX 25349)
Goulds D-P, Drakos Polemis Pumps Manufacturers Inc.—Athens Greece (30-1) 80-34-411 (TLX 2126929)
Celtic Engineering Co. Ltd—Dublin Ireland (353-1) 47-081 (TLX 4315)
Miguel Schmid & Cia. S.R.L.—Buenos Aires Argentina 67-7319

Pump Service Facility

Goulds-Lecourtenay Division—Newark NJ (201) 589-2805 (TLX 138655)

Corporate Headquarters

Goulds Pumps, Inc.—Seneca Falls NY (315) 568-2811 (TLX 93 7280)

*Servicing Warehouse

GOULDS PUMPS, INC. SENECA FALLS, NEW YORK 13148

1.2.7 Primary and Secondary Fire Water Pumps

1.2.7.1 Identification

Tag Number	Description
P705	Primary Electric Fire Pump and Controller with controller pressure switch tag number PS 1511
P706	Secondary Diesel Fire Pump and Controller with controller pressure switch tag number PS1502

1.2.7.2 Description

1.2.7.2.1 Primary Electric Fire Pump and Controller (P705)

Pump

Manufacturer:	Aurora Pump 800 Airport Road North Aurora, Illinois 60542
Part Number:	Model 5-481-17

Motor

Manufacturer:	U.S. Electrical Motors Old Gate Lane Milford, Conn. 06460
Part Number:	See Aurora Pump model 5-481-17

Controller (with pressure switch tag number PS1511)

Manufacturer:	Metron Instruments, Inc. 1051 So. Platte River Drive Denver, Colorado 80223
Part Number:	Model M300

1.2.7.2.2 Secondary Diesel Fire Pump and Controller (P706)

Pump

Manufacturer:	Aurora Pump 800 Airport Road North Aurora, Illinois 06542
Part Number:	Model F14TM

Engine

Manufacturer:	Cummins Engine Co. Columbus, Indiana 47201
Part Number:	Model V-378-F2

Controller (with pressure switch tag number PS 1502)

Manufacturer:	Metron Instruments, Inc. 1051 So. Platte River Drive Denver, Colorado 80223
Part Number:	Model FD2

1.2.7.3 Vendor

McLemore Pump & Equipment Co.
4895 Joliet St.
Denver, CO 80239

1.2.7.4 Procurement Specification

Stearns-Roger Specification Number D46.8
(DOE Specification Number 40M700-14S)

1.2.7.5 Piping Connections

P705	See construction package 9, dwg no. 40P7005133155, sht. P6-1
P706	See construction package 9, dwg no. 40P7005133246, sht. P6-2

1.2.7.6 Operation/Maintenance

P705	See attached Aurora Pump Manual, 912 section with motor, accessories, and controller data included.
P706	See attached Aurora Pump Manual, 915 section with engine, accessories, and controller data included.

GS **AURORA PUMP**
A UNIT OF GENERAL SIGNAL

	FOR APPROVAL
X	FINAL

SALES OFFICE: McLEMORE PUMP & EQUIPMENT CO. **PO #** A01-104.5.86

FACTORY ORDER NUMBER: 4G0-65706,4D0-65707,& 4A0-7434

JOB: SOLAR-ONE PILOT PLANT

SERVICE: 2-FIRE PUMPS, 1-JOCKEY PUMP

ENGINEER: STEARNS-ROGER ENGINEERING CORP.

CONTRACTOR: STEARNS-ROGER ENGINEERING CORP.

SOLD TO: TOWNSEND & BOTTOM, INC. **PO #** 2001-C21700

REFERENCE: PROJECT NO. C21700

912 SECTION
SPLIT CASE FIRE PUMP
ELECTRIC DRIVE

TABLE OF CONTENTS
MOTOR-DRIVEN
SPLIT-CASE FIRE PUMP

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA ILLINOIS · 60542

NO. OF PRINTS	
	FOR APPROVAL
8	FINAL

4 REPROS

SALES OFFICE: McLEMORE PUMP & EQUIPMENT CO PO# A01-104
FACTORY ORDER NUMBER: 4DO-65707
JOB: SOLAR-ONE PILOT PLANT
SERVICE: MOTOR-DRIVEN FIRE PUMP
ENGINEER: STEARNS-ROGER ENGINEERING CORP.
CONTRACTOR: STEARNS-ROGER ENGINEERING CORP.
SOLD TO: TOWNSEND & BOTTOM, INC. PO# 2001-C21700
REFERENCE: PROJECT No C21700

PUMP

ONE NUMBER OF UNITS 5-481-17 SIZE 481 MODEL 4 POWER SERIES PUMP ONLY ☐
1,000 GPM 290' TDH 1770 RPM ROTATION: RH ☐ LH ☒

BASE:
☒ STEEL DRIP RIM
☐ STEEL
☐ FABRICATED STEEL
☐ CAST IRON RING TYPE

CONSTRUCTION:
☒ STANDARD FITTED
☐ ______
CASE CI
IMP. BRZ
SHAFT STL
SLEEVE BRZ
CASE RING BRZ
IMP. RING ____

COUPLING:
☒ STANDARD
☐ SPACER
☒ GUARD

STUFFING BOX:
☐ MECHANICAL SEAL
☐ STANDARD
☐ ______
☒ PACKING
☒ LANTERN RING

CONNECTIONS
☐ THREADED
☒ FLANGE
☒ 125 #
☐ 250 #
☐ ______

LUBRICATION
☒ GREASE
☐ OIL

MOTOR

150 HP. 3 PHASE 60 HERTZ 460 VOLTS 1770 RPM 444TS FRAME

BY: ☒ AURORA ☐ OTHERS
☒ ODP ☐ TEFC ☐ XPROOF
☐ VERTICAL ☒ HORIZONTAL ☐ PART WINDING
U.S. MOTORS
MANUFACTURER

NOTE: MOTOR NOT MOUNTED AT FACTORY ON VERTICAL UNITS.

SPECIAL REQUIREMENTS

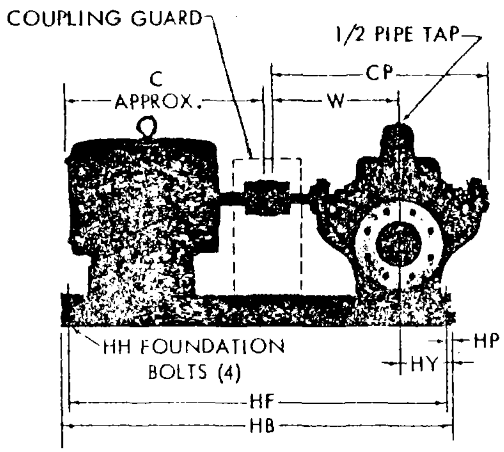
PUMP: CERTIFIED PERFORMANCE TEST; NPSH TEST; FLOW METERING SYSTEM; ACCESSORIES PER ATTACHED SHEETS
DRIVE: ______
ELECTRICAL: METRON FIRE PUMP CONTROLLER PER ATTACHED SHEETS.

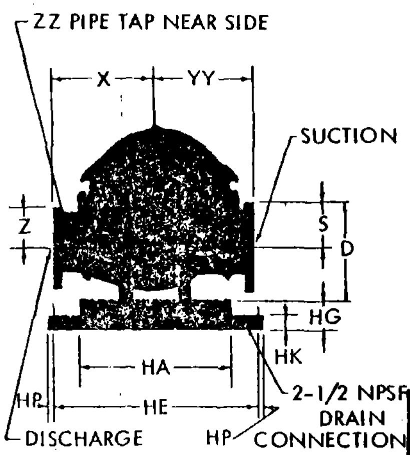
CERTIFIED PRINT: SECTION: 912 PAGE: 302 CURVE NUMBER: 27PC-119726
SPECIAL: ______ MAINTENANCE: ______
REVISED 12-10-80 WJW
BY: WJW DATE: 6/27/80 OFFICE: AURORA

THIS ORDER WILL NOT BE PROCESSED FOR MANUFACTURING UNTIL APPROVAL IS RECEIVED.
PRINTS ARE NOT TO SCALE AND ARE CERTIFIED CORRECT ONLY FOR THIS ORDE[illegible]L
ORDERS SUBJECT TO ACCEPTANCE AT AURORA PUMP, NORTH AURORA, ILLINOIS.

THIS ORDER CAN BE RELEASED FOR MANUFACTURING AS SHOWN: ☐ AUTHORITY: ______
RELEASE FOR MANUFACTURING PER ATTACHED CHANGE ORDER: ☐ OFFICE: ______
DATE: ______

40130 (9-77)





BASE	SIZE	HA	HB	HE	HF	HG	HH	HK	HP
5	11x36	11	36-1/2	15-7/8	35-1/8	3	1/2	1-1/2	11/16
6	11x42	11	42-1/2	15-7/8	41-1/8	3	1/2	1-1/2	11/16
8	14x42	14	42-1/2	19	41	3	5/8	1-1/2	3/4
9	14x48	14	48-1/2	19	47	3	5/8	1-1/2	3/4
10	14x56	14	56-1/2	19	55	3	5/8	1-1/2	3/4
11	18x46	18	46-1/2	25-1/8	44-7/8	4	3/4	2	13/16
12	18x54	18	54-1/2	25-1/8	52-7/8	4	3/4	2	13/16
15	22x54	22	54-1/2	29-1/8	52-7/8	4-1/2	3/4	2	13/16
16	22x64	22	64-1/2	29-1/8	62-7/8	4-1/2	3/4	2	13/16
17	22x74	22	74-1/2	29-1/8	72-7/8	4-1/2	3/4	2	13/16
20	26x90	26	90-1/2	33-1/8	88-7/8	4-1/2	3/4	2	13/16

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

LEFT HAND PUMP

NOTES:
1. All dimensions in inches.
2. Dimensions may vary ± 3/8.
3. Not for construction purposes unless certified.
4. Coupling gap may vary 1/8" to 1".
5. Conduit box is shown in approximate location. Dimensions are not specified as they vary with each motor manufacturer.
6. Discharge and Suction flange - American Standard flat face.
7. Three grout holes are provided in top of base.

† D is 10-1/2" when using frames 324TS - 365TS.
* D is 12 when using frames 404TS - 445TS.

DISCH ☐ 125# FLANGE UP TO 175 PSI ☐ 250# FLANGE OVER 175 PSI

PUMP SIZE DISCH	MODEL	CASE BORE	SUCTION	POWER SERIES	D	S	W	X	Z	CP	HY	YY	ZZ
3	481	10	4	2	9†	1-1/2	13-1/2	10	4-1/2	24	5-1/2	11	3/4
4	481	11	5	3	10	5	14-1/2	11-1/4	5	26	6-1/2	12-3/4	
4	481	15	5	3	11	5-1/2	14-1/2	13	5-1/2	26	6-1/2	14	
5	481	11	6	4	11*	5-1/2	16	11-1/4	5-1/2	28-1/2	6-1/2	13-1/4	
5	481	15	6	4	12-1/2	6-1/4	16	13-1/4	6-1/4	28-1/2	6-1/2	15	
	481	17	6	4	12-1/2	6-1/4	16	14	6-1/4	28-1/2	6-1/2	15	
	481	[illegible]	[illegible]	4	12-1/2	6-1/4	16	11-3/4	6-1/4	28-1/2	6-1/2	14-1/2	1-1/4
6	481	15	8	5	13-1/2	6-3/4	18	14-1/4	6-3/4	32	7-1/2	16-3/4	
6	481	18	8	5	14-3/4	8	18	16	8	32	7-1/2	18	
	481	20	8	5	[illegible]	8	18	15-3/4	8	32	7-1/2	18	
8	481	12	10	5	[illegible]	8	18	17	9	32	7-1/2	17-3/4	
8	481	15	10	5	[illegible]	8	18	17	9	32	7-1/2	17-3/4	
8	481	17	10	5	[illegible]	8	18	17	8	32	7-1/2	17-3/4	
10	481	18	12	6H	[illegible]	13-1/2	21-7/8	18	13-1/2	38	11-1/2	22	2

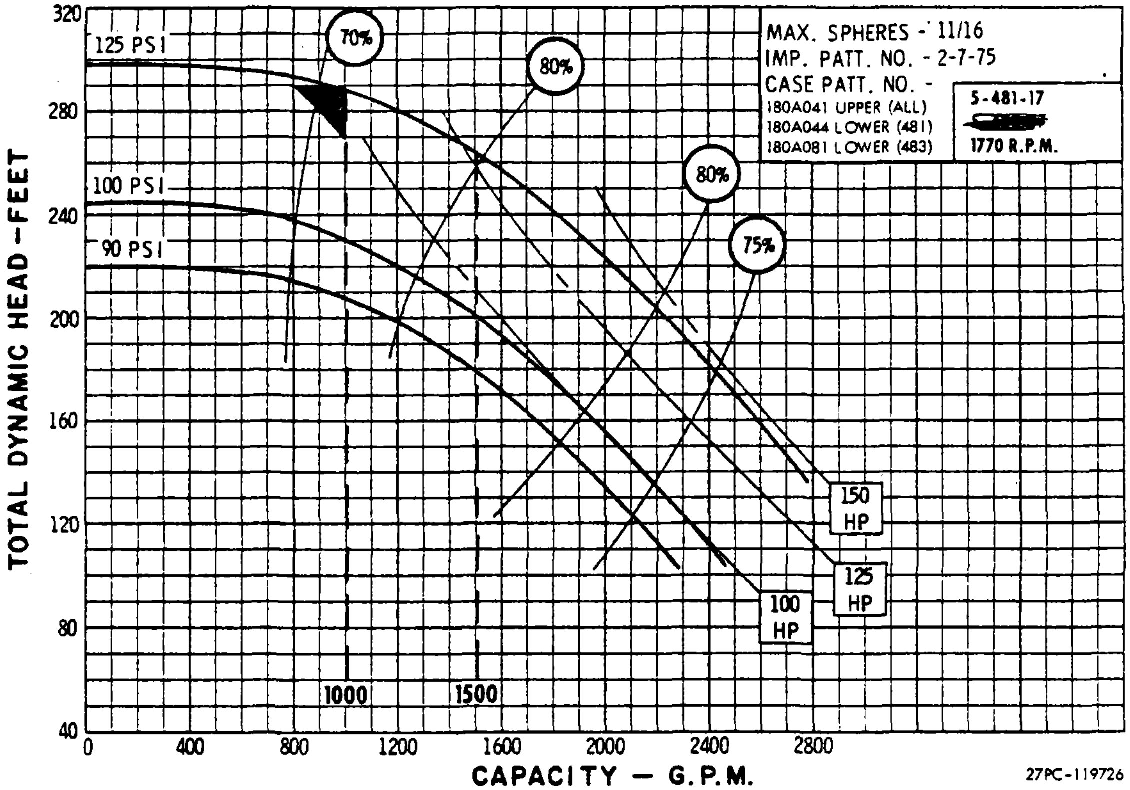
MOTOR FRAME	215 T	254 T	256 T	284 TS	284 T	286 TS	286 T	324 TS	324 T	326 TS	326 T	364 TS	364 T	365 TS	365 T	404 TS	404 T	405 TS	405 T	444 TS	444 T	446 TS	445 T	505 US	508 US	447 TS	447 T
C APPROX.	18	21	23	22	24	24	25	25	26	26	28	29	29	28	30	30	33	32	35	34	38	36	40	38-1/2	40-1/2	38-9/16	43-5/16
BASE (3-481-10)	5	8	8	8	8	8	8	11	11	11	11	11	11	11													
BASE (4-481-11)	8	8	8	8	9	9	9	11	11	11	12	11	12	12	12	15	15	15									
BASE (4-481-15)		8	8	8	9	9	9	11	11	11	12	11	12	12	12	15											
BASE (5-481-11)	6	8	9	9	9	9	9	12	12	12	12	12	12	12	12	15	15	15	16	16	16	16					
BASE (5-481-15)		8	9	9	9	9	9	12	12	12	12	12	12	12	12	15	15										
BASE (481-17)				9	9	9	9	12	12	12	12	12	12	12	12	15	15	15	16	16	16						
BASE (481-[illegible])	6	8	9	9	9	9	9	12	12	12	12																
BASE (6-481-15)			9	9	9	10	10	12	12	12	12	12	12	12	12	15	16	16	16	16	16						
BASE (6-481-18)									12	12	12	12	12	12	12	15	16	16	16	16	16	16	17				
BASE (481-20)											12	12	12	12	12	15	16	16	16	16	16	16	17				
BASE (8-481-12)		9	9	9	9	10	10	12	12	12	12	12	12														
BASE (8-481-15)			9	9	9	10	10	12	12	12	12	12	12	12	12	15	16	16	16	16	16						
BASE (8-481-17)											12	12	12	12	12	15	16	16	16	16	16	16	17				
BASE (10-481-18)																								20	20	20	20

1.2.7-7

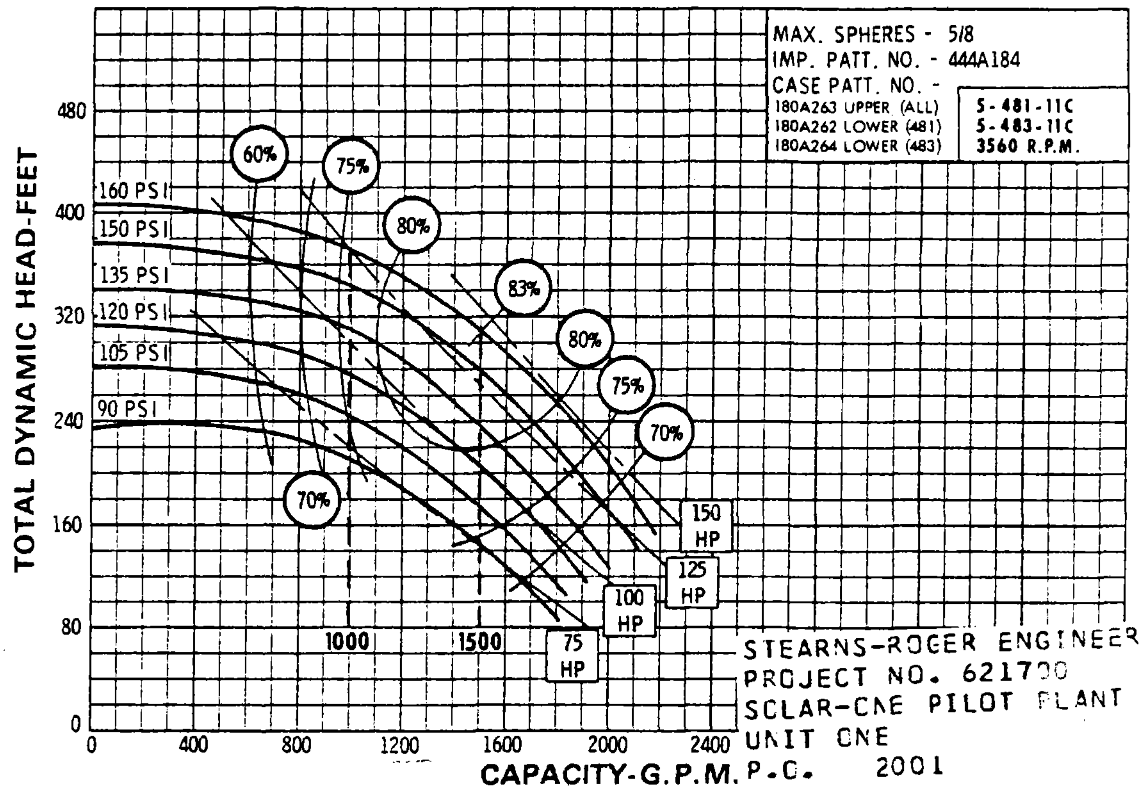
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD • NORTH AURORA, ILLINOIS • 60542

1000 G.P.M. FIRE PUMP
ELECTRIC MOTOR DRIVE

90 TO 125 P.S.I



90 TO 160 P.S.I



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

SECTION 6 ITEM 411
DATED JULY 1980
SUPERSEDES ITEM 411
DATED JANUARY 1973

AURORA® PUMPS

INSTRUCTION MANUAL
REPAIR
MODEL 411 & 481

6

SERVICE

Your Aurora pump requires no maintenance other than periodic inspection, lubrication and occasional cleaning. The intent of inspection is to prevent breakdown, thus obtaining optimum service life.

LUBRICATION OF BEARINGS

Model 411 pump is available with two options for lubricating the shaft bearings. They are:

1. Regreasable (standard)
2. Oil Lubrication

Regreasable bearings will require periodic lubrication and can be accomplished by using the zerk or lubrication fittings in the bearing cartridge. Lubricate the bearings at regular intervals using a grease of high quality. Lithium, lithium soda or calcium base grease is recommended as lubricants for pumps operating in both wet and dry locations. Mixing of different brands of grease should be avoided due to possible chemical reactions between the brands which could damage the bearings. Accordingly, avoid grease of vegetable or animal base which can develop acids, as well as grease containing rosin, graphite, talc and other impurities. Under no circumstances should grease be reused.

Over lubrication should be avoided as it may result in overheating and possible bearing failure. Under normal application, adequate lubrication is assured if the amount of grease is maintained at 1/3 to 1/2 the capacity of the bearing and adjacent space surrounding it.

In dry locations, each bearing will need lubrication at least every 4,000 hours of running time or every 6 to 12 months, whichever is more frequent. In wet locations the bearings should be lubricated at least after every 2,000 hours of running time or every 4 to 6 months, whichever is more frequent. A unit is considered to be installed in a wet location if the pump and motor are exposed to dripping water, to the weather, or to heavy condensation such as is found in unheated and poorly ventilated underground locations.

Oil lubricated bearings are optional on all Model 411 pumps. A fixed oil level is maintained within the bearing cartridge by an oiler which allows visual indications of reserve oil.

At initial installation and before starting a unit that has been shut down for repairs or for any extended length of time, run enough 10/20 weight motor oil through the oiler to maintain a constant oil level to insure that the bearing will never be without an oil supply. Oil will have to be added at intervals to maintain a constant level in the oiler. This interval can only be determined by experience.

Under working conditions, oil will breakdown and need to be replaced at regular intervals. The length of these intervals will depend on many factors. Under normal operation, in clean and dry locations, the oil should be changed about once a year. However, when the pump is exposed to dirt contamination, high temperatures (200° F. or above) or a wet location, the oil may have to be changed every 2 or 3 months.

At times it may be necessary to clean the bearings due to accumulated dirt or deteriorated lubricants. This can be accomplished by flushing the bearing with a light oil heated to 180 to 200° F. while rotating it on a spindle. Wipe the bearing housing with a clean rag soaked in a cleaning solvent, and flush all surfaces.

Dry bearing thoroughly before relubricating. Compressed air can be used to speed drying, but care should be taken not to let bearings rotate while being dried.

CAUTION

Use normal fire caution procedures when using any petroleum cleaner.

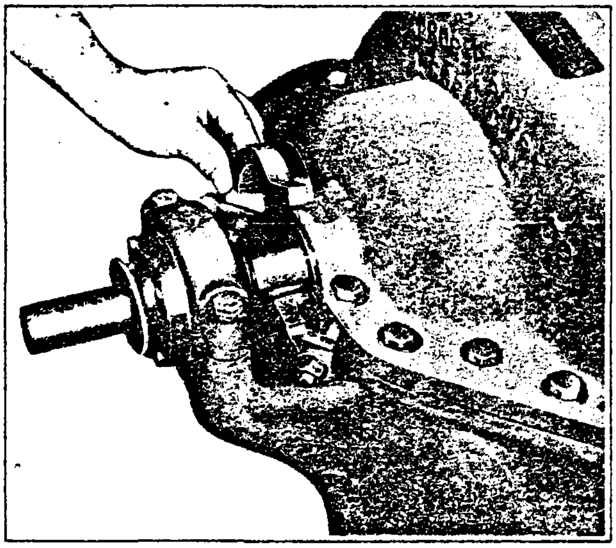
The motor which drives your Aurora pump may or may not require lubrication. Consult the manufacturer's recommendations for proper maintenance instructions.

REPAIRS

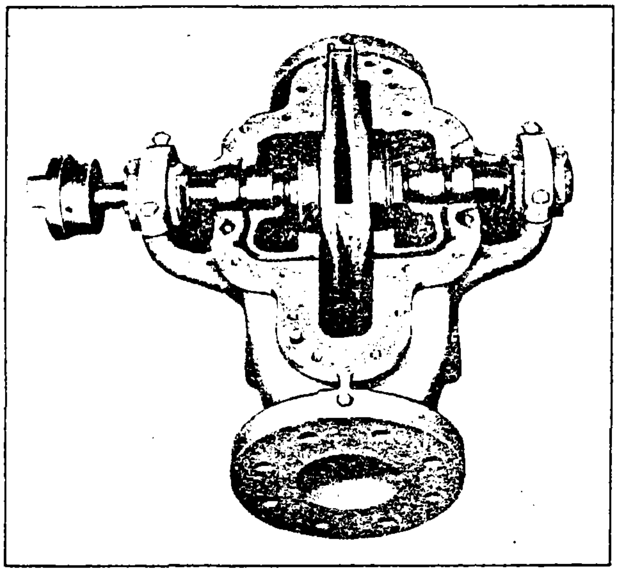
The pump may be disassembled using the illustrations and text provided. Although complete disassembly is covered, it will seldom be necessary to completely disassemble your Aurora pump.

The illustrations accompanying the disassembly instructions show the pump at various stages of disassembly. The illustrations are intended to aid in the correct identification of the parts mentioned in the text.

Inspect removed parts at disassembly to determine their reusability. Cracked castings should never be reused. All packing and gaskets should be replaced with new ones at reassembly simply as a matter of economy; they are much less expensive to replace routinely than to replace as the need occurs. In general it is economical to return to the manufacturer for repair only the motor and motor controller.



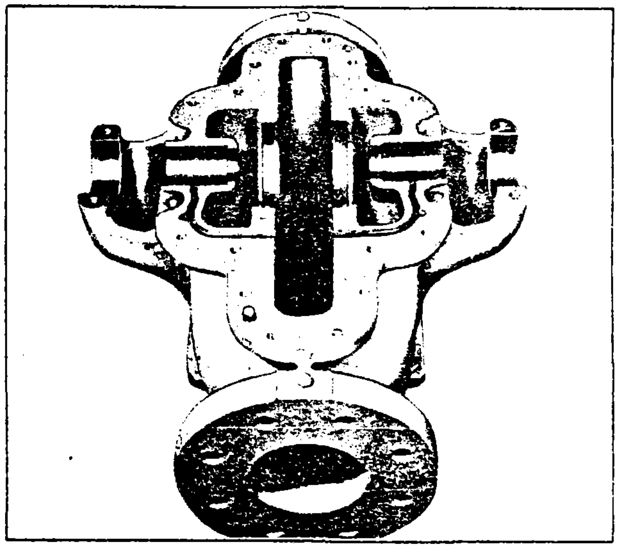
A. Removing upper packing gland.



B. Pump assembly with upper casing, packing glands, and swing bolts removed.

Disassembly of the Pump. Disassemble only what is needed to make repairs or accomplish inspection. Proceed to disassemble the pump as follows: (See Figure 4.)

1. Break electrical connection to motor or take similar steps to make certain drive unit will not be unintentionally energized during disassembly.



C. Lower pump casing.

2. Close such valves or flow-control devices necessary to make certain flow of liquid will not take place during disassembly.

NOTE

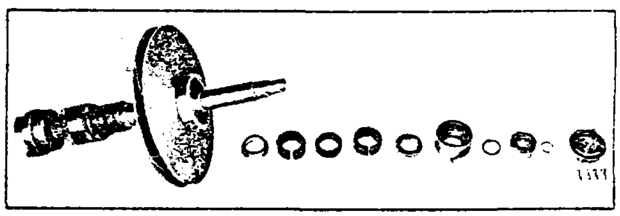
Discharge and suction piping need not be disturbed unless complete pump assembly is to be removed.

3. Drain liquid from pump by removing plugs (1 and 2). Disconnect by-pass lines if applicable.

4. Loosen and remove capscrews (6) securing upper casing (8) to remainder of pump assembly.

NOTE

If pump being disassembled is a size 4 x 5 x 11 or larger, remove capscrew (7) also before attempting to separate upper casing.



D. Inboard rotating element components removed illustrating disassembly order.

5. Make certain all securing capscrews are removed, then carefully remove upper casing (8) using hoist or crane with sling attached to cast hooks.

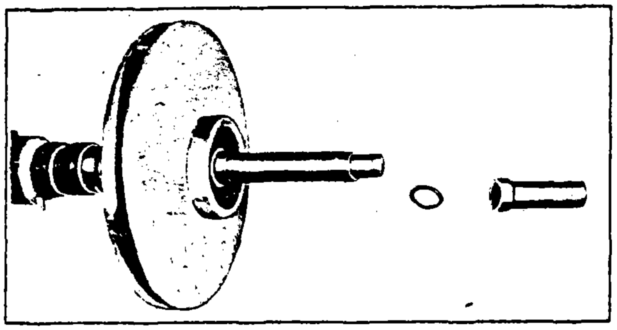
6. Remove gasket (9) and scrape mating surfaces of casing halves to remove pieces of gasket which may have adhered in separation. Take care not to scratch or mar mating surfaces.

7. Loosen setscrews in flexible coupling and slide the halves apart.

8. Remove four capscrews (25) securing two bearing caps (26). Lift off bearing caps (26) and pins (27). Mark caps to insure correct replacement and orientation on the respective bearing arms.

9. Loosen and remove four nuts (18), washers (19), clamps (20); securing split halves of packing glands (21). Remove four swing bolts (22).

10. Assuming that further work is required on the shaft and impeller assembly, use properly secured rope slings and hoist or crane as required to lift it from lower pump casing (69) and place it on suitable bench or work surface.



E. Sleeve and thrust washer removed.

CAUTION

Take care not to dent or damage impeller and/or other parts. Use of a supporting cradle or work stand is recommended.

NOTE

Disassembly procedure from this point covers pumps having standard packing. If pump has mechanical seals, refer to specific instructions.

11. Remove and discard rings of packing (23). Replacement with new packing is recommended whenever pump is disassembled.

12. Slide pump half of flexible coupling off shaft (65) remove key (24). Pry up on end of key so as not to damage shaft. If preferred, the key may be removed by carefully tapping from outer end with a brass drift or similar non-marring tool, using a small hammer.

13. Remove casing wearing rings (28).

14. If pump is grease lubricated remove zerks (10) and pipe plugs (12) from cartridge caps (32 and 42). If pump has the oil lubrication option remove breather cap from top of cartridge caps and remove close nipples from bottom of cartridge caps. The remaining oil cups, street elbows and nipples are loose at this point and can be removed as an assembly.

15. Loosen and remove four capscrews (31) from cartridge cap (32). The outboard shaft end protector (29) may be removed from its recess in outboard cartridge cap at this time if necessary.

NOTE

If the unit has a tandem shaft, protector (29) is not used. Remove slinger and capscrews (31). Slide cartridge cap (32) and grease seal off shaft. Press grease seal out of cartridge cap if it is necessary to replace this seal. Remove retainer ring (35) with a pair of Truarc pliers. Also remove gasket (34).

16. Outboard bearing (38) is press-fitted onto shaft (65). To remove it place a puller on bearing cartridge (36) and pull cartridge, grease seal (37), and bearing from the shaft. The grease seal can be pressed from the bearing cartridge if it needs replacing. On 6B and 7 Power Frames remove snap ring on inboard side of bearing. Then slide slinger (39), lantern ring (52), bushing (56) off shaft.

17. Removal of inboard bearing is basically the same as for outboard bearing. Remove capscrews (41), slide slingers (40), cartridge cap (42), grease seal (43) and gasket (44) off shaft.

18. Pull or press off bearing cartridge (45), grease seal (46), and bearing (47). Remove slinger (48), lantern ring (52), and bushing (56) from shaft.

19. If unit has right-hand rotation, unscrew and remove outboard sleeve (57) first. Remove gasket (58). If unit has left-hand rotation unscrew and remove inboard sleeve (64) first. Remove gasket (62).

20. Key (63) holds impeller (59) and sleeve (64) if unit is right-hand or sleeve (57) for left-hand unit. These parts can be removed by pulling the impeller from shaft (65) and removing key (63) from its position in keyway and sleeve. Unscrew and remove the remaining sleeve and gasket.

21. Disassemble wearing ring(s) (61) (optional) from impeller (59) only if necessary. On power frames 5, 6B and 7, remove setscrews (78). Apply a puller

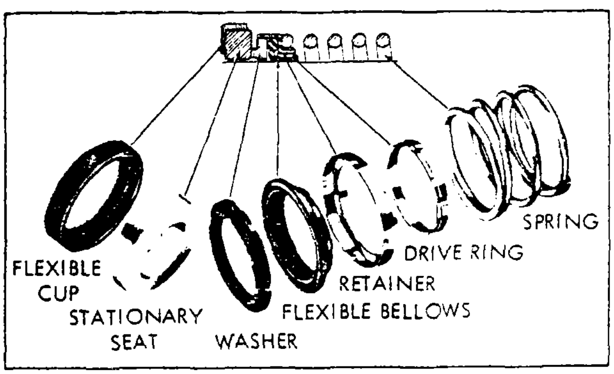
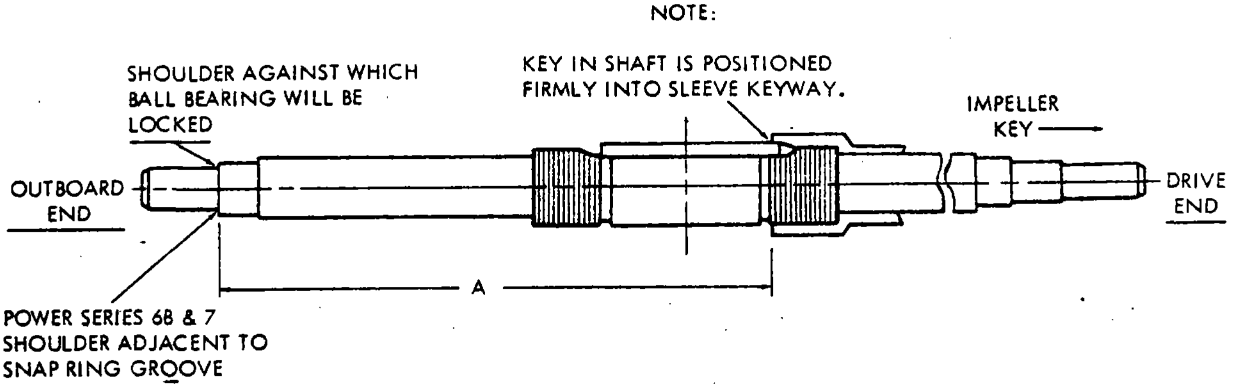


Figure 1. Mechanical Seal

and gradually withdraw wearing rings (61) from impeller (59). Wearing rings may have to be cut or trimmed off the impeller. If a lathe is used to trim rings off, use care not to clamp impeller too tight and cause distortion. Also use care not to remove any metal from impeller.

22. Remove locking and locating pins (66, 67, and 68) from lower casing (69) only if replacement is necessary.

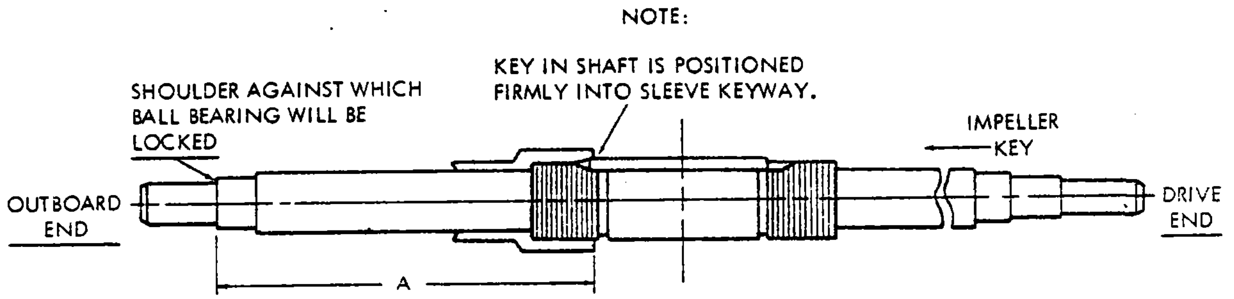


POWER SERIES	PUMP SIZE	A
1	2 x 2½ x 9 2 x 2½ x 10 2 x 2½ x 12	8 13/64
2	2½ x 3 x 10 2½ x 3 x 12 3 x 4 x 10 3 x 4 x 14 4 x 5 x 10	10 21/64
3	4 x 5 x 11 4 x 5 x 13 4 x 5 x 15	11 11/64

POWER SERIES	PUMP SIZE	A
4	4 x 6 x 18 5 x 6 x 11 5 x 6 x 15 5 x 6 x 17 6 x 8 x 11 8 x 8 x 11	11 19/64
5	6 x 8 x 15 6 x 8 x 18 6 x 8 x 20 8 x 10 x 12 8 x 10 x 15 8 x 10 x 17	13 11/64

POWER SERIES	PUMP SIZE	A
6B	10 x 12 x 12B 10 x 12 x 15B 10 x 12 x 18	15 11/32
7	12 x 14 x 15B 12 x 14 x 18 14 x 16 x 18	18 1/64

Figure 2. Locating Shaft Sleeve on Shaft, Right Hand Rotation



POWER SERIES	PUMP SIZE	A
1	2 x 2½ x 9 2 x 2½ x 10 2 x 2½ x 12	5 43/64
2	2½ x 3 x 10 2½ x 3 x 12 3 x 4 x 10 3 x 4 x 14 4 x 5 x 10	6 19/64
3	4 x 5 x 11 4 x 5 x 13 4 x 5 x 15	7 1/64

POWER SERIES	PUMP SIZE	A
4	4 x 6 x 18 5 x 6 x 11 5 x 6 x 15 5 x 6 x 17 6 x 8 x 11 8 x 8 x 11	7 33/64
5	6 x 8 x 15 6 x 8 x 18 6 x 8 x 20 8 x 10 x 12 8 x 10 x 15 8 x 10 x 17	8 19/64

POWER SERIES	PUMP SIZE	A
6B	10 x 12 x 12B 10 x 12 x 15B 10 x 12 x 18	10 11/32
7	12 x 14 x 15B 12 x 14 x 18 14 x 16 x 18	12 21/64

Figure 3. Locating Shaft Sleeve on Shaft, Left Hand Rotation

23. Nameplate (71) and its securing screws (70) should only be removed if replacement is necessary.

Disassembly of Pumps with Mechanical Seals

1. Perform disassembly procedures as previously given through step 8.

2. Loosen and remove four nuts (18) and washer (19) thus freeing swing bolts (22) to allow shaft and impeller assembly to be lifted from lower housing (69) with sling and hoist or crane as described in paragraph 10 above.

CAUTION

Use extreme care in moving this assembly, because ceramic seats can be cracked by sliding loose on shaft. To prevent this, wrap seal securely in shop cloth or other protective covering to stop seal parts from sliding on shaft.

3. With shaft and impeller assembly on a suitable bench, cradle, or work stand, loosen and remove pipe plug (12) from inboard cartridge cap (42). Remove grease zerk (10) and capscrews (41). Slide cartridge cap with grease seal (43) off end of shaft (65). Remove gasket (44).

4. Either pull or press bearing cartridge (45), grease seal (46), and bearing (47) off shaft. Remove slinger (48).

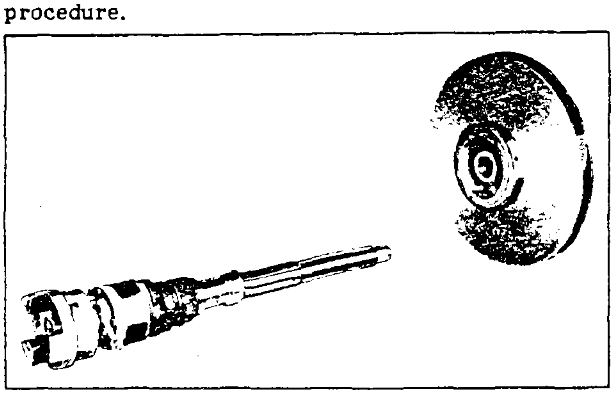
5. The one-piece gland (49) used with the mechanical seal assembly can now be removed from shaft. "O" ring (50) can be removed from seal gland if desired.

CAUTION

6. Exercise great care in removing seal assembly (53) to keep from marring or otherwise damaging precision ground mating surfaces.

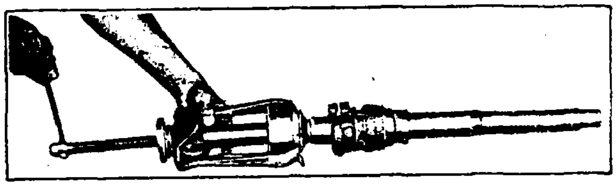
7. Scribe a mark on shaft sleeves for relocating seal collar on reassembly. Loosen setscrews (55), securing seal collars (54) to shaft sleeves and slide them off.

8. Proceed with further disassembly of outboard ball bearing and seal assembly using the same basic procedure.



F. Impeller removed from outboard rotating element.

9. After removal of mechanical seals proceed with balance of disassembly in the same manner as described for packing design.



G. Removing bearing from shaft using conventional puller.

REASSEMBLY

Reassembly will generally be in reverse order of disassembly. If disassembly was not complete, use only those steps related to your particular repair program.

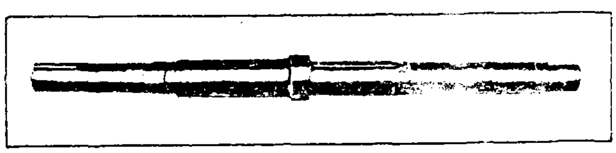
1. Position locating pins (67) in lower casing (69), adding swing bolt pins (68) if used on your pump. Install wearing ring pins (66). Tap pins gently to seat them in place. If nameplate (71) was removed, install it with screws (70).

2. On a right-hand unit thread inboard sleeve (64) onto shaft (65) distance A (refer to Figure 2). On a left-hand unit thread outboard sleeve (57) onto shaft distance A (refer to Figure 3). When the sleeve is in position its keyway should align with keyway on shaft. Coat key and keyway with Loctite sealant grade CVV. Insert key (63) into keyways of shaft and sleeve. Tap key firmly in place.

3. Coat inside diameter of impeller wearing rings (61) (optional) with Loctite sealant Grade AV and press them over hubs of impeller (59). Do not attempt to hammer impeller wear rings into position, since they are a press fit. Use of an arbor press is preferred. However, placing a block of wood over the impeller wearing ring and pressing it in will work satisfactorily. For power frames 5, 6B and 7 only, two setscrews (78) will be installed by drilling into wearing rings and impeller. The opposite surface of the impeller should be protected from damage throughout the procedures by resting it against soft wood on the surface of work bench.

CAUTION

Impeller wearing rings must be given special care because they are press fit. Be sure rings are positioned squarely over hubs of impeller. A softheaded hammer may be used to gently tap impeller wearing rings into correct alignment before they are pressed into place.



H. Shaft with sleeve and key in position.

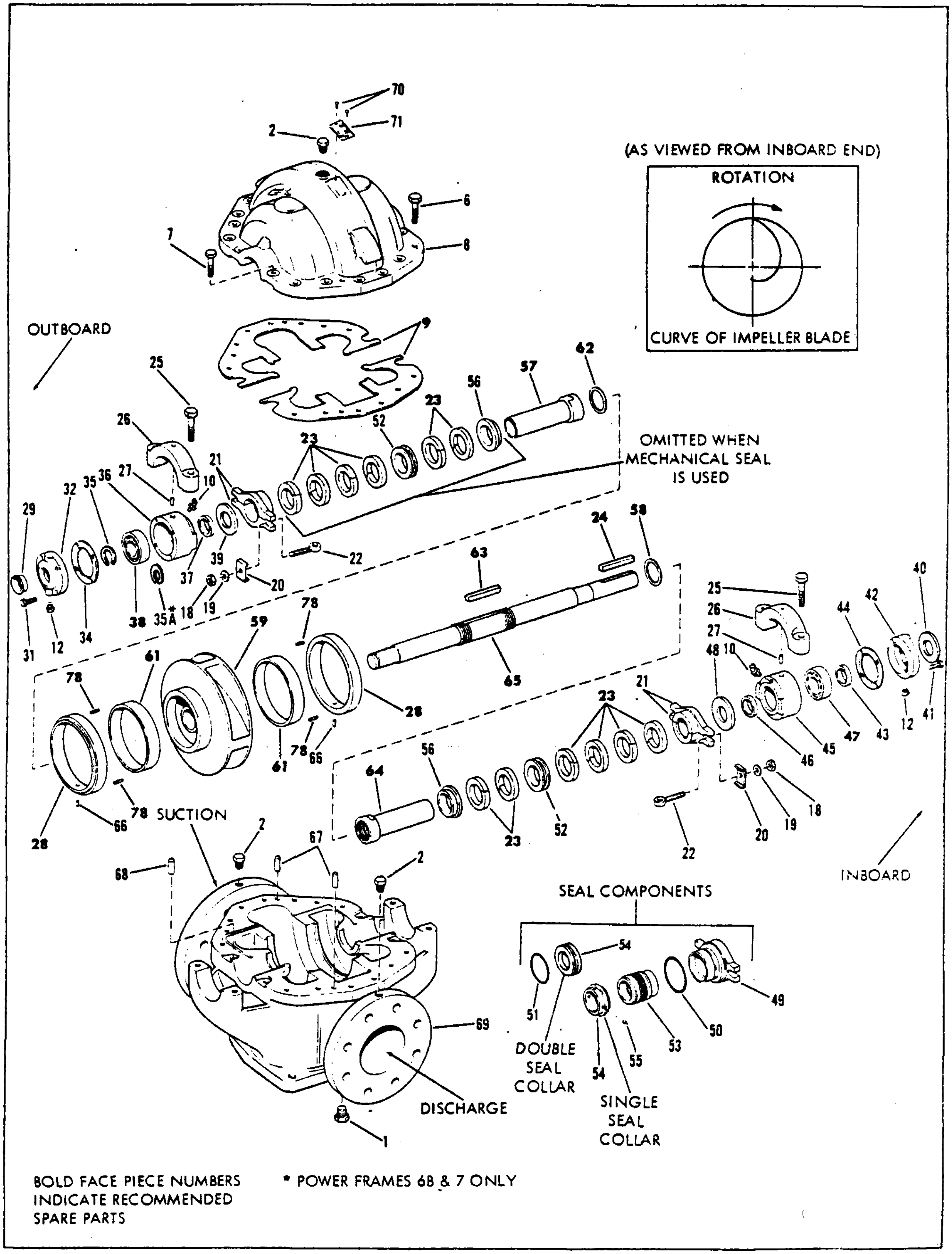


Figure 4. Model 411 Exploded View

MODEL 411 List of Parts (See Figure 4)

1. Plug
2. Plug
6. Capscrew
7. Capscrew
8. Casing
9. Gasket
10. Grease Fitting
12. Plug
18. Nut
19. Washer
20. Clamp
21. Gland Half
22. Swing Bolt
23. Packing
24. Key
25. Capscrew
26. Bearing Cap
27. Pin
28. Wearing Ring
29. Protector
31. Capscrew
32. Cartridge Cap
34. Gasket
35. Retaining Ring

35A. Retaining Ring

36. Cartridge
37. Grease Seal
38. Bearing
39. Slinger
40. Slinger
41. Capscrew
42. Cartridge Cap
43. Grease Seal
44. Gasket
45. Cartridge
46. Grease Seal
47. Bearing
48. Slinger
49. Gland
50. "O" Ring
51. "O" Ring
52. Lantern Ring
53. Seal
54. Collar
55. Setscrew
56. Bushing
57. Sleeve
58. Gasket
59. Impeller
61. Wearing Ring
62. Gasket
63. Key
64. Sleeve
65. Shaft
66. Pin
67. Pin
68. Pin
69. Casing
70. Drivescrew
71. Nameplate
78. Set screw

NOTE

WHEN ORDERING SPARE PARTS ALWAYS INCLUDE THE PUMP TYPE, SIZE, SERIAL NUMBER, AND THE PIECE NUMBER FROM THE EXPLODED VIEW IN THIS MANUAL.

ORDER ALL PARTS FROM YOUR LOCAL AUTHORIZED DISTRIBUTOR, FACTORY BRANCH SALES OFFICE OR THE FACTORY AT NO. AURORA, ILLINOIS.

4. Slide either gasket (62 or 58) onto shaft until it is squarely against shoulder of shaft sleeve that has been keyed in position. Slide impeller (59) after coating keyway with Loctite grade CVV onto shaft until it is firmly located against gasket and shaft sleeve. The remaining gasket is put on shaft and then the other shaft sleeve is threaded firmly against gasket and impeller.

NOTE

When assembling rotating element of a 411 Model Pump is is important that the curve of the impeller blades is in agreement with pump rotation. (See insert in figure 4.)

CAUTION

Carefully check to see that proper shaft sleeve has been keyed into place for rotation of pump. If correct shaft sleeve is not keyed onto the shaft it can spin loose during operation of pump and cause extensive damage.

5. Install packing or mechanical seals and secure according to the following specific instructions.

Standard Packing

a. Slide a bushing (56) onto each end of shaft. The raised shoulder on these bushings must face away from impeller.

b. Pump sizes 2 x 2-1/2 x 9, 2 x 2-1/2 x 10, 2 x 2-1/2 x 12 have one packing ring (23) in front of lantern ring (52). All other pump sizes have two packing rings in front of the lantern ring. Stagger joints of packing rings so that packing will not leak excessively.

Mechanical Seal

a. Single seal and balanced single seals

I. Slide one seal lock collar with setscrews (55) facing the impeller onto each end of the shaft. Position on scribe mark made during disassembly and lock in place.

II. Put a light coat of liquid dishwashing detergent on the shaft sleeve. Check rotating parts of seal to make sure they are clean. Spread a light coat of liquid detergent on inside diameters of flexible bellows and washer.

III. Place the seal's spring drive ring, retainer, flexible bellows and washer on the shaft sleeve in respective order.

IV. Thoroughly inspect cavity of seal gland (49) for burrs or nicks which could damage seat of the seal. Apply a film of liquid detergent to seal seat and install it in seal gland cavity. Taking care to seat it evenly and squarely.

NOTE

If it is not possible to insert seat with fingers, place a cardboard protecting ring, furnished with seal, over lapped face of seat and press into place with a piece of tubing having end cut square. Tubing should be slightly larger than diameter of the shaft. Remove cardboard after the seat is firmly in place.

CAUTION

Never place a mechanical seal into service after it has been used without replacing or relapping stationary seat and washer faces.

V. Place "O" rings (50) around the seal glands and slide seal glands onto ends of the shaft.

b. Double Seal

I. Place one seal seat in collar (54), the other one fits into seal gland (49). These parts are set into their cavities in the same manner as they are with a single seal.

II. Place "O" rings (51) around collars (54) and put the collars with stationary seats facing away from impeller on ends of the shaft, then slide flexible bellows, washers, and springs on the shaft in order shown in figure 1, for each half of double seal assembly (53).

III. Place "O" ring (50) around the seal glands (49) and slide seal glands onto ends of the shaft with stationary seats facing impeller.

6. Place slinger (39) onto outboard end of shaft.

7. Press grease seal (37) into bearing cartridge (36). Place outboard double row ball bearing (38) in bearing cartridge and press these parts onto outboard end of shaft. Snap retainer ring (35) in place to secure outboard bearing. Place gasket (34) and cartridge cap (32) in position and secure it with capscrews (31).

NOTE

Both grease zerk holes in bearing cartridges and pipe plug holes in cartridge caps must be facing in opposite directions when assembled.

8. Protector (29) can be placed in the cartridge cap or if unit has a tandem shaft, press grease seal into cartridge cap and slide a slinger onto shaft.

9. Place slinger (48) on inboard end of shaft.

10. Press grease seal (46) into bearing cartridge (45). Place inboard ball bearing (47) in bearing cartridge and press this assembly onto inboard end of shaft.

11. Press grease seal (43) into cartridge cap (42). Position gasket (44) and cartridge cap against bearing cartridge and secure it in place with capscrews (41). Be sure to align grease zerk hole and pipe plug hole on opposite sides.

12. Place slinger (40) onto shaft. Place grease zerks (10) in bearing cartridges and pipe plugs (12) in bearing caps. If pump is oil lubricated, breather tubes are placed in bearing cartridges and oilers with nipples and elbows are placed in cartridge caps.

13. Slide casing wearing rings (28) over impeller wearing rings (61) and set rotating element into lower casing (69). Make certain the holes that are drilled in the bottom surface of the casing wearing rings are located over pins (66) previously set in lower casing (69). Grease zerks or breather tubes should face up.

14. Install key (24) in motor end of shaft (65). Check positioning and alignment of packing rings or seal components and install swing bolts (22) and split gland halves (21) if pump has packing. Place in position clamps (20), washers (19), and nuts (18), securing loosely in place. Swing bolts (22) are set over pins (68) on 4 x 5 x 10 or smaller units. On larger units the swing bolts are held in place by capscrews (7) after upper casing is in position.

15. Place pins (27) into bearing cartridges. Place bearing caps (26) in position and secure with capscrews (25).

16. Position new casing gaskets (9) on lower casing (69). Set upper casing (8) in place and secure it to casing halve (69) with capscrews (6). Pins (67) are used as a means of locating position of the two casing halves.

17. On pumps larger than 4 x 5 x 10 thread in capscrews (7) making sure they are placed through the eye of swing bolts (22).

18. Place drain plugs (1) and (2) back in casing halves.

19. If lower casing was removed from the base, see section on Installation for proper methods of realigning pump to motor and piping.

20. Replace any flushing or cooling lines that were removed. Connect electricity back to motor.

STARTING PUMP AFTER REASSEMBLY

Do not start the pump until all air and vapor have been bled and making sure that there is liquid in the pump to provide the necessary lubrication.

NOTE

Do not over tighten standard packing assembly before returning unit to operation.

CAUTION

Read operating instructions carefully before starting pump.

Jog the pump to check for proper rotation. Allow it to run for awhile, then gradually tighten nuts (18) until dripping has been reduced to its normal level.

AURORA® PUMPS

INSTRUCTION MANUAL
INSTALLATION
FRAME MOUNTED

2

GENERAL. The life of your Aurora pump can be extended considerably by carefully following the installation instructions contained herein. Each step of the pump installation instructions plays a vital part in assuring long life, efficient operation, and reduced maintenance, from the initial location of the pump through prestarting directions.

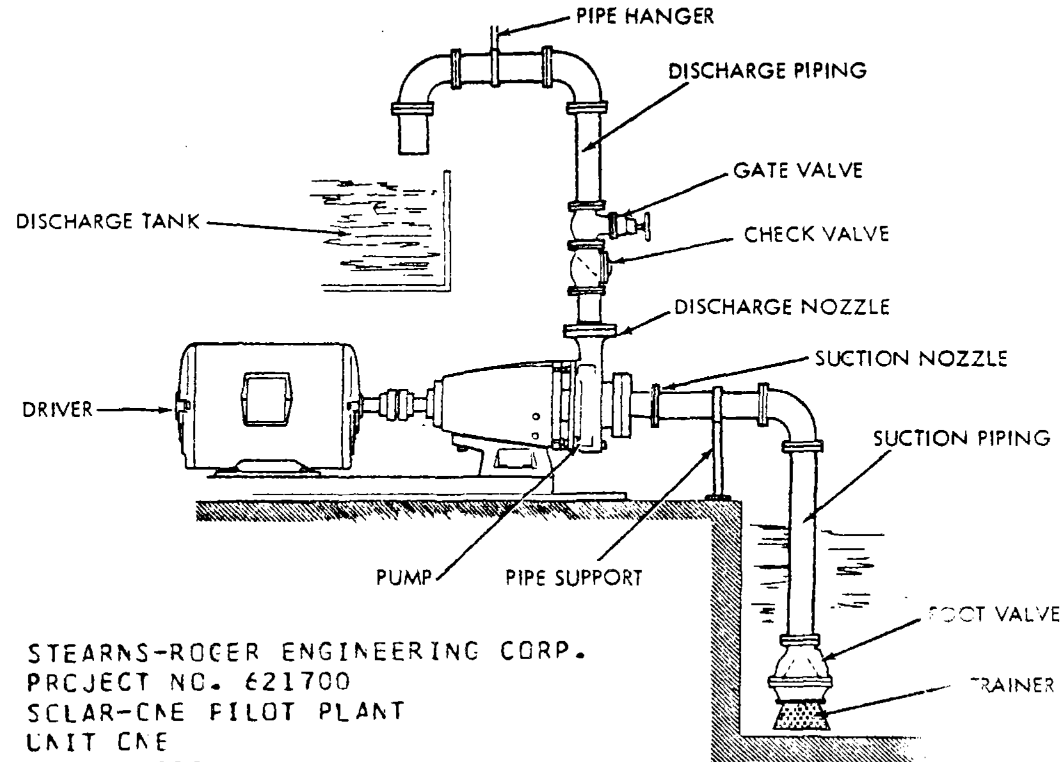
UNPACKING YOUR PUMP. The crate containing your pump should be opened immediately upon receipt from the factory, and the pump generally inspected for damage and shortage of parts. Particular attention should be given to the discharge and suction nozzle threads or flanges. Any damage or shortage of parts should be reported to the carrier immediately.

CLEANING. If your pump is to be installed immediately, it will be necessary to remove the protective covers from all openings, and to clean the exposed metal parts thoroughly with white gasoline or other suitable solvent to remove the preservative coating.

STORAGE. If your pump is not to be put in service immediately it should be covered and stored in a clean dry area. The protective covers and preservative should be left intact until the pump is put into service. For extended storage, the pump should be dried internally with hot air or some other suitable means, and once free of moisture, filled with a protective fluid such as light oil or kerosene. Accordingly, at time of installation, the pump will have to be completely dismantled and thoroughly cleaned.

PLANNING THE PUMP LOCATION. You probably have spent considerable time planning where your pump will be located. However you may have overlooked some factor which may affect your pump operation or efficiency.

The pump should be located as close to the liquid source as possible so that the suction line can be



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

FIGURE 1. RECOMMENDED LOCATION - SHORT DIRECT SUCTION

short and direct. It should be located in a clean, open area, where it is easily accessible for inspection. lubrication, and repair. Pumps installed in dark, dirty areas or in cramped locations are often neglected which can result in premature failure of both the pump and the driver.

Your pump should be located so that a hoist or crane can be used to move it without interference from piping. This factor is often overlooked in the advance planning stage.

Protect your pump against the possibility of flooding. Although water will not seriously damage the pump, the drive motor can be damaged.

The pump should be located in an area where moisture, either from leakage through the packing or from condensation, can be adequately drained off. Moisture dripping on exposed metal or wood can cause rapid deterioration of the area. Also, wet floors produce safety hazards.

Adequate provisions should be made for electrical wiring to the pump motor. A switch and overload protection should be installed near the pump unless it is impractical. The electrical conduit should be positioned in such a way as to preclude the possibility of moisture entering the conduit or the motor and causing short circuits.

Outdoor installation will normally provide all of the above mentioned conditions. However it is advisable to provide a weather shelter for your pump.

FOUNDATION. The foundation for your pump must be sufficiently rigid to absorb any vibration and stress encountered during pump operation. A raised foundation of concrete is preferable for most floor mounted pumps. The raised foundation assures a satisfactory base, protects against flooding, simplifies moisture drainage, and facilitates keeping the area clean.

Your pump should be firmly bolted to the foundation, whether it is a raised concrete base, steelwork wall, or structural member. The mounting bolts or studs should be accurately located per the applicable Aurora dimension sheet. Foundation bolts should be enclosed by a sleeve 2 to 4 diameters larger than the bolt to allow movement for proper alignment with the pump mounting holes. Refer to figure 3.

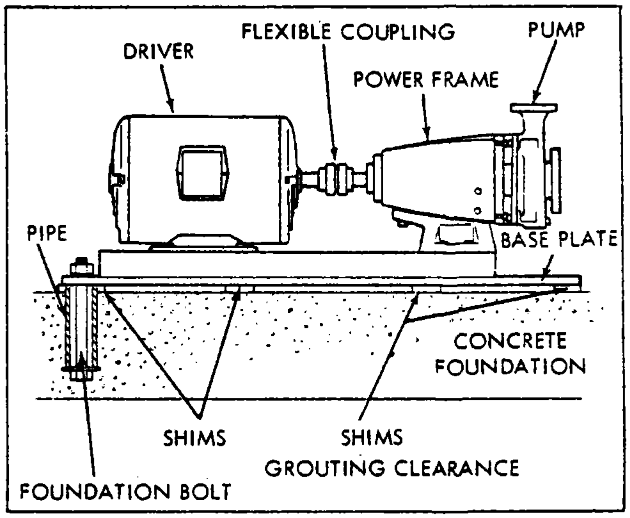


FIGURE 3. FOUNDATION FOR FRAME MOUNTED PUMPS

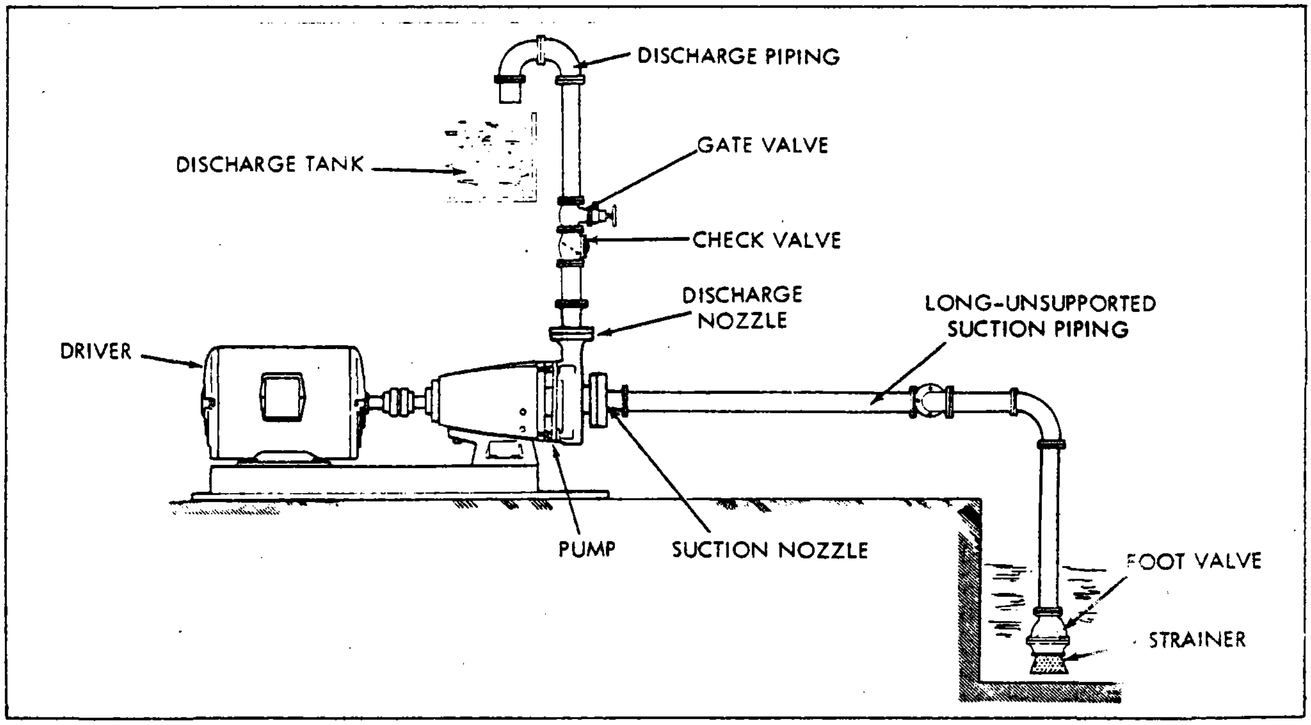


FIGURE 2. UNSATISFACTORY LOCATION - LONG INDIRECT SUCTION WITH NO SUPPORT

If the pump is to be mounted on steelwork or other structure, adequate support should be provided to prevent distortion of the base plate or the structure, which could produce excessive strain on the pump casing and piping, and seriously affect alignment of the pump and driver.

PREPARING TO INSTALL YOUR PUMP. Your pump and driver unit will normally be mounted on a common base plate. The unit has been accurately aligned and securely mounted to the base plate at the factory. However, the alignment cannot be maintained during shipping and the complete unit must be leveled and realigned at the time of installation.

LEVELING THE PUMP. Leveling the pump will require enough shims to support the base plate near the foundation bolts, and at any points of the base plate carrying a substantial weight load. The shims should be large enough to allow a gap of 3/4" to 1-1/2" between the base plate and foundation for grouting.

The pump unit should be set on the foundation, being careful not to damage the threads on the foundation bolts. The flexible coupling halves should then be disconnected. The shims should be inserted and the pump leveled. A spirit level should be used on the faces of the flexible coupling halves, and on the suction and discharge flanges. If your pump has threaded nozzles, a short piece of pipe inserted in the nozzles will serve as a smooth surface for a leveling reference point. The shims should be adjusted until the pump is leveled horizontally and vertically. Tighten the foundation bolts finger tight.

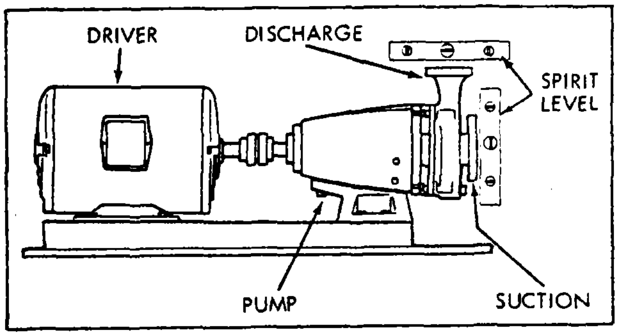


FIGURE 5. LEVELING PUMP UNIT WITH SPIRIT LEVEL ON PUMP FLANGES

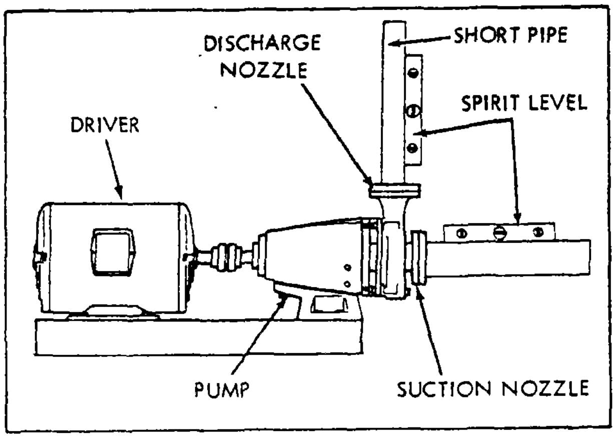


FIGURE 4. LEVELING PUMP UNIT WITH SPIRIT LEVEL AND SHORT LENGTHS OF PIPE

INITIAL ALIGNMENT OF THE FLEXIBLE COUPLING. The pump and driver were accurately aligned at the factory. However, it is impossible to maintain this alignment during shipping and handling. Therefore it will be necessary for you to realign the pump and driver. Flexible couplings are not universal joints. They should not be used to compensate for misalignment of the pump and motor shafts. Their function is to transmit power from the driver to the pump while compensating for thermal expansion and shaft end movement. The coupling faces should be far enough apart so that they do not make contact when the motor shaft is forced to the limit of the bearing clearance toward the pump shaft.

In order to properly align the coupling, you will need a taper gauge or set of feeler gauges, and a straight edge, or if available, a dial indicator.

There are two types of misalignment encountered with flexible couplings: angular misalignment, in which the shafts are not parallel, and parallel misalignment where the shafts are parallel but not on the same axis.

To check angular alignment, insert a feeler gauge or taper gage at any four places 90° apart around the

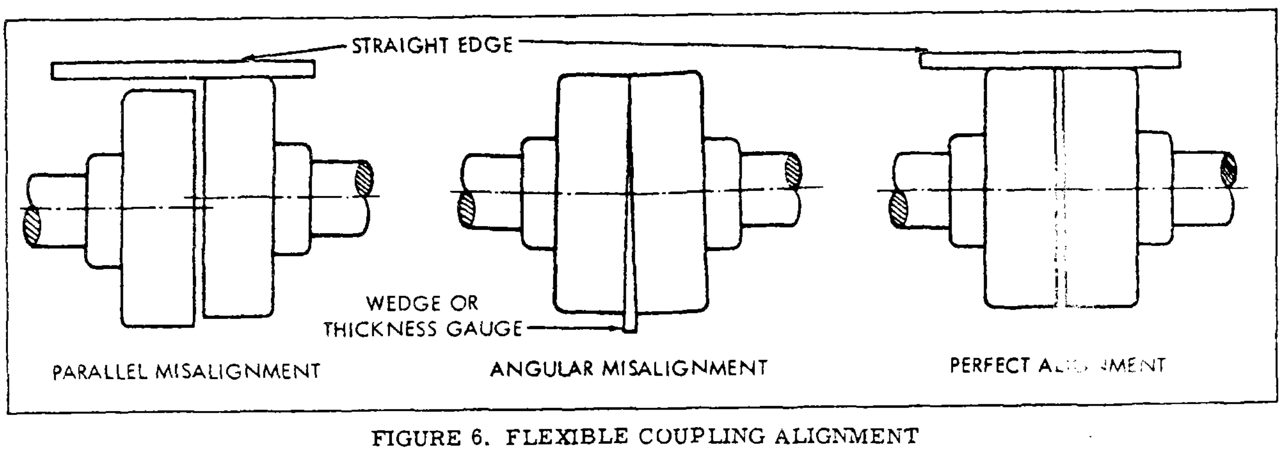


FIGURE 6. FLEXIBLE COUPLING ALIGNMENT

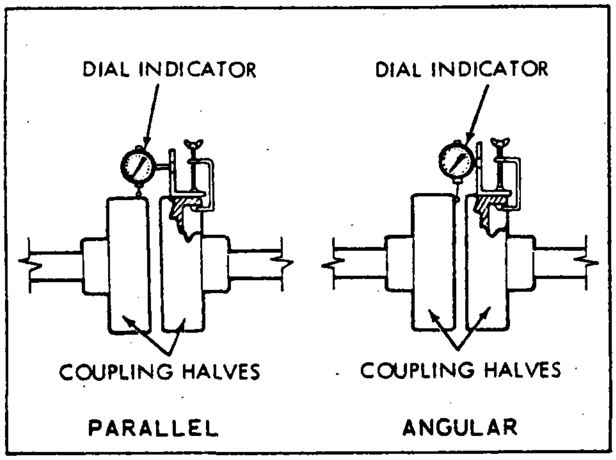


FIGURE 7. CHECKING ALIGNMENT WITH DIAL INDICATOR

coupling halves. Insert shims under the driver feet until the same reading is obtained at all four check points. The pump and driver will then be in angular alignment.

To check angular alignment with a dial indicator, clamp the dial indicator to the pump coupling half so that ball on the indicator just rests on the face of the motor coupling half. A chalk mark should be made at the point where the ball contacts the coupling half. Both the pump shaft and the motor shaft should be rotated an equal amount so that the reading is taken at all check points with the ball on the chalk mark. Insert shims as required.

To check parallel alignment, a straight edge should be held against the edges of the coupling halves at any four places 90° apart around the coupling. The straight edge should be parallel to the pump and driver shafts at all times. Insert shims until the straight edge lies flat against both coupling halves at all four check points. The pump and driver will then be in proper parallel alignment.

To check parallel alignment with the dial indicator, the ball should rest on periphery of the motor coupling half. A chalk mark should be made at the point of contact, and the shafts rotated equally so that the reading is taken with the ball on the chalk mark at all check points. Insert shims as required.

NOTE

> Any adjustment to correct one direction of alignment may affect the other direction. Therefore, it is necessary to recheck both angular and parallel alignment after each adjustment.

When the unit is properly aligned, the foundation bolts should be tightened, but not too firmly. Waste material should be stuffed into the sleeves around the foundation bolts, to prevent grout from filling the sleeves during grouting.

GROUTING THE INSTALLATION. Grouting the base plate prevents lateral movement of the base plate, and improves the vibration absorbing characteristics of the foundation by increasing its mass. A wooden dam should be constructed around the base plate to contain the grout while it is being poured. The dam can be built tight against the base plate, or slightly removed from it as desired.

The entire base plate should be completely filled with grout. A non-shrinkable type grout, such as manufactured by EMBCO is recommended. The grout should be puddled frequently to remove any air bubbles from the grout.

The leveling shims can be grouted in place, or they can be removed after the grout has set usually from 48 to 72 hours after pouring.

After the grout has set, alignment of the unit should be checked and the foundation bolts firmly tightened down.

PIPING. Your pump unit is now ready to be piped. The piping practices you follow will directly affect the efficiency and power consumption of your pump.

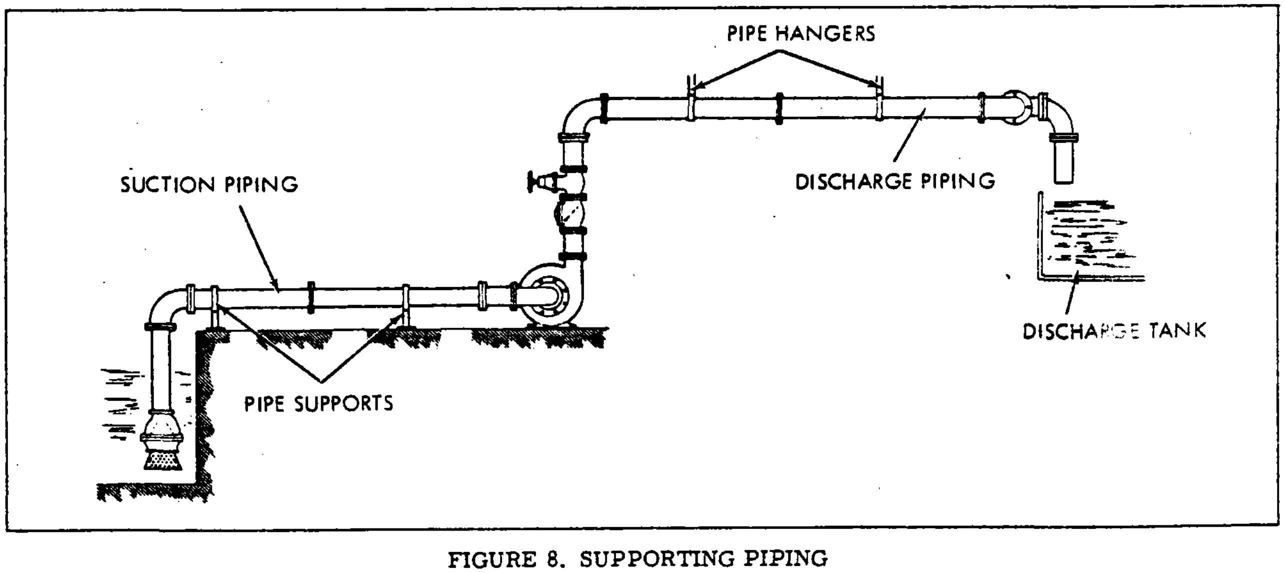


FIGURE 8. SUPPORTING PIPING

Pay particular attention to the seemingly insignificant details involved in piping your pump for they make the difference between a good and bad installation.

SUPPORTING THE PIPE. Both the suction and the discharge piping should be independently supported near the pump. Liberal use of pipe hangers and support blocks will prevent excessive strain on the pump casing and on the pipe joints.

SUCTION PIPING. The suction piping should be short, but no less than ten pipe diameters in length, and direct with as few elbows and fittings as possible, to keep head loss from friction at a minimum. However, the suction pipe should provide a minimum uninterrupted length, equal to ten pipe diameters, to the pump suction flange. A horizontal suction line should have a gradual rise to the pump, and pass under any interfering piping.

PIPE. The suction pipe diameter should be at least the same diameter as the suction nozzle on the pump, and preferably larger. Use of a smaller diameter pipe will result in loss of head due to friction. All joints must be tight to maintain prime on the pump.

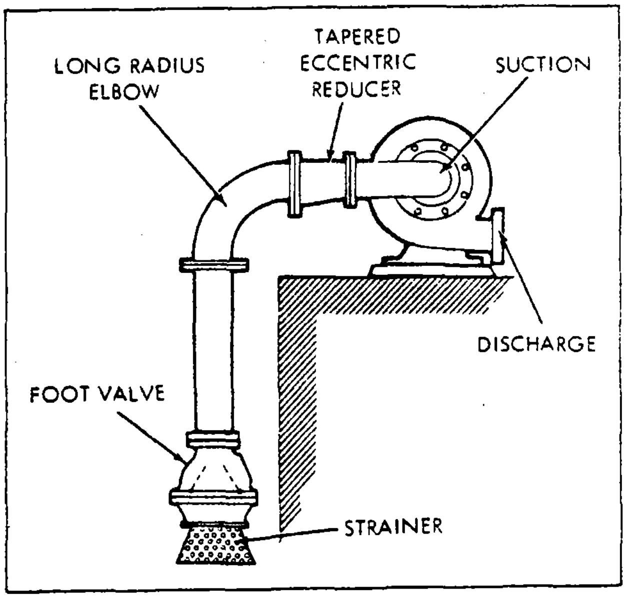


FIGURE 9. RECOMMENDED SUCTION LIFT PIPING - SHORT AND DIRECT

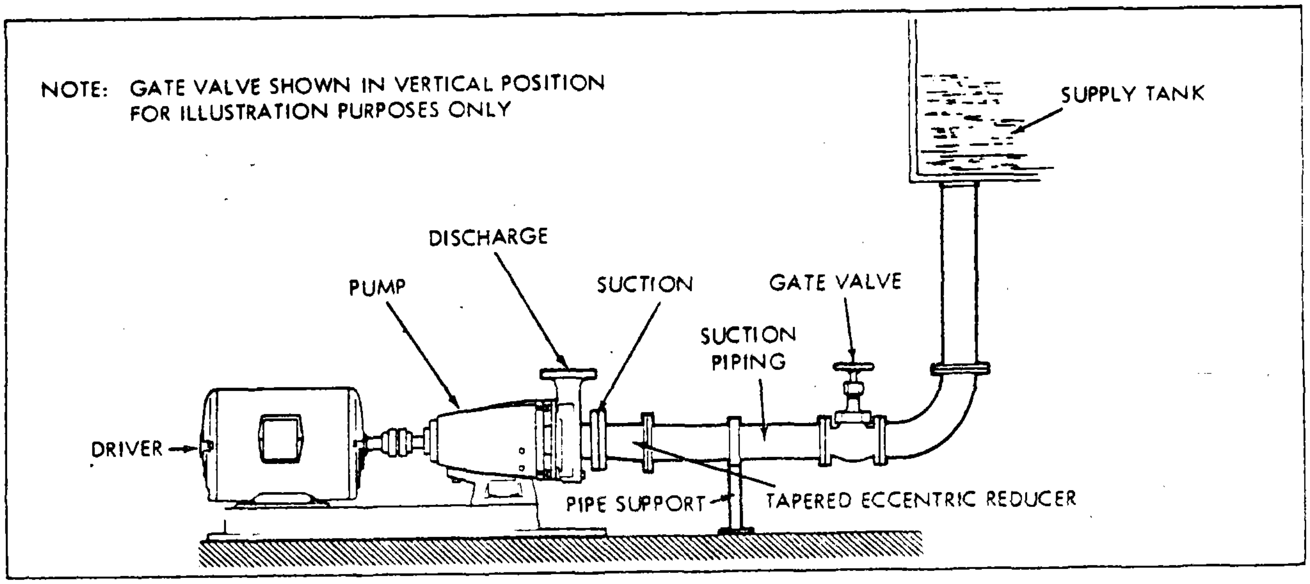


FIGURE 10. RECOMMENDED FLOODED SUCTION PIPING - SHORT AND DIRECT

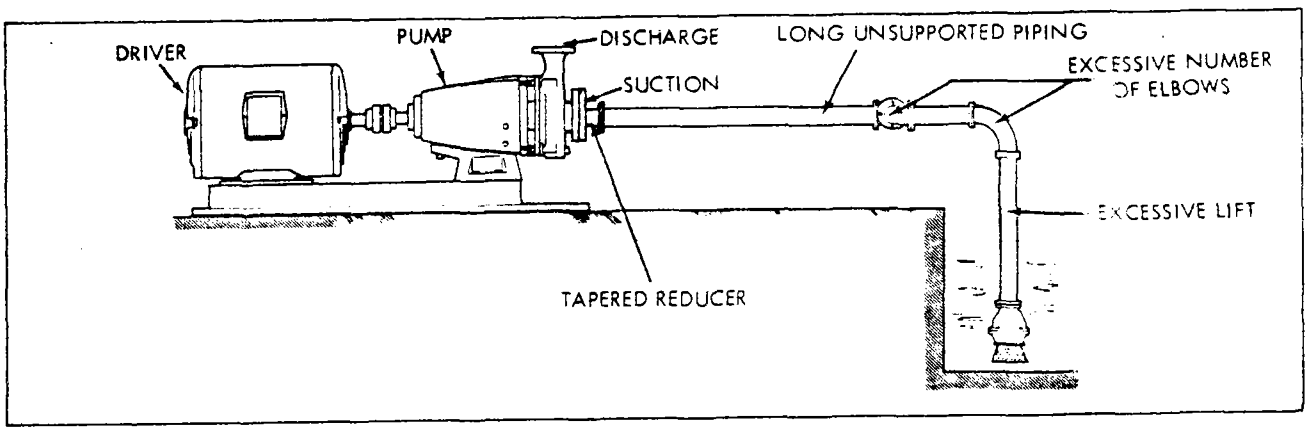


FIGURE 11. UNSATISFACTORY SUCTION LIFT PIPING - LONG AND INDIRECT WITH NO SUPPORT

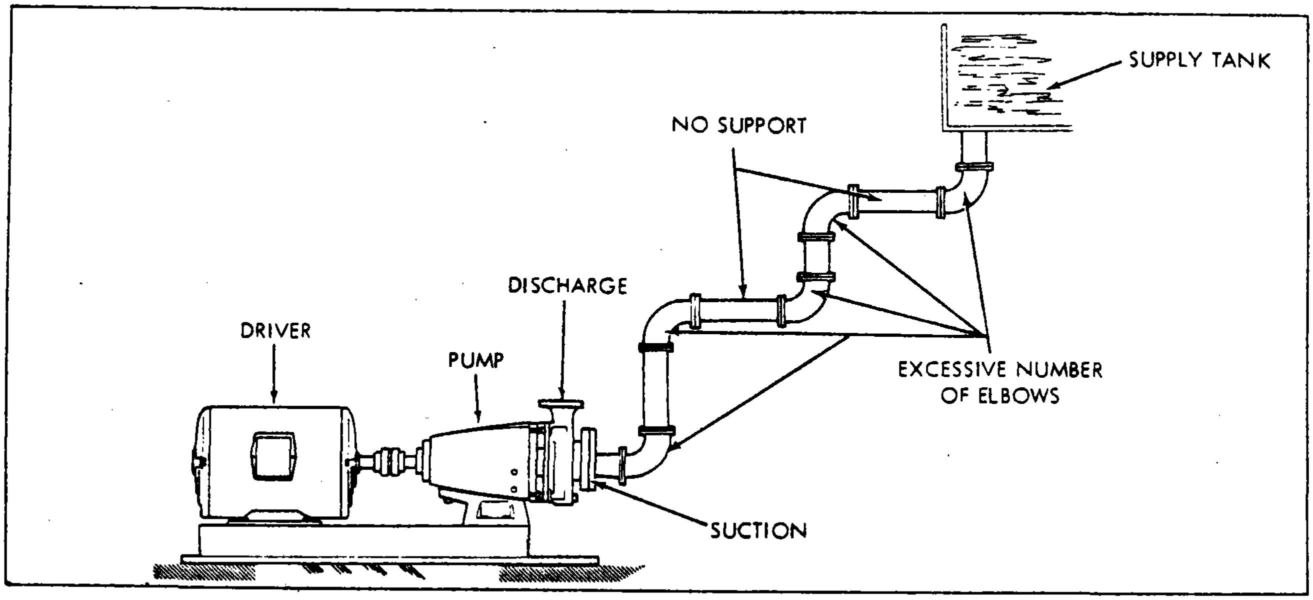


FIGURE 12. UNSATISFACTORY FLOODED SUCTION PIPING - LONG AND INDIRECT WITH NO SUPPORT

ELBOWS. Long radius elbows should be used in place of standard elbows wherever possible, because of their superior flow characteristics. For instance, head loss in a standard four inch elbow is equivalent to the head loss in a piece of pipe 11 feet long, while the head loss in a long radius elbow is approximately half as much. Elbows should not be used at the suction nozzle, but if it is unavoidable, they should be installed in a vertical position. Elbows installed in any position at the suction nozzle have a tendency to distribute the liquid unevenly in the impeller chamber, causing a reduction in capacity, and creating an undesirable thrust condition.

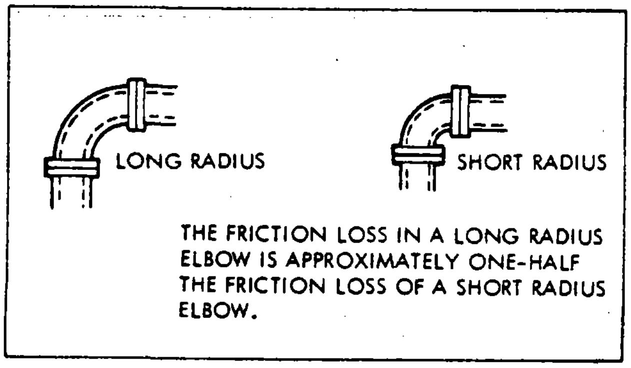


FIGURE 13. LONG VERSUS SHORT RADIUS ELBOWS

REDUCERS. Eccentric reducers should be installed directly at the suction nozzle, with the taper at the bottom to prevent air pockets from forming. Straight taper reducers should never be used in a horizontal suction line because of the air pocket that is formed at the leg of the reducer and the pipe.

DISCHARGE PIPING. Discharge piping should also be short and direct as possible, with few elbows and fittings, to reduce head loss from friction.

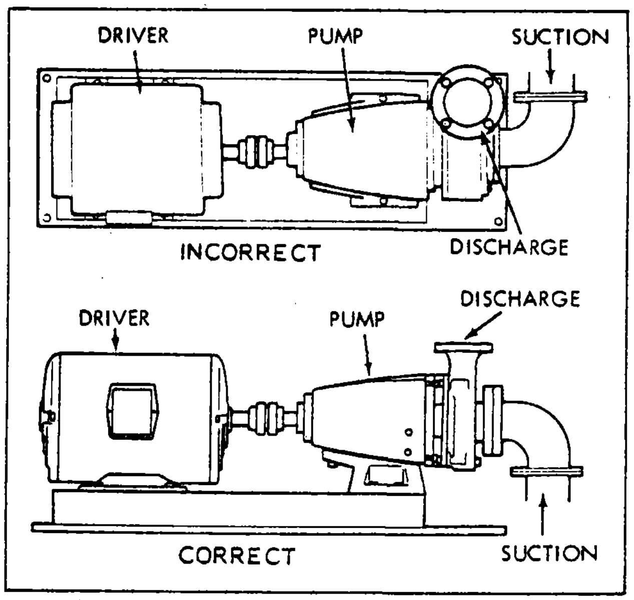


FIGURE 14. ELBOW INSTALLATION IN SUCTION NOZZLE

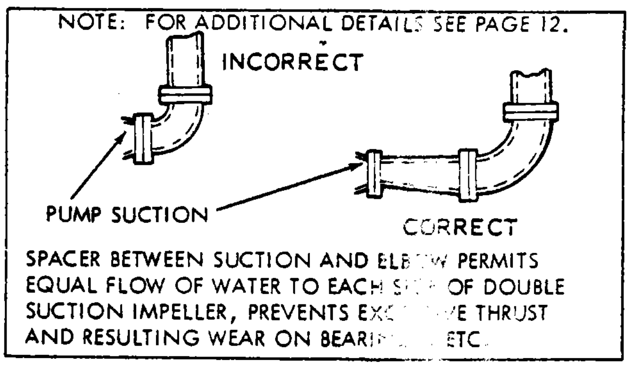


FIGURE 15. REDUCER BETWEEN ELBOW AND PUMP SUCTION NOZZLE

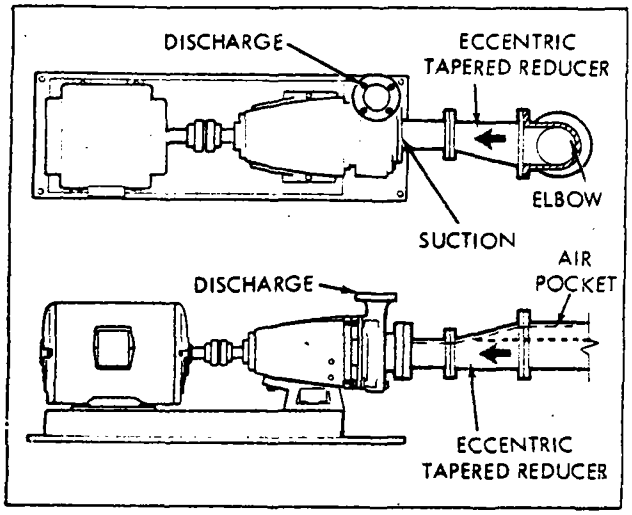


FIGURE 16. UNSATISFACTORY INSTALLATION OF TAPERED REDUCER

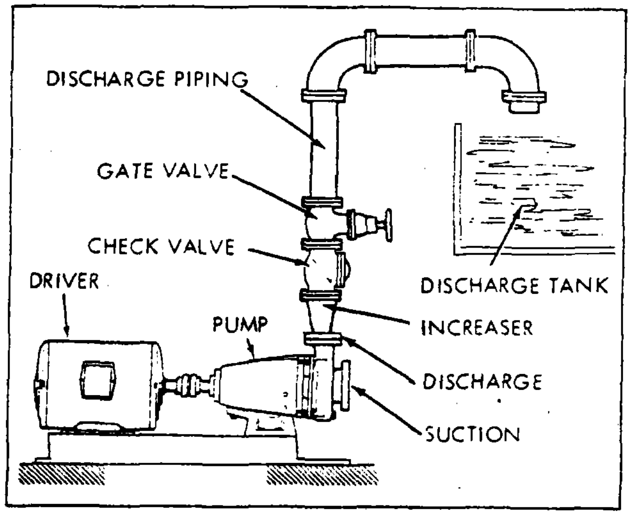


FIGURE 17. RECOMMENDED DISCHARGE PIPING - SHORT AND DIRECT

PIPE. The discharge pipe diameter should be the same as, or larger than, the discharge nozzle diameter. The size of discharge pipe to be used is dependent upon its application.

The recommended pipe diameter can be obtained from your nearest Aurora Pump Sales Office.

ELBOWS. Long radius elbows should be used in the discharge piping as well as in the suction piping to prevent excessive head loss due to friction. Whenever possible, elbows should not be installed directly at the discharge nozzle as the turbulence created by the elbow will affect pressure gauge readings.

REDUCERS AND INCREASERS. An increaser should be installed at the discharge nozzle if larger diameter

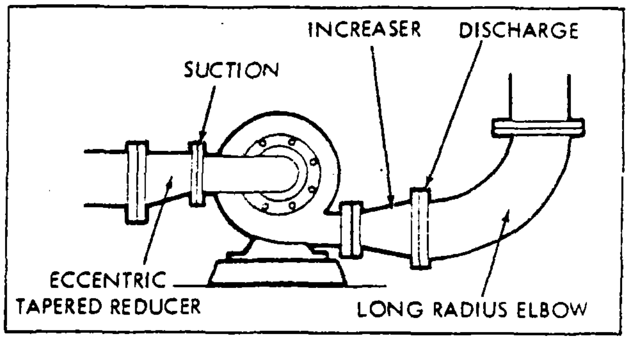


FIGURE 19. REDUCER AND INCREASER INSTALLATION

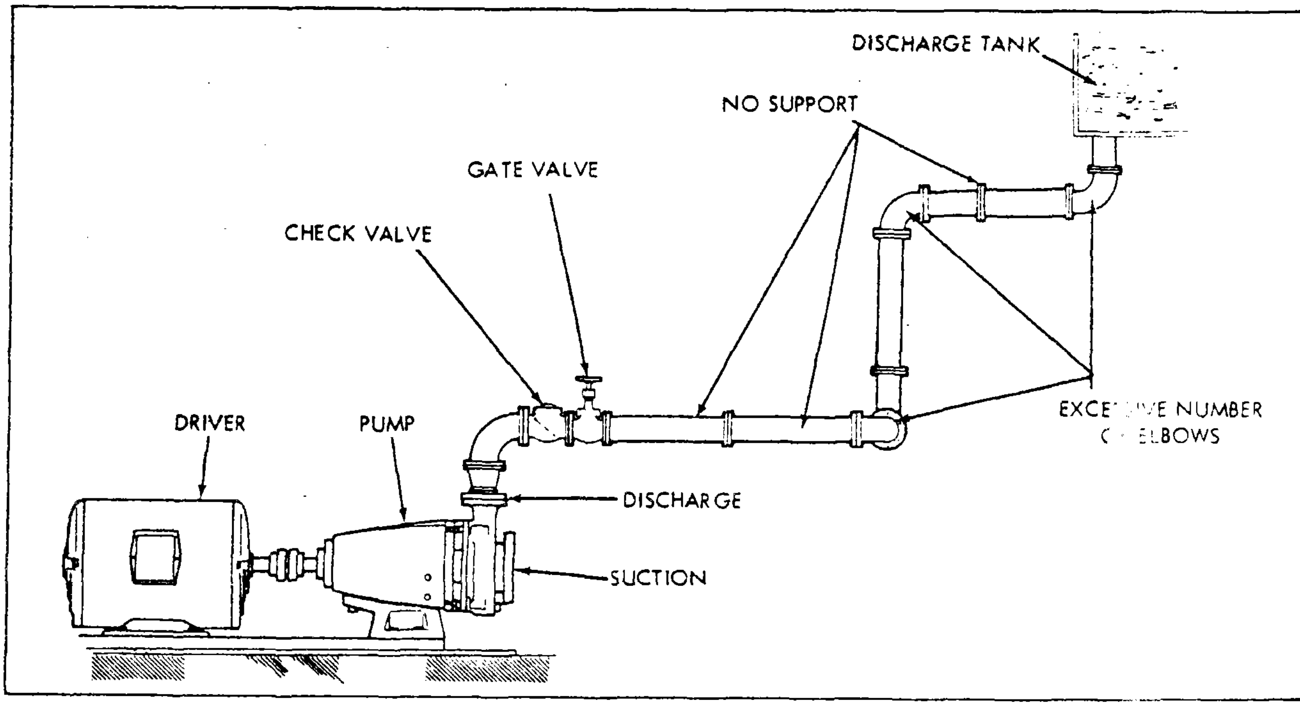


FIGURE 18. UNSATISFACTORY DISCHARGE PIPING - LONG WITH EXCESSIVE ELBOWS AND JOINTS AND NO SUPPORT

discharge piping is used. Straight taper increasers and/or reducers are satisfactory in discharge applications.

EXPANSION JOINTS. Expansion joints are used primarily to prevent the transmission of piping strain, caused by thermal expansion and contraction, piping misalignment, pressure changes, or other causes, to the pump casing. They are also used to suppress any noise that may be transmitted through the piping.

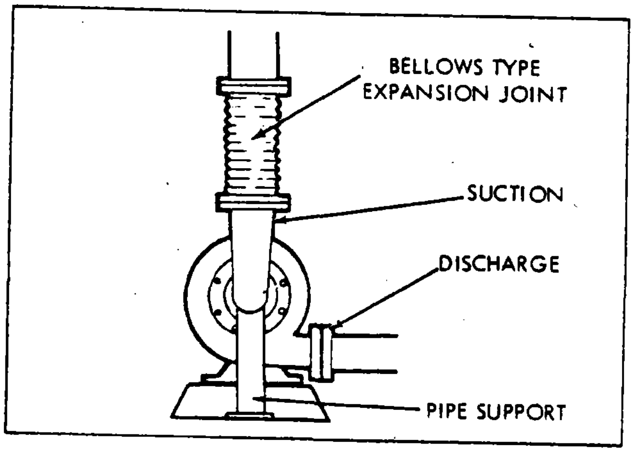


FIGURE 20. EXPANSION JOINT IN SUCTION LINE

It is recommended that the flexible metal type of expansion joint be used, because rubber expansion joints, while costing less, have a tendency to deteriorate, making frequent replacement necessary.

If an expansion joint must be used, an anchor or restraining device should be installed between the joint and the pump to prevent objectional forces from being transmitted to the pump. If an anchor is not installed at this point, a force equal to the area of the joint times the pressure in the pipe is developed and transmitted to the pump. This force may exceed the allowable flange loading, and could result in damage to the pump or piping.

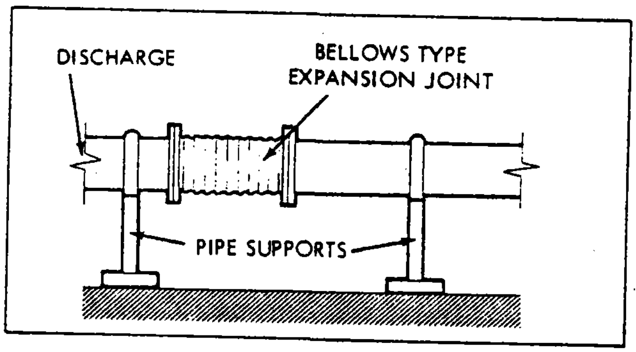


FIGURE 21. EXPANSION JOINT IN DISCHARGE PIPING

PIPE ALIGNMENT. Proper piping alignment is essential before connection is made. Piping alignment should never be achieved by force, this could produce strain on the piping and the pump casing. Proper supports should be installed for the piping to keep its weight off the pump casing.

When flange bolts are used, line up the piping first, then loosely install flange bolts. Check the piping alignment, and tighten the flange bolts until all bolts are tightened securely.

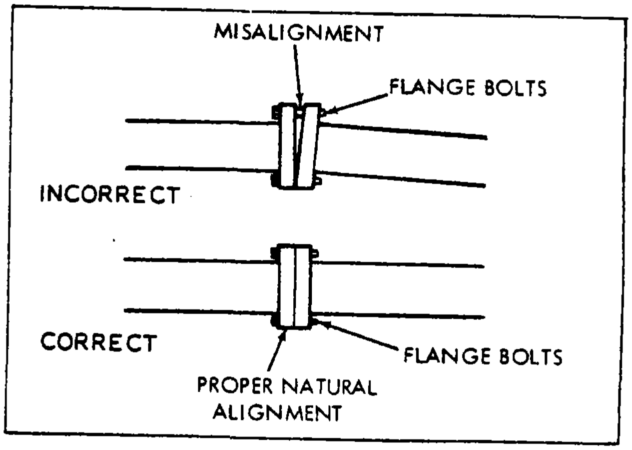


FIGURE 22. PIPE ALIGNMENT

AIR IN PIPING. One of the most common conditions affecting pump efficiency is the formation of air pockets in the suction line. The air pockets are a result of high points and improper installation of elbows, reducers, and valves in the suction piping.

For suction lift applications, lantern rings are required to prevent air from leaking into the pump through the stuffing box, or at the joints.

The pump packings or seal depend on the liquid being pumped for lubrication. Excessive air can prevent proper lubrication with resultant damage to them.

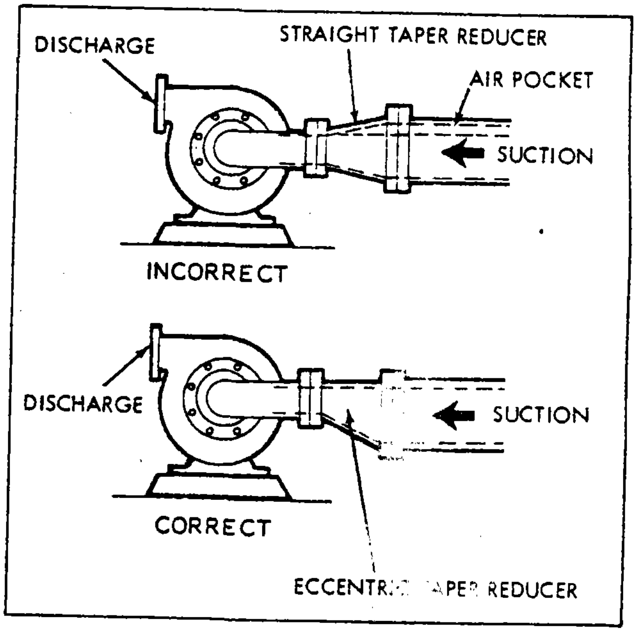


FIGURE 23. AIR POCKETS IN REDUCER

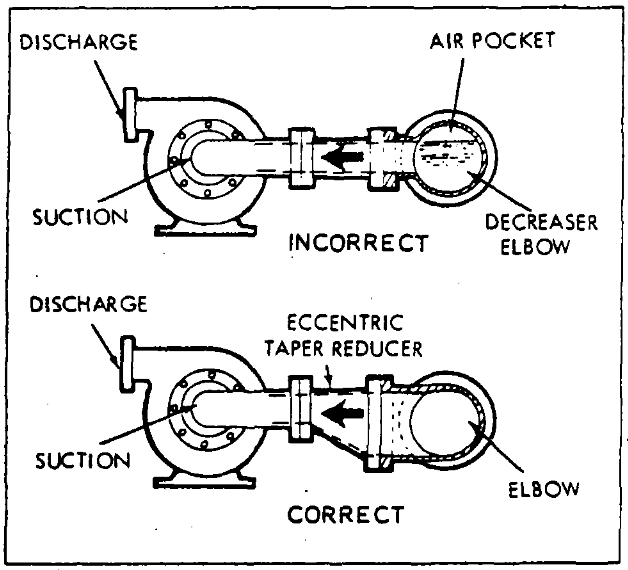


FIGURE 24. AIR POCKET IN ELBOW

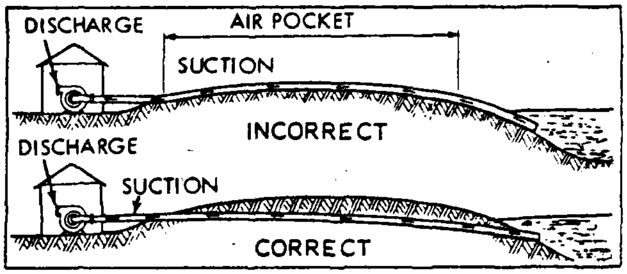


FIGURE 25. AIR POCKET IN HORIZONTAL SUCTION PIPING

In suction lift applications the suction pipe in the liquid well must be sufficiently submerged to prevent exposure of the end of the pipe when the well is at its minimum level and to prevent vortexing action (whirlpool effect) of the liquid at the suction pipe, which will draw air into the pipe. Also, care should be taken to keep the suction pipe located away from the well inlet since the incoming liquid may be carrying air bubbles. Another cause of air in the liquid is dropping of the liquid from too high a point into the well.

VALVES. Valves are an important part of your installation, for they facilitate priming of the pump, and control the volume of the pumped liquid.

SUCTION LIFT. In suction lift applications where the suction lift is low a foot valve can be installed, to maintain the prime on the pump. A foot valve is essentially a check valve, allowing flow in one direction only toward the pump. When the pump is shut down, the pressure of the liquid returning to the well, causes the valve to close, retaining the liquid in the suction line.

A slow closing check valve should be installed when the static discharge head is high. A foot valve should not be used under these conditions, as failure of the driver would allow the water to rush back rapidly thus causing a heavy water hammer.

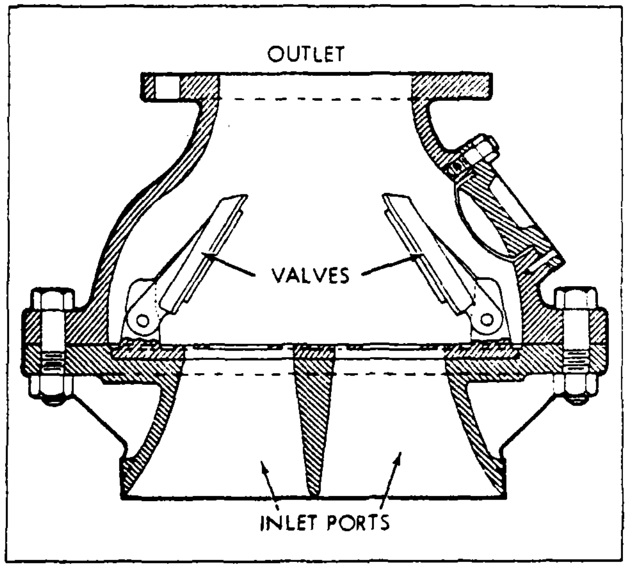


FIGURE 26. FOOT VALVE

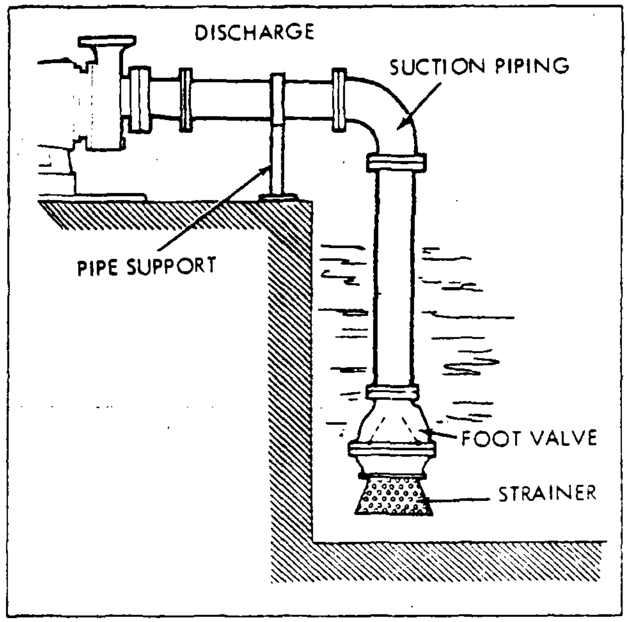


FIGURE 27. FOOT VALVE INSTALLED WITH SCREEN

Foot valves, when used, should be of the flat type rather than multiple spring type. The valve should have a large inlet area, because the friction loss in a foot valve is high. Install check and foot valves as indicated by arrow to ensure proper installation.

FLOODED SUCTION. When the liquid source is above the pump centerline, a flooded suction condition exists, and a gate valve is required to shut off the liquid supply for pump inspection and maintenance. The gate valve should be installed with the stem in a horizontal or downward position to prevent formation of an air pocket in the valve.

DISCHARGE VALVES. The discharge piping should include a check valve and a gate valve. The check

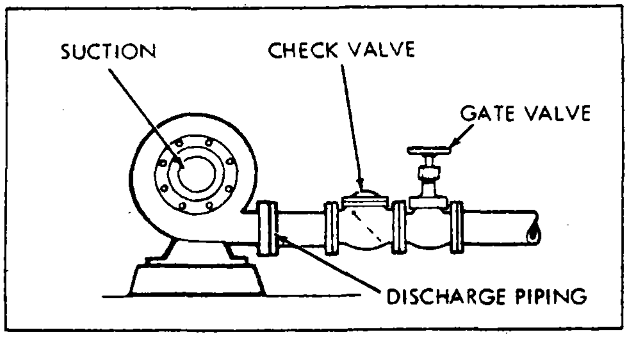


FIGURE 28. GATE VALVE AND CHECK VALVE

valve should be located between the gate valve and the pump. If an increaser is used in the discharge piping, the increaser should be installed between the pump nozzle and the check valve. The check valve protects against a reverse flow of the liquid if the driver fails.

The gate valve is used in the priming operation, as a throttling valve to control pump volume; and to shut down the pump for inspection and maintenance.

AIR VENT VALVE. Vent valves are installed at the high points in the pump casing to allow air or vapor to escape. These valves are used to release trapped air from the pump casing during priming and when pump becomes air bound.

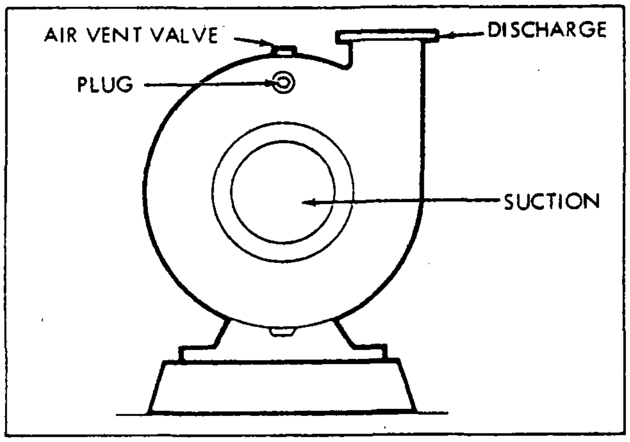


FIGURE 29. AIR VENT VALVE OR PLUG

STRAINERS AND SCREENS. It is important to screen the suction piping to remove foreign matter that can clog the pump and impair its capacity, or stop it completely. Small particles such as sand, dirt, scale from inside pipe and other extraneous materials can get into the close clearance parts of the pump and cause considerable damage to the parts.

Strainers should be selected so as to have a total area of holes equal to at least four times the suction pipe area.

In applications where sticks, twigs, leaves and other large debris are present, a larger outside screen should be placed around the suction inlet to prevent choking of the strainer. This screen should have sufficient openings so that flow velocity does not exceed two feet per second.

PRIMING THE PUMP. Your pump will not operate satisfactorily until it is primed. All air must be expelled from the suction piping and pump casing, and replaced by the liquid to be pumped. There are several methods of priming pumps. The one you select will depend on your specific requirements.

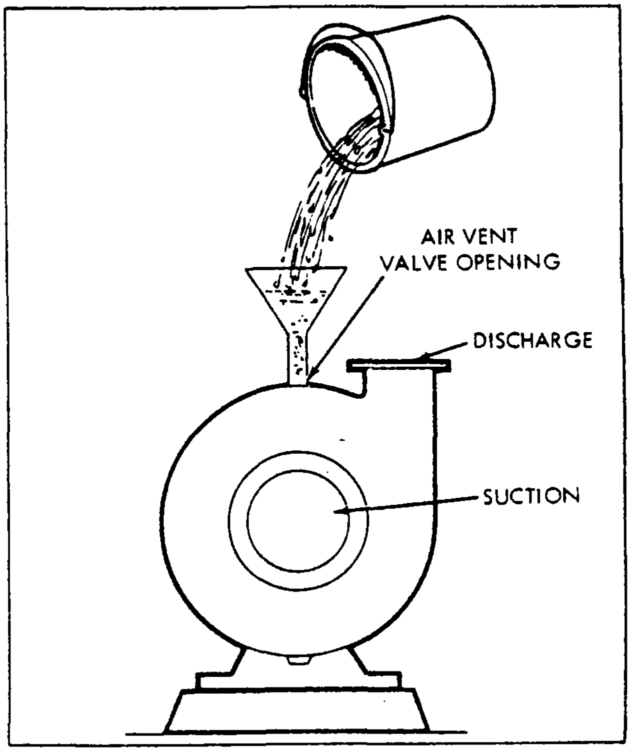


FIGURE 30. PRIMING BY HAND

FLOODED SUCTION PRIMING. This method of priming a pump is relatively simple. The liquid source is located above the pump, and all that is necessary to prime the pump is to open the air vent valve or plug in the pump casing, and to crack the gate valve in the suction line. The suction line and pump should be filled slowly until a steady stream of liquid is observed flowing from the air vent. After your pump is operating, it is recommended that the air vent valve or plug be opened again to insure that all air has been expelled from the pump casing.

FOOT VALVE PRIMING. A foot valve can be used for priming on suction lift applications. The foot valve located at the bottom end or foot of the suction piping, functions as a check valve which allows flow in one direction only, toward the pump.

Initial priming is accomplished by completely filling the suction piping and pump casing with the liquid to be pumped. This can be done by removing the air vent valve or plug at the top of the pump casing and inserting a pipe nipple in the orifice, with an appropriate increaser to accommodate a hose connection.

A priming line can also be inserted in the discharge piping between the check valve and the pump or the priming can be done with a bucket and funnel. The important thing is to completely fill the suction pipe and pump casing with liquid.

When the pump is started, the vacuum created by pumping the priming fluid, combined with atmospheric pressure in the liquid well, forces liquid into the suction piping, thus opening the foot valve and keeping it open until the pump is shut down. When the pump is shut down, the liquid being pumped reverses its flow, causing the foot valve to close, trapping the liquid in the suction piping and pump casing, thus maintaining a prime on the pump.

VACUUM PRIMING. Vacuum priming consists of removing air from the pump casing and suction piping and drawing liquid into them by means of a vacuum creating device. The types of vacuum equipment range from a simple hand pump to complex central priming systems. Your specific priming requirements will govern what type of vacuum primer to use.

AIR EJECTOR. One type of vacuum primer is the air ejector. If liquid under pressure or steam is available, an ejector can be used. The ejector is connected to the air vent orifice. A stream of the ejecting medium is passed through the ejector creating a vacuum in the ejector, and drawing air from the pump casing and suction piping. When liquid flows steadily from the ejector discharge pipe, the pump is primed.

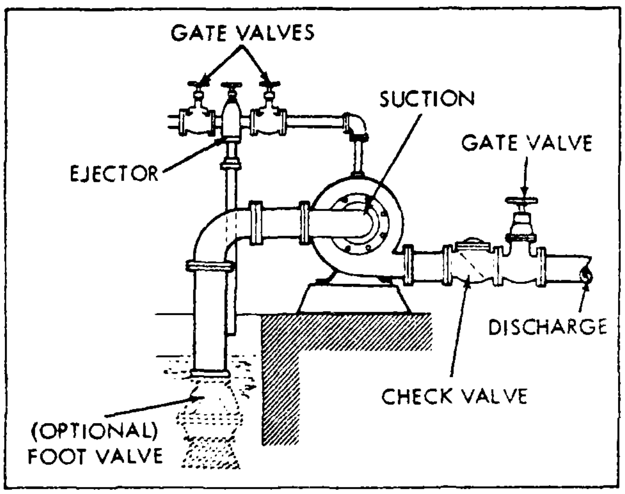


FIGURE 31. PRIMING BY EJECTOR

VACUUM PUMPS. Rotary or reciprocating pumps are frequently used as vacuum pumps. They fall into two categories, wet-vacuum and dry-vacuum. The principle of operation is essentially the same, however, the dry-vacuum pump cannot accommodate a liquid and air mixture while the wet-vacuum pump can accommodate liquid, air or a combination of both.

Vacuum pumps can be installed as part of a central priming system servicing many pumps, as an auto-

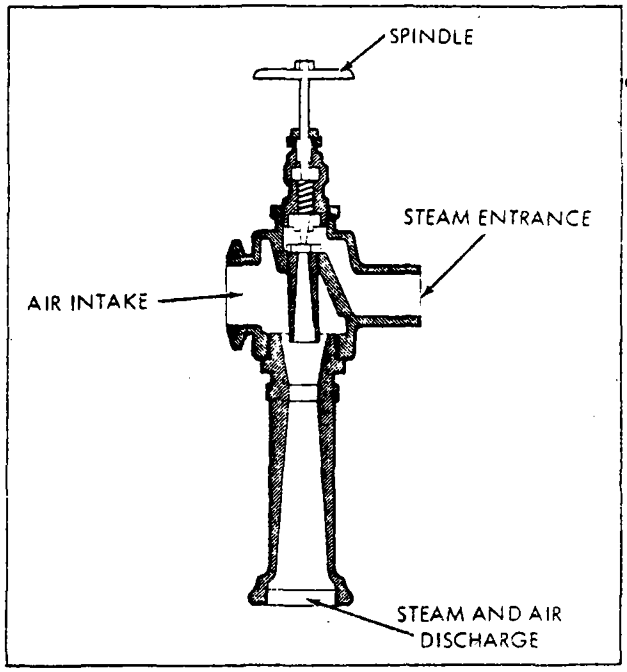


FIGURE 32. EJECTOR CUTAWAY

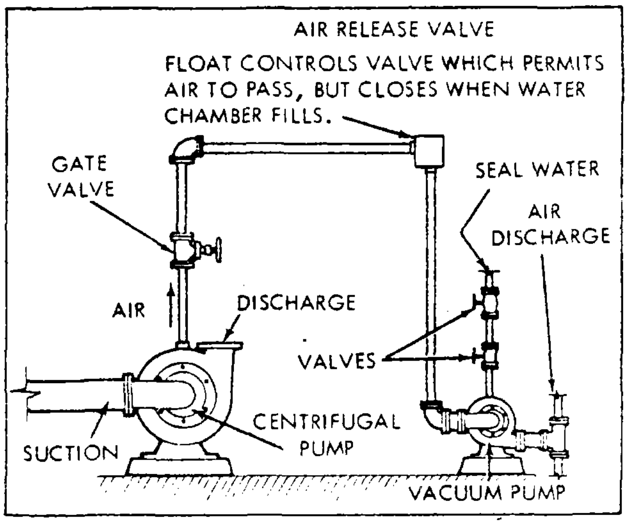


FIGURE 33. PRIMING BY VACUUM PUMP

matic priming system, or as a manually controlled independently driven pump.

The suction piping of the vacuum pump is connected to the air vent orifice on the pump to be primed. The vacuum produced by the vacuum pump removes air from the centrifugal pump suction piping and casing, and draws liquid from the liquid well into the centrifugal pump. Dry-vacuum pumps must be installed so that no liquid is taken into the air pump. Installation of a water trap, or use of a vacuum tank are recommended for dry vacuum pumps.

INDUCTOR PRIMING. On suction lift applications it may be desirable to prime your pump with a priming inductor. This type of primer is comprised of a liquid nozzle and an inductor at the foot end of the

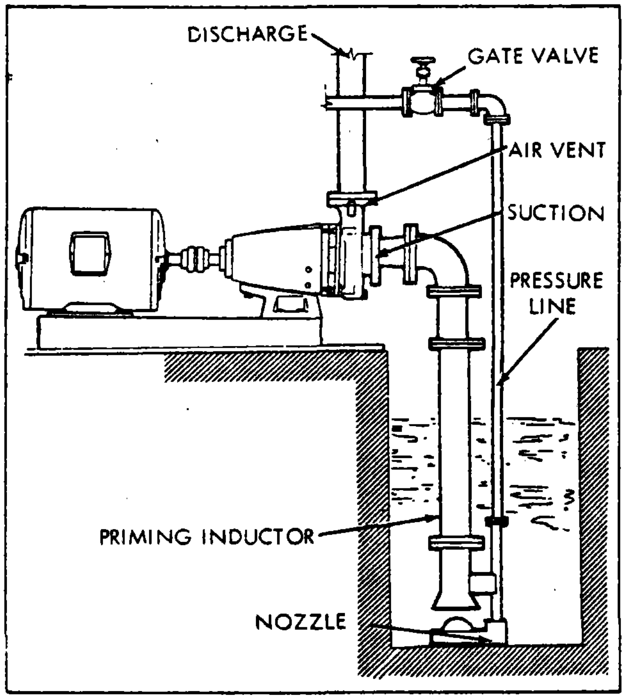


FIGURE 34. PRIMING BY INDUCTOR

suction piping. The nozzle and inductor are connected to a high pressure liquid supply such as a city water service.

The pump is primed by opening the valve in the pressure line, which allows the liquid to flow through the nozzle into the inductor. The velocity of the high pressure liquid drives the liquid into the suction piping and up to the pump, priming it.

ELECTRICAL WIRING. Normally, your pump will be supplied with an attached drive motor. The motor should be wired in accordance with the wiring diagram found on the motor name plate. Be sure the voltage, frequency, and phase of your power supply corresponds with the name plate data. It is advisable to provide a separate switch and overload protection for your pump motor to protect against power failure in some other area. Conversely, if the pump motor develops electrical problems, it will be isolated from other equipment.

PRESTARTING INSTRUCTION. The coupling halves should be connected. Prior to connection however, the drive motor should be started to make sure the direction of roatation is the same as the direction indicated by the arrow on the pump casing.

The suction and discharge piping should now be connected to the pump, and the pump primed.

CAUTION

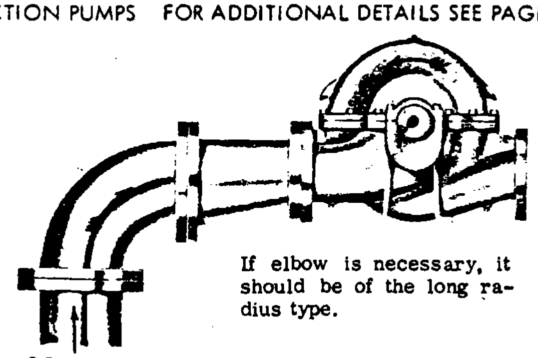
Do not operate the pump without liquid. Pump seals or packing depend on the liquid being pumped for lubrication.

Open or close the various valves as required by your specific application. Start the pump and bring it up to operating temperature. After the temperature has stabilized, the pump should be shut down and the alignment rechecked. It will be necessary to check the alignment with the coupling halves both connected and disconnected.

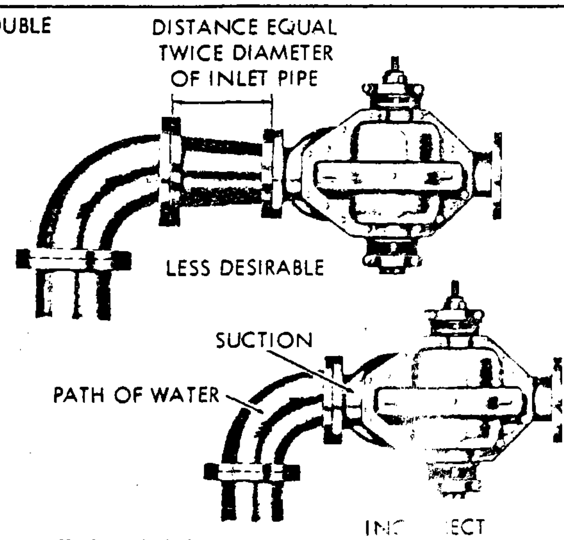
Remember, any alignment adjustment made in one direction may affect the other direction so extreme care should be taken when final adjustment is made.

Make sure all pump, motor and base plate mounting bolts are firmly tightened down.

SPECIAL SUCTION PIPING SPECIFICATIONS FOR HORIZONTAL DOUBLE SUCTION PUMPS FOR ADDITIONAL DETAILS SEE PAGE 6



CORRECT



Discharge piping and suction piping should be supported close to the pump flange to prevent vibration and strain on pump casing.

The suction pipe on horizontal double suction pumps, should not be installed so that there is an elbow close to the suction nozzle unless the elbow is mounted vertically. There is always an uneven flow of liquid through an elbow and when the elbow is installed at any angle other than vertical more water will enter one side of the impeller than enters the other side. This causes a reduction in capacity and efficiency and creates an axial thrust load which may over heat and possibly cause rapid wear of the thrust bearing.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA® PUMPS

INSTRUCTION MANUAL

4

OPERATION
CENTRIFUGAL PUMP

CENTRIFUGAL PUMP OPERATION. Centrifugal pumps operate under a wide range of conditions. The pump you have selected exactly fits your specific requirements. Before putting your pump into operation however, there are certain basic ground rules that have to be followed to assure maximum efficiency, long pump life, and maintenance free service.

Centrifugal pumps should never be started or run dry. Operating a pump dry can cause burning of the packings or seal, resulting in distruction of the packings or seals, and possible scoring of the pump shaft. To prevent the pump from being run dry, the pump should be primed before starting it.

A centrifugal pump should not be throttled, or the volume controlled on the suction side of the pump. Throttling the pump on the suction side, not only reduces the capacity, but also reduces pump efficiency, and more important, can cause serious damage to the pump due to cavitation. Cavitation occurs when the pressure at any point inside the pump drops below the vapor pressure of the liquid. The liquid flashes and forms vapor bubbles. These bubbles move along with the liquid into a higher pressure area, where the bubbles collapse or implode creating an area of low pressure. The implosion phenomenon is characterized by a crackling noise and sometimes by loud knocking as the vapor bubbles are collapsed. Repetition of this action causes a wearing away of the metal on the impeller and other parts of the pump, and if allowed to continue can result in serious damage to the pump.

Pump capacity can be effectively controlled by use of a throttling valve in the discharge piping. Most centrifugal pumps can be operated for brief periods of time with the throttling valve closed without building up excessive pressure or overloading the drive unit. In fact, a centrifugal pump operating against a closed discharge line at its rated capacity, actually requires less power to operate than it does when the throttling valve is open.

The pump should never be started with the throttling valve completely closed however because a condition of water hammer could exist. The condition of water hammer is caused by an increase in pressure due to changes in velocity of the liquid flowing through the pipe line. When the velocity is changed by closing a valve or by some other means, the magnitude of the pressure produced is frequently much greater than the static pressure on the line, and may cause rupture or damage to the pump, piping, or fittings. Water hammer may be controlled by regulating valve closure, or the use of relief valves and slow closing check valves.

On pumps equipped with packings, there should be sufficient leakage from the packing to insure lubrication of the packing and effective cooling of the stuffing box. The packing glands should always be adjusted evenly and not too tightly. Over tightening the packing can generate heat which will burn the packing and cause scoring of the shaft, making it necessary to replace both the shaft and the packings.

Adequate precautions should be taken to prevent freezing of liquid in the pump when the pump is not in operation. If there is any possibility of freezing, the water should be drained off by removal of the plugs provided in the pump casing.

All mounting bolts and piping connections must be firmly tightened to prevent excessive vibration, leakage, and possible damage to the pump. The mounting bolts are particularly important. If they are not firmly tightened, the base plate upon which the pump is mounted may deflect, causing a misalignment of the pump and the driver.

STARTING THE PUMP. In order to start your pump, it will first be necessary to prime it.

PRIMING THE PUMP. Your pump will not operate satisfactorily until it is primed. All air must be

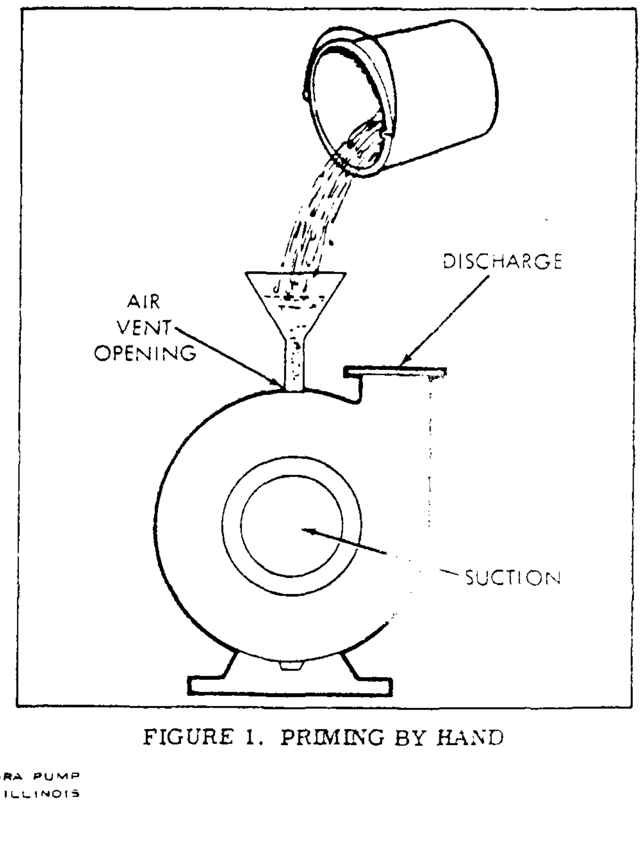


FIGURE 1. PRIMING BY HAND

expelled from the suction piping and pump casing, and replaced by the liquid to be pumped. There are several methods of priming pumps. The one you select will depend on your specific requirements.

FLOODED SUCTION PRIMING. This method of priming a pump is relatively simple. The liquid source is located above the pump, and all that is necessary to prime the pump is to open the air vent valve or plug in the pump casing, and to crack the gate valve in the suction line. The suction line and pump should be filled slowly until a steady stream of liquid is observed flowing from the air vent. After your pump is operating, it is recommended that the air vent valve or plug be opened again to insure that all air has been expelled from the pump casing.

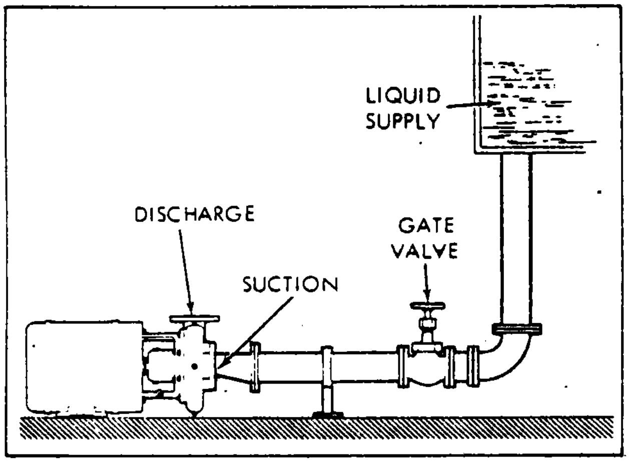


FIGURE 2. FLOODED SUCTION PRIMING

FOOT VALVE PRIMING. A foot valve can be used for priming on suction lift applications. The foot valve located at the bottom end or foot of the suction

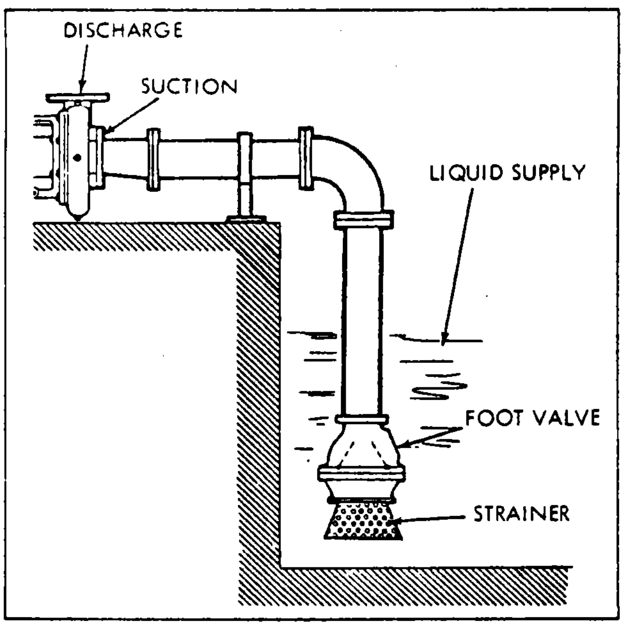


FIGURE 3. PRIMING WITH A FOOT VALVE

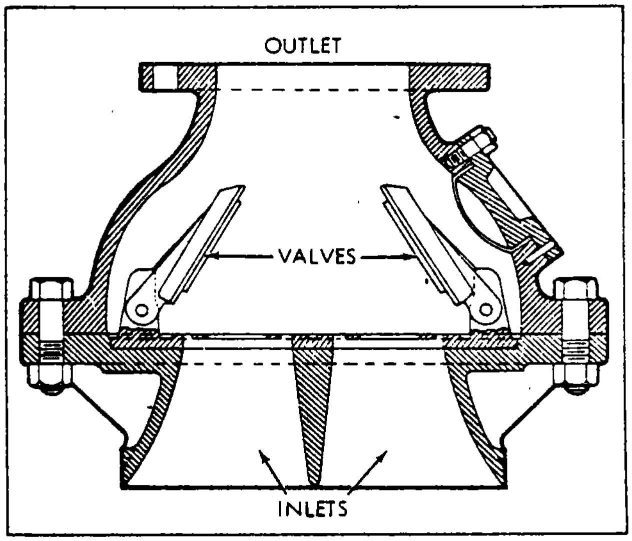


FIGURE 4. FOOT VALVE CUTAWAY

piping, functions as a check valve which allows flow in one direction only, toward the pump.

Initial priming is accomplished by completely filling the suction piping and pump casing with the liquid to be pumped. This can be done by removing the air vent valve or plug at the top of the pump casing, and inserting a pipe nipple in the orifice with an appropriate increaser to accommodate a hose connection. A priming line can also be inserted in the discharge piping between the check valve and the pump, or the priming can be done with a bucket and funnel. The important thing is to completely fill the suction pipe and pump casing with liquid.

When the pump is started, the vacuum created by pumping the priming fluid, combined with atmospheric pressure in the liquid well, forces liquid into the suction piping, thus opening the valve and keeping it open until the pump is shut down. When the pump is shut down, the liquid being pumped reverses its flow causing the valve to close. The liquid is now trapped in the suction piping and pump casing, thus maintaining a prime on the pump.

VACUUM PRIMING. Vacuum priming consists of removing air from the pump casing and suction piping, and drawing liquid into them by means of a vacuum creating device. The types of vacuum equipment range from a simple hand pump to complex central priming systems. Your specific priming requirements will govern what type of vacuum primer you use.

AIR EJECTOR. One type of vacuum primer is the air ejector. If liquid under pressure, or steam is available, an ejector can be used. The ejector is connected to the air vent orifice. A stream of the ejecting medium is passed through the ejector creating a vacuum in the ejector, and drawing air from the pump casing and suction piping. When liquid flows steadily from the ejector discharge pipe, the pump is primed.

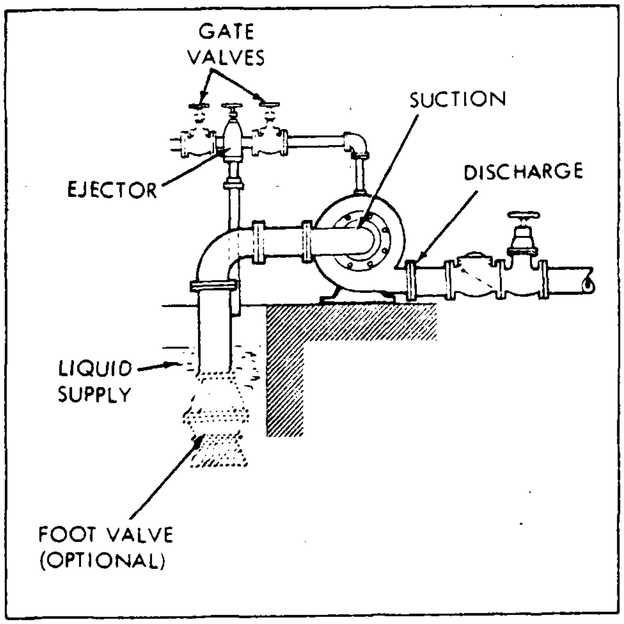


FIGURE 5. PRIMING BY EJECTOR

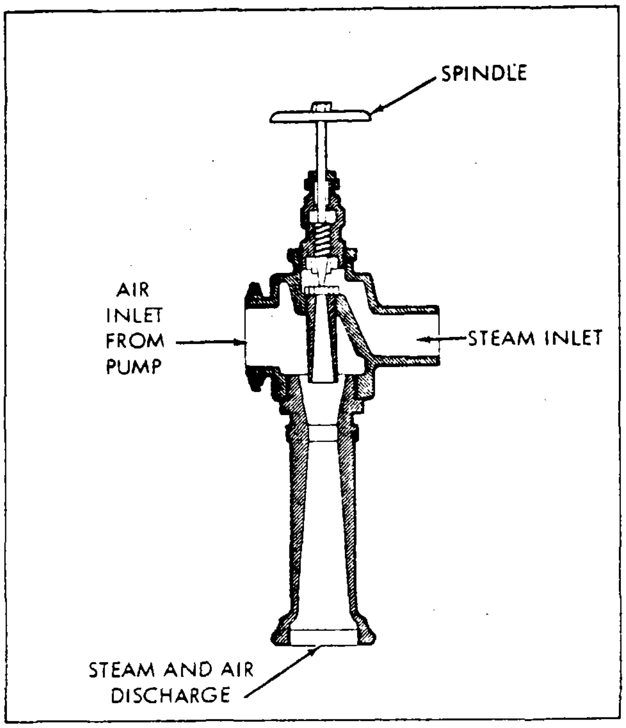


FIGURE 6. EJECTOR CUTAWAY

VACUUM PUMPS. Rotary or reciprocating pumps are frequently used as vacuum pumps. They fall into two categories, wet-vacuum and dry-vacuum. The principle of operation is essentially the same, however, the dry-vacuum pump cannot accommodate a liquid and air mixture, while the wet-vacuum pump can accommodate liquid, air, or a combination of both.

Vacuum pumps can be installed as part of a central priming system servicing many pumps, as an automatic priming system, or as a manually controlled independently driven pump.

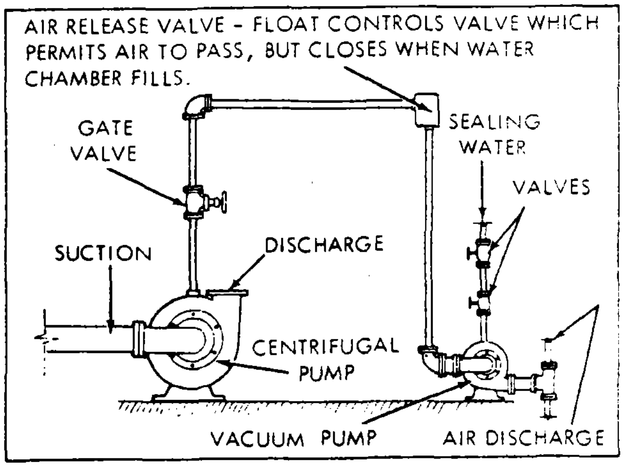


FIGURE 7. VACUUM PUMP PRIMING

The suction piping of the vacuum pump is connected to the air vent orifice on the pump to be primed. The vacuum produced by the vacuum pump removes air from the turbine pump suction piping and casing, and draws liquid from the liquid well into the turbine pump. Dry-vacuum pumps must be installed so that no liquid is taken into the air pump. Installation of a water trap, or use of a vacuum tank are recommended for dry vacuum pumps.

INDUCTOR PRIMING. On suction lift applications it may be desirable to prime your pump with a priming

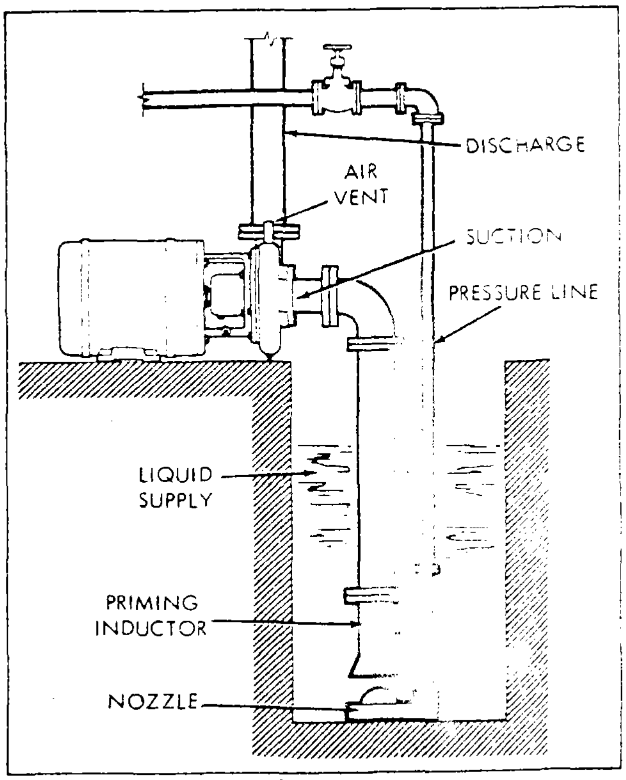


FIGURE 8. INDUCTOR PRIMING

inductor. This type of primer is comprised of a liquid nozzle and an inductor at the foot end of the suction piping. The nozzle and inductor are connected to a high pressure liquid supply such as a city water service.

The pump is primed by opening the valve in the pressure line. This will allow the liquid to flow through the nozzle and into the inductor. The velocity of the high pressure liquid drives the liquid into the suction piping and up to the pump, thus completing the priming operation.

POSITION OF DISCHARGE GATE VALVE WHEN STARTING. The discharge gate valve should partially be closed when a high or medium head centrifugal pump is started, because this type of pump requires much less power with the gate valve closed, than when it is operated at rated capacity and head with the discharge gate valve open. As soon as the pump is up to operating speed, the discharge gate valve should be opened to the desired position.

POSITION OF SUCTION PIPING GATE VALVE. In flooded suction applications, the gate valve is opened at the time the pump is being primed, and will remain open for starting and operation.

COOLANT VALVES. Valves in the cooling liquid line should be opened prior to the pump's being started, and will remain open while the pump is in operation, unless it is desirable to check the rate of leakage from the stuffing box.

SHUTTING DOWN THE PUMP. To shut down your pump, simply close the discharge gate valve and shut down the motor. If it is necessary for the pump to maintain its prime while it is shut down, it is advisable to install either a foot valve or a check valve in the suction piping.

AURORA® PUMPS

INSTRUCTION MANUAL

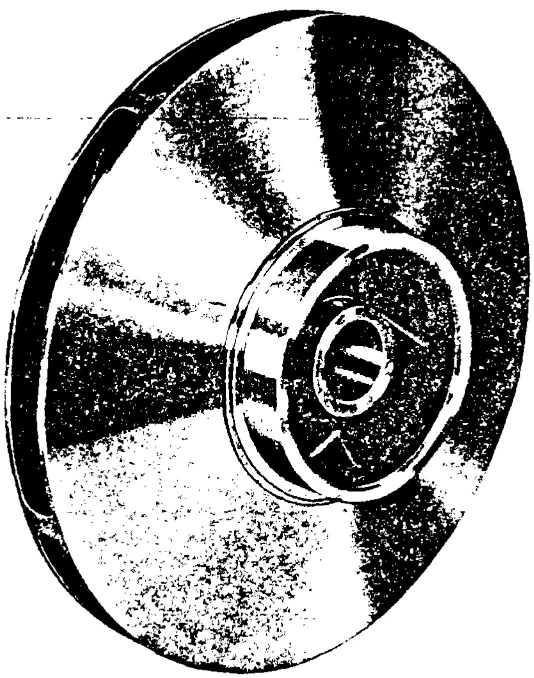
TROUBLESHOOTING CENTRIFUGAL PUMP

5

Your Aurora Pump has been engineered and carefully selected for your application. It should provide years of trouble-free service. However, any piece of machinery is subject to wear and occasional malfunctions.

To help you quickly isolate and rectify any malfunction the following troubleshooting chart has been prepared.

Frequent use of the chart to determine the cause of minor operating problems may prevent a major problem or possible breakdown of your pump.



STEARNS-ROCER ENGINEERING CORP.
PRCJECT NO. 62170O
SCLAR-CNE FILOT PLANT
UNIT CNE
P.C. 2001

CENTRIFUGAL PUMP TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
1. Pump fails to prime or loses its prime	a. Air leaks in suction lines b. Suction strainer is clogged c. Suction lift is too high d. Defective priming valve e. Defective packing or seal	a. Clean and tighten all suction connections; relocate suction inlet in liquid source b. Remove dirt, leaves or other material from strainer. c. Re-evaluate pump requirements and correct suction conditions accordingly. Consult your local Aurora Pump Sales Office. d. Replace valve. e. Replace packing or seal.
2. No discharge from pump	a. Pump is not properly primed b. Total head is too high c. Driver is not operating at rated speed d. Impeller or discharge line is clogged e. Wrong direction of rotation f. Pump is vapor bound	a. Reprime the pump; refer to priming troubles and remedies. b. Re-evaluate head calculations; measure elevation differences between pump and liquid source, and pump and discharge point. Consult your local Aurora Pump Sales Office. c. Check voltage of electric motor; check steam pressure of steam turbine; check engine R.P.M.'s. Refer to applicable maintenance manuals for possible troubles and corrective action. d. Back flush pump to clear obstruction; disassemble pump and/or piping and remove obstruction. e. Check wiring against diagram on motor name plate and in controller; reverse any two power leads on a three-phase motor; replace a single phase motor. f. Provide additional pressure on liquid being pumped by elevating liquid source or pressurizing the supply tank.
3. Pump does not deliver rated capacity	a. Pump is not properly primed b. Suction lift is too high c. Excessive air in liquid d. Air leakage through stuffing box e. Driver is not operating at rated speed f. Impeller is clogged g. Wearing rings are worn h. Impeller is damaged i. Pump is vapor bound	a. See 2.a. above. b. See 1.c. above. c. See 1.a. above. d. See 1.e. above. e. See 2.c. above. f. See 2.d. above. g. Replace wearing rings. h. Replace impeller. i. See 2.f. above.
4. Insufficient pressure	a. Excessive air in liquid b. Drive is not operating at rated speed c. Wrong direction or rotation d. Total head is too high e. Wearing rings are worn f. Impeller is damaged g. Casing gasket is defective allowing internal leakage h. Liquid is vaporizing	a. See 3.c. above. b. See 2.c. above. c. See 2.e. above. d. See 2.b. above. e. See 3.g. above. f. See 3.h. above. g. Replace casing gasket. h. See 2.f. above.

CENTRIFUGAL PUMP TROUBLESHOOTING

TROUBLE	PROBABLE CAUSE	REMEDY
5. Pump starts then stops pumping	a. Air leaks in suction line	a. See 1.a. above.
	b. Air pocket in suction line	b. Reprime the pump; eliminate air pocket conditions.
	c. Water seal line is plugged	c. Remove obstruction from water line.
	d. Excessive air in liquid	d. See 1.a. above.
	e. Suction lift too high	e. See 1.c. above.
	f. Defective packing or seal	f. See 1.e. above.
	g. Pump is vapor bound	g. See 2.f. above.
6. Excessive power consumption	a. Speed is too high	a. Internal electric motor wiring is incorrect; replace motor; refer to applicable driver maintenance manuals for possible troubles and corrective action.
	b. Wrong direction of rotation	b. See 2.e. above.
	c. Total head is too high	c. See 2.b. above.
	d. Total head is too low	d. Re-evaluate head conditions; correct as required. Consult your local Aurora Pump Sales Office.
	e. Impeller is clogged	e. See 2.d. above.
	f. Impeller is binding	f. Relieve strain on casing; adjust impeller clearance.
	g. Motor shaft is bent or worn	g. Replace motor shaft.
	h. Driver and pump are misaligned	h. Realign driver with pump.
	i. Power frame shaft is bent	i. Replace shaft.
	j. Wearing rings are worn	j. See 3.g. above.
	k. Packing is incorrectly installed	k. Install packings correctly; replace if necessary.
7. Pump is noisy or has excessive vibration	a. Magnetic hum	a. Consult motor manufacturer.
	b. Motor bearings are worn	b. Replace bearings.
	c. Foreign material in impeller	c. Remove foreign material.
	d. Impeller is binding	d. See 6.f. above.
	e. Motor shaft is bent or worn	e. See 6.g. above.
	f. Driver and pump are misaligned	f. See 6.h. above.
	g. Power frame shaft is bent	g. See 6.i. above.
	h. Foundation is not rigid	h. Strengthen foundation [illegible]ge method of mounting pump un[illegible]
	i. Worn bearing in power frame	i. Replace bearing.
	j. Impeller is damaged	j. See 3.h. above.
	k. Lack of lubrication in power frame	k. Lubricate power fra[illegible]arings; replace bearings if da[illegible]
	l. Pump is not properly leveled	l. Check levelness of [illegible]
	m. Piping is not supported	m. Provide support for s[illegible] a[illegible] discharge piping.
	n. Pump is cavitating	n. Re-evaluate pump application; consult local Aurora Pump Sales Office.

GENERAL INSTALLATION, OPERATION & MAINTENANCE INSTRUCTIONS

SAFETY FIRST

High voltage and rotating parts can cause serious or fatal injury. Safe installation, operation and maintenance must be performed by qualified personnel. Familiarization with and adherence to NEMA MG2, the National Electrical Code, and local codes is recommended. It is important to observe safety precautions to protect personnel from possible injury. Personnel should be instructed to:

1. Avoid contact with energized circuits or rotating parts.
2. Disconnect and lock out all power sources before initiating any maintenance or repair.
3. Act with care in accordance with prescribed procedures in handling and lifting this equipment.
4. Be sure unit is electrically grounded in accordance with code requirements.
5. Be sure equipment is properly enclosed to prevent access by children or other unauthorized personnel in order to prevent possible accidents.
6. Be sure shaft key is fully captive before unit is energized.
7. Avoid contact with capacitors until safe discharge procedures have been completed.
8. Most units are shipped without oil. Always be sure oil lubricated units are filled with correct oil to proper level before operating.
9. Provide proper safeguards for personnel against rotating parts and applications involving high inertia loads which can cause overspeed.
10. Avoid extended exposure to equipment with high noise levels.
11. Be familiar with the equipment and read all instructions thoroughly before installing on equipment.

INSPECTION AND HANDLING

Inspect unit to make sure no damage has occurred during shipment. Check Nameplate for correct speed, horsepower, voltage, Hertz and phase for conformance with power supply and equipment. **WARNING**: Units should be lifted using all eyebolts or lugs if provided. These eyebolts or lugs are provided for lifting this unit only and must not be used to lift any additional weight. Lifting angle must not exceed 15 degrees with shank of eyebolt. If not provided, eyebolts to be used must be per ASTM A489 or equivalent. All eyebolts must be securely tightened. Be careful not to touch overhead power lines with lifting equipment. Failure to observe this warning may result in serious personal injury or property damage.

STORAGE

Units should be stored indoors, in a clean, dry location. Winding should be protected from excessive moisture absorption. **NOTE**: If motors are to be stored for over one year, refer to U.S. Electrical Motors. If gear and belt transmission units are to be stored for over six months, refer to U.S. Electrical Motors.

LOCATION

Units should be located in a clean, well-ventilated area for maximum life. **WARNING**: Units should be located in a suitable enclosure to prevent access by children or other unauthorized personnel to prevent possible accidents.

MOUNTING

Mount units on a firm, flat surface sufficiently rigid to prevent vibration.

Drive belts and chains should be within recommended limits of tightness. Couplings should be properly aligned and balanced. For drive recommendations, refer to drive or equipment manufacturers or U.S. Electrical Motors. For application of drive equipment, refer to NEMA MG1.

Motors have been dynamically balanced using a half key the same length as the full key shipped with the motor. If pulley length is less than this key length, rework long key by removing one-half of excess length between pulley and end of key to maintain balance.

Do not restrict motor ventilation. Unless otherwise specified on Nameplate, motor is designed for operation in 40°C (104°F) maximum ambient temperature. **NOTE**: Motors operating under rated load and ambient conditions may feel hot when touched; this is normal and should not be cause for concern. When in doubt, measure frame temperature and confer with nearest office. Standard grease lubricated units can be operated in minimum ambient of -25°F. Special lubricants are required for temperature outside this range.

If unit has been stored in a damp location, dry out thoroughly before operating.

WARNING: Guards should be provided for all exposed rotating parts to prevent possible personal injury. Keep fingers and foreign objects away from ventilation and other openings. Applications involving HIGH INERTIAL LOADS may damage this equipment due to motor overspeed during shut down. Such application should be referred to U.S. Electrical Motors.

CAUTION: Do not force drive coupling or other equipment onto shaft, as bearing damage may result.

POWER SUPPLY AND CONNECTIONS

The power supply must agree with values on Nameplate. Terminal voltage should not vary more than ±10% of Nameplate voltage at rated frequency. Unbalanced line voltage, even a small amount, will cause overheating. Do not exceed the continuous rated operating current on the Nameplate. Starting controls and overload protection should be properly sized in accordance with the National Electrical Code and the control manufacturer's recommendations.

Motor connections should be made by fo[illegible]ng instructions on connection diagram. Determine di[illegible]on of rotation before connecting driven equipment. No[illegible]ection of rotation label if supplied. Rotation may b[illegible]ersed on three phase motors by interchanging any t[illegible]e connections. On two phase motors, interchange [illegible] A-2; and on single phase motors interchange leads [illegible]onnection diagram on motor. Wiring of units, controls and grounding shall be in accordance with local and National Electrical Code requirements. **WARNING**: Failure to properly ground unit may cause serious injury to personnel. Where unexpected starting could be hazardous to personnel, do not use automatic reset starting devices.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

OIL LUBRICATION

Most oil lubricated units are shipped without oil. Add oil of the correct viscosity for the ambient temperature, per Nameplate on unit, to proper level.

Make certain an oil with mild EP additives is used on wormgear units.

Refer to Nameplate or Lubrication Instruction Plate for oil viscosity and oil change interval. Refer to list for recommended oils. **WARNING**: For applications in the food and drug industry (including animal food), consult the petroleum supplier for lubricants that are acceptable to the Food and Drug Administration and other governing bodies.

MAINTENANCE

Inspect units at regular intervals. Keep units clean and ventilation openings clear of dust, dirt or other debris. Lubricate units per this operating instruction folder and instruction plate on unit. Excessive lubrication may damage the unit. Do not over grease! **WARNING**: Disconnect all power sources to the unit and discharge all parts which may retain an electrical charge before attempting any maintenance or repair. Screens and covers must be maintained in place when unit is in operation. Motor for use in hazardous locations – class I & II Installation: Repairs of these motors must be made by the manufacturer or authorized service station approved by the manufacturer and U.L. to maintain the U.L. Listing. The U.L. Listing applies to the electrical motor only and not to the belt or gear transmissions or other devices that may be connected to the motor.

VARIDRIVE UNITS

Do not turn control wheel while unit is not operating as this may cause damage to the unit. Handwheel position is a relative speed indication only. Use direct speed sensing accessory for precise speed indication. Units equipped with electric remote speed indicator accessory are not calibrated at the factory and must be calibrated at site. Refer to calibration instructions with meter.

VARIDRIVES equipped with ENDOLUBE construction do not require lubrication of the sliding Varidiscs.

VARIDRIVES equipped with splined shafts require monthly lubrication for 8 hour/day service, and semi-monthly for 24 hour/day service. (For complete instructions for entire drive, refer to the lubrication instruction plate on unit.) Operate VARIDRIVE through its entire speed range weekly. **WARNING**: Do not force control wheel beyond speed limits shown on Nameplate. The mechanism and belt are designed for the rated speed and horsepower shown on the Nameplate. Operation beyond these limits may result in damage to the belt and mechanism and possible injury to personnel. The covers on the frame case must not be removed or left off while unit is in operation. Do not attempt to disassemble or repair the driven pulley discs because high spring tension may be released causing injury to personnel. Refer to authorized Service Center. Refer to VARIDRIVE Installation and Maintenance Manual for complete belt changing instructions.

For additional detailed information, request specific product installation and maintenance manual from U.S. Electrical Motors, Milford, Conn. 06460.

RENEWAL PARTS AND WARRANTY SERVICE

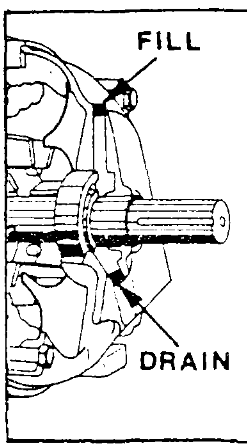
When inquiring for renewal parts call the nearest U.S. Electrical Motors Service Department (Los Angeles, Calif., or Milford, Conn.) or Parts Stocking Distributors. For warranty service call the nearest U.S. Electrical Motors Service Station. Give them complete Nameplate data including serial number, etc.

LUBRICATION INSTRUCTIONS

Some small motors have sealed-for-life bearings which require no relubrication. Regreasable bearings are shipped with a high quality, wide temperature-range grease in the bearings.

Motors can be regreased by stopping the motor, removing drain plug and pumping new grease into fillhole. Run motor with drain plug removed to discharge excess grease. Replace drain plug.

Units that operate at speeds greater than 1800 RPM should be lubricated on a more frequent maintenance schedule depending on duty cycle. Use a low pressure grease gun and avoid overgreasing.



SUGGESTED REGREASING INTERVALS			
SERVICE	MOTOR HORSEPOWER		
	UNDER 50	50-100	100 Up
A	1-2 Yrs.	1-2 Yrs.	1 Yr.
B	1 Yr.	1 Yr.	6 Mos.
C	1 Yr.	6 Mos.	3 Mos.
D	4 Mos.	3 Mos.	3 Mos.
SERVICE SYMBOL	TYPES OF SERVICE		
A	Infrequent operation or light duty in clean atmosphere		
B	8-16 Hrs/Day in clean, relatively dry atmosphere.		
C	12-24 Hrs/Day, heavy duty, or if moisture is present		
D	Heavy duty in dirty, dusty locations; high ambients; moisture laden atmosphere; vibration.		

RECOMMENDED GREASES

The following table lists recommended products which should be used for regreasing motors.

MANUFACTURER	TRADE NAME OF GREASE	MANUFACTURER	TRADE NAME OF GREASE
U.S. Electrical Motors	(Syn) 83343	Lubriplate Div., Fiske Bros. Refining	(L) Multi-Lube A
American Oil Co.	(L) Amolith #2	MacMillan Petroleum Co.	(L) All Purpose Grease 2 (802)
Atlantic Richfield Co.	(L) Litholine EP2	Master Lubricants Co.	(L) Lubriko L 206
Cities Service Oil Co.	(L) Citgo Trojan H-2	Mobil Oil Co.	(L) Mobilux 2
Continental Oil Co	(L) Conoco Super STA Grease	Pennzoil United	(L) Multi-Purpose Lube 705
Getty Oil Co.	(L) Veedol All-Purpose	Phillips Petroleum Co.	(L) Phillips IB & RB Grease 2
Gulf Oil Corp.	(L) Gulfcrown 2 or Gulfex A	Shell Oil Co.	(L) Alvania #2
E. F. Houghton & Co.	(L) Cosmolube 2	Standard Oil Co. of Calif., Inc.	(Syn) SRI-2 or BRB-2
Exxon	(L) Unirex N2	Standard Oil Co. of Ohio	(L) Bearing Gard
Jet Lube, Inc.	(L) CB-2 Grease	Sun Oil Co.	(L) Prestige 42
Keystone Div., Pennwalt Corp.	(L) Keystone Grease #81 Light	Texaco Inc.	(L) Premium RB #2
Lubrication Engineers, Inc.	(L) 187 Almasol Elec. Mtr. Lube	Valvoline Div., Ashland Oil Inc.	(L) Val-Lith #2 EP
			(L) Lithium (Syn) Synthetic

RECOMMENDED OILS

For use in Syncrogears (Parallel Shaft) and Vertical (Includes T/E, Etc.) Pump Motors. Refer to Lubrication Instruction Plate for proper viscosity of oil required for operating temperatures.

MANUFACTURER	TRADE NAME OF OILS		
	145-175 SSU @ 100 F	180-240 SSU @ 100 F AGMA #1	280-360 SSU @ 100 F AGMA #2
U.S. Electrical Motors	Viscolube R772101 Oil		Viscolube R772103
American Oil Co.	Rykon Ind. Oil 15	Rykon Ind. Oil 21	Rykon Ind. Oil 31
Atlantic Richfield Co.	Duro S-150	Duro S-200	Duro S-315
Cato Oil & Grease Co., Inc.	Pawnee R&O Ind. Oil A.5	Pawnee R&O Ind. 8	Pawnee R&O Ind. D
Cities Service Oil Co.	Citgo Pacemaker T-15	Citgo Pacemaker T-20	Citgo Pacemaker T-30
Continental Oil Co.	Conoco Turbine Oil Light	Conoco Dectol Light Medium	Conoco Dectol Medium
Famous Lubricants, Inc.			Orange Fluid Oil #300 MC
Getty Oil Co.	Veedol Aturbrio 50		Veedol Aturbrio #60
Gulf Oil Corp.	Harmony Oil 44	Harmony 47	Harmony 53
E. F. Houghton & Co.	Hydro-Drive MIH Light	Hydro-Drive MIH 10	Hydro-Drive MIH 20
Exxon	Teresstic 43 or Nuto 43	Teresstic 47 or Nuto 47	Teresstic 52 or Nuto 53
Keystone Div., Pennwalt Corp.	KLC 6	KLC 5	KLC-4A
Lubrication Engineers, Inc.	6401 Monolec Turbine Oil Light	6402 Monolec	6403 Monolec Turbine Oil Heavy
Lubriplate Div. Fiske Bros. Refining	Lubriplate Hydraulic Oil #0	Lubriplate Hydraulic Oil #1	Lubriplate Hydraulic Oil #2
Mobil Oil Co.	DTE Oil 797	DTE Medium	DTE Oil Heavy Medium
Pennzoil United	Pennbell #1	Pennbell #1	Pennbell #2
Phillips Petroleum Co.	Magnus Oil 150		Magnus Oil 315
Shell Oil Co.	Tellus 27	Tellus 29	Tellus 33
Standard Oil Co. of Calif., Inc.	Chevron OC Turbine #32	Chevron OC Turbine #46	Chevron OC Turbine #68
Standard Oil Co. of Ohio	Industron 44	Industron 48	Industron 53
Sun Oil Co.	Sunvis 916	Sunvis 921	Sunvis 931
Texaco, Inc.	Regal A (R&O)	Regal B (R&O)	Regal PC (R&O)
Union Oil Co. of Calif.	Red Line Turbine 150	Union Turbine Oil 215	Union Turbine Oil 315
Valvoline Div., Ashland Oil Inc.	Valvoline ETC 15	Valvoline ETC 20	Valvoline ETC 30

For use in Syncrogears (Parallel Shaft) and Vertical (Includes T/E, Etc.) Pump Motors. Refer to Lubrication Instruction Plate for proper viscosity of oil required for operating temperatures.

MANUFACTURER	TRADE NAME OF OILS		
	490-700 SSU @ 100 F AGMA #3	700-1000 SSU @ 100 F AGMA #4	80-105 SSU @ 210 F AGMA #5
U.S. Electrical Motors	Viscolube R772105		
American Oil Co.	Rykon Ind. Oil 51	Rykon Ind. Oil 95	Rykon Ind. Oil 150
Atlantic Richfield Co.	Duro S-600	Duro S-900	Duro S-1000
Cato Oil & Grease Co., Inc.	Pawnee R&O Ind. E	Pawnee R&O Ind. F	Pawnee R&O Ind. G
Cities Service Oil Co.	Citgo Pacemaker T-50	Citgo Pacemaker T-75	Citgo Pacemaker T-100
Continental Oil Co.	Conoco Dectol Heavy	Conoco Dectol Heavy	Conoco Dectol Special Heavy
Famous Lubricants, Inc.	Orange Fluid Oil #500		Orange Fluid Oil #800
Getty Oil Co.	Veedol Aturbrio #70		Veedol Aturbrio #77
Gulf Oil Corp.	Harmony 69	Harmony 76	Harmony 97
E. F. Houghton & Co.	Hydro-Drive MIH 30	Hydro-Drive MIH 40	Hydro-Drive MIH 50
Exxon	Teresstic 65	Teresstic 85 or Nuto 76	Teresstic 85 or Nuto 93
Keystone Div., Pennwalt Corp.	KLC-4	KLC-3	KLC-2
Lubrication Engineers, Inc.	6404 Monolec Turb. Oil Ext. Heavy		6204 Monolec Air Comp. Oil Heavy
Lubriplate Div., Fiske Bros. Refining	Lubriplate Hydraulic Oil #3	Lubriplate Hydraulic Oil #4	
Mobil Oil Co.	DTE Oil Heavy Medium	DTE Oil BB	DTE Oil BB
Pennzoil United	Pennbell #3	Pennbell #4	Pennbell #5
Phillips Petroleum Co.	Magnus Oil 465	Magnus Oil 1000	Magnus Oil 1000
Shell Oil Co.	Tellus 41	Tellus 69	Tellus 71
Standard Oil Co. of Calif., Inc.	Chevron OC Turbine #100	Chevron OC Turbine #150	Chevron OC Turbine #220
Standard Oil Co. of Ohio	Industron 66	Industron 80	Industron 100
Sun Oil Co.	Sunvis 951	Sunvis 975	Sunvis 999
Texaco, Inc.	Regal F (R&O)	Regal G (R&O)	Regal H (R&O)
Union Oil Co. of Calif.	Union Turbine Oil 700	Union Turbine Oil 1000	Union Turbine Oil 1000
Valvoline Div., Ashland Oil Inc.	Valvoline ETC 70	Valvoline ETC 100	Valvoline ETC 100

RECOMMENDED WORM GEAR OILS

First Refer to Lubrication Instruction Plate for Proper Viscosity of Oil Required for Operating Temperature
Second Select One of Many Brands Listed

MANUFACTURER	TRADE NAME OF WORM GEAR OIL		
	280-400 SSU @ 100 F AGMA = 2EP	70-100 SSU @ 210 F AGMA = 5EP	125-150 SSU @ 210 F AGMA = 7EP
U.S. Electrical Motors		Viscolube 160441	Viscolube 503180
American Oil Co.	*Amogear Compound* ≠1	*Amogear Compound* ≠3	*Amogear Compound* ≠5
Atlantic Richfield Co.		Pennant EP S-1000	Pennant EP 2450
Cato Oil & Grease Co., Inc.	Worm Gear Lube 80 (1628)	Mystic JT-7 GL-5 (1663)	Mystic JT-7 GL-5 (1663)
Cities Service Oil Co.	Trojan Compound L-00	Trojan Compound L-2	Trojan Compound L-3X
Continental Oil Co.		*Conoco Mil Gear L-100*	*Conoco Mil Gear L-136*
Famous Lubricants, Inc.		Gear Life PB 3	Gear Life PB 6
Getty Oil Co.		Apreslube 80	Apreslube 90
Gulf Oil Corp.	EP Lubricant 55	EP Lubricant 75	EP Lubricant 145
E. F. Houghton & Co.	MP Gear Oil 80	MP Gear Oil 90	MP Gear Oil 140
Exxon	Spartan EP 0	Spartan EP 3	Spartan EP 5
Keystone Div., Pennwalt Corp.		SR3	SR1
Lubrication Engineers, Inc.	≠600 Almasol Trans-Worm Lube	≠601 Almasol Trans-Worm Lube	≠602 Almasol Trans-Worm Lube
Lubriplate Div., Fiske Bros. Refining		Lubriplate APG 90	Lubriplate APG 140
Mobil Oil Co.	Mobil Compound AA	Mobil Compound DD	Mobil Compound FF
Non-Fluid Oil Co.		Non-Fluid Oil ≠S-581	Non-Fluid Oil ≠S-583
Pennzoil United		Pennzoil Worm Gear Oil 410	Pennzoil Worm Gear Oil 420
Phillips Petroleum Co.	All Purpose Gear Oil 80	All Purpose Gear Oil 90	All Purpose Gear Oil 140
Shell Oil Co.	Macoma 33	Macoma 72 or 73	Macoma 75 or 76
Standard Oil Co. of Calif., Inc.	Chevron NL Gear Compound 68	Chevron NL Gear Lubricant 220	Chevron NL Gear Compound 460
Standard Oil Co. of Ohio	Gearep 80	Gearep 90	Gearep 140
Sun Oil Co.		Sunep 90	Sunep 150
Texaco, Inc.	Meropa 1	Meropa 2	Meropa 5
Union Oil Co. of Calif.	Union Extra Duty NL Gear Lub - 2EP	Union Extra Duty NL Gear Lub - 5EP	Union Extra Duty NL Gear Lub - 7EP
Valvoline Div., Ashland Oil Inc.	Valvoline EP Gear Compound ≠30	Valvoline EP Gear Compound ≠70	Valvoline EP Gear Compound ≠200

NOTE: The recommended lubricants listed above are compounded worm lubricants containing non-corrosive extreme pressure additives. DO NOT USE lubricants containing sulfur and/or chlorine extreme pressure additives which are corrosive to worm gear bronze. The oil bath in worm gear cases may reach a temperature of 200 F (94°C) without alarm.

U.S. ELECTRICAL MOTORS

DIVISION OF EMERSON ELECTRIC COMPANY

OFFICES

WORLD HEADQUARTERS Milford, Connecticut	Old Gate Lane, Milford, Conn. 06460 (203) 878-9311.
CALIFORNIA (San Francisco)	1380 Kifer Rd., Sunnyvale, Calif. 94086 (408) 732-7111.
CALIFORNIA (Orange)	1740 West Katella Ave., Suite G., Orange, Calif. 92667 (714) 632-9752
ILLINOIS	1505 Birchwood Ave., Des Plaines, Illinois (312) 296-9300
TENNESSEE	3276 Democrat Road, Memphis, Tenn. 38118 (901) 365-2360
TEXAS (Dallas)	3441 Halifax St., Dallas, Texas 75247 (214) 630-9061

EMERSON
U.S. ELECTRICAL MOTORS
DIVISION OF EMERSON ELECTRIC CO
125 OLD GATE LANE
MILFORD, CONNECTICUT 06460

F. O. NO. 4DO-65707

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD·NORTH AURORA, ILLINOIS·60542

AURORA PUMPS

FIRE PUMP ACCESSORIES LIST

ITEM NO.		QTY	DESCRIPTION		SIZE	REMARKS	ITEM NO
1	☐		ECCENTRIC REDUCER	250 lb			1
2	☐		CONCENTRIC INCREASER	250 lb			2
3	☒	1	CONCENTRIC INCREASER	125 lb	6×5		3
4	☒	1	ECCENTRIC REDUCER	125 lb	8×6		4
5	☐		OUTSIDE HOSE MANIFOLD				5
6	☐		3000-3500 GPM HOSE VALVE HEADER	125 lb		FOR VERTICAL TURBINE	6
7	☐		3000-3500 GPM HOSE VALVE HEADER			FOR SPLIT CASE	7
8	☐		4000-4500 GPM HOSE VALVE HEADER	125 lb			8
9	☐		125 lb FLANGE STRAIGHT TEE				9
10	☐		REDUCING TEE STD. 125"& 250"				10
11	☐		SET 2-1/2 HOSE VALVE W/CAPS & CHAINS			NATL. STD. THREAD	11
12	☐		BLIND FLANGE STD. 125 LB C.I.				12
13	☐		AUTOMATIC BALL DRIP VALVE				13
14	☐		UMBRELLA HOOD UNDERWRITERS COCK				14
15	☐		AIR COCK				15
17	☒	1	SUCTION AND DISCHARGE GAUGES		1/4"		17
18	☒	1	AIR RELEASE VALVE (FLOAT OPERATED)		1/2"		18
19	☐		MAIN RELIEF VALVE				19
20	☒	1	CASING RELIEF VALVE		3/4"		20
21	☐		SWING CHECK VALVE			(Used as automatic air release valve)	21
22	☐		OPEN WASTE CONE				22
23	☐		ENCLOSED WASTE CONE				23
24	☐		SPLASH SHIELD HORIZONTAL			POWER SERIES NO.___	24
25	☐		SPLASH SHIELD VERTICAL			POWER SERIES NO.___	25
26	☐						26
27	☐						27
28	☐						28
29	☐						29
30	☐						30
31	☐						31

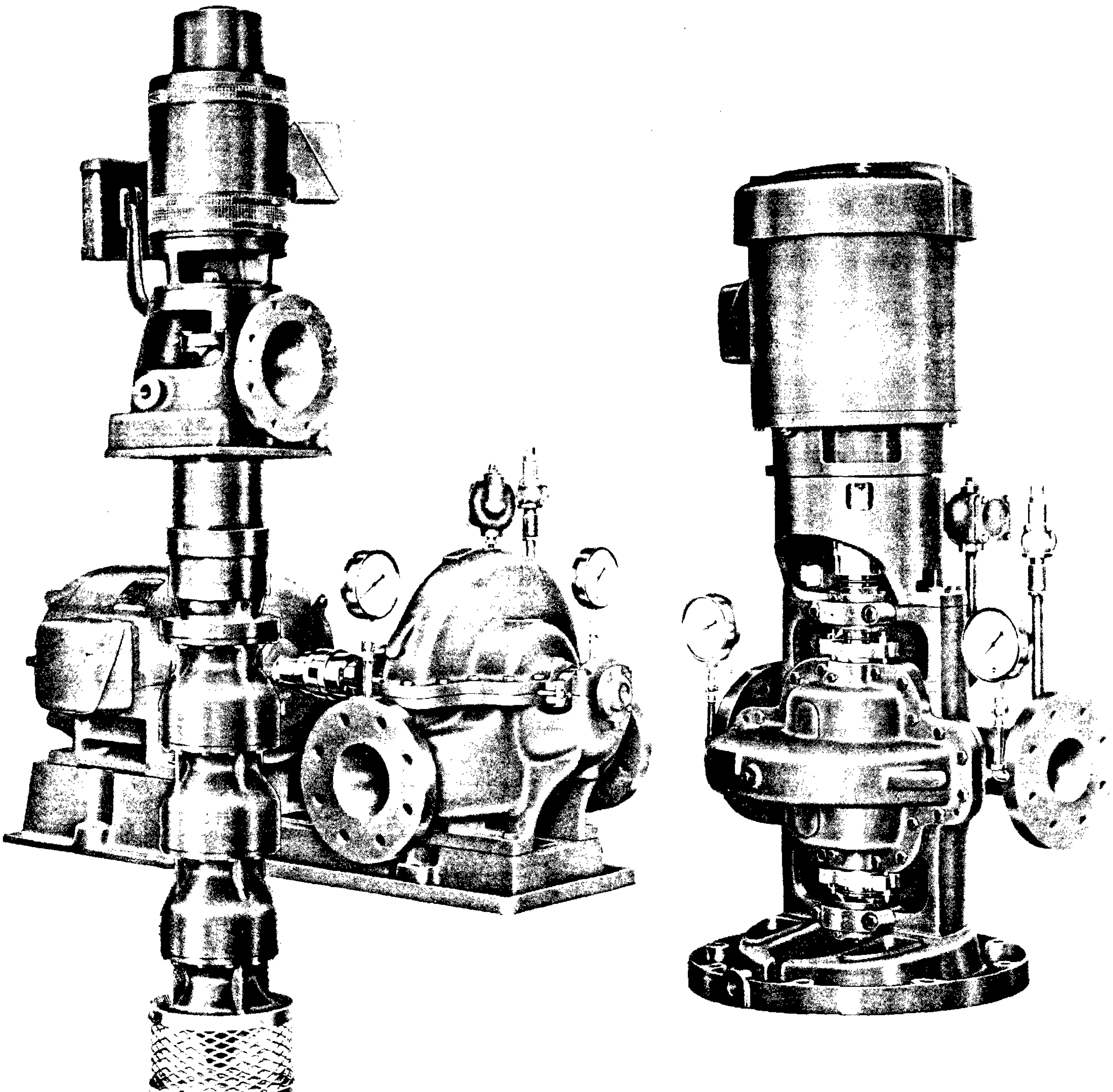
DATE 12-10-80

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

1.2.7.40

AURORA® PUMPS

SUBMITTAL DATA
FIRE PUMP
ACCESSORIES



F. O. NO.________________

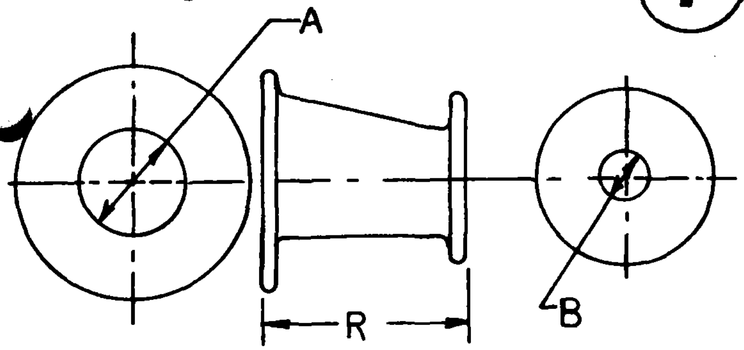
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

FIRE PUMP ACCESSORIES LIST

ITEM NO.	QTY	DESCRIPTION	SIZE	REMARKS	ITEM NO
1 ☐		ECCENTRIC REDUCER 250 lb			1
2 ☐		CONCENTRIC INCREASER 250 lb			2
3 ☐		CONCENTRIC INCREASER 125 lb			3
4 ☐		ECCENTRIC REDUCER 125 lb			4
5 ☐		OUTSIDE HOSE MANIFOLD			5
6 ☐		3000-3500 GPM HOSE VALVE HEADER 125 lb		FOR VERTICAL TURBINE	6
7 ☐		3000-3500 GPM HOSE VALVE HEADER		FOR SPLIT CASE	7
8 ☐		4000-4500 GPM HOSE VALVE HEADER 125 lb			8
9 ☐		125 lb FLANGE STRAIGHT TEE			9
10 ☐		REDUCING TEE STD. 125#& 250#			10
11 ☐		SET 2-1/2 HOSE VALVE W/CAPS & CHAINS		NATL. STD. THREAD	11
12 ☐		BLIND FLANGE STD.. 125 LB C.I.			12
13 ☐		AUTOMATIC BALL DRIP VALVE			13
14 ☐		UMBRELLA HOOD UNDERWRITERS COCK			14
15 ☐		AIR COCK			15
17 ☐		SUCTION AND DISCHARGE GAUGES			17
18 ☐		AIR RELEASE VALVE (FLOAT OPERATED)			18
19 ☐		MAIN RELIEF VALVE			19
20 ☐		CASING RELIEF VALVE			20
21 ☐		SWING CHECK VALVE		(Used as automatic air release valve)	21
22 ☐		OPEN WASTE CONE			22
23 ☐		ENCLOSED WASTE CONE			23
24 ☐		SPLASH SHIELD HORIZONTAL		POWER SERIES NO.___	24
25 ☐		SPLASH SHIELD VERTICAL		POWER SERIES NO.___	25
26 ☐					26
27 ☐					27
28 ☐					28
29 ☐					29
30 ☐					30
31 ☐					31

DATE ________________

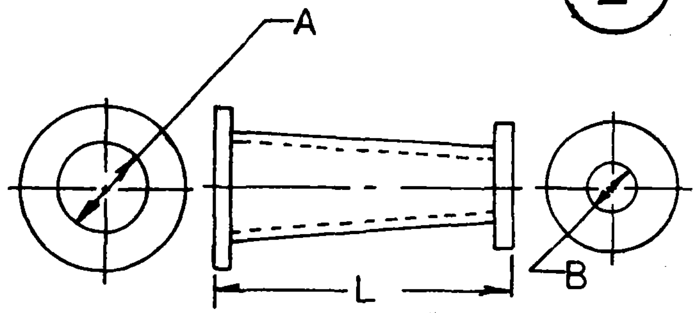
ECCENTRIC REDUCER ①



250# FLANGES

size		
A	B	R
3	2	6
4	3	7
5	4	8
6	4	9
6	5	9
8	5	11
10	6	12
10	8	12
12	8	14
14	8	16
8	6	11

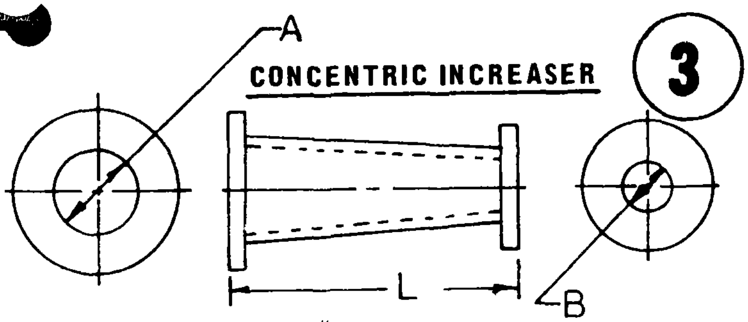
CONCENTRIC INCREASER ②



250# FLANGES

size		
A	B	L
4	3	7
5	4	8
	3	8
6	3	9
	4	9
	5	9
8	4	11
	5	11
	6	11
10	6	12
	8	12
12	8	14
	10	

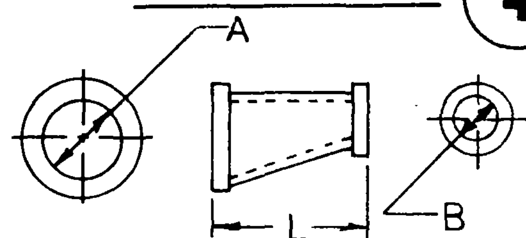
CONCENTRIC INCREASER ③



125# FLANGES

size		
A	B	L
4	3	7
5	3	8
	4	
6	3	9
	4	
	5	
8	4	11
	5	
	6	
10	6	12
	8	
12	6	14
	8	
	10	
16	10	18

ECCENTRIC REDUCER ④



125# FLANGES

size		
A	B	L
5	4	8
6	4	9
	5	9
8	4	11
	5	11
	6	11
10	5	12
	6	12
	8	12
12	6	14
	8	14
	10	14
14	8	16
	10	6
16	8	18
	10	
18	12	19
16	12	18

NOTE: ALL DIM. ARE BY VENDOR STD'S.

OUTSIDE HOSE MANIFOLD

125 & 250# FLANGES

5

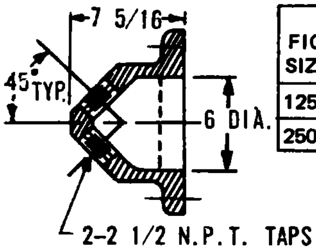


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	8	7/8	9-1/2
250#	12	7/8	10-5/8

6"
2 HOSE VALVE CONN.

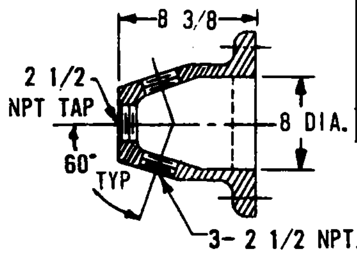


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	8	7/8	11-3/4
250#	12	1	13

8"
4 HOSE VALVE CONN.

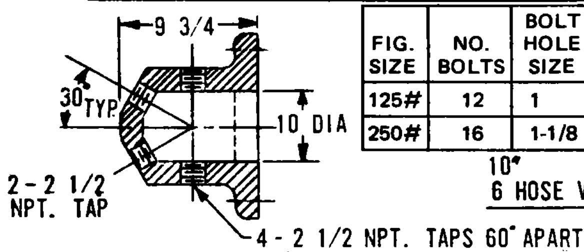
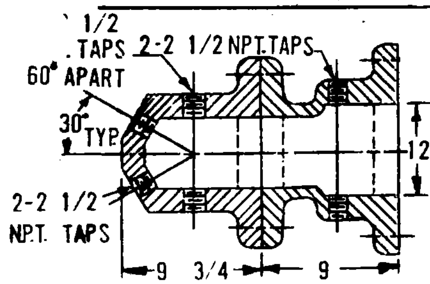


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	12	1	14-1/4
250#	16	1-1/8	15-1/4

10"
6 HOSE VALVE CONN



12"
8 HOSE VALVE CONN.

FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	12	1	17
250#	16	1-1/8	17-3/4

NOTE: ASSEMBLY CONSISTS OF 10" HEADER, 6 VALVE CONN., 10x12 ADAPTER, 2 VALVE CONN.

3000-3500 GPM HOSE VALVE HEADER 125 # & 250 # FLANGES

7

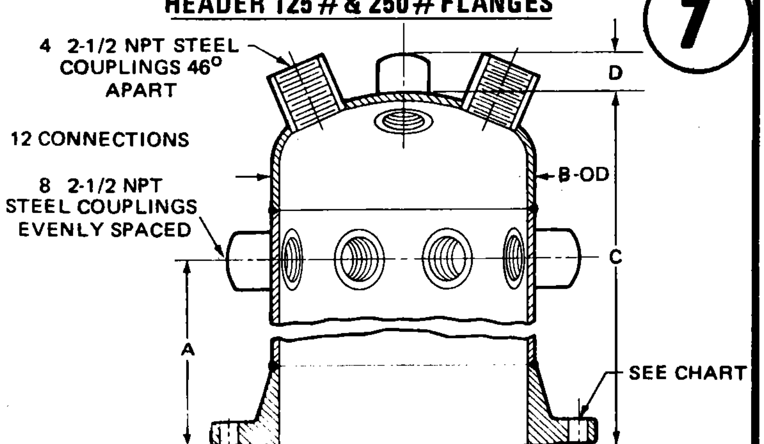


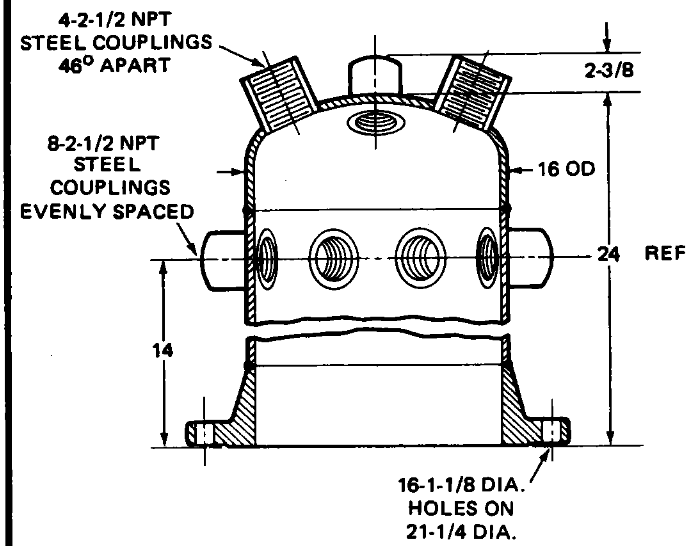
FIG. SIZE	NO. BOLT HOLES	BOLT HOLE SIZE	BOLT CIRCLE DIA.	A	B	C	D
125#	12	1	17	10-1/2	12-3/4	22-1/2	1-9/16
250#	16	1-1/4	17-3/4	10-1/2	12-3/4	23-1/8	1-9/16

3000-3500 GPM HOSE HEADER

125 # FLANGE

6

12 CONNECTIONS



4000-4500 GPM HOSE HEADER

125# & 250# FLANGES

8

16 CONNECTIONS

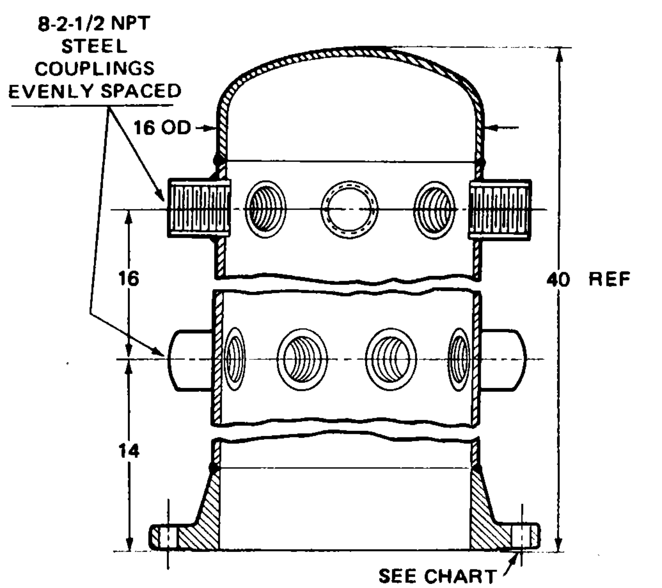
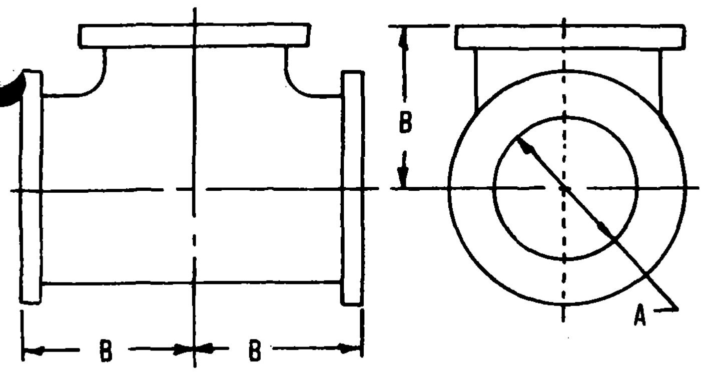


FIG. SIZE	NO. BOLT HOLES	BOLT HOLE SIZE	BOLT CIRCLE SIZE
125LB	16	1-1/8	21-1/4
250LB	20	1-3/8	22-1/2

NOTE: ALL DIM. ARE BY VENDOR STD'S.

125# FLANGED STRAIGHT TEE

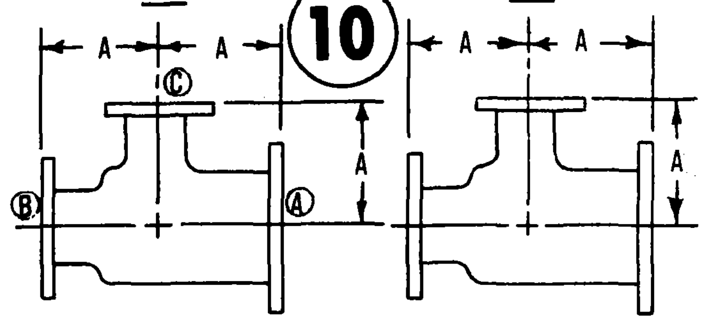
9



A	B
1-1/2	4
2	4-1/2
2-1/2	5
3	5-1/2
3-1/2	6
4	6-1/2
5	7-1/2
6	8
8	9
10	11
12	12
14	14
16	15
18	16-1/2
20	18
22	22

REDUCING TEE STD.

125# 10 250#



SIZE	A
8x6x8	9
5x5x3	7-1/2
6x4x3	8
6x6x4	8
8x6x4	9
8x8x4	9
8x8x6	9
10x8x6	11
10x10x6	11
10x10x8	11
12x12x8	12
12x12x6	12
12x8x8	12
6x4x4	8
8x6x6	9
8x4x6	9
8x4x8	9
8x6x3	9
10x10x4	11
14x14x8	14

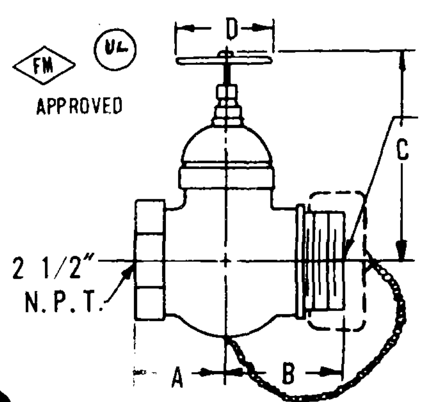
SIZE	A
6×6×3	8 1/2
6×6×4	8 1/2
8×6×8	10
8×8×4	9
8×8×6	10
10×10×8	11-1/2
5x5x3	8
10x10x6	11-1/2

NOTE: SIZE INDICATED AS FOLLOWS

A	B	C
8 X	6 X	8

2 1/2 HOSE VALVE W/CAPS & CHAINS

11



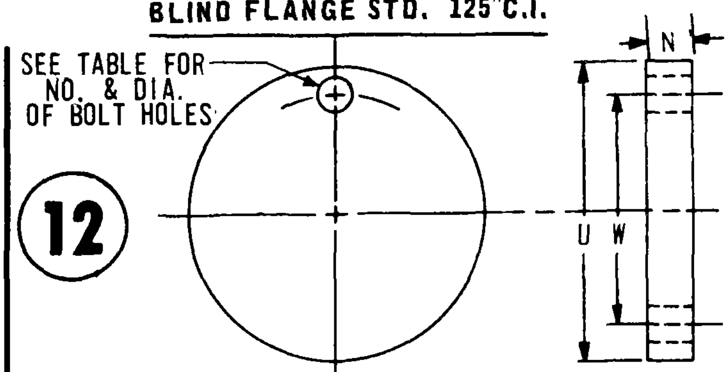
AMERICAN NATIONAL STANDARD FIRE HOSE COUPLING SCREW THREAD MAX. MAJOR DIA.(O.D.) OF MALE THREAD 3.0686 DIA. 7 1/2 THREADS PER INCH

	A	B	C	D
175 PSI	2 1/4	2 7/8	10 1/4	6
300 PSI	2 5/16	2 5/8	11	6

NOTE: ALL DIM. ARE BY VENDOR STD'S.

1.2.7.45

BLIND FLANGE STD. 125# C.I.

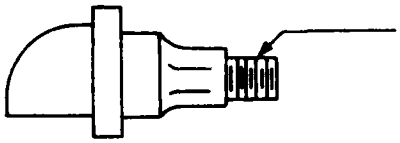


PIPE SIZE	FLANGE SIZE	N	U	W	DIA.OF HOLES	NO. OF HOLES
3	3x7 1/2	3/4	7 1/2	6	3/4	4
4	4x9	15/16	9	7 1/2	3/4	8
5	5x10	15/16	10	8 1/2	7/8	8
6	6x11	1	11	9 1/2	7/8	8
8	8x13 1/2	1 1/8	13 1/2	11 3/4	7/8	8
10	10x16	1 3/16	16	14 1/4	1	12
*12	12x19	1 1/4	19	17	1	12

*SIZES 12 AND LARGER HAVE DISHED FACES

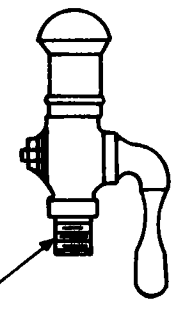
AUTOMATIC BALL DRIP VALVE

13



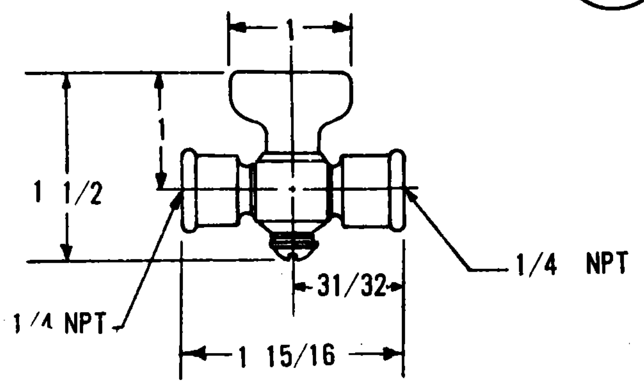
UMBRELLA HOOD UNDERWRITERS COCK

14



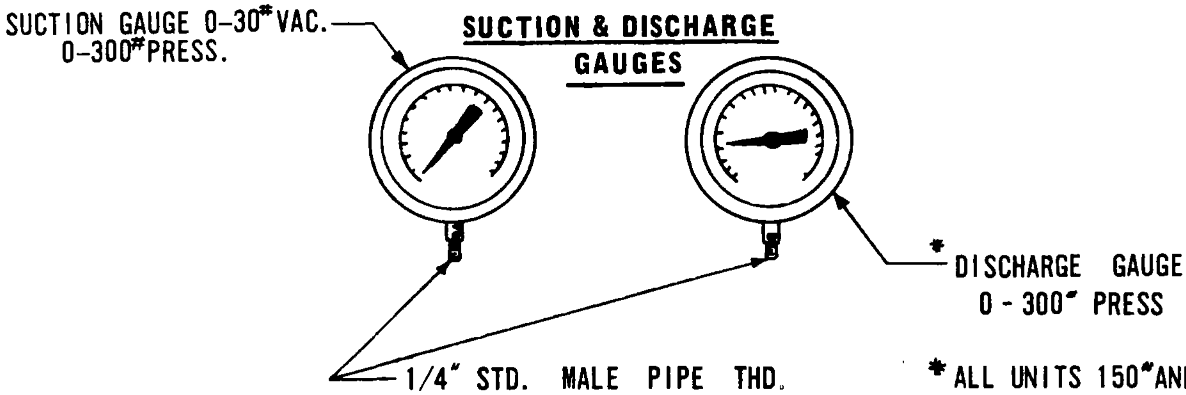
AIR COCK

15



17

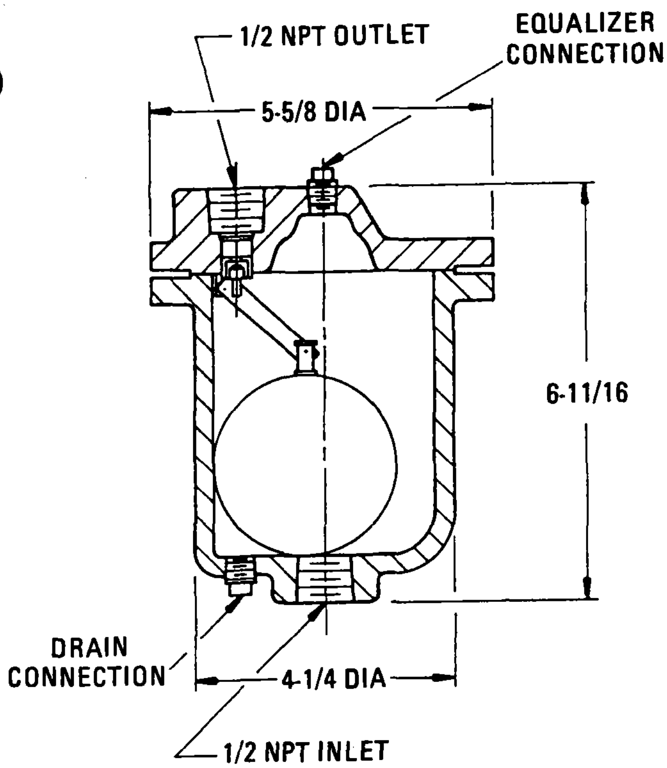
SUCTION & DISCHARGE GAUGES



* ALL UNITS 150#AND OVER WILL BE FURNISHED WITH 0-600#GAUGE

NOTE: ALL DIM. ARE BY VENDOR STD'S.

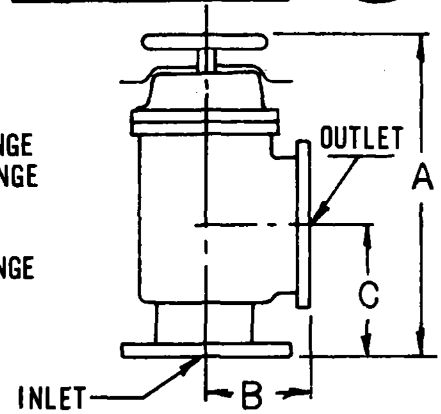
AIR RELEASE VALVE (FLOAT OPRTATED) (18)



MAIN RELIEF VALVE (19)

STANDARD
125 lb INLET FLANGE
125 lb OUTLET FLANGE

OPTION
250 lb INLET FLANGE



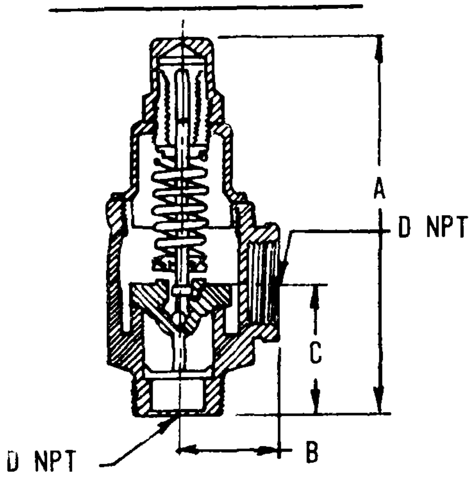
APPROVED

SIZE	A	B	C
3X3	21 1/4	5 7 8	6 1/8
3½X3½	21 5/8	5 7/8	6 1/8
4X4	22 5/8	6 7/16	6 5/8
5X5	29 1/4	7 9/16	8 5/8
6X6	36	8 1/2	9 3/8
8x8	23 3/4	12 3/4	8

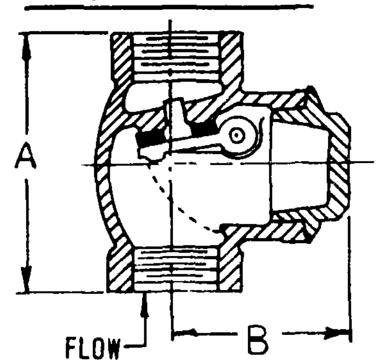
(20)

SIZE	A	B	C	D
1/2	6	1 5/8	2	1/2
3/4	6	1 5/8	2	3/4
1	6 7/8	1 7/8	2 1/4	1

CASING RELIEF VALVE



SWING CHECK VALVE (21)

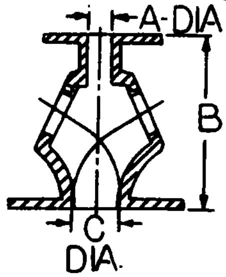


SIZE	A	B
3/8	1 7/8	1 3/8
1/2	2 1/4	1 5/8
3/4	2 11/16	1 7/8
1	3 3/16	2 1/4
1 1/4	3 11/16	2 5/8
1 1/2	4 1/4	2 7/8
2	5 1/8	3 1/4
2 1/2	6 1/16	4
3	7 3/8	4 3/8

NOTE: ALL DIM. ARE BY VENDOR STD'S.

22 OPEN WASTE CONE

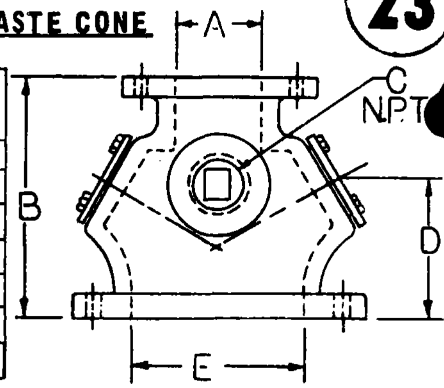
ZE	A	B	C
3x5	3	10	5
4x8	4	11	8
6 x10	6	14	10
8x14	8	16	14



FLANGE SIZE	NO BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIAMETER
3	4	3/4	6
4	8	3/4	7 1/2
5	8	7/8	8 1/2
6	8	7/8	9 1/2
8	8	7/8	11 3/4
10	12	1	14 1/4
14	12	1 1/8	18 3/4

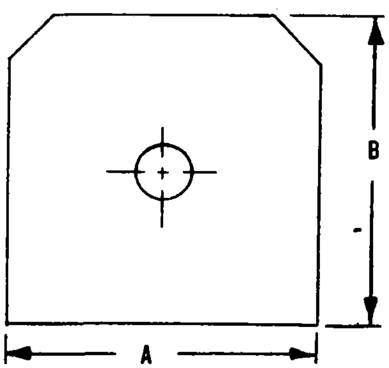
23 ENCLOSED WASTE CONE

FLANGE SIZE	NO BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIAMETER
3	4	3/4	6
4	8	3/4	7 1/2
5	8	7/8	8 1/2
6	8	7/8	9 1/2
8	8	7/8	11 3/4
10	12	1	14 1/4
14	12	1 1/8	18 3/4



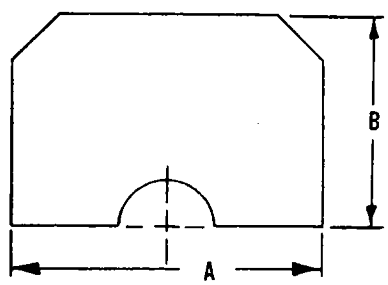
GPM	SIZE	A	B	C	D	E
500	3x5	3	10	1 1/4	5 3/4	5
750-1000	4x8	4	11	2	6 7/16	8
1500-2500	6x10	6	14	2 1/2	9 5/16	10
3000-4500	8x14	8	16	2 1/2	9	14

24 SPLASH SHIELD FOR HORIZONTAL PUMPS MOTOR DRIVEN PUMP



POWER SERIES	A	B
2	12	16 3/4
3	12	19 3/4
3	14	20 3/4
4	14	22 1/4
5	18	26 1/4
5	18	27 1/2

25 SPLASH SHIELD FOR VERTICLE PUMPS

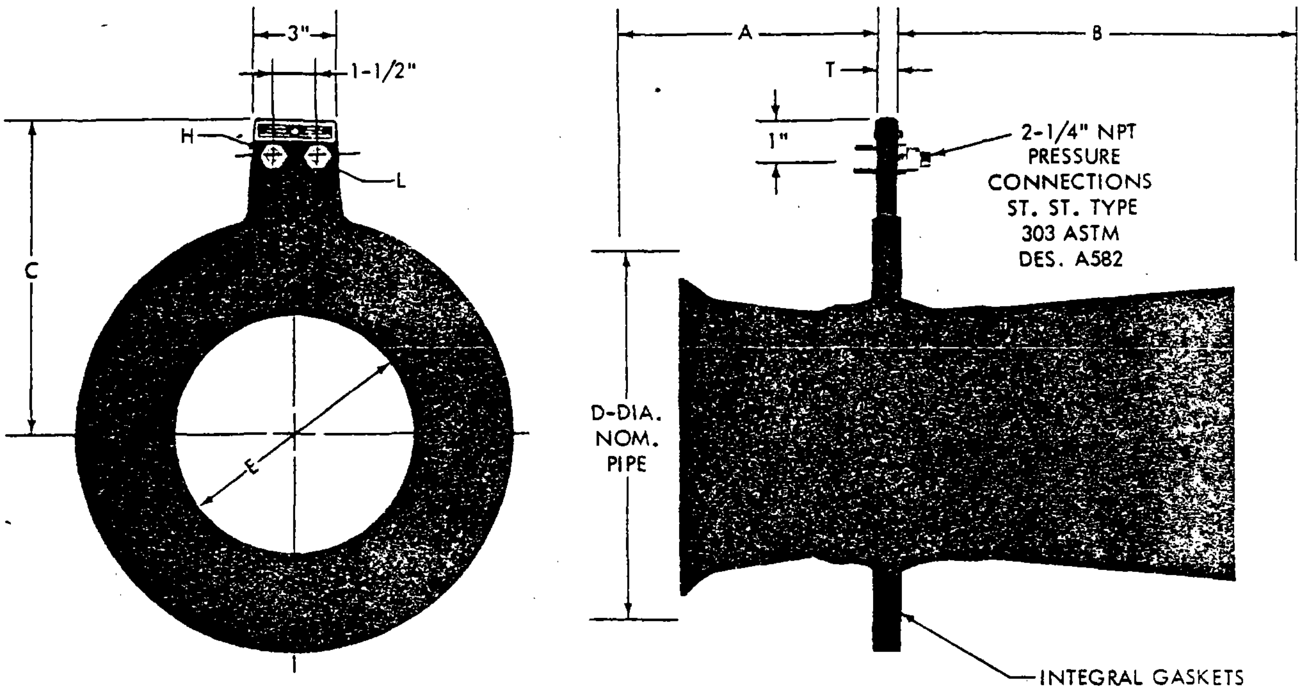


POWER SERIES	A	B
2	12	8
3	14	10
4	14	10
5	17 1/2	13

NOTE. ALL DIM. ARE BY VENDOR STD'S.

AURORA FLOW ELEMENT
UNIVERSAL VENTURI TUBE

SECTION 920 PAGE 201
DATED JULY 1978
SUPERSEDES PAGE 201 DATED MAY 1974



T=3/4" FOR STD. 125# FLANGES - T=1" FOR OPT. 250# FLANGES

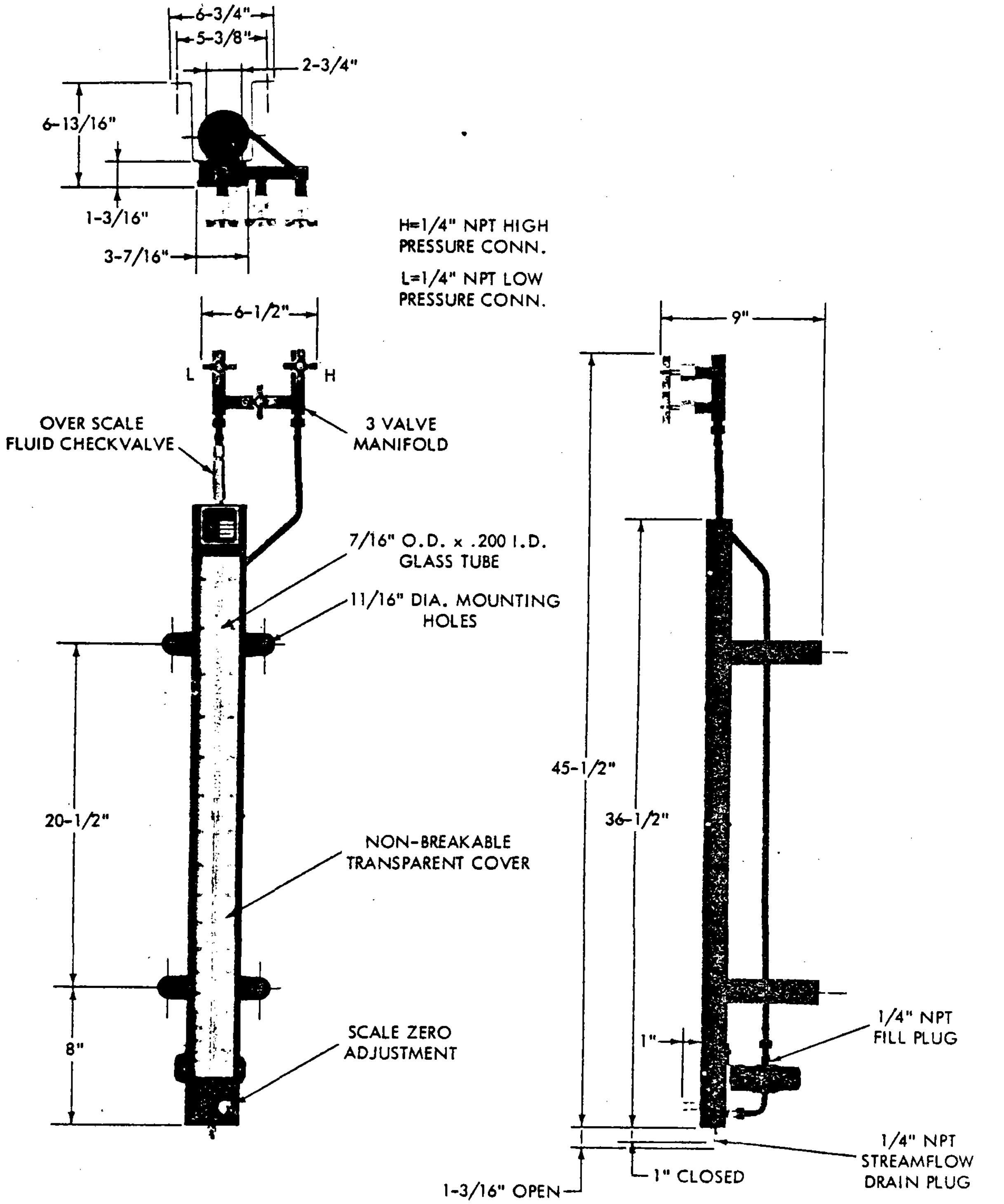
FIRE PUMP CAPACITY G.P.M.	MAX. TEST FLOW G.P.M.	MODEL	CLEARANCE A	CLEARANCE B	C	D	E
500 & 750	1490	6B	6	12	7-1/2	6	3.610
1000	2000	6C	6	12	7-1/2	6	4.359
1500 & 2000	4000	8C	8	15	8-3/4	8	5.810
2500 & 3000	6000	10C	9	17	10	10	7.258
3500 TO 4500	9000	12C	10	20	11-1/2	12	8.711

NOTES:

1. All dimensions in inches.
2. Dimensions may vary ± 1/32.
3. Not for construction purposes unless certified for approval.
4. Mounting . . . . Between 125 #ASA Flanges (Std.)
   Between 250 #ASA Flanges (Optional)

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA FLOW INDICATOR
WELL TYPE MERCURY MANOMETER



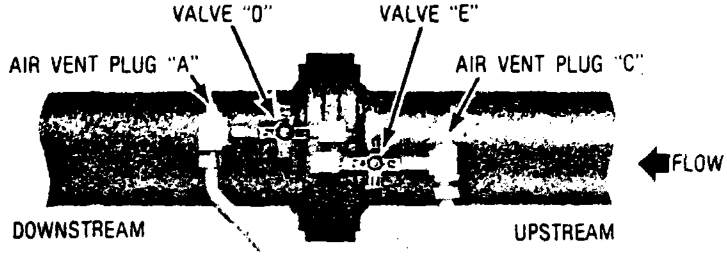
NOTES:

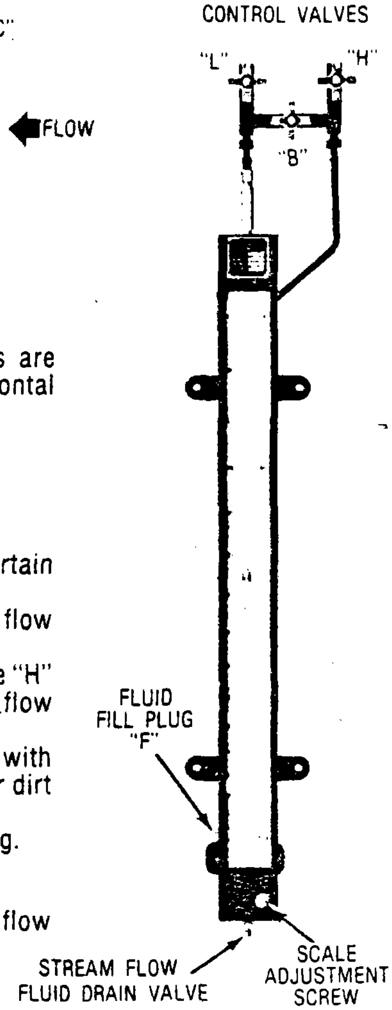
1. All dimensions in inches.
2. Dimensions may vary ± 1/8.
3. Not for construction purposes unless certified for approval.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD·NORTH AURORA, ILLINOIS·60542

AURORA FLOW METERING SYSTEM
INSTALLATION AND OPERATION





INSTALLATION FLOW ELEMENT

A. Handle carefully on outside surface only.
B. Center flow element in pipe line and clamp between flanges. Gaskets are integral with element. Pressure connections should be positioned on horizontal axis to eliminate accumulation of air.
C. Direction of arrow must agree with flow direction.

FLOW INDICATOR

A. Mount the flow indicator vertically at a convenient reading height. Be certain indicator is level. Check with level on side and front of case.
B. Connect the flow element flange pressure taps through valves to the flow indicator with 1/4 inch pipe or 1/2 copper tubing and fittings as shown.
C. Upstream or high pressure tap connects to the well of the indicator at the "H" connection point. Downstream or low pressure tap connects to the flow indicator at the "L" connection point.
D. Maintain a definite up or down grade of at least 1/2 inch per foot of length with the connecting pipe or tubing. Avoid rises or drops that would allow air or dirt to collect. If unavoidable, provide blow off valves at these points.
E. If 90° bends are necessary, use plugged tees or crosses for easy rodding.
F. Ream ends of piping to avoid inward flares.
G. Clean out piping before making final connections.
H. Anchor piping securely to prevent transmitting vibration from main line to flow indicator.

OPERATION

A. Close both valves "D" and "E".
B. Open flow indicator control valves, "L", "B" and "H".
C. Remove air vent plugs "A" and "C".
D. Slowly open valves "D" and "E" to fill the flow indicator and piping with water until it flows from the vent openings. All the air in the system must be eliminated.
E. Close valves "D" and "E".
F. Replace vent plugs "A" and "C".
G. Remove fluid fill plug "F" and fill with mercury.
H. Replace fluid fill plug "F".
I. Set zero scale graduation to the meniscus by turning the scale adjustment screw on the flow indicator. Lock the adjustment screw.
J. Open valves "D" and "E" to put flow indicator under pressure.
K. Close flow indicator bypass valve "B".
L. Read water flow rate as indicated by the indicating fluid column.

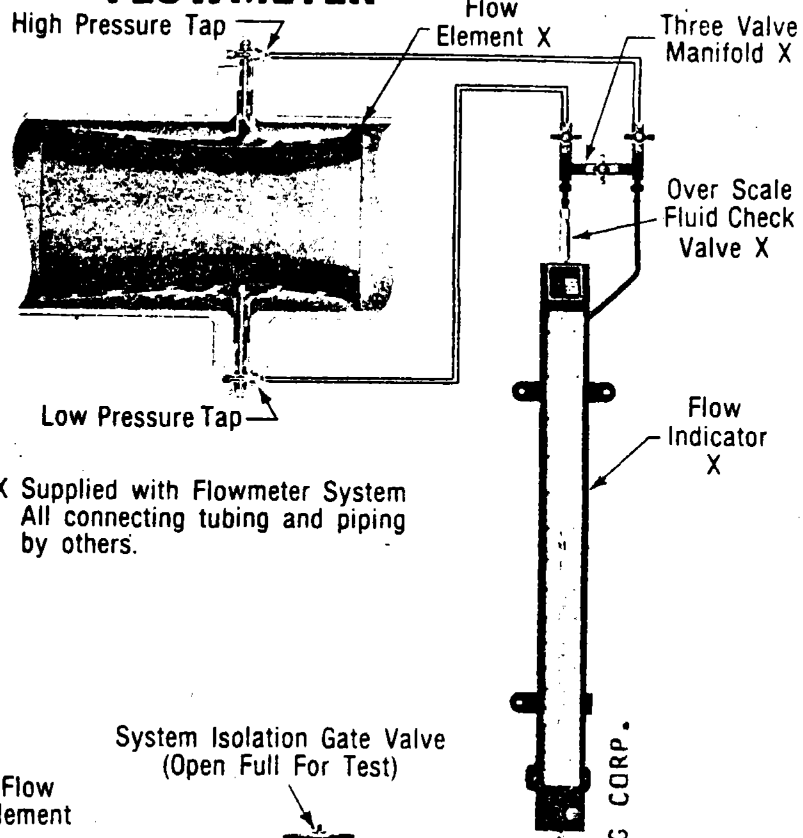
STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA FIRE SYSTEM
FLOWMETER

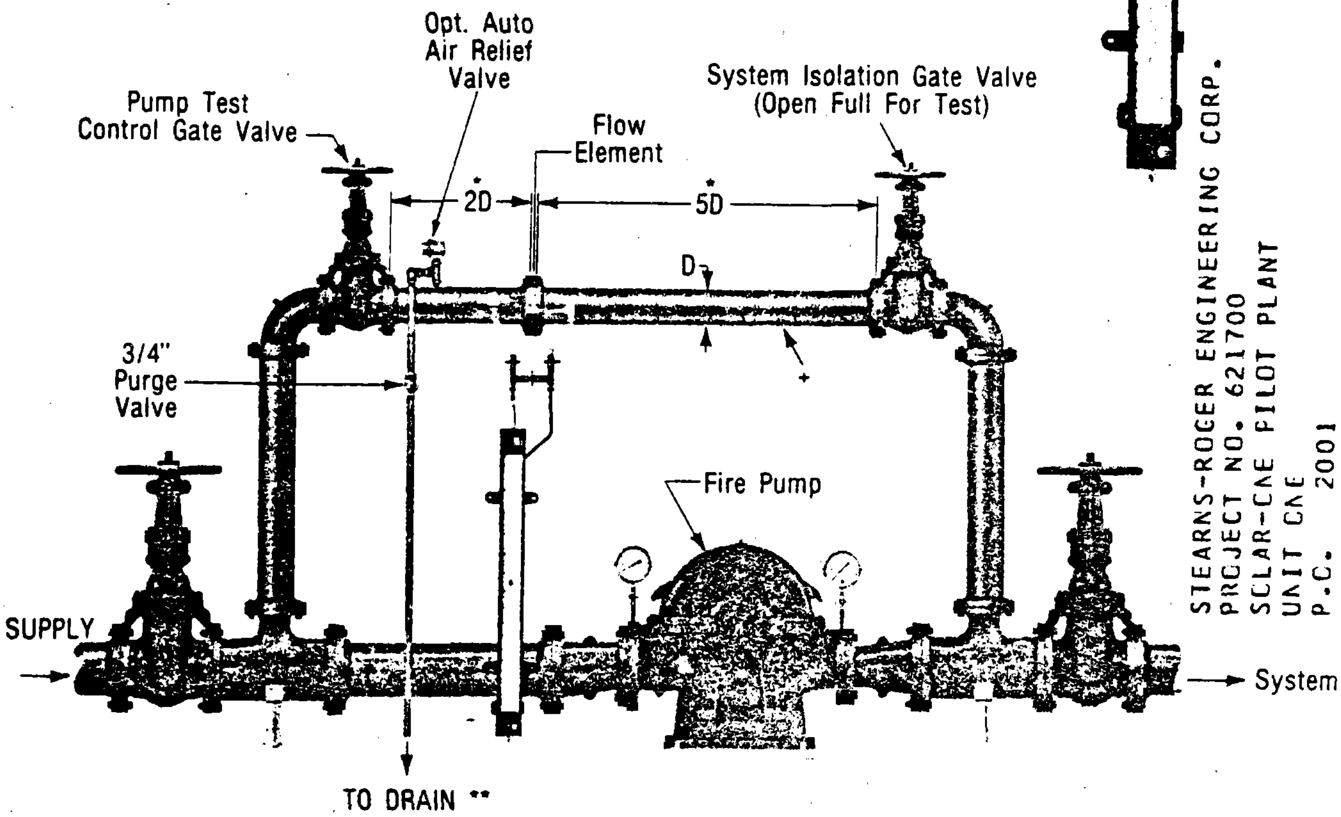
DATED JULY 1978

SUPERSEDES PAGE 112
DATED APRIL 1978

INSTALLATION WITH FLOWMETER DISCHARGE PIPED BACK TO PUMP SUCTION



X Supplied with Flowmeter System
All connecting tubing and piping by others.



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-CAE PILOT PLANT
UNIT CAE 2001
P.C.

\+ Upstream meter pipe must be schedule 40, same size as flow element.

* Minimum length of straight pipe for physical installation requirements as well as to insure high accuracy.

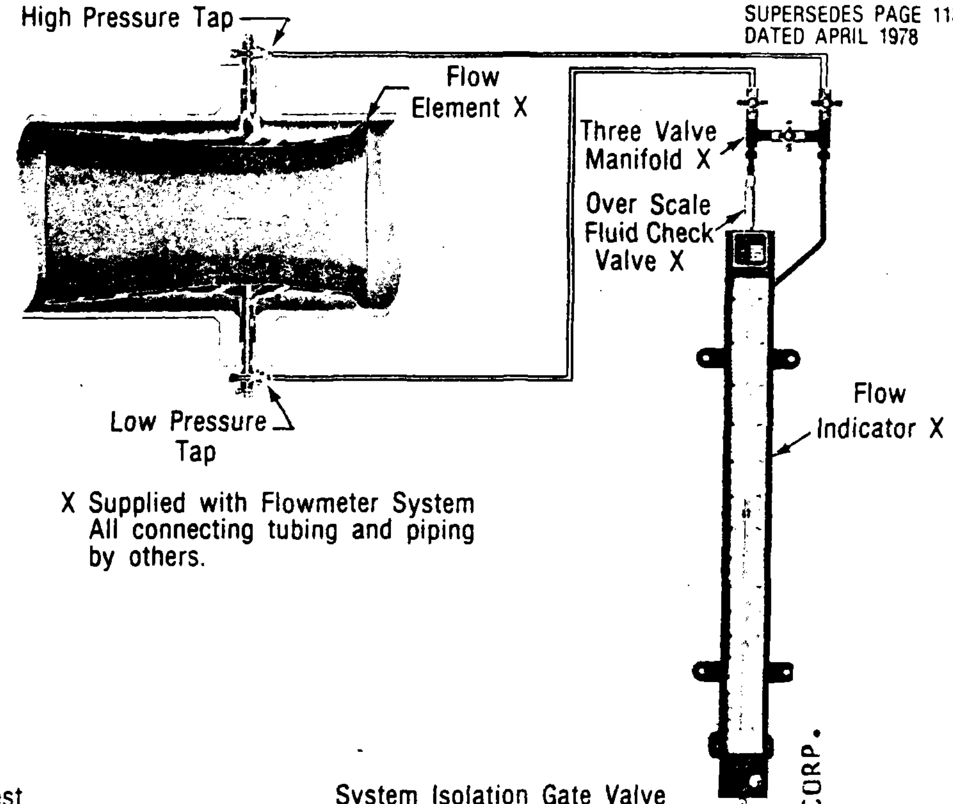
** Sustained operation of pump in the test mode requires minimum purge flow to drain = $\frac{\text{Maximum pump BHP}}{5}$ = (GPM).

FM Approved UL Listed

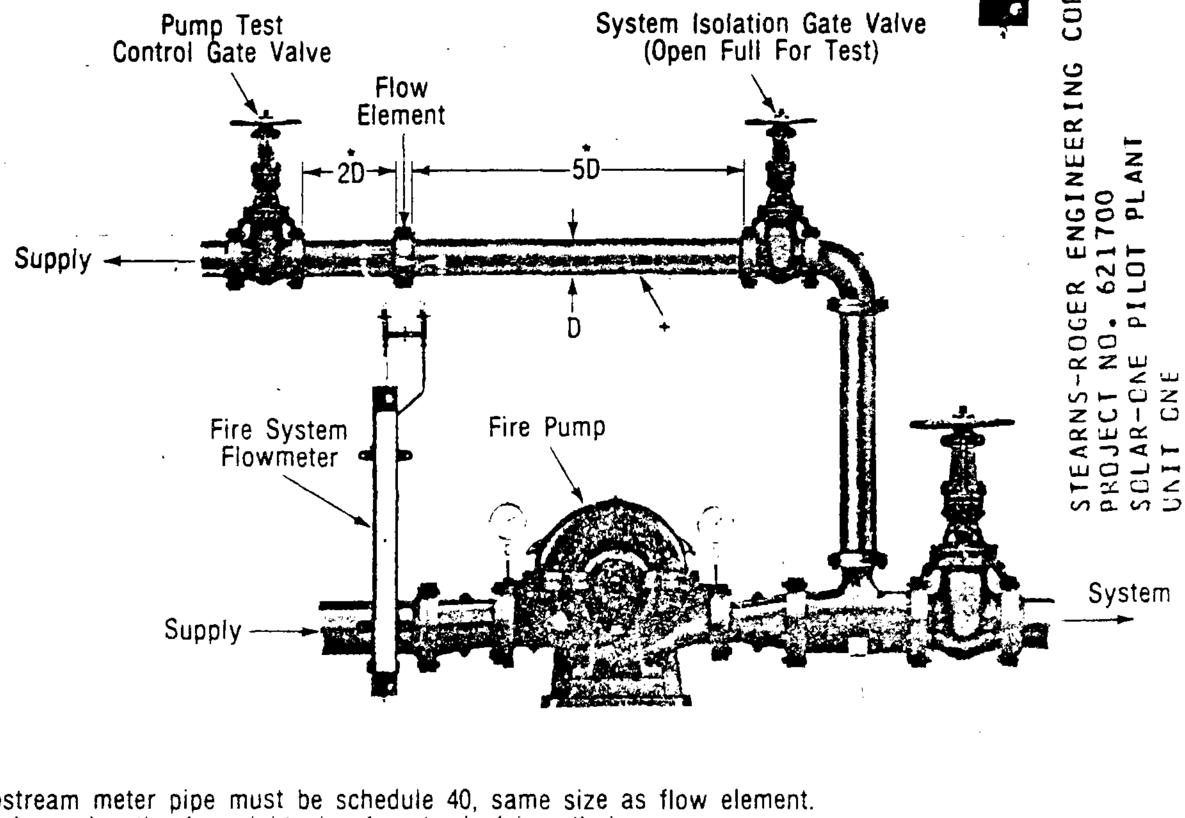
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

AURORA FIRE SYSTEM FLOWMETER

INSTALLATION WITH FLOWMETER DISCHARGE PIPED BACK TO SUPPLY TANK OR RESERVOIR



X Supplied with Flowmeter System
All connecting tubing and piping by others.



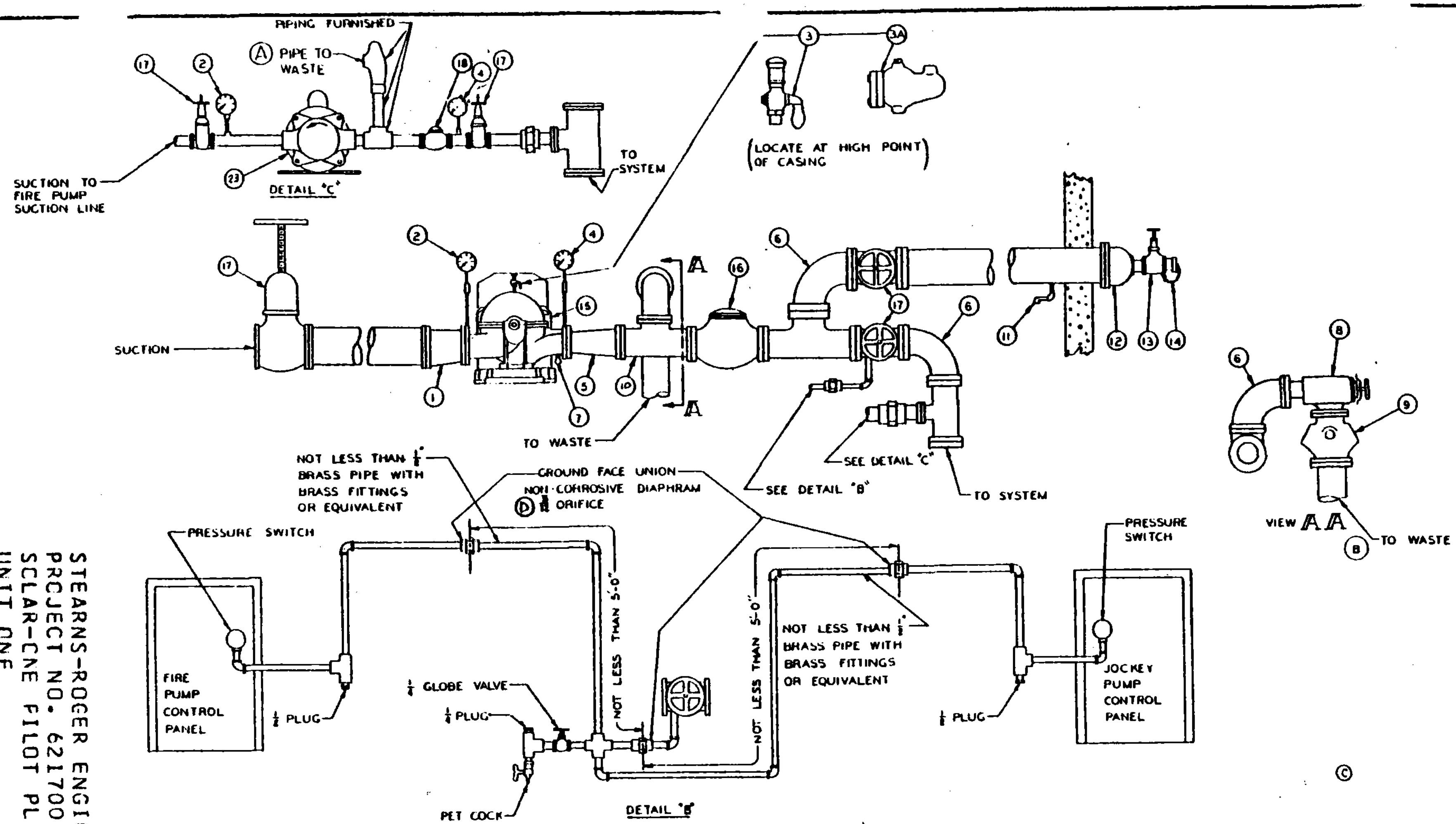
STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

+ Upstream meter pipe must be schedule 40, same size as flow element.
* Minimum length of straight pipe for physical installation requirements as well as to insure high accuracy.

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

FM Approved UL Listed



RIPING CONNECTION FOR PRESSURE SWITCH (AUTOMATIC UNITS)

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

1.2.7.54

1. ECCENTRIC REDUCER
2. SUCTION GAUGE
3. UMBRELLA AIR COCK (MANUAL UNITS)
3A. FLOAT OPERATED AIR RELEASE (AUTOMATIC UNITS)
4. DISCHARGE GAUGE
5. CONCENTRIC INCREASER
6. ELBOW
7. CIRCULATION RELIEF VALVE (AUTOMATIC UNITS PIPED TO DRAIN)
8. RELIEF VALVE (IF REQUIRED)
9. WASTE CONE (OPEN & ENCLOSED)
10. DISCHARGE TEE
11. BALL DRIP VALVE
12. HOSE VALVE MANIFOLD
13. HOSE VALVES
14. HOSE VALVE CAPS & CHAINS
15. SPLASH SHIELD
16. DISCHARGE CHECK VALVE
17. O.S. & Y. GATE VALVE
18. CHECK VALVE
23. JOCKEY PUMP (AUTOMATIC UNITS)

©

STD. MAT'L:
REFERENCE:
PATT. TIES TO:
PATTERN NUMBER

NOTE: DO NOT SCALE DRAWING
DRAWN BY C.P. HORN
CHECKED BY
APPROVED BY
DATE: 5-5-72
SCALE: NONE
ROUGH WEIGHT

C

AURORA PUMP

NAME: MODEL 481 OR 482 INSTALLATION SUCTION PRESSURE MOTOR DRIVEN
PART NUMBER 0320047000C

AURORA PUMP

A UNIT OF GENERAL SIGNAL

ENGINEERING DEPT.
NORTH AURORA, ILLINOIS· 60542

FIRE PUMP CONTROLLER

FIRE PUMP F.O. # 400-65707

FIRE PUMP CONTROLLER

X COMBINATION MANUAL-AUTOMATIC *

____ PRIMARY RESISTOR TYPE

____ PART WINDING TYPE

____ LIMITED SERVICE TYPE

____ WITH TIMER

____ WITHOUT TIMER

C.B. INTERRUPTING CAPACITY 22,000 AMPS

FOR 150 H.P. 1770 R.P.M.

3 PHASE 60 CYCLE 460 VOLTS

0-300 # RANGE PRESSURE SWITCH

12 # SUCTION PRESSURE

* w/ DELUGE VALVESTART
SPACE HEATER
POWER FAILURE START

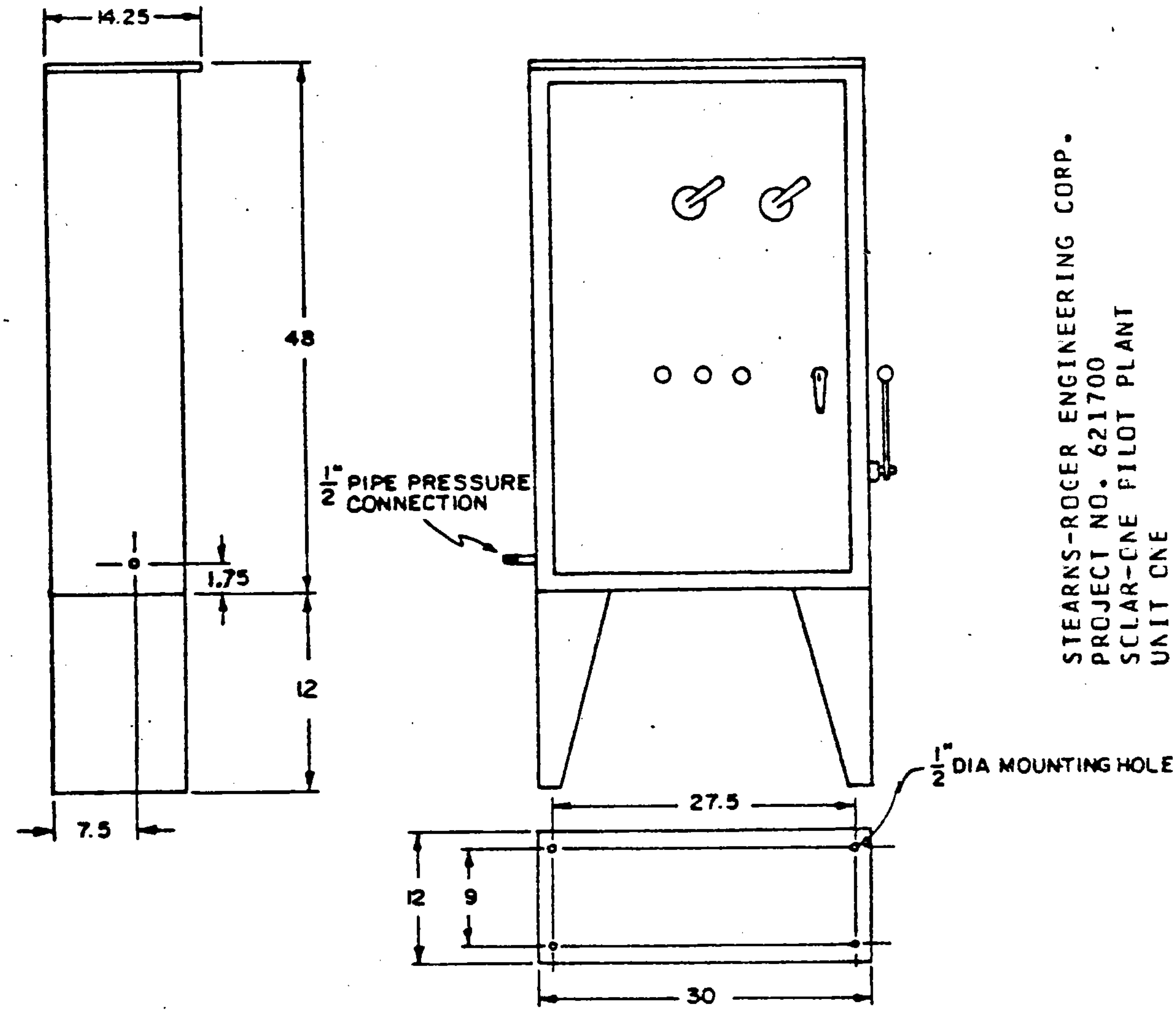
BY: WJW

DATE: 12-10-80

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

SP-106968

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



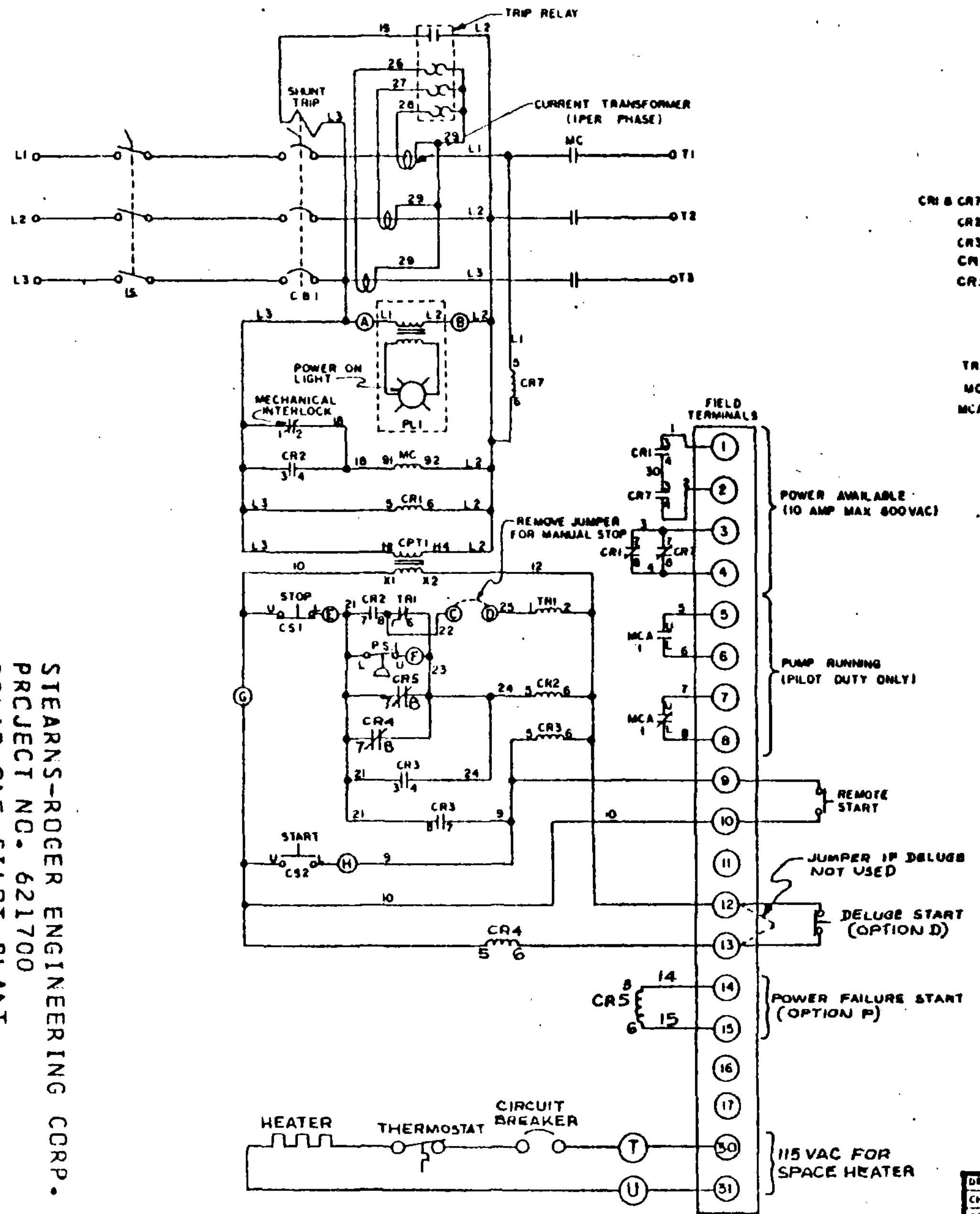
STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

NOTE: WHEN HIGH INTERRUPT BREAKER IS USED
CHANGE 48 INCH TO 57 INCH

NEMA 12 ENCLOSURE

CERTIFIED CORRECT DRAWING *James S. Hathaway*

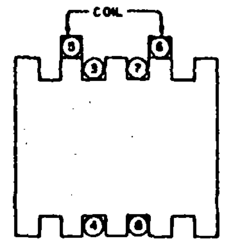
DRAWN *Mack 5-1-74*	Metron — METRON INSTRUMENTS, INC.
CHECK	
PPD	
TOLERANCE FRACTIONS ± .015 .XX ± .03 .XXX ± .005 ANGLES ± 0° 30' REMOVE BURRS & SHARP CORNERS	OUTLINE DIMENSIONS ELECTRIC FIRE PUMP CONTROLLER ACROSS THE LINE AND PART WINDING
CODE IDENT NO. 40021	SIZE A — 10431C
SCALE	SHEET



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

CR1 & CR7 - POWER AVAILABLE RELAY
CR2 - CONTROL RELAY
CR3 - MANUAL START RELAY
CR4 - DELUGE START (OPTION D)
CR5 - POWER FAILURE START (OPTION P)

TR1 - RUN PERIOD TIMER
MC - MOTOR CONTACTOR
MCA - MOTOR CONTACTOR AUXILIARY CONTACT



TERMINAL DESIGNATIONS I.T.E. CONTROL RELAYS

NOTE FOR FIELD WIRING:

1. USE COPPER WIRING ONLY EXCEPT AT TERMINALS MARKED CU-AL
2. MOTOR CONTACTOR AUXILIARY CONTACTS MCA RATED FOR PILOT DUTY ONLY.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SCLAR-ONE FILOT PLANT
UNIT ONE
P.O. 2001

1.2.7.57

CERTIFIED CORRECT DRAWING

James S. Hathaway

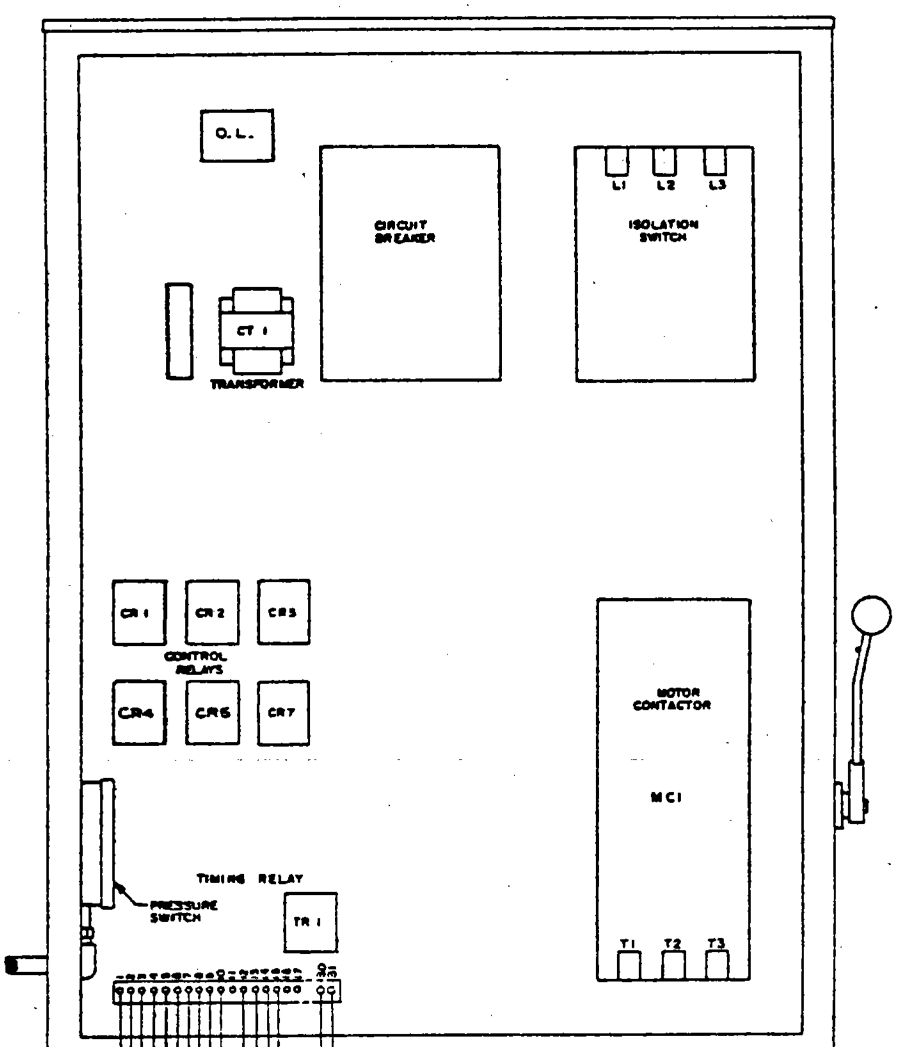
DRAWN MVN	10-1-79	Metron — METRON INSTRUMENTS, INC.
CHECK		
APPD	3-27-81	

ELECTRIC MOTOR FIRE PUMP CONTROLLER
MODEL M300, COMBINED MANUAL-AUTOMATIC
ACROS THE LINE (NO OPTIONS)

CODE IDENT NO 40011 | SIZE C | 30721-3612 | SCALE | SHEET

NOTES - UNLESS OTHERWISE SPECIFIED

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001



31, 30 } 115 VAC FOR SPACE HEATER

15, 14 } CONNECT 115 V. RELIABLE SOURCE. CONTROLLER WILL START ON LOSS OF THIS POWER

13, 12 } DELUGE START, USE SWITCH THAT OPENS TO START MOTOR. (JUMPER IF DELUGE SWITCH NOT USED.)

10, 9 } REMOTE START. MOTOR WILL START WHEN SWITCH CLOSES.

8, 7 } N.C. CONTACT. OPENS WHEN PUMP RUNNING.

6, 5 } N.O. CONTACT. CLOSES WHEN PUMP RUNNING.

4, 3 } N.C. CONTACT. CLOSES ON LOSS OF CONTROLLER POWER

2, 1 } N.O. CONTACT. OPENS ON LOSS OF CONTROLLER POWER

CERTIFIED CORRECT DRAWING James S. Hathaway

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
B	REVISED TO SHOW LINE TERMINAL DESIGNATIONS & LOAD TERMINAL DESIGNATIONS ECO1089	4-2-74	

METRON INSTRUMENTS, INC.

CONTROLLER HOOKUP, EXTERNAL
FIRE PUMP CONTROLLER, SERIES M 300
ELECTRIC MOTOR DRIVE

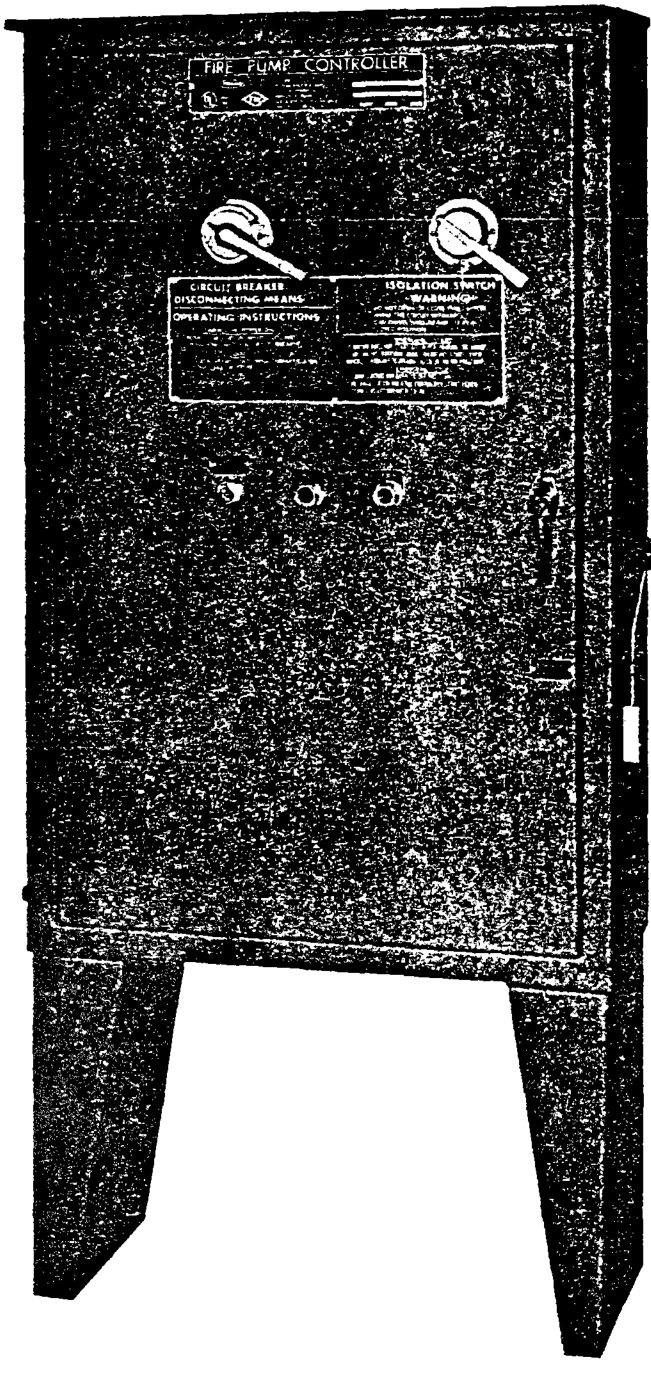
DRAWN E.H. 2-9-74

SIZE C 30451B-3612

NOTES - UNLESS OTHERWISE SPECIFIED

FIRE PUMP CONTROLLER

FOR ELECTRIC MOTOR DRIVEN FIRE PUMPS



ACROSS-THE-LINE TYPES

SERIES M300

COMBINED MANUAL AND AUTOMATIC

SERIES M100

MANUAL NON-AUTOMATIC

METRON FIRE PUMP CONTROLLERS

Metron Fire Pump Controllers conform to all requirements of Chapter 7, National Fire Protection Association Pamphlet 20, Standard for Centrifugal Fire Pumps. They are listed by Underwriter's Laboratories and approved by Factory Mutual Engineering Corporation.

Sizes range from 15 to 400 horsepower, 208 to 600 volts, 60 Hz. These controllers are for use on Across-the-Line type installations.

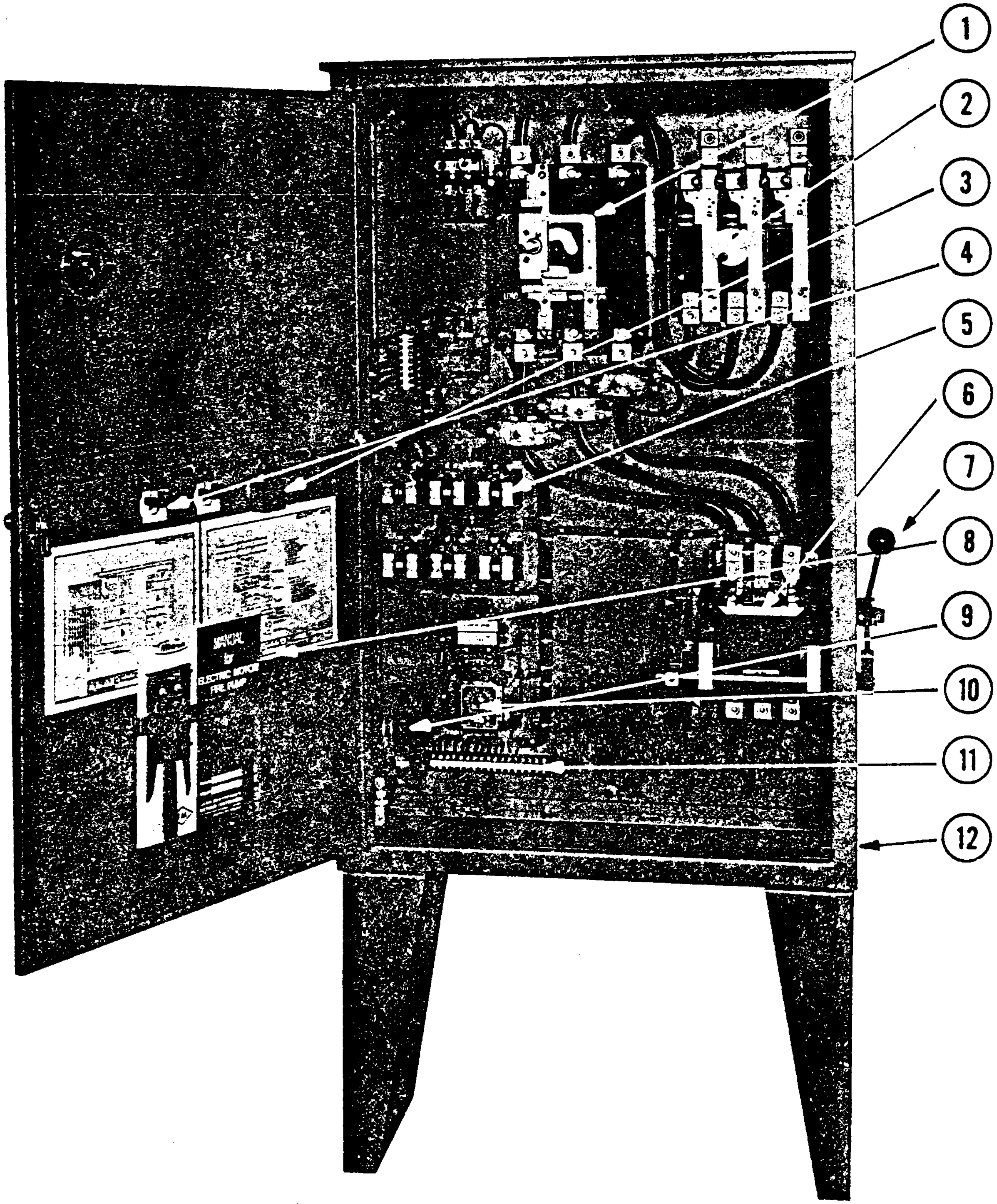
Only the highest quality components, all U.L. listed, are used throughout to assure the best possible reliability. The cabinet is fabricated of heavy gauge reinforced steel with drip-proof hood. All field wiring and service connections may be made from the front, allowing the controller to be mounted flush against a wall.

The controller is completely wired, assembled and tested at the factory before shipment.

ULC UL FM

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

M300-7-75


1
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MANUAL
for
ELECTRIC MOTOR
FIRE PUMP

STANDARD FEATURES

STARTING

All series M300 Combined Manual-Automatic Controllers have provision for automatic starting from the pressure switch. Optional starting methods include supervisory power failure, deluge valve switch, dry pipe valve switch, etc. Manual starting is accomplished by means of the start pushbutton or emergency start lever on the controller, or remotely by actuation of pushbutton stations. Series M100 Manual-Non-Automatic Controllers have no provision for automatic start and must be manually stopped after manual starting.

STOPPING

Stopping the motor after it has been automatically started (Series M300) may be either manual or automatic. If the controller is supplied for automatic stop, a running period timer is included which keeps the motor running for a preset period of time even though the demand switch actuates only momentarily. When the controller is specified for manual stop the running period timer may be jumpered or deleted, and once started, the motor will continue to run until manually stopped. If the motor has been started by any of the manual start methods, it will have to be manually stopped.

ALARMS AND SIGNALS

In addition to the power available pilot lamp on the controller, terminals on the terminal bar provide a signal for remote audible or visual alarms indicating that the controller has operated into a pump running condition or loss of line power to the motor contactor.

SERIES M300

Combined Manual-Automatic Across-The-Line

1. **CIRCUIT BREAKER (DISCONNECTING MEANS).** This is a magnetic trip-type breaker which provides protection against overcurrent conditions caused by locked rotor or instantaneous short circuit. Interrupting capacity must be determined in advance based upon recommendations by the power company and consulting engineer. This rating takes into account the maximum possible short circuit current at the pump room. The breaker is externally operable by means of a handle and will trip free of the handle with the trip pushbutton.

2. **ISOLATION SWITCH.** A heavy duty, U.L. listed, non-automatic circuit breaker used to isolate the incoming service power from the rest of the controller. It is horsepower rated and is externally operable by means of the isolation switch handle. A spring latch is provided in the closed position requiring a two-hand operation to open the switch. This is to prevent the switch being inadvertently opened under load.

3. **PILOT LAMP.** Indicates that incoming power service is connected, the isolation switch and circuit breaker are closed, and that power is available at the motor starter contacts ready for starting.

4. **MANUAL START AND STOP PUSHBUTTONS.** These are mounted in the door, readily accessible for manually starting and stopping the controller.

5. **CONTROL RELAYS.** These are heavy duty industrial-type relays and timing devices, all U.L. listed, providing utmost reliability. Relays and timers are used in control circuits for such functions as automatic starting from pressure switch, deluge or dry pipe valve switches, supervisory power failure, sequential starting, etc.

6. **MOTOR CONTACTOR.** The motor starter contactors are supplied in various ratings up through size 6 depending upon motor horsepower. Automatic actuation of the contactor is made by means of the pressure switch or other external demand switches. Manual starting is accomplished with the start pushbutton on the controller or a remote start station. In addition, manual mechanical closure of the contactor may be made under emergency conditions by means of the externally operable lever which includes a mechanical latch.

7. **EMERGENCY START LEVER WITH LATCH.**

8. **WIRING DIAGRAMS.** Permanently mounted on door, instruction manual in pocket.

9. **PRESSURE SWITCH.** This pressure switch is provided on automatic start models for automatic starting upon drop in water line pressure. The switch has calibrated, independently adjustable high and low setpoints.

10. **RUNNING PERIOD TIMER. (USED WITH AUTOMATIC STOP CONTROLLERS.)** Prevents frequent starting and stopping of the motor due to momentary actuation of the pressure switch or other demand signal. In accordance with pamphlet 20, this timer keeps the motor running after automatic start for a pre-set length of time, specified as 1 minute for each 10 horsepower of the motor, or a maximum of 7 minutes. This timer can be omitted on manual stop controllers, or it may be disconnected by removing a jumper.

11. **FIELD WIRING.** Terminal bar for field wiring of remote alarms, remote starting methods, and other control functions.

12. **CUBICLE.** Fabricated of heavy gauge reinforced steel. Chassis is mounted a minimum of 12 inches from floor to prevent possible damage from flooding. When specified, the legs can be omitted and wall mounting brackets supplied.

STEARNS-ROGER ENGINEERING CORP.
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ORDERING INFORMATION

GENERAL. When ordering any controller always specify motor horsepower, actual operating voltage, and interrupting capacity of circuit breaker. Also make sure that optional features are specified when applicable. It is advisable that the local authority having jurisdiction be consulted when quoting in order to assure that acceptable equipment is supplied on each particular job. It is especially important that the correct interrupting capacity of the circuit breaker be determined. This rating is normally supplied by the engineering firm in conjunction with the power company.

SERIES M300

COMBINED MANUAL—AUTOMATIC ACROSS THE LINE

M-300 ACROSS-THE-LINE ELECTRIC FIRE PUMP CONTROLLER

	CIRCUIT BREAKER "B"				CIRCUIT BREAKER "C"			
HP	208 V. 50,000 I.C.	220/240 V 50,000 I.C.	430/480 V 35,000 I.C.	550/600 V 25,000 I.C.	208 V 150,000 I.C.	220/240 V 150,000 I.C.	430/480 V 100,000 I.C.	550/600 V 75,000 I.C.
15	$2710	$2710	$2710		$5100	$5100		
20	2710	2710	2710	$2710	5100	5100	$5100	
25	2710	2710	2710	2710	5100	5100	5100	$5100
30	2710	2710	2710	2710	5100	5100	5100	5100
40	3230	3230	2710	2710	5620	5620	5100	5100
50	3230	3230	2710	2710	5620	5620	5100	5100
60	3760	3760	3230	3230	6150	6150	5620	5620
75	3760	3760	3230	3230	6150	6150	5620	5620
100	4630	4630	3230	3230	6150	6150	5620	5620
125	6090	6090	3760	3760	7610	7610	6150	6150
150	6090	6090	3760	3760	7610	7610	6150	6150
200		6090	4630	3760		7610	6150	6150
250			6090	6090			7610	7610
300			6090	6090			7610	7610
350			7520	7520			9040	9040
400			7520	7520			9040	9040

OPTIONS:

D. Deluge Valve Start .... Add $ 45.00 List
E. Engine Lockout For Dual Pump Installations .... Add $ 35.00 List
H. Space Heater with Thermostat .... Add $ 95.00 List
Without Thermostat .... Add $ 75.00 List
M. Electric Motor Lockout .... Add $ 45.00 List
P. Supervisory Power Failure Start .... Add $ 45.00 List
S. Sequential Starting Timer for Multiple Pump Installations .... Add $145.00 List
(1—50 sec. Adj. Delay Between Controllers)
Omit Mounting Feet . . Controller to be Wall or Skid Mount .... Deduct $ 50.00 List
Omit Running Period Timer (Man. Stop Controller) .... Deduct $ 75.00 List
Nema-3R, 4 or 12 Enclosures . . . Consult Factory
Nomenclature: For a 100-H.P., 460 V., 35000 A.I.C. controller, the correct model number would be M300-100-460B.

Series M-100, Manual Non-Automatic same as Series M-300, except that all automatic start methods are omitted as well as the running period timer. Deduct $200.00 list from Series M-300 in box prices above.
OPTIONS: Only Option "E" is available with M-100 control.
Nema-3R, 4 or 12 enclosures . . . Consult Factory.

SERIES M100

MANUAL-NON-AUTOMATIC ACROSS-THE-LINE

These controllers are the same in all respects as the series M300 except that all automatic starting and stopping methods are omitted. The controller is started only by manually operating the start pushbutton on the controller, a remote start station, or the emergency start lever. Once started, the motor can be stopped only by manual means at the controller. The pressure switch and running period timer are always deleted on the series M100 non-automatic controllers.

CUSTOM BUILT CONTROLS DIVISION OF
METRON INSTRUMENTS, INC.
1051 SOUTH PLATTE RIVER DRIVE DENVER, COLORADO 80223
PHONE 303 744-1791 TELEX 4-5729

MANUAL

ELECTRIC FIRE PUMP CONTROLLERS

METRON Series M100 through M420

TABLE OF CONTENTS

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

METRON INSTRUMENTS, INC. 1051 So. Platte River Drive, Denver, Colorado 80223

PHONE 303 744-1791 TELEX 4-5729

PART I

GENERAL DESCRIPTION

The basic function of the Fire Pump Controller is to start the pump motor to maintain the water system pressure. This may be accomplished in automatic controllers, Series M300, M400 and M420, by automatically starting the pump motor upon drop in pressure in the water main or from a number of other demand signals. Manual controllers, Series M100, M200 and M220 must be started manually while the automatic controller can be started automatically or manually. All can be started by remote manual means, but cannot be stopped remotely. The automatic controller can be set to stop automatically or require manual stop after an automatic start.

STEARNS-ROGER ENGINEERING CORP.
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PART II

FUNCTIONS

1. **Automatic Starting From:**

   a) Drop in water line pressure.

   b) Deluge valve operation, Option D

   c) Loss of remote alarm power, Option P

2. **Alarm and Signals:**

   a) Remote indication of pump operation.

   One set of normally open and one set of normally closed contacts located in the controller operate when the pump is running.

   b) Loss of power to controller.

   One set of normally open and one set of normally closed contacts located in the controller operate when power to the controller is off.

   c) Pilot light on controller.

   This light is on whenever both the isolation switch and circuit breaker of the controller are closed indicating that the controller is set for operation.

   d) *Engine lockout*

   When dual drive systems (pump can be driven by either the electric motor or internal combustion engine) are used, the preferred method of operation is to drive the pump with the electric motor unless power is not available for the motor. A normally open auxiliary contact on the motor contactor is provided to prevent the engine from starting if the electric motor is running.

   e) Electric motor lockout.

   The electric motor lockout is generally used on dual drive sets in conjunction with engine lockout above. If the engine is running due to a power outage, or other reasons, the electric motor should be locked out until the engine is stopped.

3. *Sequential Starting:*

   This optional feature is provided for multiple fire pump installations. This provision times the start of the pump motors by a preset time interval so that all motors do not come on at once.

4. Principal Components of Controller:

   a) Isolation switch

b) Circuit Breaker

c) Contactor

d) Pressure Switch

The incoming power line is connected directly to the isolation switch. From there, power is fed to the circuit breaker and then to the contactor. Both the isolation switch and circuit breaker are normally closed. The contactor is operated either manually or automatically to start the motor.

PART III

INSTALLATION

The Fire Pump Controller has been assembled and wired at the factory with the highest workmanship standards. All wiring and functions have been thoroughly tested to assure correct operation when properly installed. Before operating the controller, perform the Initial Installation Start-up Procedure, Part IV.

The cubicle should be well grounded according to local standards. Make sure that all applicable external control wires are connected to appropriate terminals as shown in Controller Hookup, External drawing. If deluge valve is not used, the terminals for this must be jumpered (see Controller Hookup, External drawing). Failure to make the proper connections will cause the controller to malfunction. Connection from the contactor to the motor may be done after the test procedure is completed. The contact ratings of the remote and alarm signal circuits of the controller are shown in Controller Hookup, External drawing.

After installation has been completed, perform the Initial Installation Start-Up Procedure, Part IV, before operating the controller.

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PART IV

INITIAL INSTALLATION START-UP PROCEDURE

A. General:

All but the final functional test can be made with the motor disconnected. This will eliminate the need for starting and stopping the motor several times during the test procedure.

If the output connections from the contactor to the motor were made on initial installation, disconnect them for the first part of the Initial Installation Start-Up Procedure. Refer to Controller Hookup, External drawing for nomenclature of all controls.

The controls and their functions are as follows:

a) Isolation Switch:

This switch is connected in the circuit between the line and the circuit breaker. Its function is to disconnect the main power to the controller.

b) Circuit Breaker:

The circuit breaker is located between the motor contactor and the isolation switch. Its function is to protect the line from damage due to a short in the load.

c) Emergency Contactor Lever:

This control is used to start the fire pump in case of any malfunction within the control circuits.

d) Start Button:

This pushbutton starts the pump motor by exciting the contactor coil so that it closes.

e) Stop Button:

This control is to stop the pump motor by opening the contactor coil circuit, thereby disconnecting the current to the pump motor.

B. Series M100 Manual Non-Automatic:

1. Close isolation switch and measure voltage at output of isolation switch. Voltage should be the same as incoming line voltage.
2. Close circuit breaker and measure voltage at input of motor contactor. Voltage should be the same as in Step 1. Pilot light on controller should be on.
3. Push manual start button. Motor contactor should close. Measure voltage at output of contactor. It should be the same as in Step 1. Remote pump operating alarm should be energized.
4. Push stop button. Motor contactor should open.

5. Push trip button on circuit breaker. Remote power available alarm should indicate loss of power.

6. Connect output from contactor to pump motor.

7. Close circuit breaker.

8. Push start button. Motor should start.

9. Push stop button. Motor should stop.

C. **Series M200 Manual Primary Resistance Start:**

The start-up procedure is the same as for the Series M100. There are two contactors instead of one and a set of starting resistors. The smaller starting contactor is connected in series with the resistors to reduce the voltage to the motor for a preset time. After this preset time delay, the larger or main contactor will close in parallel with the smaller contactor and resistors and thus apply full voltage to the motor.

If the motor is not connected for this test, there will be no voltage drop across the resistors and full voltage will appear at the output terminals of the contactors as soon as the starting contactor closes.

D. **Series M220 Manual Part-Winding Start:**

The start-up procedure is the same as for the Series M100. There are two contactors for part-winding start. One contactor will close immediately on demand, and the other will close after a preset time delay. Full voltage will be present at the output of both contactors.

E. **Series M300 Combined Manual Automatic:**

1. Close isolation switch and measure voltage at output of isolation switch. Voltage should be the same as incoming line voltage.

2. Close circuit breaker and measure voltage at input of motor contactor. Voltage should be the same as in Step 1. Pilot light on controller should be on.

3. Push start button. Motor contactor should close. Measure voltage at output of contactor. It should be the same as the incoming line voltage. Remote pump operating alarm should be energized.

4. Push stop button. Motor contactor should open.

5. Drop water pressure at water inlet to controller so pressure switch will close. Motor contactor should close. Allow water pressure to return to normal. If controller is set for automatic stop, set running period timer for 1 minute for each 10 h.p. rating of motor, but not to exceed 7 minutes. Motor contactor should open after this time period. If controller is set for manual stop, push stop button. Motor contactor should open.

6. Repeat Step 5 except momentarily open deluge valve switch instead of dropping pressure to close pressure switch.

7. Connect output from contactor to pump motor.

8. Close circuit breaker.

9. Push start button. Motor should start.

10. Push stop button. Motor should stop.

F. Series M400 Combined Manual-Automatic Primary Resistance Start:

The start-up procedure is the same as for the Series M300. There are two contactors instead of one and a set of starting resistors. The starting contactor is connected in series with the resistors to reduce the voltage to the motor for a preset time. After this preset time delay the main contactor will close in parallel with the starting contactor and resistors and thus apply full voltage to the motor.

If the motor is not connected for this test, there will be no voltage drop across the resistors and full voltage will appear at the output terminals of the contactors as soon as the starting contactor closes.

G. Series M420 Combined Manual-Automatic Part-Winding Start:

The start-up procedure is the same as for the Series M300. There are two contactors for part-winding start. One contactor will close immediately on demand, and the other will close after a preset time delay. Full voltage will be present at the output of both contactors.

H. Sequential Starting:

Where sequential starting is used, set the sequential start relays for approximately 10 second intervals. Perform Initial Installation Start-Up Procedure for appropriate controller above and check for sequential timing on automatic starts. Sequential starting is bypassed by manual starting.

PART V

OPERATION OF CONTROLLER

After the installation and test procedures are completed, the controller is ready for normal operation.

A. Manual Controller:

Isolation switch and circuit breaker should be closed. Controller is now ready for manual operation. The controller is started by pushing the start button. If for some reason the motor fails to start when the start button is pushed, the emergency manual lever may be moved to the on position. This lever must be manually locked in the on position or it will return to off when released. This lever is for emergency use only.

B. Automatic Controllers — (All types):

The isolation switch and circuit breaker should be closed. For a sequential start controller and sequential start, timing relay TR3 should be set for approximately 10 second intervals. Local requirements may dictate different time settings. For controllers set for automatic stop, set the running period timer to 1 minute for each 10 H.P. rating of motor but not to exceed 7 minutes.

C. Emergency Manual Operation:

Emergency manual operation is provided in case of failure of control circuitry. This lever is manually moved to the on position and must be manually latched in the on position or it will return to off when released. The lever should be moved from the OFF position to the ON position in as quick a motion as possible to prevent burning the contacts. The circuit breaker should be tripped to disconnect circuit before releasing emergency lever. This lever is for emergency use only. A mechanical interlock switch is connected to the emergency lever to operate the contactor electrically when all circuitry is functioning properly. This is provided to prevent inadvertant slow closing of contactor and burning of contacts.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
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PART VI

SEQUENCE OF OPERATION

A. Introduction:

The explanation of the sequence of operation will start with the assumption that the controller has been properly installed, all external connections have been made and the isolation switch and circuit breaker are closed. In other words, the controller is operational. The pilot light should be on.

All wiring on the primary side of the transformer CT-1 will be referred to as the primary circuit. All wiring on the secondary side of transformer CT-1 will be referred to as the secondary circuit.

B. Manual Operation:

a) M100, M200 and M220 Manual Controllers.

For manual operation there is a start button switch on the controller and terminals for an optional remote start switch located elsewhere. These switches have normally open contacts which close to energize CR-3. CR-3 locks in on its own N.O. contact and stays energized until the stop button is depressed. The N.O. contact of CR-3 in the primary circuit closes the circuit to the motor contactor to start the motor. On models M200 and M220 CR-3 also energizes a time delay relay TR-2. After a preset time delay N.O. contacts of TR-2 close to energize the second or run contactor.

To stop the controller manually, the stop push button switch is depressed. This breaks the circuit to the coil of CR-3 and it is de-energized. At the same time the N.O. contact of CR-3 in the primary circuit opens and de-energizes the motor contactor(s) and stops the motor.

b) M300, M400 and M420 Combined Manual-Automatic Controllers.

Manual operation of the combined manual-automatic controllers is the same as for the manual controllers. The electrical sequence is different in that the N.O. contact of CR-3 does not energize the contactor coil directly, but energizes the coil of CR-2, and a N.O. contact of CR-2 in the primary circuit energizes the motor contactor. On models M400 and M420 CR-3 also energizes a time delay relay TR-2. After a preset time delay N.O. contacts of TR-2 close to energize the second or run contactor.

C. Automatic Operation — (Pressure Switch):

On drop of water pressure the N.O. contact in the pressure switch closes energizing the coil of CR-2. CR-2 locks in on its N.O. contact in the secondary circuit. At the same time the N.O. contact in the primary circuit energizes the motor contactor to start the motor. In controllers with sequential starting, TR-3 is energized by the pressure switch starting its timing cycle and at the end of the time period, a N.O. contact of TR-3 closes energizing CR-2. A N.O. contact of CR-2 in the primary circuit closes and energizes the motor contactor as above. On Models M400 and M420 CR-2 also energizes a time delay relay TR-2. After a preset time delay N.O. contacts of TR-2 close to energize the second or run contactor.

On controllers set for automatic stop, a running period timer is used to keep the motor running for a preset time period regardless of whether the contact of the pressure switch has opened. This is accomplished by keeping CR-2 (or TR-3) locked in through the N.C. contacts of the timer until the timer times out and these contacts open.

On controllers set for manual only stop, a jumper is removed preventing the timer motor from operating, thus CR-2 (or TR-3) is held in the energized state. The controller must be stopped with the manual stop pushbutton switch which breaks the circuit to CR-2 (or TR-3). The N.O. CR-2 contact in the primary circuit opens and stops the motor.

D. Automatic Operation — (Deluge Valve):

The deluge valve switch is a N.C. switch. When it opens, CR-4 is de-energized. The N.C. contacts of CR-4 in the automatic circuit close and energize CR-2 (or TR-3). The remaining sequence to start and stop the motor is the same as automatic operation with the pressure switch closing.

E. Remote — Pump Running Signal:

One N.O. and one N.C. contact is available for remote indication that the pump is running.

F. Remote — Power Available Alarm:

One N.O. and one N.C. contact are available for remote indication of loss of line power.

G. Engine Lockout — (Option E) — For Dual Drive Installations:

A N.O. auxiliary contact on the motor contactor is provided to prevent an engine type controller from starting if the electric motor controller is running. Circuitry for this is provided in the engine controller.

H. Electric Motor Lockout (Option M):

Terminals are available to connect to an external switch to lockout the electric motor. This may be necessary, when the engine is running on dual drive systems, low suction cutoff, etc.

The external switch will close to energize CR-6. A N.C. contact of CR-6 will break the circuit to CR-2 (or TR-3) and stop the motor.

I. Power Failure Start (Option P):

On loss of reliable source of 120V AC, Relay CR-5 will be de-energized. The N.C. contact of CR-5 will close and start the electric motor in the same manner as for drop in water pressure described above.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

PART VII

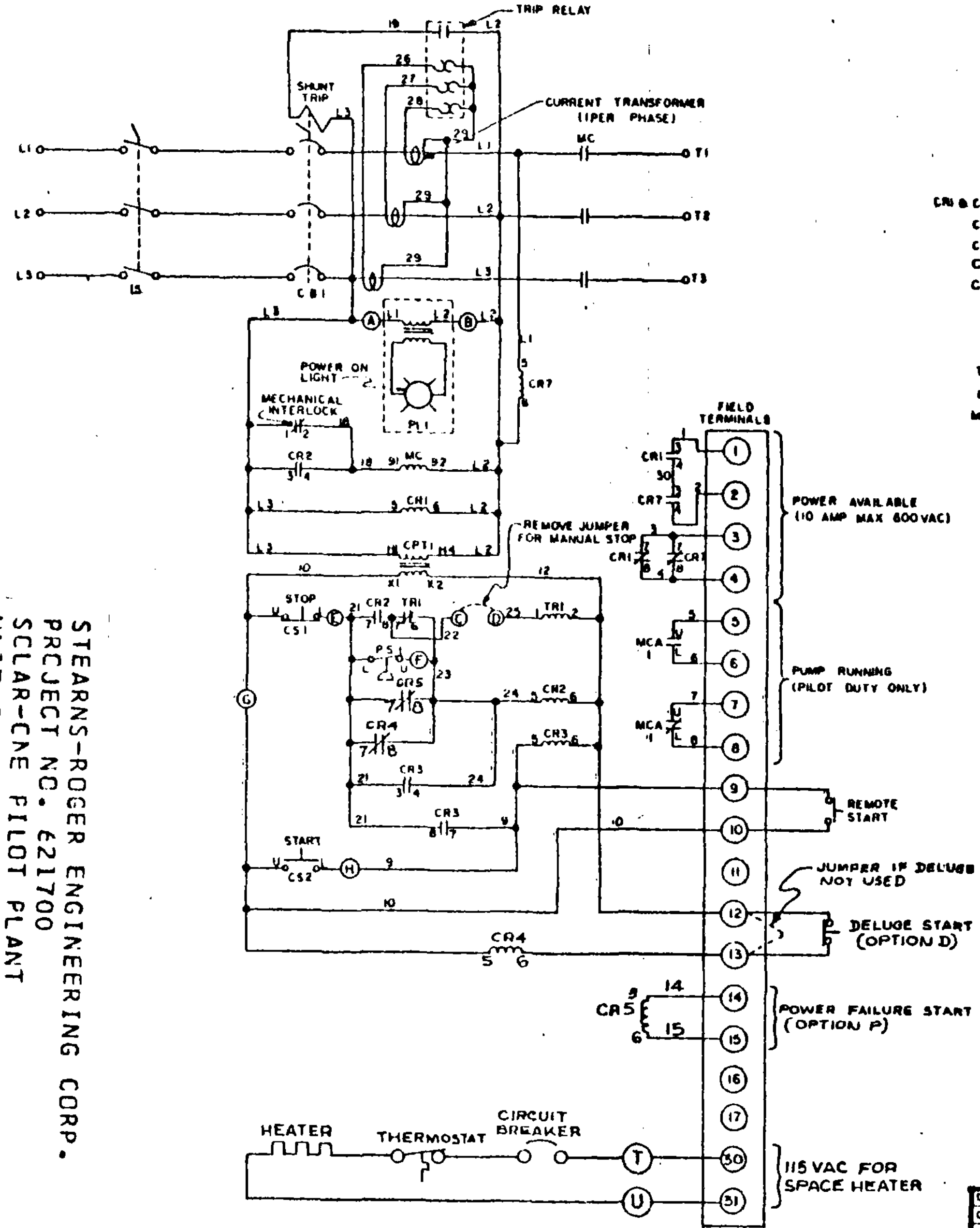
NOMENCLATURE

IS1	Isolation Switch
CB1	Circuit Breaker
MC	Motor Contactor
PL1	Pilot Light
MCA	Motor Contactor Auxiliary Contacts
CR1	Power Available Relay
CR2	Control Relay
CR3	Manual Start Relay
CR4	Deluge Relay (Option D)
CR5	Power Failure Start Relay
CR6	Electric Motor Lockout Relay
TR1	Run Period Timer
TR2	MC2 Delay Timer
TR3	Sequential Start Timer
PS1	Pressure Switch
CS1	Stop Switch, Manual
CS2	Start Switch, Manual
CT1	Control Transformer

1.2.7.75

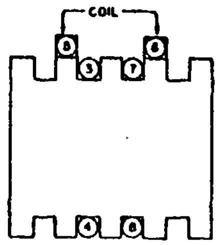
STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SCLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



CR1 & CR7 - POWER AVAILABLE RELAY
CR2 - CONTROL RELAY
CR3 - MANUAL START RELAY
CR4 - DELUGE START (OPTION D)
CR5 - POWER FAILURE START (OPTION P)

TR1 - RUN PERIOD TIMER
MC - MOTOR CONTACTOR
MCA - MOTOR CONTACTOR AUXILIARY CONTACT



TERMINAL DESIGNATIONS I.T.E. CONTROL RELAYS

NOTE FOR FIELD WIRING:

1. USE COPPER WIRING ONLY EXCEPT AT TERMINALS MARKED CU-AL
2. MOTOR CONTACTOR AUXILIARY CONTACTS MCA RATED FOR PILOT DUTY ONLY.

CERTIFIED CORRECT DRAWING

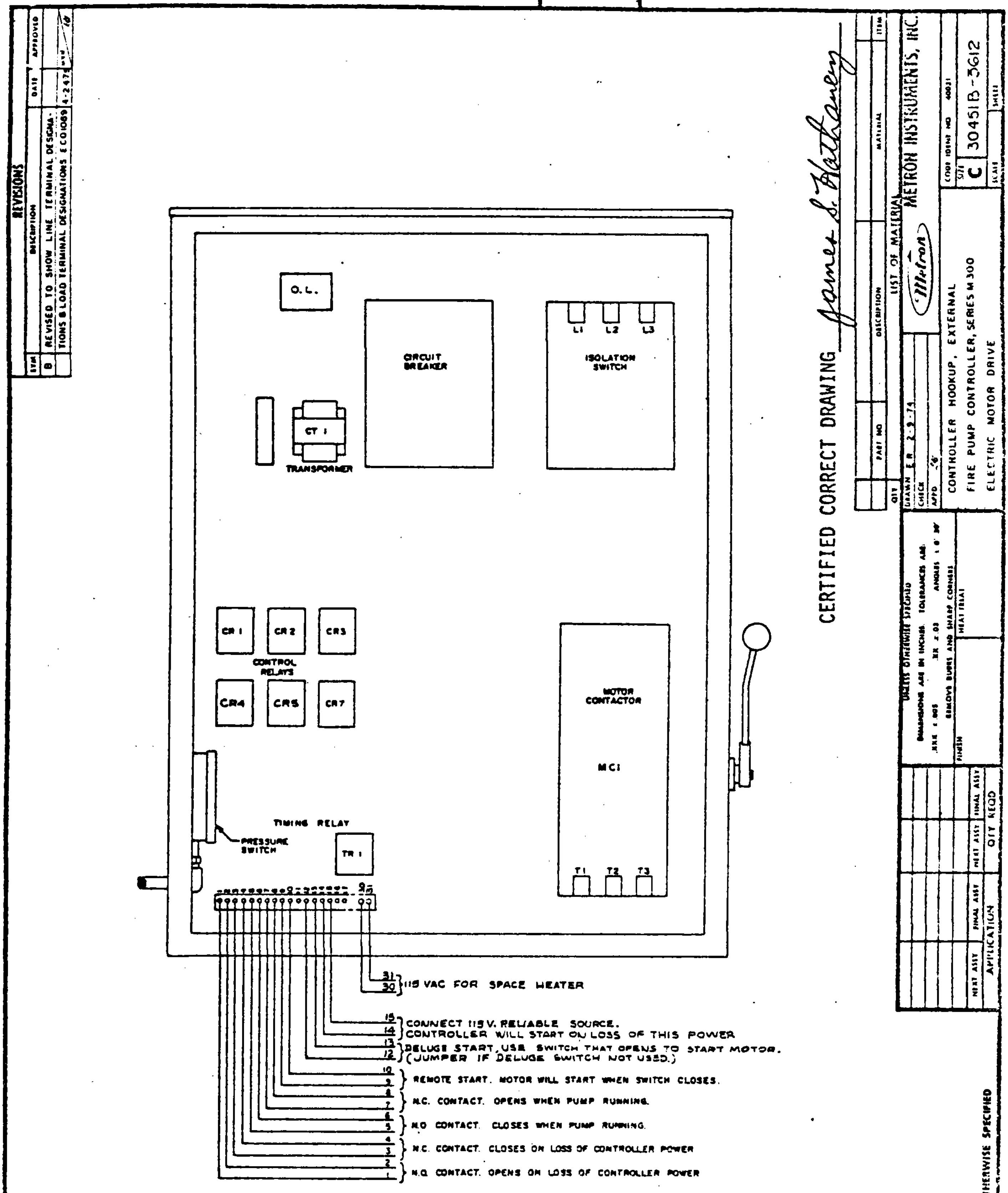
James S. Hathaway

DRAWN M V N	10-1-79	Metron — METRON INSTRUMENTS, INC.
CHECK		
APPD	3-27-81	

ELECTRIC MOTOR FIRE PUMP CONTROLLER
MODEL M300, COMBINED MANUAL-AUTOMATIC
ACROS THE LINE (NO OPTIONS)

CODE IDENT NO. — SIZE C — 30721-3612
SCALE — SHEET

NOTES - UNLESS OTHERWISE SPECIFIED



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

FIRE PUMPS
ELECTRIC MOTOR DRIVE
CERTIFIED PERFORMANCE TEST PROCEDURES
(Form A-60006 is used for recording data)

A. The Hydrostatic Test (see procedures) should already have been accomplished (Hydrostatic test procedures are from the Q.C. Manual. A copy is provided here).

B. The Calibrated test motor is mounted with pump.

C. The pump is piped into the Pos. Pressure System. Proper gauge pipe must be on suction & discharge.

D. A properly sized suction & discharge gauge is selected. The gauges are then calibrated against the dead-weight testor or the calibrated master gauge. A mark of "OK" or a correction is recorded on the test sheet (form A-60006) along with the gauge number. The gauges are then placed on the proper gauge pipe. (See gauge calibration Procedures). Record on the data sheet as gauge distance, the vertical distance, in feet, between the centerlines of the suction and discharge gauges.

E. The test form (A-60006) is completed with the following information: Pump size and type (If the pump is being tested of a construction other than a called for on the order, this must be recorded under "remarks"), impeller number, impeller diameter, impeller tips (plain or sharpened) pump serial number and F.O. number.

F. The motor calibration number, make, horsepower, R.P.M. is then recorded on the test form.

G. Pump rating information is taken from the order and recorded. Also, the nameplate is checked for complete and accurate information.

H. The Electrical Power Measurement equipment is recorded on data sheets. Be sure to record proper ratio of wattmeter. (See Power Measurement Procedures).

I. The pump should be connected and ready to operate.

J. Start test pump, bleed air from pump and discharge manifold and calibrate flowmeter. (See instructions on "Flowmeter Calibration").

K. Set pump at duty point specified on order. Set pressure and read flow. Record this information on the V.I.P. test data card. This card should be completely filled out. If the duty stated on the order is met, and the pump is operating smoothly, proceed with performance test. If duty is not met or pump does not seem to be operation properly, check with supervisor.

L. Return pump to shut-off setting and record the following information: Discharge gauge reading, suction gauge reading (Mark if this reading is positive (+) or negative (-), flowmeter reading, wattmeter reading, and R.P.M.

M. Continue taking test points at different flow settings (approximately in increments of 10 on flowmeter) until the maximum wattmeter reading is passed and/or extreme cavitation is encountered. One test point should be a 150% of rated flow.

N. Throttle suction valve until -15 is showing on suction gauge. (Pump should be operating at near free delivery).

O. Observe and record on separate data sheet the discharge pressure, the suction pressure (-15.0), and the flowmeter reading.

P. Throttle back on discharge until a small increase in discharge pressure is made. Again set suction at -15 and record readings as above.

Q. Continue as above until the flow point of 150% of the rated flow is passed. Example: pump is rated at 1000 GPM, 100 PSI. 150% of 1000 GPM is 1500 GPM. Test with -15.0 suction was started with pump running wide open. Keep taking test point, each with slight increase in discharge pressure, until a flow reading of less than 1500 GPM is observed.

R. Return pump to duty point if operation seems alright, return to shut-off setting. Always stop pump at shut-off point. This is because the flowmeter should always be kept full of water.

S. Remove or shut-off suction and discharge gauges. Turn off power to test pump. Turn off power to Pos., Pressure Pump.

T. Analyze test for compliance to requirements. Check with supervisor if needed. (See procedures for analyzing tests).

U. Record test in test log and place test number on data sheet along with date and technician initials. Mark test data sheet as Fire Pump Test in "Remarks" column. If suction or discharge gauge pipes differ from pump suction or discharge sizes this must be recorded on test sheets. Also, mark make and size of motor for job.

V. Test Data Sheets must be complete with the following information:

Impeller Number
Impeller Diameter
Impeller Tips
Pump Serial Number, F.O. Number, or AFD Project Number
Motor Information
Pump Rating Information (Except AFD Projects)
Wattmeter Make
Test Number, Date and Technician Initials
Suction & Discharge Gauge Pipe sizes (If different from pump)
Suction & Discharge Gauge Number (Gauge marking of "OK" or a correction value)
Barometer Reading
Remarks column should carry the type of test and any other remark as applicable.
(See procedures for the type of test)
Minimum of 6 test points with information as follows:
Discharge Pressure
Suction Pressure (marked head (+) or lift (-)
Gauge Distance (Vertical Distance between suction gauge and discharge gauge centerline. If discharge gauge is highest, number is positive (+). If suction gauge is highest, number is negative (-).
Flowmeter readings and full scale setting
Watt reading and proper ratio
RPM Readings

W. Remove equipment and pump from test set-up.

X. Hydro Test Pump to twice the shut-off point, but never less than 250 PSI.

1.2.7.79

Y. Tag pump "Hold for Approval" and return to shop for mounting with its own motor. Also mark hydraulic and hydro as OK, initial and date.

Z. After pump and motor is mounted, run a check test. Take readings at shut-off rated condition and maximum horsepower draw point. Record motor amps, watts, volts, and power factor and RPM.

NOTE: This applies only to pumps with motors of which we are capable of operating properly.

A. Remove pump from test and place in, "Hold for Approval"area.

AURORA PUMP
A UNIT OF GENERAL SIGNAL CORPORATION
Quality Control Department
North Aurora, Illinois

PREPARED BY: Q. C. Department

CHECKED BY:

QCP 29

Page No. 1 of 2 Rev.

Date

PROCEDURE: Hydro Test Stand MACH. #3220

PUMP MODELS: Split Case. Sewage Pump. End Suction

1. Remove the pump to be tested from the conveyor, truck or skid, using the electric hoist provided for this purpose, and place it on the proper pedestal, or in the case of sewage or end suction pumps, position it so that all air can be eliminated from the pump.

2. Attach the air vent tube assembly at the highest point in order to vent all air from the pump. Remove pipe plugs where necessary.

CAUTION All air must be vented from the pump before hydrostatic pressure is applied.

2.1 Close off suction and discharge openings using flanges or pipe plugs provided for this purpose.

2.2 Adjust the packing for minimal leakage on packing type pumps.

2.3 Attach the pump filler hose (quick coupling attached to the submersible pump.)

2.4 Write the pump model and serial number on Form QC-43.

2.5 While the pump is being filled with water, set up another pump, or pumps, on adjacent test fixtures, as per preceeding instructions.

2.6 After water begins flowing from the air vent tube, close the petcock on the air vent tube assembly.

2.7 Disconnect the filler hose. 1.2.7.81

AURORA PUMP
A UNIT OF GENERAL SIGNAL CORPORATION
Quality Control Department
North Aurora, Illinois

PREPARED BY: Q. C. Department QCP 29

CHECKED BY: ______ Page No. 2 of 2 Rev. ______

Date ______

2.8 The No. 1 test station is marked 0 to 110, No. 2, 110 to 185, No. 3, 185 to 260. Take the HEAD FEET from the pump nameplate or the pump order and compare it with these three stations.

2.9 Connect the hose from the coinciding station.

2.10 Visually check the pump for leaks. Carefully check the casing, seals, "O" rings, gaskets, studs, capscrews, pipe plugs or fittings. If any of the above leak, reject the pump and attach a red rejection tag.

2.11 Back off the packing gland nuts (only if packing type pump) and let the hydrostatic pressure blow the packing out until some leakage occurs. This is to prevent the shaft from scoring on initial starting of the pump.

2.12 Remove the pressure hose from the pump.

2.13 Open the vent tube assembly petcock to release the pressure.

2.14 Remove the drain plugs to drain the pump.

2.15 Remove the vent tube assembly.

2.16 Remove the test flanges or plugs.

2.17 Remove all trapped water remaining in the pump.

2.18 Replace all pipe plugs.

2.19 Record findings (accept or reject) on Form QC-43, and the reason if rejected.

2.20 If rejected, return to Assembly department for correction.

2.21 If accepted, place the pump on the conveyor for mounting or painting.

TEST LAB PROCEDURE

NPSH TEST (VACUUM BREAK OFF)

1. Run full perf., cold water test.
2. Throttle suction so the following suction lift gauge readings are obtained. Run test from wide open to near shut-off for each lift condition.
   - 5' Lift
   - 10' Lift
   - 15' Lift
   - 20' Lift
   - 25' Lift
   - 27' Lift
3. Plot cold water test (Refer to Fig. 1)
4. Superimpose break off tests on cold water test.
5. Calculate NPSH. The required NPSH can be calculated from the following formula (FOR EACH BREAK OFF POINT).

$$NPSH_R = \frac{B.P. + H_s}{S.G.} + \frac{V^2}{2g} - VP$$

WHERE B.P. = Barometric press in inches of Mercury x 1.133 = feet of water

H_s = Suction head (If suction gauge reading)

$\frac{V^2}{2g}$ = Velocity head, This value is taken from the flow at the break off point from cold water curve, through the suction pipe size only.

V.P. = Vapor Pressure (feet of water) for 70°F water this = .89 feet of water & is usually neglected.

S.G. = Specified Gravity (on a cold water break off test this is 1.0)

6. The NPSH curve can now be plo-ted (use two (2) cycle semi-log paper to plot NPSH curve. $NPSH_R$ for any flow for this diameter can be selected.

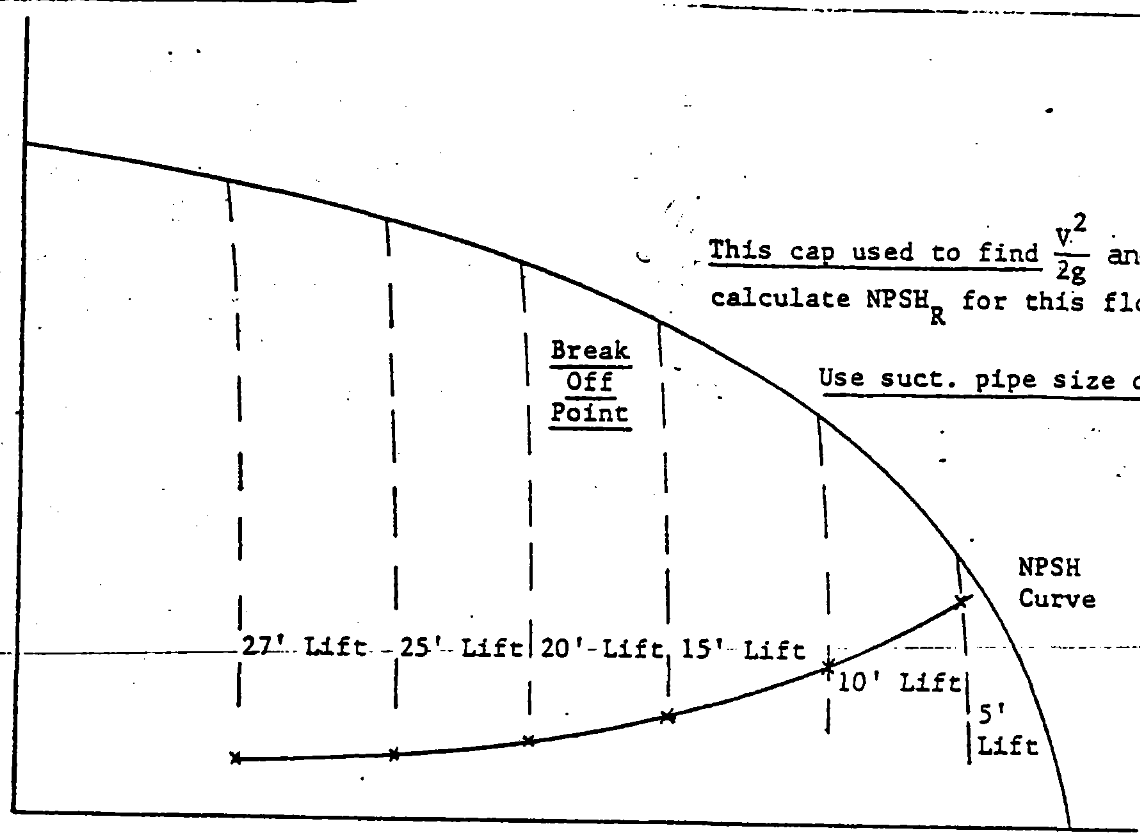


Fig. 1

NPSH - HOT WATER

7. Test can also be ran using hot water. This is accomplished by running a cold water test & tests at various temperatures up to boiling. Temperature should be as follows:

170°F
180°F
190°F
200°F
206°F
212°F (Boiling)

To analyze this type of test, proceed as for Vac Break Off except use correct values for S.G. and V.P. These values vary with temperature.

PROPERTIES OF WATER

Temp. °F.	Absolute Vapor Pressure Psi.	Absolute Vapor Pressure Ft. Water	Specific Gravity (Water at 39.2°F = 1.000)
60	0.26	0.59	0.999
70	0.36	0.89	0.998
80	0.51	1.2	0.997
85	0.60	1.4	0.996
90	0.70	1.6	0.995
100	0.95	2.2	0.993
110	1.27	3.0	0.991
120	1.69	3.9	0.989
130	2.22	5.0	0.986
140	2.89	6.8	0.983
150	3.72	8.8	0.981
151	3.81	9.0	0.981
152	3.90	9.2	0.980
153	4.00	9.4	0.980
154	4.10	9.7	0.979
155	4.20	9.9	0.979
156	4.31	10.1	0.979
157	4.41	10.4	0.978
158	4.52	10.7	0.978
159	4.63	10.9	0.978
160	4.74	11.2	0.977
161	4.85	11.5	0.977
162	4.97	11.7	0.977
163	5.09	12.0	0.976
164	5.21	12.3	0.976
165	5.33	12.6	0.976
166	5.46	12.9	0.975
167	5.59	13.3	0.975
168	5.72	13.6	0.974
169	5.85	13.9	0.974
170	5.99	14.2	0.974
171	6.13	14.5	0.973
172	6.27	14.9	0.973
173	6.42	15.2	0.973
174	6.56	15.6	0.972
175	6.71	15.9	0.972
176	6.87	16.3	0.972
177	7.02	16.7	0.971
178	7.18	17.1	0.971
179	7.34	17.4	0.971
180	7.51	17.8	0.970
181	7.68	18.3	0.970
182	7.85	18.7	0.970
183	8.02	19.1	0.969
184	8.20	19.5	0.969
185	8.38	20.0	0.969
186	8.57	20.4	0.968
187	8.76	20.9	0.968
188	8.95	21.4	0.967
189	9.14	21.8	0.967
190	9.34	22.3	0.966
191	9.54	22.8	0.966
192	9.75	23.3	0.965
193	9.96	23.8	0.965
194	10.17	24.3	[illegible]
195	10.38	24.9	0.964
196	10.60	25.4	0.964
197	10.83	25.9	0.963
198	11.06	26.6	0.963
199	11.29	27.1	0.963
200	11.53	27.6	0.963
201	11.77	28.2	0.962
202	12.01	28.8	0.962
203	12.26	29.4	0.962
204	12.51	30.0	0.961
205	12.77	30.6	0.961
206	13.03	31.2	0.960
207	13.30	32.0	0.960
208	13.57	32.6	0.960
209	13.84	33.2	0.959
210	14.12	33.9	0.959
211	14.41	34.6	0.958
212	14.70	35.4	0.958
213	14.99	36.2	0.957
214	15.29	37.0	0.957

1.2.7.85

AURORA PUMP
A UNIT OF GENERAL SIGNAL

CERTIFICATE OF COMPLIANCE

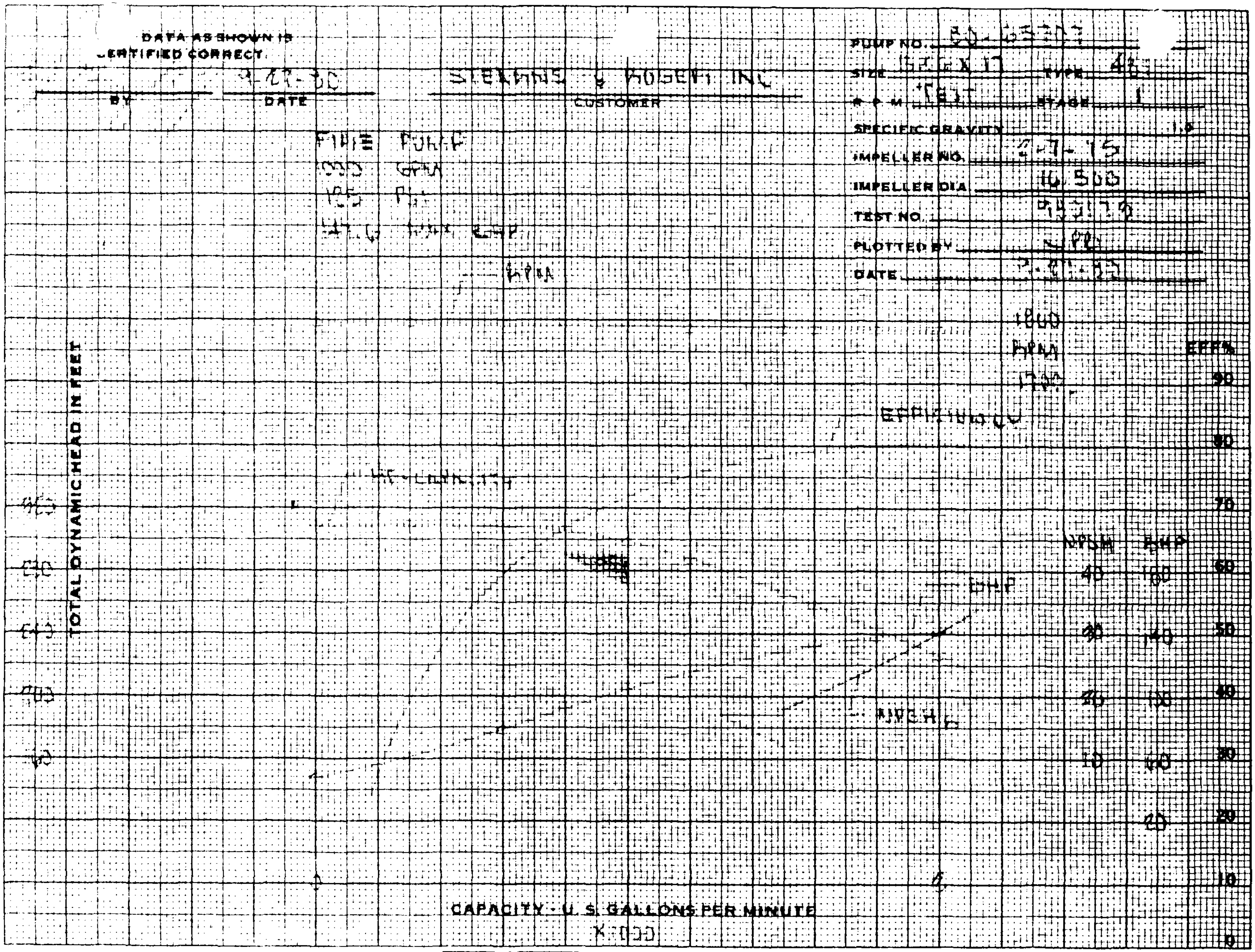
I hereby certify that Pump Serial Number 4D0-65707 has been "VIP" Hydrostatically Tested in compliance to specification at 303 P.S.I. and found to be built with structurally sound castings. During the time this pump was tested, no escape of fluid through the external surfaces of the pump was seen.

FOR J R Conner
Warren Randall
Manager of Quality Control

December 11, 1980
Date

JC:lkp4/1

800 AIRPORT ROAD · NORTH AURORA, ILLINOIS 60542 · PHONE: 312-859-7000



A-40040 REV. 2-78 K&E

AURORA PUMP
A UNIT OF GENERAL SIGNAL

SHEET NO.

915 SECTION
TURBINE FIRE PUMP
DIESEL DRIVE

TABLE OF CONTENTS
DIESEL-DRIVEN, VERTICAL
TURBINE FIRE PUMP

AURORA PUMP
A UNIT OF GENERAL SIGNAL
900 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

NO. OF PRINTS	
	FOR APPROVAL
8	FINAL

4 REPROS

SALES OFFICE: McLEMORE PUMP & EQUIPMENT CO. PO# A01-106
FACTORY ORDER NUMBER: 4GO-65706
JOB: SOLAR-ONE, PILOT PLANT
SERVICE: DIESEL FIRE PUMP
ENGINEER: STEARNS-ROGER ENGINEERING CORP.
CONTRACTOR: STEARNS-ROGER ENGINEERING CORP
SOLD TO: TOWNSEND & BOTTOM, INC. PO# 2001-C21700
REFERENCE: PROJECT No. C21700

PUMP

ONE NUMBER OF UNITS EP125SF14TM SIZE 1,000 GPM 295' TDH 1750 RPM
17AC8 DISCHARGE HEAD ____ COMPANION FLANGE ____ SEPARATE BASEPLATE ____ SOL. OILER VOLTAGE
8" COLUMN ☒ THREAD ☐ FLANGE ____ TUBE 1½" SHAFT
F14TMH BOWL ASSEMBLY 3 NUMBER OF STAGES #7 BRONZE ☐ CONE ☒ BASKET STRAINER

ENGINE

V-378-F2 MODEL 2600 RPM CUMMINS MANUFACTURER
BY: ☒ AURORA
☐ OTHERS

GEAR DRIVE N.R.R.

AMARILLO MFR. 1255 SIZE 3:2 RATIO ____ ROTATION
FURNISHED BY: ☒ AURORA ☐ OTHERS

SPECIAL REQUIREMENTS

PUMP: CERTIFIED PERFORMANCE TEST; HYDROSTATIC TEST; BRONZE BOWL WEAR RINGS; ACCESSORIES PER ATTACHED SHEETS
ENGINE: ACCESSORIES PER ATTACHED SHEETS

ELECTRICAL: METRON FIREPUMP CONTROLLER PER ATTACHED SHEETS

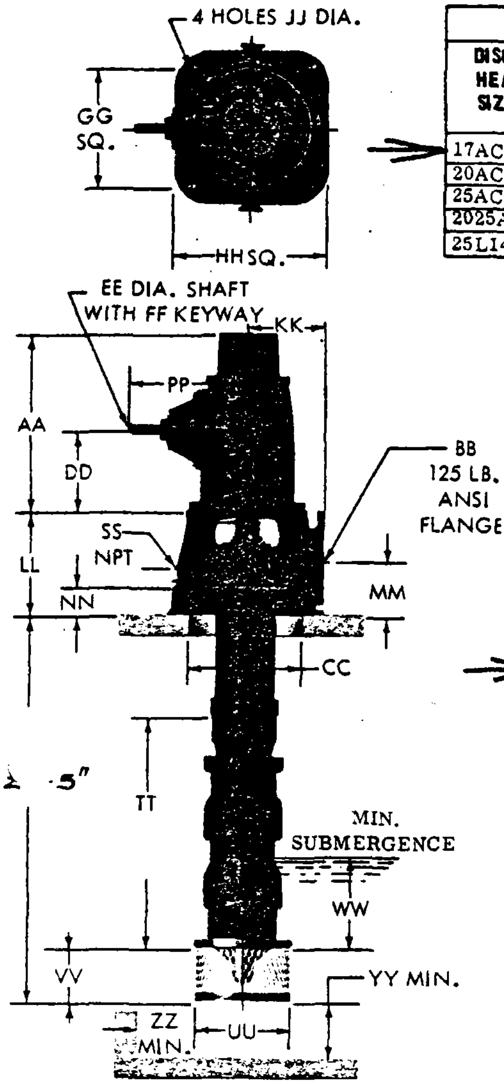
CERTIFIED PRINT: SECTION: 915 PAGE: 202 & 351 CURVE NUMBER: 9PC-130386
SPECIAL: ____ MAINTENANCE: ____
REVISED 12-10-80 W/W BY: WJW DATE: 6/27/80 OFFICE: AURORA

THIS ORDER WILL NOT BE PROCESSED FOR MANUFACTURING UNTIL APPROVAL IS RECEIVED. PRINTS ARE NOT TO SCALE AND ARE CERTIFIED CORRECT ONLY FOR THIS ORDER. ALL ORDERS SUBJECT TO ACCEPTANCE AT AURORA PUMP, NORTH AURORA, ILLINOIS.

THIS ORDER CAN BE RELEASED FOR MANUFACTURING AS SHOWN: ☐ AUTHORITY: ____
RELEASE FOR MANUFACTURING PER ATTACHED CHANGE ORDER: ☐ OFFICE: ____
DATE: ____

40150 (1-78) 1.2.7.90

AURORA MODEL F
VERTICAL FIRE PUMPS
GEAR DRIVEN - AMARILLO
SUMP INSTALLATION



DISCHARGE HEAD DIMENSIONS												
DISCH HEAD SIZE	BB	CC MIN	CC MAX	GG	HH	JJ	KK	LL	MM	NN	RR	SS
17ACA8	8	15-1/4	20-1/4	17	22	1	13	15	8	4	6	1-1/4
20AC10	10	21	24-1/2	20	26	1	13	18	10	5	7	1-1/4
25AC12	12	22	25	24	33	1-3/32	17	22	12	6	8-1/4	1-1/4
2025AC10	10	21	24-1/2	20	26	1	13	18-1/8	10	5	7	1-1/4
25L14S	14	22	25	30	34	1	18	42	15	1-1/2	23-5/8	1-1/4

PUMP AND SUMP DIMENSIONS											
GPM	PUMP MODEL	TT FOR	NO. OF STGS.	ADD'L STG.	TT'	UU	VV	WW	XX	YY MIN.	ZZ MIN.
500	F12EL	39-7/8	4	7		14	8	24		12	7
750	F12EH	50-1/2	4	9-1/8		15	8	24		12	8
1000	F14TM	44-1/8	3	9-3/4		15	8	24		12	8
1500	F14R	58-1/4	3	13-3/8		20	10	25		12	10
2000	F16EH	52	3	12		18	10	24		12	9
2500	F18EH	45	2	14		21	10	24		12	11
3000	F18EH	43-5/8	2	14		21	10	24		12	11
3500 to 4500	F20K	54-5/8	2	18-1/4		23	12	33		12	12

<table>
<tr><th colspan="7">GEAR DRIVE MFR.</th><th colspan="9">GPM AND DISCHARGE HEAD SIZE</th></tr>
<tr><th colspan="7">AMARILLO</th><th rowspan="2">500</th><th rowspan="2">750</th><th rowspan="2">1000</th><th rowspan="2">1500</th><th rowspan="2">2000</th><th rowspan="2">2500</th><th rowspan="2">3000</th><th rowspan="2">3500 4000</th><th rowspan="2">4500</th></tr>
<tr><th>MODEL</th><th>MAX HP</th><th>AA</th><th>DD</th><th>PP</th><th>EE DIA.</th><th>FF KEYWAY</th></tr>
<tr><td>60</td><td>60</td><td>28</td><td>11-1/2</td><td>16-3/4</td><td>1-1/2</td><td>3/8 Sq.</td><td rowspan="2">17ACA8</td><td>NR</td><td rowspan="2">NR</td><td rowspan="3">NR</td><td rowspan="5">NR</td><td rowspan="5">NR</td><td rowspan="6">NR</td><td rowspan="7">NR</td><td rowspan="7">NR</td></tr>
<tr><td>80</td><td>80</td><td>28-1/2</td><td>11-1/2</td><td>16-3/4</td><td>1-7/8</td><td>3/8 Sq.</td><td rowspan="3">17ACA8</td></tr>
<tr><td>100</td><td>100</td><td>28-1/2</td><td>11-1/2</td><td>16-3/4</td><td>1-7/8</td><td>3/8 Sq.</td><td rowspan="8">NR</td><td rowspan="2">17ACA8</td></tr>
<tr><td>125</td><td>125</td><td>29-3/8</td><td>11-1/2</td><td>18-3/4</td><td>2-7/16</td><td>5/8 Sq.</td><td>17ACA8</td></tr>
<tr><td>150</td><td>150</td><td>33-3/4</td><td>13-3/4</td><td>20-3/4</td><td>2-7/16</td><td>5/8 Sq.</td><td rowspan="6">NR</td><td>20AC10</td><td rowspan="2">20AC10</td></tr>
<tr><td>200</td><td>200</td><td>33-3/4</td><td>13-3/4</td><td>20-3/4</td><td>2-7/16</td><td>5/8 Sq.</td><td rowspan="5">NR</td><td>20AC10</td><td>20AC10</td></tr>
<tr><td>275</td><td>275</td><td>43-7/8</td><td>16</td><td>25-1/2</td><td>2-15/16</td><td>3/4 Sq.</td><td>2025AC10</td><td rowspan="2">2025AC10</td><td rowspan="2">2025AC10</td><td rowspan="3">25AC12</td></tr>
<tr><td>375</td><td>375</td><td>43-5/8</td><td>16</td><td>25-1/2</td><td>2-15/16</td><td>3/4 Sq.</td><td rowspan="3">NR</td><td rowspan="3">25AC12</td><td rowspan="3">25L14S</td></tr>
<tr><td>450</td><td>450</td><td>43-5/8</td><td>16</td><td>25-1/2</td><td>3-3/4</td><td>7/8 Sq.</td><td rowspan="2">NR</td><td rowspan="2">NR</td></tr>
<tr><td>600</td><td>600</td><td>50</td><td>18</td><td>26-3/4</td><td>3-3/4</td><td>7/8 Sq.</td><td>NR</td></tr>
</table>

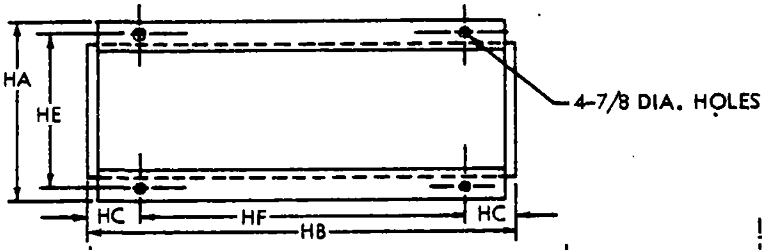
NOTES:
NR INDICATES NOT REQUIRED.
ALL DIM'S. IN INCHES UNLESS OTHERWISE SPECIFIED.
"SS" NPT IS CONNECTION FOR ENGINE COOLING PIPING LOOP.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA PUMPS

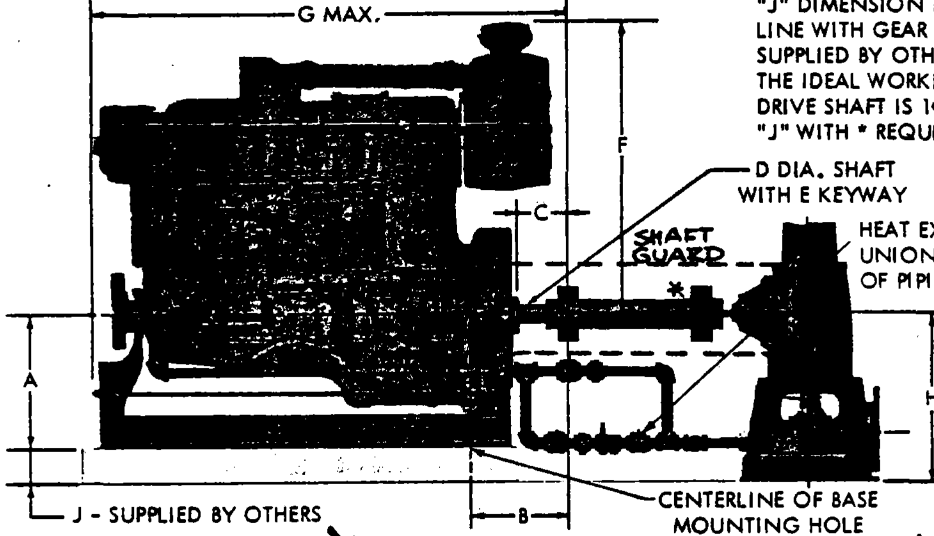
1.2.7.91

AURORA MODEL F
VERTICAL FIRE PUMPS
ENGINE DRIVEN - AMARILLO GEAR DRIVE



BASE NO.	HA	HB	HC	HE	HF	WT. LBS.
1	29	42	6	27	30	175
2	29	62	10	27	42	221
3	30	66	10	28	46	305

IMPORTANT
"J" DIMENSION PLACES ENGINE SHAFT IN LINE WITH GEAR SHAFT. CONCRETE PAD SUPPLIED BY OTHERS.
THE IDEAL WORKING ANGLE FOR THE DRIVE SHAFT IS 1° TO 5°.
"J" WITH * REQUIRES ELEVATION OF PUMP.



*20" SHAFTING

GPM	PUMP MODEL	DISCH HEAD SIZE	GEAR HP	GEAR MODEL	H	J: CUMMINS MODEL V-378-F1	V-378-F2	V-504-F	N-855-F	NT-855-F1	NT-855-F2	VT-1710-F	J: DETROIT MODEL 1034-7110	1044-7110	1064-7110	7084-7010
500	F12EL	17ACA8	60 90	60 90	26-1/2	1-1/8	1-1/8	1-1/8	NR	NR	NR	NR	1-1/4	1-1/4	NR	NR
750	F12EH	17ACA8	90 100 125	90 100 125	26-1/2	1-1/8 NR	1-1/8	1-1/8	NR	NR	NR	NR	1-1/4 NR	1-1/4	NR 1-1/4	NR
1000	F14TM	17ACA8 20AC10	100 125 150	100 125 150	26-1/2 31-3/4	NR	1-1/8 NR	1-1/8 6-3/8	1-1/4 6-1/2	NR	NR	NR	NR	1-1/4 NR	1-1/4 6-1/2	NR
1500	F14R	17ACA8 20AC10 2025AC10	125 150 200 273	125 150 200 275	26-1/2 31-3/4 34-1/8	NR	NR	1-1/4 6-3/8 NR	NR 6-1/2 NR	NR 6-1/2 9-7/8	NR 8-7/8	NR	NR	NR	1-1/4 6-1/2 NR	NR 6-1/2 9-7/8
2000	F16EH	20AC10 2025AC10	200 275 375	200 275 375	31-3/4 34-1/8	NR	NR	NR	6-1/2 NR	6-1/2 3-7/8 NR	NR 8-7/8 NR	NR 1-3/4*	NR	NR	NR	6-1/2 3-7/8 NR
2500	F18EH	20AC10 2025AC10	200 275 375	200 275 375	31-3/4 34-1/8	NR	NR	NR	6-1/2 NR	6-1/2 9-7/8 NR	NR 9-7/8 NR	NR 1-3/4*	NR	NR	NR	6-1/2 3-7/8 NR
3000	F18EH	25AC12	275 375 450	275 375 450	38	NR	NR	NR	NR	NR	12-3/4 NR	NR 2-1/8	NR	NR	NR	NR
3500 4000	F20K	25AC12	375 450 600	375 450 600	38 40	NR	NR	NR	NR	NR	NR	2-1/8 4-1/8	NR	NR	NR	NR
4500	F20K	25L14S	375 450 600	375 450 600	58 60	NR	NR	NR	NR	NR	NR	22-1/8 24-1/8	NR	NR	NR	NR

NOTES:
1. NR INDICATES NOT REQUIRED.
2. ALL DIM'S. IN INCHES UNLESS OTHERWISE SPECIFIED.
3. NOT FOR CONSTRUCTION PURPOSES UNLESS CERTIFIED.
4. HEAT EXCHANGER LOOP PIPING IS 1-1/4" EXCEPT FOR VT-1710-F ENGINE WHICH IS 2".

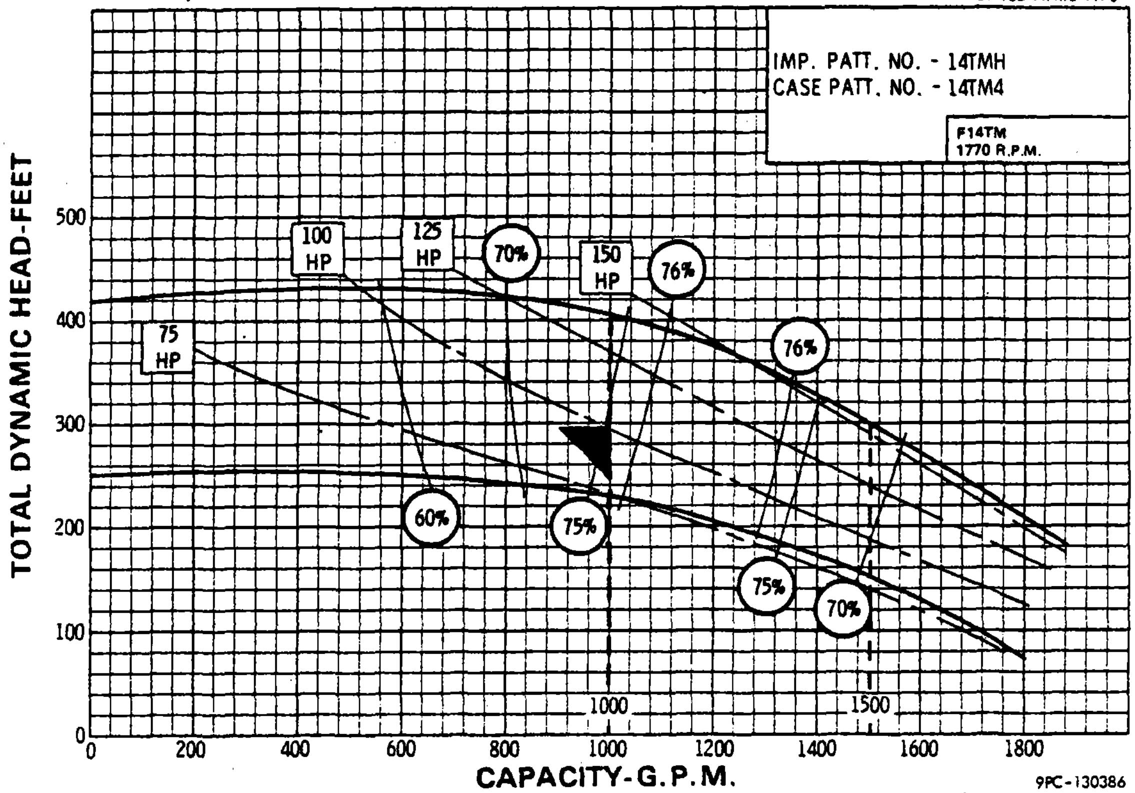
ENGINE MF'R.	ENGINE MODEL	A	B	C	D DIA.	E KEYWAY	F	G MAX.	ENGINE WIDTH	ENGINE WEIGHT LBS.	BASE NO.
CUMMINS	V-378-F1 V-378-F2 V-504-F	25-3/8	10-3/16	4	2-1/2	5/8 SQ.	28-15/16 29-9/16	42-7/8 48-3/8	32-11/16	1568 1568 1838	1
	N-855-F NT-855-F1 NT-855-F2	25-1/4	15-7/16	4-1/2	2-3/4	3/4 SQ.	38-1/2 45-7/16 44-13/16	56-1/4	31-5/8 31-1/4	2800 3150 3200	2
	VT-1710-F	35-7/8	17-7/8	5	3	3/4 SQ.	47-3/4	98-7/8	32-1/4	7000	3
DETROIT	1034-7110 1044-7110 1064-7110	25-1/4	18-15/16 22-15/16	5-3/4	2-1/4	5/8 SQ.	34-1/8	51-15/16 57-11/16 69-3/16	30-3/4 31-5/8 31-1/2	1775 1910 2330	1 2
	7084-7010		34-11/16	10	3-15/16	1 SQ.	43-1/4	72-1/8	45-1/2	2930	2

AURORA PUMPS

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001 1.2.7.92

1000 G.P.M. FIRE PUMP

ELECTRIC MOTOR DRIVE



100 TO 169 P.S.I.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

M-20

INSTALLATION & OPERATING INSTRUCTIONS

CLOSE COUPLED VERTICAL TURBINE PUMPS

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

Aurora Pump

A UNIT OF GENERAL SIGNAL

RECOMMENDED SPARE PARTS LIST

OPEN/ENCLOSED LINESHAFT CONSTRUCTION

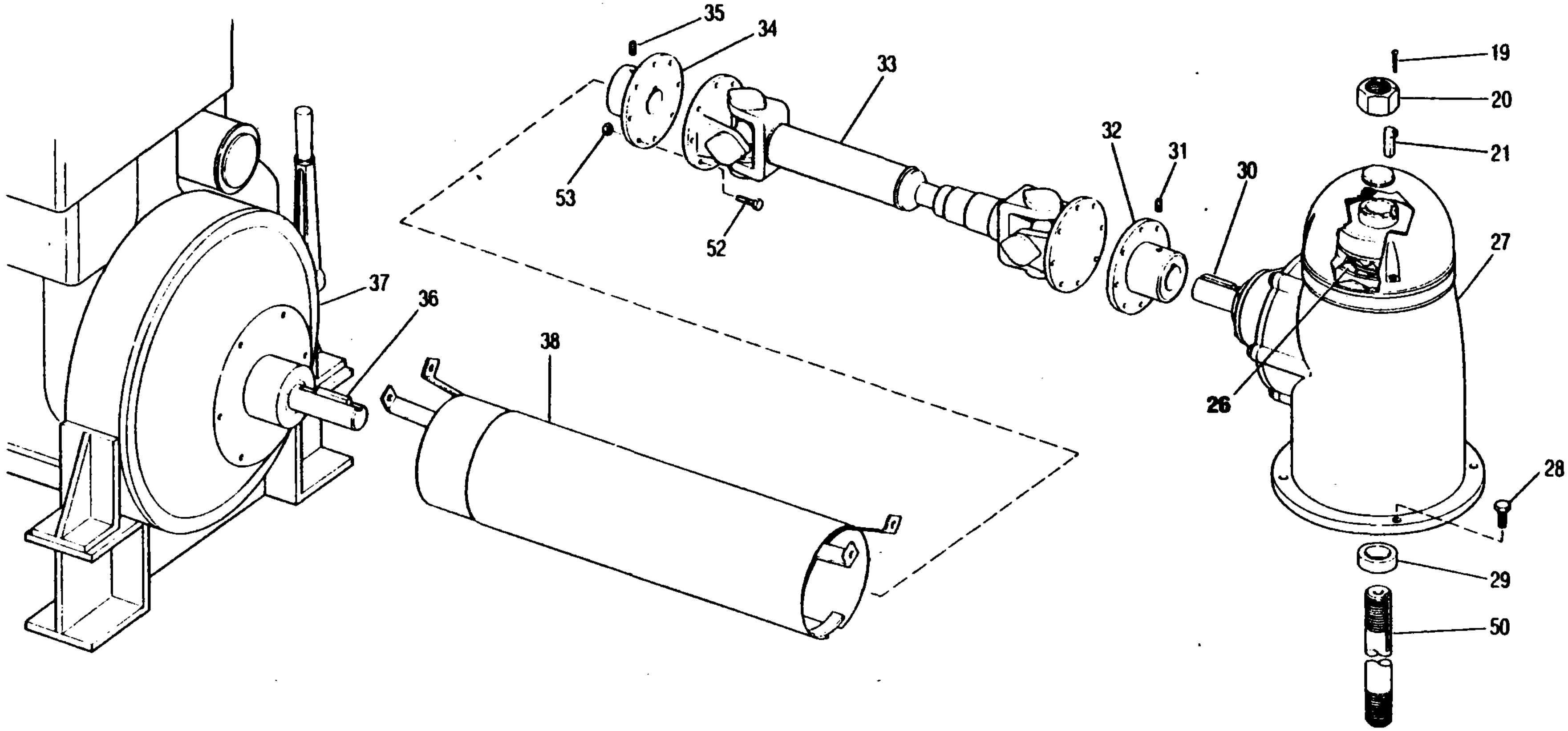
FACTORY ORDER NUMBER 460-6570C

QUANTITY	DESCRIPTION
1	THRUST BEARING FOR DRIVER
1	RADIAL BEARING FOR DRIVER
1	TUBE CONNECTOR
NR	PACKING BOX BEARING
1	SET SQUARE PACKING
1	PACKING GLAND
1	TOP COLUMN FLANGE GASKET
2	LINESHAFT BEARING
NR	TUBE ADAPTOR BEARING
1	DISCHARGE CASE CAP
1	DISCHARGE CASE BEARING
2	INTERMEDIATE BOWL BEARING
NR	SUCTION CASE BEARING
3	BOWL WEAR RING
NR	IMPELLER WEAR RING
1	PUMP BOWL SHAFT
1	PACKING BOX GASKET

NR INDICATES:
NOT REQUIRED

AURORA PUMP • 800 AIRPORT RD. • N. AURORA, ILLINOIS 60542 • TEL 312-859-7000
VERTI-LINE • P. O. BOX 1300 • LA PUENTE, CALIF. 91749 • TEL 213-330-3411

AURORA 1100 SERIES
REPAIR PARTS LIST
RIGHT ANGLE GEAR DRIVE
ENGINE ASSEMBLY



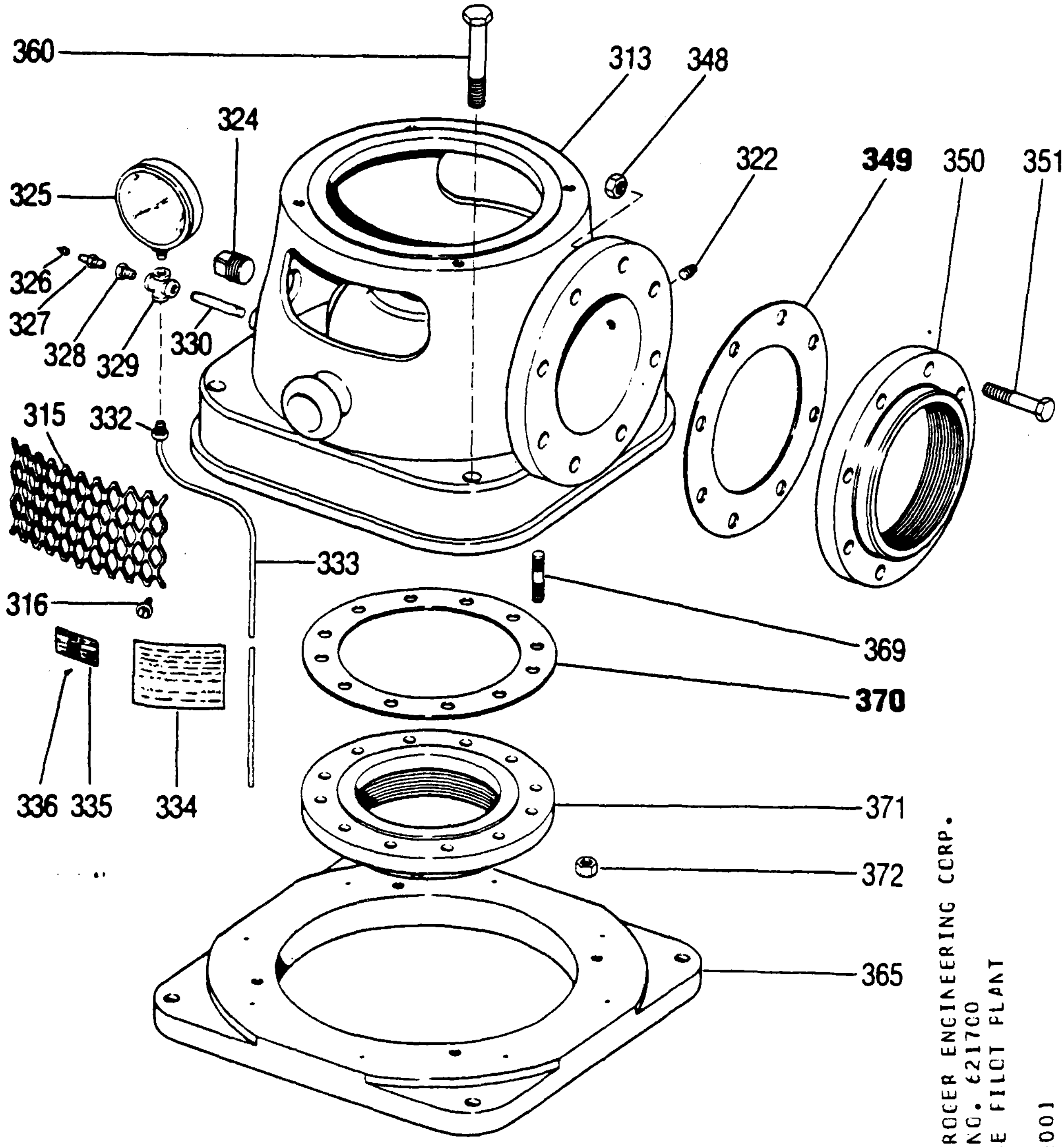
1.2.7.96

BOLD FACE PIECE NUMBERS INDICATE RECOMMENDED SPARE PARTS

AURORA PUMP
A UNIT OF GENERAL SIGNAL

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA 1110-1130 SERIES
REPAIR PARTS LIST
AC CAST SURFACE DISCHARGE
HEAD ASSEMBLY



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

BOLD FACE PIECE NUMBERS INDICATE RECOMMENDED SPARE PARTS

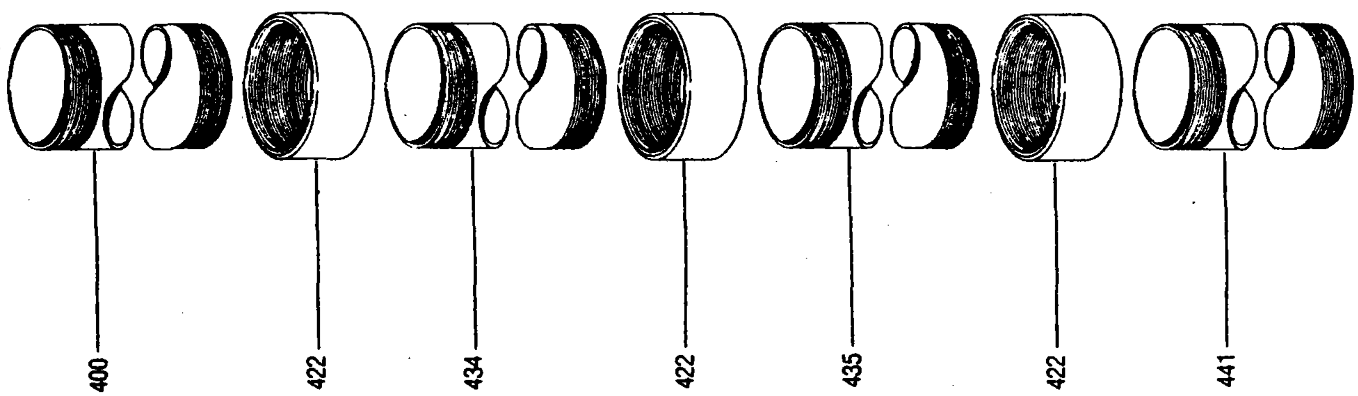
AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS · 60542

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA 1110-1120-1130 SERIES
REPAIR PARTS LIST
THREADED COLUMN PIPE
ASSEMBLY FOR OPEN
LINESHAFT

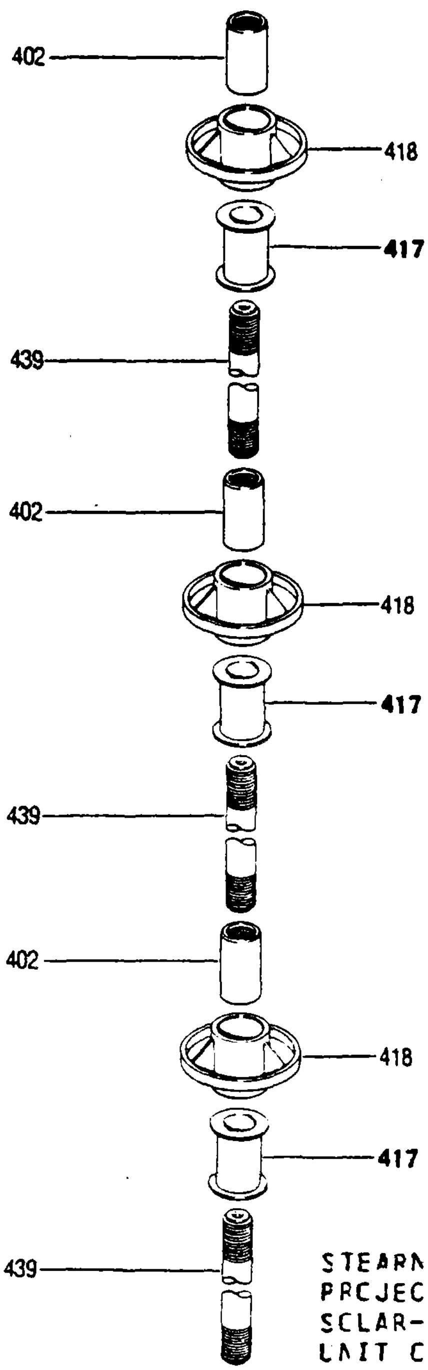
1.2.7.98



BOLD FACE PIECE NUMBERS INDICATE RECOMMENDED SPARE PARTS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA, ILLINOIS 60542

AURORA 1110-1120-1130 SERIES
REPAIR PARTS LIST
OPEN LINESHAFT ASSY.
FOR THREADED
COLUMN PIPE

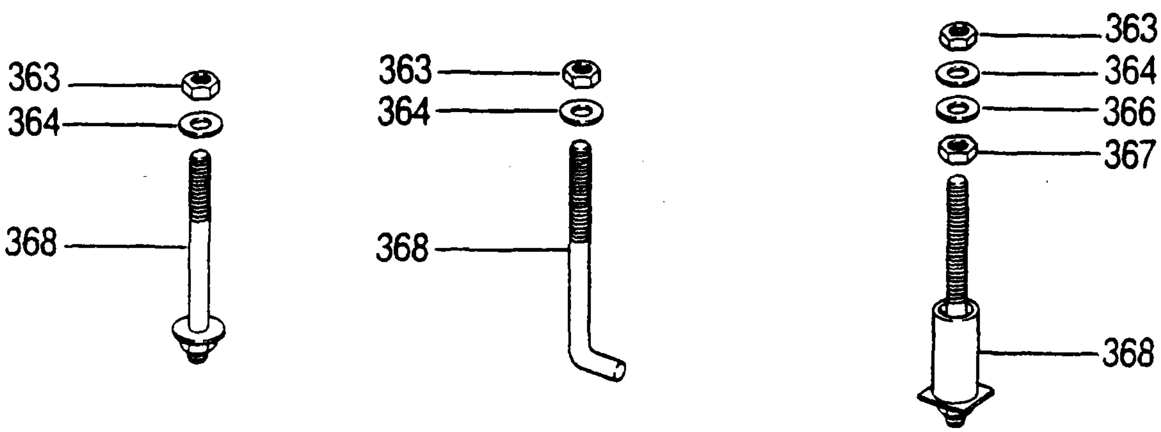


BOLD FACE PIECE NUMBERS INDICATE RECOMMENDED SPARE PARTS

AURORA PUMPS
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD NORTH AURORA ILLINOIS 60542

STEARNS-RCGER ENGINEERING CORP.
PRCJECT NC. 6217CO
SCLAR-CNE FILCT PLANT
UNIT CNE
1.2.7.99 P.C. 2001

AURORA 1100 SERIES
REPAIR PARTS LIST
FOUNDATION ANCHOR BOLT ASSEMBLIES



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMPS
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD · NORTH AURORA ILLINOIS · 60542

PART DESCRIPTION
DRIVER ASSEMBLY
(1-99)

PIECE NO.	PART DESCRIPTION
1	SCREW, Lock
2	NUT, Adjusting
3	KEY, Nut
4	SHAFT, Driver
5	BEARING, Thrust
5A	BEARING, Radial
6	MOTOR, Electric
7	CAPSCREW, Driver
8	BUSHING, Stabilizer
9	ADAPTER, Plate
10	CAPSCREW, Adapter
11	CAPSCREW, Coupling
12	COUPLING, Half
13	SETSCREW, Coupling
14	KEY, Shaft
15	KEY, Shaft
16	COUPLING, Half
17	SETSCREW, Coupling
18	NUT, Coupling
19	SCREW, Lock
20	NUT, Adjusting
21	KEY, Nut
22	BRACKET, Gear Drive
23	CAPSCREW, Bracket
24	GUARD, Coupling
25	SCREW, Guard
26	BEARING, Thrust
27	DRIVE, Gear
28	CAPSCREW, Gear Drive
29	BUSHING, Stabilizer
30	KEY, Shaft
31	SETSCREW, Coupling
32	COUPLING, Flexible
33	SHAFT, Flexible
34	COUPLING, Flexible
35	SETSCREW, Coupling
36	KEY, Shaft
37	ENGINE, Combustion
38	GUARD, Coupling
39	CAPSCREW, Guard
40	KEY, Shaft
41	SETSCREW, Coupling
42	COUPLING, Half
43	INSERT, Coupling
44	COUPLING, Half
45	SETSCREW, Coupling
46	KEY, Shaft
47	MOTOR, Electric
48	GUARD, Coupling
49	CAPSCREW, Guard
50	SHAFT, Gear Drive
51	SLINGER, Shaft
52	CAPSCREW, Coupling
53	NUT, Coupling

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA PUMPS
AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

AURORA 1100 SERIES

PART DESCRIPTION
COUPLING ASSEMBLY
(100-199)

PIECE NO.	PART DESCRIPTION
100	COUPLING, Shaft
101	KEY, Shaft
102	CAPSCREW, Coupling
103	COUPLING, Half
104	SETSCREW, Coupling
105	RING, Split Thrust
106	SPACER, Coupling
107	NUT, Coupling
108	CAPSCREW, Coupling
109	NUT, Adjusting
110	SCREW, Nut
111	COUPLING, Half
112	SETSCREW, Coupling
113	NUT, Coupling
114	KEY, Shaft
115	BRACKET, Driver
116	GUARD, Coupling
117	SCREW, Guard
118	CAPSCREW, Bracket
119	WRENCH, Adjusting

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD - NORTH AURORA, ILLINOIS - 60542

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA 1100 SERIES
PART DESCRIPTION
SEALING INSERT ASSEMBLY
(200-299)

PIECE NO.	PART DESCRIPTION
200	CAP, Tank
201	CLIP, Cap
202	SCREW, Clip
203	GASKET, Cap
204	TANK, Lube
205	FITTING, Gauge
206	GLASS, Gauge
207	SCALE, Gauge
208	RODS, Protector
209	VALVE, Gauge
210	PLUG, Drain
211	SUPPORT, Tank
212	BUSHING, Tank
213	NIPPLE, Tank
214	VALVE, Solenoid, General Purpose
214A	VALVE, Solenoid, Explosion Proof
215	VALVE, Shut Off
216	FITTING, Tube
217	TUBING, Lube
218	CAPSCREW, Support
219	GASKET, Support
220	COLLAR, Sleeve
221	SETSCREW, Collar
222	NUT, Gland
223	WASHER, Gland
224	GLAND, Sealing
225	PACKING, Ring
225A	BUSHING, Gland
226	RING, Lantern
227	PACKING, Ring
228	SEAL ASSEMBLY, Mechanical
229	GASKET, Seal
230	SLEEVE, Shaft
231	GASKET, Sleeve
232	STUD, Gland
233	CAPSCREW, Gland
234	CAPSCREW, Housing
235	PLUG, Drain
236	ELBOW, Fitting
237	FITTING, Lube
238	BUSHING, Fitting
239	ELBOW, Fitting
240	FITTING, Tube
241	TUBING, Drain
242	FITTING, Tube
243	BUSHING, Head
244	HOUSING, Sealing
245	BEARING, Housing
246	GASKET, Housing
247	SLINGER, Shaft
248	LOCKNUT, Tension

PIECE NO.	PART DESCRIPTION
249	CAPSCREW, Nut
250	GASKET, Nut
251	NUT, Tension
252	GASKET, Housing
253	PLUG, Connector
254	CONNECTOR, Tube
255	BUSHING, Connector
256	FITTING, Tube
257	GASKET, Collar
258	COLLAR, Lock
259	SETSCREW, Collar
260	WRENCH, Adjusting
261	CAP, Tank
262	GASKET, Cap
263	CLAMP, Cover
264	COVER, Tank
265	GASKET, Cover
266	TANK, Lube
267	STRAP, Tank
268	BOLT, Strap
269	NUT, Strap
270	SUPPORT, Tank
271	BUSHING, Tank
272	NIPPLE, Pipe
273	TEE, Pipe
274	NIPPLE, Pipe
275	CLAMP, Pipe
276	HOSE, Pipe
277	CLAMP, Pipe
278	NIPPLE, Pipe
279	VALVE, Shut-Off
280	PIPE, Connecting
281	SCREW, Machine
282	SPACER, Collar
283	BUSHING, Pipe
290	PACKING INSERT, Assembly
291	SEAL INSERT, Assembly
292	TUBE TENSIONING, Assembly
293	
294	COIL ASSEMBLY
294A	COIL ASSEMBLY
295	MANUAL LUBRICATOR ASSEMBLY
295A	AUTOMATIC LUBRICATOR ASSEMBLY
295B	AUTOMATIC LUBRICATOR ASSEMBLY
296	WASHER, Strap
297	ELBOW, Valve
298	RING, Retaining

284 NIPPLE, Pipe

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA 1100 SERIES
PART DESCRIPTION
HEAD ASSEMBLY
(300-399)

PIECE NO.	PART DESCRIPTION
300	SCREW, Cover
301	COVER, Box
302	GASKET, Cover
303	CONNECTOR, Cable
304	BOX, Electrical
305	CAPSCREW, Box
306	GASKET, Box
307	SUPPORT, Box
308	BOLT, Lifting
309	PLUG, Airline
310	ELBOW, Discharge
311	BOLT, Elbow
312	GASKET, Elbow
313	HEAD, Discharge
314	NUT, Elbow
315	GUARD, Coupling
316	SCREW, Guard
317	VALVE, Air Relief
318	NIPPLE, Valve
319	BUSHING, Valve
320	PLUG, Suction
321	PLUG, Vent
322	PLUG, Discharge
323	CAP, Vent
324	PLUG, Vent/Pre-Lube
325	GAUGE, Air
326	CAP, Valve
327	VALVE, Air
328	BUSHING, Valve
329	TEE, Gauge
330	SUPPORT, Gauge
331	BUSHING, Fitting
332	FITTING, Tube
333	TUBE, Airline
334	DECAL, Head
335	NAMEPLATE, Head
336	PIN, Nameplate
337	BUSHING, Fitting
338	FITTING, Tube
339	TUBING, Drain
340	FITTING, Tube
341	TEE, By-Pass

PIECE NO.	PART DESCRIPTION
342	SUPPORT, By-Pass
343	FITTING, Tube
344	TUBING, By-Pass
345	FITTING, Tube
346	ELBOW, Fitting
347	GAUGE, Discharge
348	NUT, Flange
349	GASKET, Flange
350	FLANGE, Companion/ Bushing
351	BOLT, Flange
352	NUT, Coupling
353	CLAMP, Coupling
354	RETAINER, Coupling
355	GASKET, Coupling
356	RETAINER, Coupling
357	CLAMP, Coupling
358	BOLT, Coupling
359	GASKET, Plate
360	CAPSCREW, Plate
361	PLATE, Head
362	GASKET, Base
363	NUT, Foundation
364	WASHER, Foundation
365	PLATE, Base
366	WASHER, Foundation
367	NUT, Foundation
368	BOLT, Foundation
369	STUD, Flange
370	GASKET, Flange
371	FLANGE, Top Column
372	NUT, Flange
373	CAPSCREW, Flange
374	BOLT, Seal
375	PIN, Cotter
376	PLUG, Seal
377	CAP, Seal
378	GASKET, Seal
379	RETAINER, Seal
380	SHAFT, Head
381	PLUG, Drain

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
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AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD - NORTH AURORA, ILLINOIS - 60542

AURORA 1100 SERIES
PART DESCRIPTION
COLUMN ASSEMBLY
(400-499)

PIECE NO.	PART DESCRIPTION
400	PIPE, Top Column
401	TUBE, Top Enclosing
402	COUPLING SHAFT
403	KEY, Coupling
404	CAPSCREW, Coupling
405	CAP, Coupling
406	RING, Split Thrust
407	SPACER, Coupling
408	RING, Split Thrust
409	CAP, Coupling
410	CAPSCREW, Coupling
411	KEY, Coupling
412	SHAFT, Top
413	NUT, Flange
414	STABILIZER, Tube
415	RING, Retaining
416	WASHER, Thrust
417	BEARING, Shaft
418	RETAINER, Bearing
419	RING, Spacer
420	SLEEVE, Shaft
421	COLLET, Sleeve
422	COUPLING, Pipe
423	GASKET, Flange
424	PIPE, Top Column
425	TUBE, Top Enclosing
426	BOLT, Flange

PIECE NO.	PART DESCRIPTION
427	NUT, Flange
428	TEE, Discharge
429	NUT, Flange
430	GASKET, Flange
431	FLANGE, Companion
432	BOLT, Flange
433	TUBE, Intermediate
434	PIPE, Intermediate Enclosing
435	PIPE, Column
436	TUBE, Enclosing
437	GASKET, Flange
438	BOLT, Flange
439	SHAFT, Line
440	VALVE, Check
441	PIPE, Lower Column
442	BEARING, Reducing
443	TUBE, Lower Enclosing
444	CLAMP, Cable
445	CABLE, Power
446	SPLICE, Cable
447	ELEVATOR, Pipe
448	GROMMET, Cable
449	GUARD, Cable
450	LOCKWIRE, Coupling
451	LOCKWIRE, Coupling

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMPS

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

AURORA 1100 SERIES
PART DESCRIPTION
DISCHARGE CASE ASSEMBLY
(500-599)

PIECE NO.	PART DESCRIPTION
500	CAPSCREW, Case
501	NUT, Case
502	GASKET, Flange
503	STUD, Case
504	FLANGE, Adapter
505	COUPLING, Adapter
506	PLUG, Lubrication
507	ADAPTER, Tube
508	CAP, Discharge
509	SEAL, Shaft

PIECE NO.	PART DESCRIPTION
510	SLINGER, Shaft
511	CASE, Discharge
512	PLUG, Relief
513	BEARING, Discharge
514	COLLAR, Bearing
515	SETSCREW, Collar
516	SPACER, Ring
517	CAPSCREW, Adapter
518	CAP, Adapter
519	GASKET, Adapter

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA 1100 SERIES
PART DESCRIPTION
BOWL ASSEMBLY
(600-699)

PIECE NO.	PART DESCRIPTION
600	COUPLING, Shaft
601	KEY, Coupling
602	CAPSCREW/MACHINE SCREW, Coupling
603	CAP, Coupling
604	RING, Split Thrust
605	SPACER, Coupling
606	RING, Split Thrust
607	CAP, Coupling
608	CAPSCREW/MACHINE SCREW, Coupling
609	KEY, Coupling
610	SHAFT, Pump
611	BEARING, Upper
612	GASKET, Bowl
613	BOWL, Top
614	PLUG, Relief
615	BEARING, Lower
616	SEAL, Bearing
617	SCREW, Collar
618	COLLAR, Thrust
619	RING, Split Thrust
620	KEY, Impeller
621	COLLET, Impeller
622	RING, Upper Bowl
623	RING, Upper Impeller
624	IMPELLER, Bowl

PIECE NO.	PART DESCRIPTION
625	PROPELLER, Bowl
626	RING, Lower Impeller
627	RING, Lower Bowl
628	RING, Split Thrust
629	COLLAR, Thrust
630	SCREW, Collar
631	BOWL, Intermediate
632	STUD, Bowl
633	NUT, Bowl
634	CAPSCREW, Bowl
635	COLLET, Sleeve
636	SLEEVE, Stabilizer
637	STABILIZER, Interstage
638	BEARING, Stabilizer
639	RING, Retaining
640	DRIVER, Collet
641	REMOVER, Collet
642	SETSCREW, Ring
643	LOCKWIRE, Coupling
644	LOCKWIRE, Coupling
645	DRIVER, Impeller
646	SETSCREW, Impeller
647	
648	
649	
650	FASTENER SET, Bowl

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

AURORA 1100 SERIES
PART DESCRIPTION
SUCTION CASE ASSEMBLY
(700-799)

PIECE NO.	PART DESCRIPTION
700	SETSCREW, Locking
701	STUD, Case
702	RING, Suction
703	COLLAR, Protecting
704	SETSCREW, Collar
705	BEARING, Suction
706	CASE, Suction
707	NUT, Case
708	CAPSCREW, Case
709	COLLAR, Protecting
710	SETSCREW, Collar
711	GASKET, Housing
712	CAP, Housing
713	CAPSCREW, Housing
714	PLUG, Lubrication
715	COUPLING, Suction
716	PIPE, Suction
717	COUPLING, Strainer
718	STRAINER, Suction
719	CAPSCREW, Strainer
720	SCREW, Strainer
721	BODY, Valve
722	SCREW, Stop
723	DISC, Valve
724	GASKET, Valve
725	WEIGHT, Valve
726	SCREW, Weight
727	STRAINER, Valve
728	SCREW, Strainer
729	UMBRELLA, Suction
730	UMBRELLA, Half
731	UMBRELLA, Half
732	WASHER, Umbrella
733	NUT, Umbrella
734	CLAMP, Umbrella
735	WASHER, Clamp

PIECE NO.	PART DESCRIPTION
736	NUT, Clamp
737	KEY, Coupling
738	COUPLING, Motor
739	SETSCREW, Coupling
740	SCREW, Coupling
741	ADAPTER, Bracket
742	STUD, Adapter
743	NUT, Adapter
744	CAPSCREW, Adapter
745	BRACKET, Motor
746	GUARD, Coupling
747	SCREW, Guard
748	STUD, Motor
749	KEY, Coupling
750	NUT, Motor
751	CAPSCREW, Motor
752	MOTOR, Submersible
753	STABILIZER, Motor
754	CAPSCREW, Stabilizer
755	NUT, Stabilizer
756	ROD, Stabilizer
757	CAPSCREW
758	WASHER, Rod
759	NUT, Rod
760	NAMEPLATE, Suction
761	SCREW, Nameplate
762	VESSEL, Suction
763	PLUG, Gauge
764	PLUG, Drain
765	PLUG, Vent
766	GASKET, Cover
767	COVER, Vessel
768	CAPSCREW, Cover
769	
770	CHECKVALVE, Assembly

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD-NORTH AURORA, ILLINOIS-60542

F. O. NO. 4GO-65706

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD·NORTH AURORA, ILLINOIS·60542

FIRE PUMP ACCESSORIES LIST

ITEM NO.		QTY	DESCRIPTION	SIZE	REMARKS	ITEM NO
1	☐		ECCENTRIC REDUCER 250 lb			1
2	☐		CONCENTRIC INCREASER 250 lb			2
3	☐		CONCENTRIC INCREASER 125 lb			3
4	☐		ECCENTRIC REDUCER 125 lb			4
5	☐		OUTSIDE HOSE MANIFOLD			5
6	☐		3000-3500 GPM HOSE VALVE HEADER 125 lb		FOR VERTICAL TURBINE	6
7	☐		3000-3500 GPM HOSE VALVE HEADER		FOR SPLIT CASE	7
8	☐		4000-4500 GPM HOSE VALVE HEADER 125 lb			8
9	☒	1	125 lb FLANGE STRAIGHT TEE	4×4×4		9
10	☒	1	REDUCING TEE STD. 125"& 250"	8×8×4		10
11	☐		SET 2-1/2 HOSE VALVE W/CAPS & CHAINS		NATL. STD. THREAD	11
12	☐		BLIND FLANGE STD. 125 LB C.I.			12
13	☐		AUTOMATIC BALL DRIP VALVE			13
14	☐		UMBRELLA HOOD UNDERWRITERS COCK			14
15	☐		AIR COCK			15
17	☒	1	DISCHARGE GAUGE	1/4"		17
18	☐		AIR RELEASE VALVE (FLOAT OPERATED)			18
	☒	1	MAIN RELIEF VALVE	4×4	CLAYTON	
20	☐		CASING RELIEF VALVE			20
21	☒	1	SWING CHECK VALVE	1½"	(Used as automatic air release valve)	21
22	☐		OPEN WASTE CONE			22
23	☒	1	ENCLOSED WASTE CONE	8×4		23
24	☐		SPLASH SHIELD HORIZONTAL		POWER SERIES NO.___	24
25	☐		SPLASH SHIELD VERTICAL		POWER SERIES NO.___	25
26	☐					26
27	☐					27
28	☐					28
29	☐					29
30	☐					30
31	☐					31

ATE 12-10-80

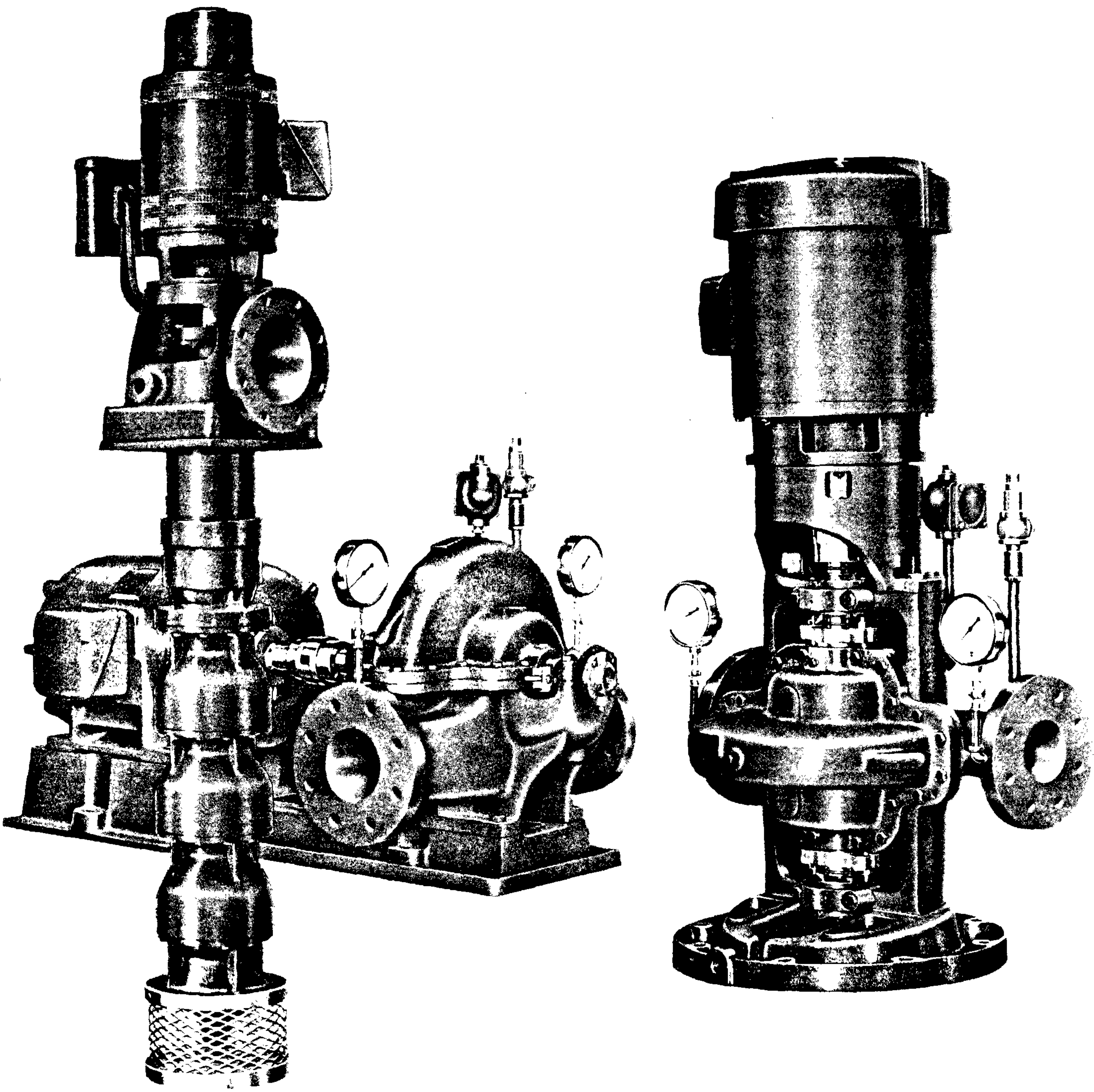
STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001 1.2.7.110

AURORA® PUMPS

SUBMITTAL DATA

FIRE PUMP

ACCESSORIES



F. O. NO. ____________________

AURORA PUMP
A UNIT OF GENERAL SIGNAL
800 AIRPORT ROAD·NORTH AURORA, ILLINOIS·60542

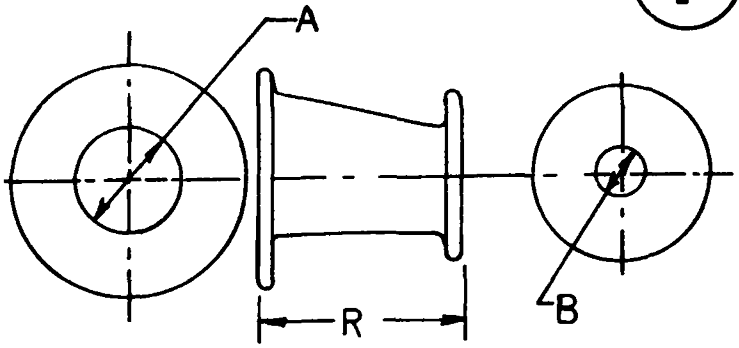
FIRE PUMP ACCESSORIES LIST

ITEM NO.	QTY	DESCRIPTION	SIZE	REMARKS	ITEM NO
1 ☐		ECCENTRIC REDUCER 250 lb			1
2 ☐		CONCENTRIC INCREASER 250 lb			2
3 ☐		CONCENTRIC INCREASER 125 lb			3
4 ☐		ECCENTRIC REDUCER 125 lb			4
5 ☐		OUTSIDE HOSE MANIFOLD			5
6 ☐		3000-3500 GPM HOSE VALVE HEADER 125 lb		FOR VERTICAL TURBINE	6
7 ☐		3000-3500 GPM HOSE VALVE HEADER		FOR SPLIT CASE	7
8 ☐		4000-4500 GPM HOSE VALVE HEADER 125 lb			8
9 ☐		125 lb FLANGE STRAIGHT TEE			9
10 ☐		REDUCING TEE STD. 125*& 250*			10
11 ☐		SET 2-1/2 HOSE VALVE W/CAPS & CHAINS		NATL. STD. THREAD	11
12 ☐		BLIND FLANGE STD.. 125 LB C.I.			12
13 ☐		AUTOMATIC BALL DRIP VALVE			13
14 ☐		UMBRELLA HOOD UNDERWRITERS COCK			14
15 ☐		AIR COCK			15
17 ☐		SUCTION AND DISCHARGE GAUGES			17
18 ☐		AIR RELEASE VALVE (FLOAT OPERATED)			18
19 ☐		MAIN RELIEF VALVE			19
20 ☐		CASING RELIEF VALVE			20
21 ☐		SWING CHECK VALVE		(Used as automatic air release valve)	21
22 ☐		OPEN WASTE CONE			22
23 ☐		ENCLOSED WASTE CONE			23
24 ☐		SPLASH SHIELD HORIZONTAL		POWER SERIES NO.___	24
25 ☐		SPLASH SHIELD VERTICAL		POWER SERIES NO.___	25
26 ☐					26
27 ☐					27
28 ☐					28
29 ☐					29
30 ☐					30
31 ☐					31

DATE ____________________

ECCENTRIC REDUCER

1

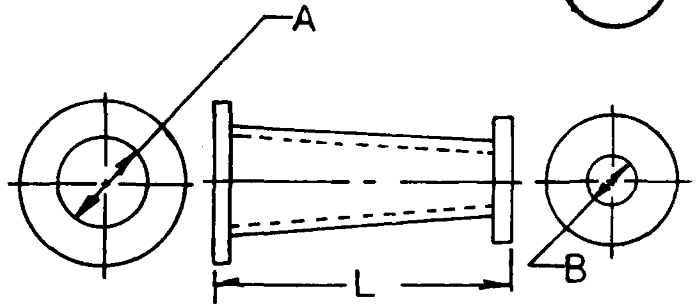


250# FLANGES

size		
A	B	R
3	2	6
4	3	7
5	4	8
6	4	9
6	5	9
8	5	11
10	6	12
10	8	12
12	8	14
14	8	16
8	6	11

CONCENTRIC INCREASER

2

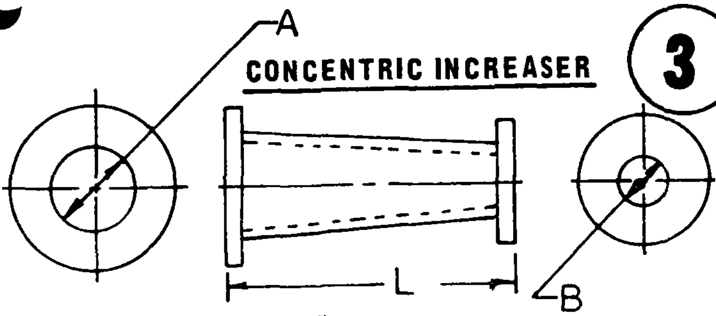


250# FLANGES

size		
A	B	L
4	3	7
5	4	8
	3	8
6	3	9
	4	9
	5	9
8	4	11
	5	11
	6	11
10	6	12
	8	12
12	8	14
	10	

CONCENTRIC INCREASER

3

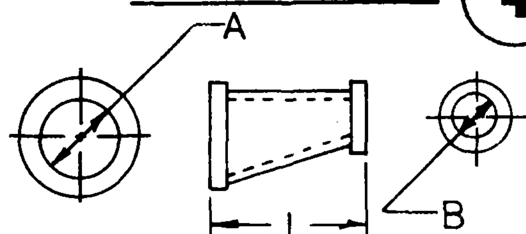


125# FLANGES

size		
A	B	L
4	3	7
5	3	8
	4	
6	3	9
	4	
	5	
8	4	11
	5	
	6	
10	6	12
	8	
12	6	14
	8	
	10	
16	10	18

ECCENTRIC REDUCER

4



125# FLANGES

size		
A	B	L
5	4	8
6	4	9
	5	9
8	4	11
	5	11
	6	11
10	5	12
	6	12
	8	12
12	6	14
	8	14
	10	14
14	8	16
	10	6
16	8	18
	10	
18	12	19
16	12	18

NOTE: ALL DIM. ARE BY VENDOR STD'S.

OUTSIDE HOSE MANIFOLD
125 & 250 # FLANGES

5

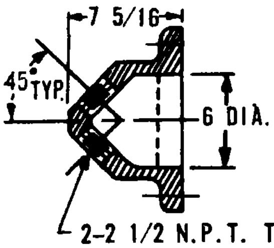


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	8	7/8	9-1/2
250#	12	7/8	10-5/8

6"
2 HOSE VALVE CONN.

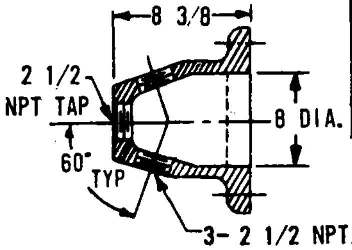


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	8	7/8	11-3/4
250#	12	1	13

8"
4 HOSE VALVE CONN.

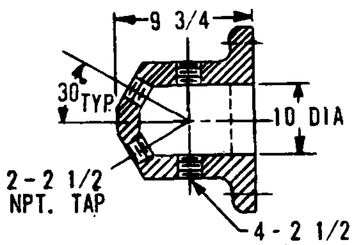


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	12	1	14-1/4
250#	16	1-1/8	15-1/4

10"
6 HOSE VALVE CONN

12"
8 HOSE VALVE CONN.

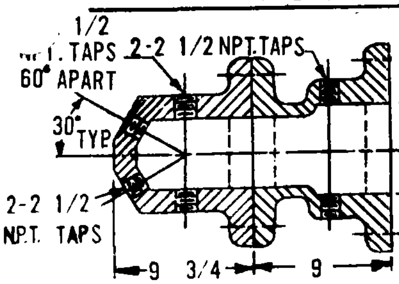


FIG. SIZE	NO. BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIA.
125#	12	1	17
250#	16	1-1/8	17-3/4

NOTE: ASSEMBLY CONSISTS OF 10" HEADER, 6 VALVE CONN., 10x12 ADAPTER, 2 VALVE CONN.

3000-3500 GPM HOSE VALVE HEADER 125 # & 250 # FLANGES

7

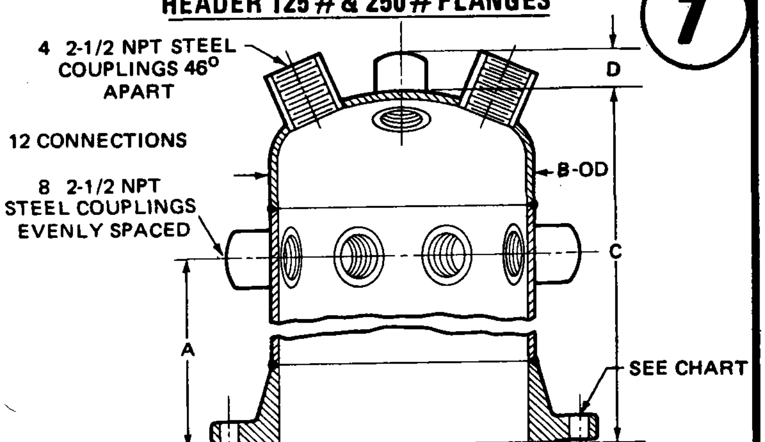
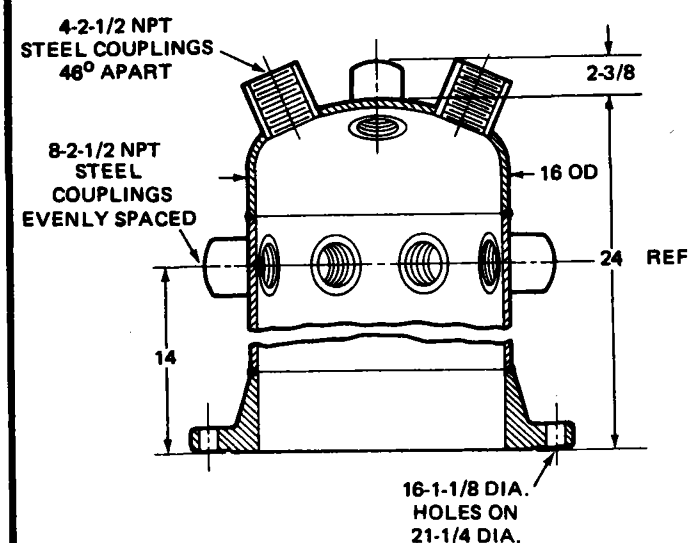


FIG. SIZE	NO. BOLT HOLES	BOLT HOLE SIZE	BOLT CIRCLE DIA.	A	B	C	D
125#	12	1	17	10-1/2	12-3/4	22-1/2	1-9/16
250#	16	1-1/4	17-3/4	10-1/2	12-3/4	23-1/8	1-9/16

3000-3500 GPM HOSE HEADER
125 # FLANGE

6

12 CONNECTIONS



4000-4500 GPM HOSE HEADER
125# & 250# FLANGES

8

16 CONNECTIONS

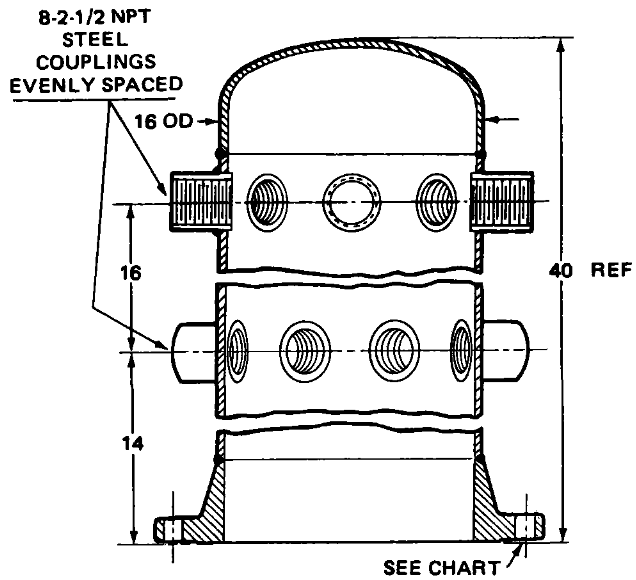
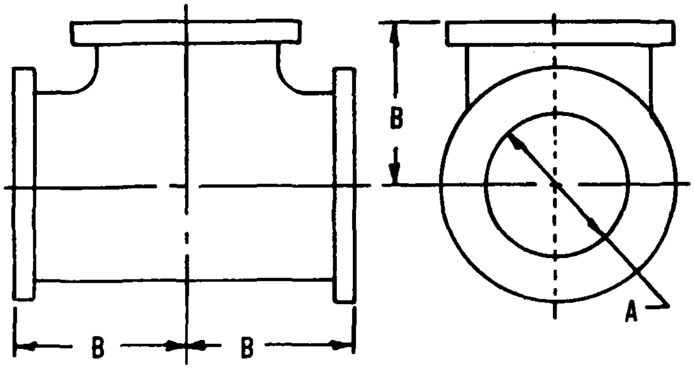


FIG. SIZE	NO. BOLT HOLES	BOLT HOLE SIZE	BOLT CIRCLE SIZE
125LB	16	1-1/8	21-1/4
250LB	20	1-3/8	22-1/2

NOTE: ALL DIM. ARE BY VENDOR STD'S

125# FLANGED STRAIGHT TEE

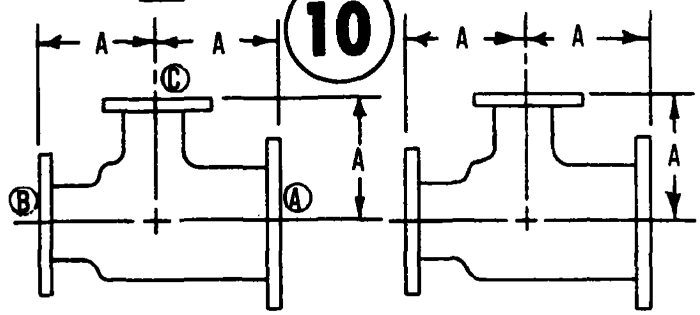
9



A	B
1-1/2	4
2	4-1/2
2-1/2	5
3	5-1/2
3-1/2	6
4	6-1/2
5	7-1/2
6	8
8	9
10	11
12	12
14	14
16	15
18	16-1/2
20	18
22	22

REDUCING TEE STD.

10



SIZE	A
8x6x8	9
5x5x3	7-1/2
6x4x3	8
6x6x4	8
8x6x4	9
8x8x4	9
8x8x6	9
10x8x6	11
10x10x6	11
10x10x8	11
12x12x8	12
12x12x6	12
12x8x8	12
6x4x4	8
8x6x6	9
8x4x6	9
8x4x8	9
8x6x3	9
10x10x4	11
14x14x8	14

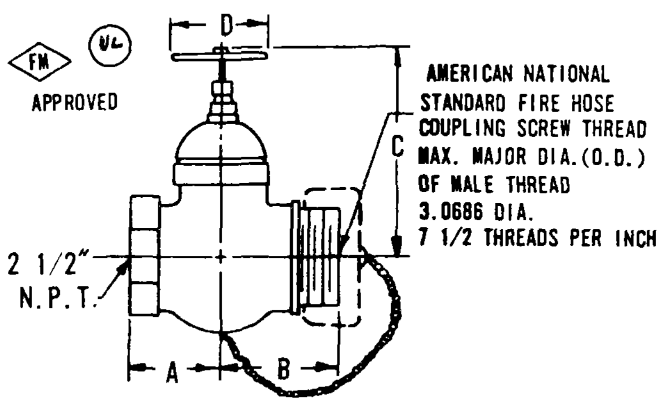
SIZE	A
6×6×3	8 1/2
6×6×4	8 1/2
8×6×8	10
8×8×4	9
8×8×6	10
10×10×8	11-1/2
5x5x3	8
10x10x6	11-1/2

NOTE: SIZE INDICATED AS FOLLOWS

A	B	C
8 X	6 X	8

2 1/2 HOSE VALVE W/CAPS & CHAINS

11



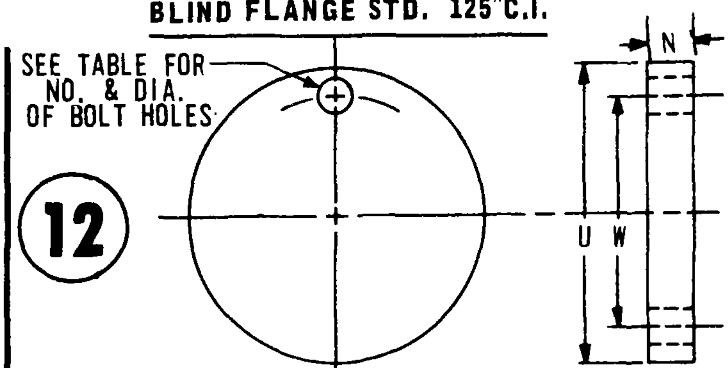
	A	B	C	D
175 PSI	2 1/4	2 7/8	10 1/4	6
300 PSI	2 5/16	2 5/8	11	6

NOTE: ALL DIM. ARE BY VENDOR STD'S.

1.2.7.115

BLIND FLANGE STD. 125# C.I.

12

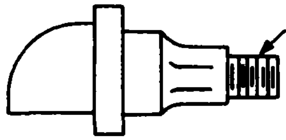


PIPE SIZE	FLANGE SIZE	N	U	W	DIA OF HOLES	NO. OF HOLES
3	3x7 1/2	3/4	7 1/2	6	3/4	4
4	4x9	15/16	9	7 1/2	3/4	8
5	5x10	15/16	10	8 1/2	7/8	8
6	6x11	1	11	9 1/2	7/8	8
8	8x13 1/2	1 1/8	13 1/2	11 3/4	7/8	8
10	10x16	1 3/16	16	14 1/4	1	12
*12	12x19	1 1/4	19	17	1	12

*SIZES 12 AND LARGER HAVE DISHED FACES

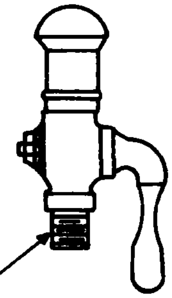
AUTOMATIC BALL DRIP VALVE

13



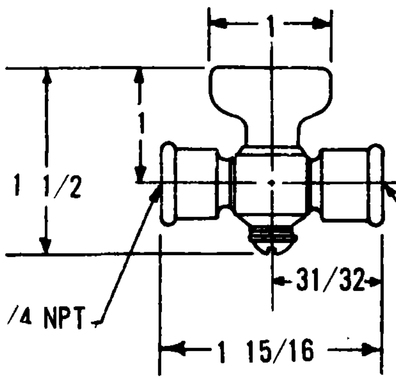
UMBRELLA HOOD UNDERWRITERS COCK

14



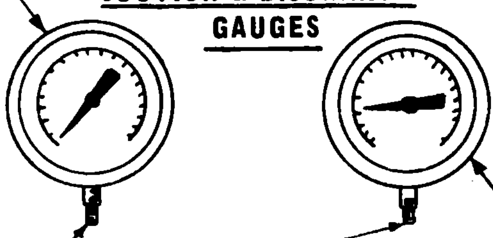
AIR COCK

15



17

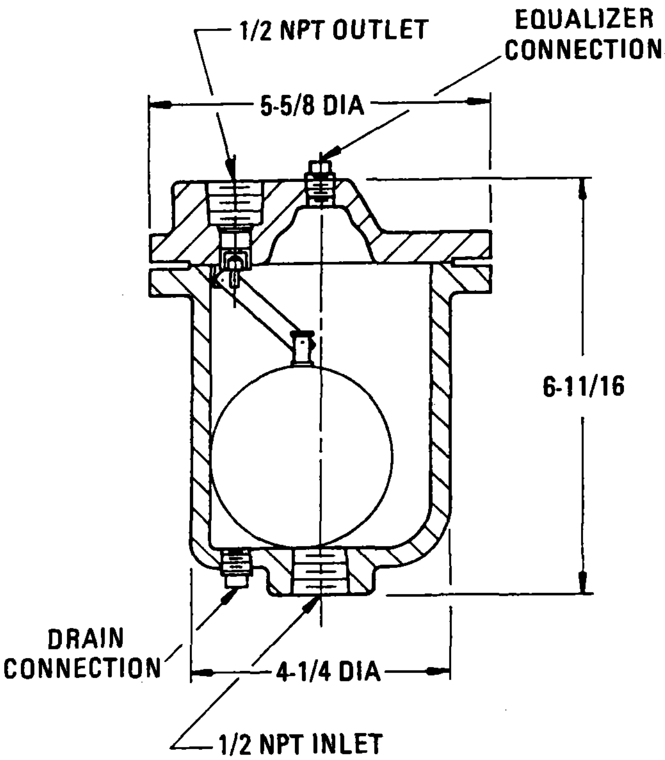
SUCTION & DISCHARGE GAUGES



* ALL UNITS 150"AND OVER WILL BE FURNISHED WITH 0-600"GAUGE

NOTE: ALL DIM. ARE BY VENDOR STD'S.

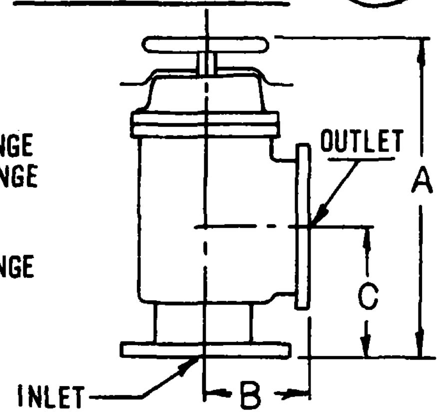
AIR RELEASE VALVE (FLOAT OPRTATED) 18



MAIN RELIEF VALVE 19

STANDARD
125 lb INLET FLANGE
125 lb OUTLET FLANGE

OPTION
250 lb INLET FLANGE



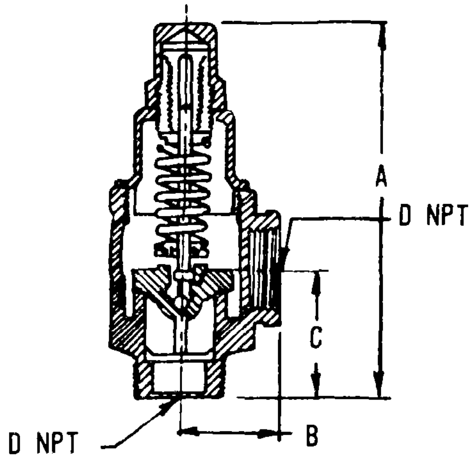
APPROVED

SIZE	A	B	C
3X3	21 1/4	5 7/8	6 1/8
3½X3½	21 5/8	5 7/8	6 1/8
4X4	22 5/8	6 7/16	6 5/8
5X5	29 1/4	7 9/16	8 5/8
6X6	36	8 1/2	9 3/8
8x8	23 3/4	12 3/4	8

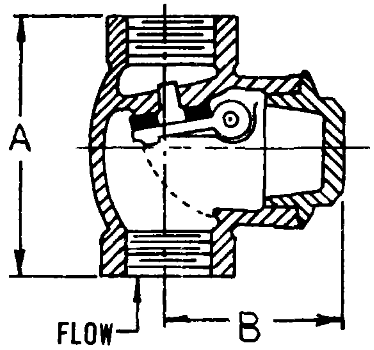
SIZE	A	B	C	D
1/2	6	1 5/8	2	1/2
3/4	6	1 5/8	2	3/4
1	6 7/8	1 7/8	2 1/4	1

20

CASING RELIEF VALVE



SWING CHECK VALVE 21

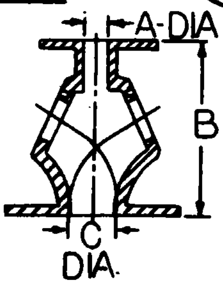


SIZE	A	B
3/8	1 7/8	1 3/8
1/2	2 1/4	1 5/8
3/4	2 11/16	1 7/8
1	3 3/16	2 1/4
1 1/4	3 11/16	2 5/8
1 1/2	4 1/4	2 7/8
2	5 1/8	3 1/4
2 1/2	6 1/16	4
3	7 3/8	4 3/8

NOTE: ALL DIM. ARE BY VENDOR STD'S.

22 OPEN WASTE CONE

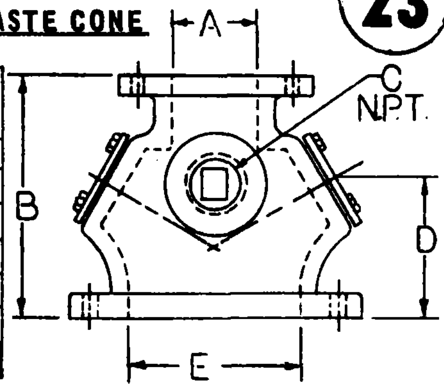
ZE	A	B	C
3x5	3	10	5
4x8	4	11	8
6 x10	6	14	10
8x14	8	16	14



FLANGE SIZE	NO BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIAMETER
3	4	3/4	6
4	8	3/4	7 1/2
5	8	7/8	8 1/2
6	8	7/8	9 1/2
8	8	7/8	11 3/4
10	12	1	14 1/4
14	12	1 1/8	18 3/4

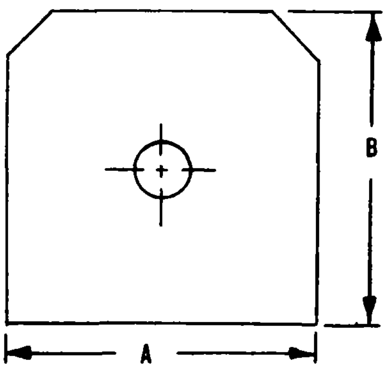
23 ENCLOSED WASTE CONE

FLANGE SIZE	NO BOLTS	BOLT HOLE SIZE	BOLT CIRCLE DIAMETER
3	4	3/4	6
4	8	3/4	7 1/2
5	8	7/8	8 1/2
6	8	7/8	9 1/2
8	8	7/8	11 3/4
10	12	1	14 1/4
14	12	1 1/8	18 3/4



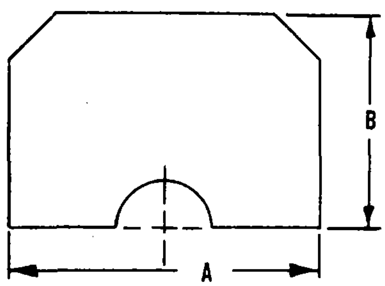
GPM	SIZE	A	B	C	D	E
500	3x5	3	10	1 1/4	5 3/4	5
750-1000	4x8	4	11	2	6 7/16	8
1500-2500	6x10	6	14	2 1/2	9 5/16	10
3000-4500	8x14	8	16	2 1/2	9	14

24 SPLASH SHIELD FOR HORIZONTAL PUMPS MOTOR DRIVEN PUMP



POWER SERIES	A	B
2	12	16 3/4
3	12	19 3/4
3	14	20 3/4
4	14	22 1/4
5	18	26 1/4
5	18	27 1/2

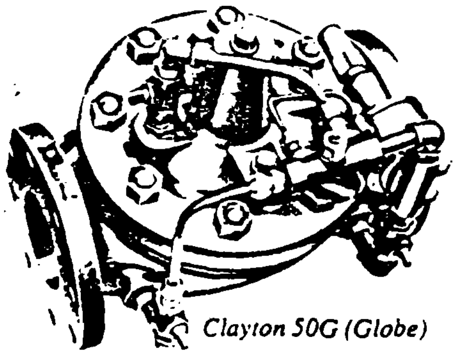
25 SPLASH SHIELD FOR VERTICLE PUMPS



POWER SERIES	A	B
2	12	8
3	14	10
4	14	10
5	17 1/2	13

NOTE. ALL DIM. ARE BY VENDOR STD'S.

PILOT-OPERATED



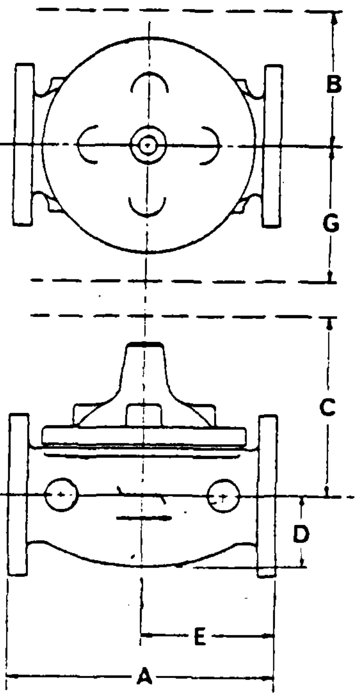
Clayton 50G (Globe)

The Clayton 50 Pressure Relief Valve is a diaphragm type valve designed to maintain constant upstream pressure to close limits. This valve is a hydraulically-operated, pilot-controlled, modulating type. It is used where problems are encountered in pressure relief, sustaining back pressure, or in unloading functions in a by-pass system.

In operation, the valve is actuated by line pressure through a pilot control system, opening fast to maintain steady line pressure but closing gradually to prevent surges. Operation is completely automatic, and pressure settings may be easily changed.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SCLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

DIMENSIONS



Note:
**If valve position indicator is used see form EX101 for additional height to be added to dimension "C".*

SPECIFICATIONS

SIZES
Globe: 1¼" - 3" screwed; 2" - 16" flanged
**Angle:* 1½" - 3" screwed; 2" - 10" flanged

END DETAILS
125 and 250 ANSI B16.1

PRESSURE RATINGS
125 class - 175 psi Max.
250 class - 300 psi Max.

TEMPERATURE RANGE
Water, Air, to +180°F. Ma

MATERIALS
Main valve body & cover:
Cast Iron ASTM A48

Main valve trim:
Brass QQ-B-626
Bronze ASTM B61

Pilot control system:
Cast bronze ASTM B62 with 303 Stainless Steel trim

Other materials available:
Cast Steel, Bronze, Aluminum

ADJUSTMENT RANGES
Available in the following relief pressure ranges:
0 to 75 psi
20 to 200 psi*
100 to 300 psi†
*Supplied unless otherwise specified
†Supplied on special order at extra cost

DIMENSIONS IN INCHES

VALVE SIZES IN INCHES →		1¼ & 1½	2	2½	3	4	6	8	10	12	14	16
	SCREWED ENDS	7¼	9⅜	11	12½	—	—	—	—	—	—	—
A	125 & 150 FLANGED		9⅜	11	12	15	20	25⅜	29¾	34	39	41⅜
	250 & 300 FLANGED		10	11⅝	13¼	15⅝	21	26⅜	31⅛	35½	40½	43½
B		4½	4½	4	4⅝	5¼	7⅞	10	12	14	16⅜	17¾
C		10½	11½	12	12	12	12½	15¾	18	21⅝	25	27
D		2	2½	2⅞	3⅛	4¼	6	7⅝	9¼	10¾	12¾	15½
	SCREWED ENDS	3¼	4¾	5½	6¼	—	—	—	—	—	—	—
E	125 & 150 FLANGED	—	4¾	5½	6	7½	10	12¼	14⅞	—	—	—
	250 & 300 FLANGED	—	5	5⅞	6⅜	7⅞	10½	13¼	15⅞	—	—	—
G		4¼	5	5½	8	8½	9	11	13	14	16¼	17¼

INTRODUCTION

This manual titled the 50-01 Series Pressure Relief Pressure Sustaining or Back Pressure Valve contains information for installation, operation and maintenance of the valve and control system. The Clayton 50-01 is an automatic valve designed to maintain constant upstream pressure to close limits. It is a hydraulically operated, pilot controlled, modulating type valve. It is used where pressure relief pressure sustaining or unloading functions in a bypass system are required.

In operation the valve is actuated by line pressure to a pilot control system, opening fast to maintain steady line pressure but closing gradually to prevent surges. Operation is completely automatic and pressure settings may be easily changed.

INSTALLATION

1. Allow sufficient room around the valve to make adjustments and for disassembly.

2. It is recommended that a gate or block valve be installed above the inlet side of the valve. Straight relief valve applications do not usually require a gate or block valve on the downstream side. This is particularly true if the primary function is surge control or pressure relief where the valve discharges to atmosphere.

3. When a back pressure function is involved in the installation a gate or block valve should also be installed on the downstream side of the valve to facilitate isolating the valve for preventive maintenance.

   NOTE: BEFORE THE VALVE IS INSTALLED, PIPE LINES SHOULD BE FLUSHED OF ALL CHIPS, SCALE AND FOREIGN MATTER.

4. Place the valve in the line with flow through the valve in the direction indicated on the inlet plate or by flow arrows. Check all fittings and hardware for proper makeup and that no apparent damage is evident.

5. Clayton Valves operate with maximum efficiency when mounted in horizontal piping with the cover UP; however, other positions are acceptable. Due to size and weight of cover and internal components of six inch valves and larger, installation with the cover up is advisable. This makes periodic inspection of internal parts readily accessible.

OPERATION AND START-UP

1. Prior to pressurizing the valve assembly make sure the necessary gauges to measure pressure in the system are installed as required by the system engineer. A Clayton X101 Valve Position Indicator may be installed in the center cover port to provide a visual indication of the valve stem position during start-up adjustment.

   CAUTION: During start-up and test a large volume of water may be discharged downstream. Check that the downstream venting is adequate to prevent damage to personnel and equipment. All adjustments in pressure should be made slowly. If the main valve closes too fast it may cause surging in upstream piping.

2. If shutoff cocks (isolation valves) are installed, open cocks (see schematic).

3. Loosen jam nut on strainer valve assembly and turn adjusting stem clockwise until it seats. Turn stem counterclockwise ¼ to ½ turn and tighten jam nut.

4. Remove cap on the CRL Pressure Relief Control, loosen jam nut and turn adjusting screw clockwise until spring is fully compressed. This puts the control in full closed mode and will cause the main valve to close when system is pressurized.

5. If a downstream block valve is installed, slowly open this valve.

6. Partially open upstream block valve. The main valve should close.

7. Carefully loosen tube fittings at highest points and bleed air from system. Carefully loosen the plug at top of cover assembly, or if an Indicator is installed, loosen the pipe plug at top of Indicator. Bleed air from cover and tighten plug. Tighten tube fittings.

8. Open fully the upstream block valve and turn the CRL adjusting screw slowly counterclockwise until you begin to hear a flow through the control. The main valve should start to open. If the pressure is below the required relief setting refer to the spring chart (Drawing No. 47117) and turn the adjusting screw clockwise the number of turns required for the proper setting. Lock the jam nut and replace cover.

   An observation of the pressure relief setting should be made during a usage cycle and the controls readjusted if required.

MAINTENANCE

1. Clayton Valves and Controls require no lubrication or packing and a minimum of maintenance. However, a periodic inspection schedule should be established to determine how the fluid handled is affecting the efficiency of the valve assembly.

2. Repair and adjustment procedures of the main valve and control components are included in separate sections of this manual. Accessory components are listed for reference.

3. Refer to the Service Suggestions Chart to identify operation symptoms.

SERVICE SUGGESTIONS

SYMPTOM	PROBABLE CAUSE	REMEDY
Main valve won't open	Inlet pressure below setting of pilot valve.	Reset pilot valve. If change in setting by tampering, seal cap with wire and lead seal.
	Pilot valve stuck closed. Mineral deposit or foreign material between disc retainer and power unit body.	Disassemble and clean.
	Pilot valve diaphragm ruptured or diaphragm nut loose. Water coming out of the vent hole in cover.	Disassemble and replace diaphragm. Tighten nut.
	Main valve stuck closed. Mineral buildup on stem. Stem damaged.	Disassemble main valve, clean parts and/or replace damaged parts.
Main valve won't close	Inlet pressure above setting of pilot valve.	Reset pilot valve.
	Clogged needle valve.	Disassemble and clean.
	Pilot valve stuck open. Mineral deposit or foreign material under disc retainer or under diaphragm assembly.	Disassemble and clean.
	Main valve stuck open. Mineral buildup on stem. Foreign material between seat and disc assembly.	Disassemble and clean.
	Main valve diaphragm ruptured.	Disassemble and replace.
Valve leaks continuously	Pilot valve disc worn out.	Disassemble and replace.
	Main valve disc worn out or small break in main valve diaphragm.	Disassemble and replace.

C CLA-VAL CO. NEWPORT BEACH, CALIFORNIA

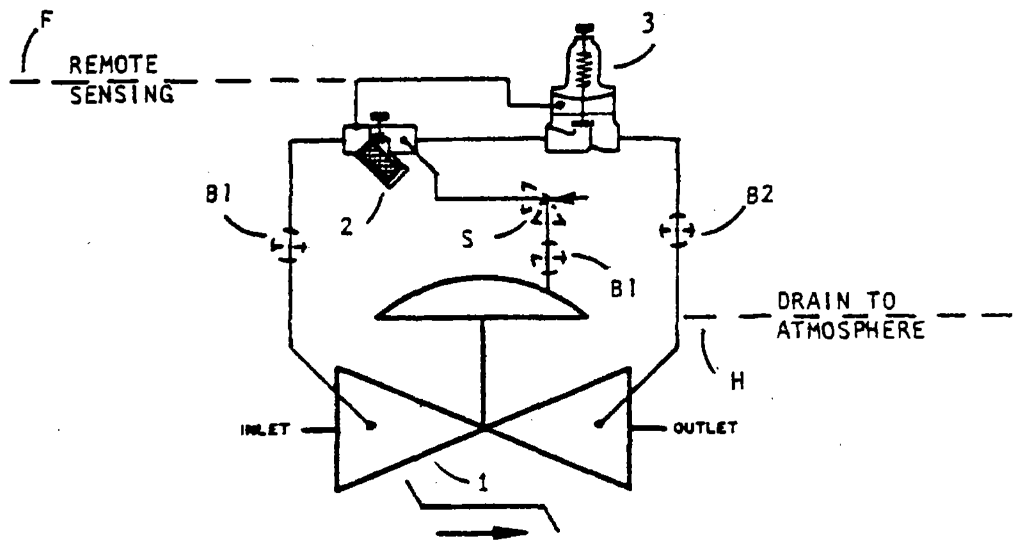
CATALOG NO.	DRAWING NO.	REV.
50-01	79488	C

TYPE OF VALVE AND MAIN FEATURES

PRESSURE RELIEF VALVE
(EQUIPPED WITH CLOSING SPEED CONTROL)

DESIGN		
DRAWN	11-30-78	JD
CHK'D.	11-30-78	GH
APP'D.	11-30-78	

——— NOT FURNISHED BY CLA-VAL CO. - - - - - OPTIONAL FEATURES



* FORMERLY 100 OR 2100

ITEM NO.	BASIC COMPONENTS	QTY.
1	* 100-01 HYTROL	1
2	X42N-2 STRAINER & NEEDLE VALVE	1
3	CRL PRESS. REL. CONTROL	1

OPTIONAL FEATURE SUFFIX ADD TO CATALOG NUMBER

B	CK2 COCK (ISOLATION VALVES)	3
F	REMOTE SENSING	
H	DRAIN TO ATMOSPHERE	
S	CV FLOW CONTROL (OPENING)	1

REVISION RECORD

LTR	DESCRIPTION	BY	DATE
C	REVISED & REDRAWN, ECO 26826	JH	11-30-78

5B 3 29 77

CLA-VAL CO. NEWPORT BEACH, CALIFORNIA CVCL 1 2 3 4	CATALOG NO. 50-01	DRAWING NO. 79488	REV. C

PRESSURE RELIEF VALVE

(EQUIPPED WITH CLOSING SPEED CONTROL)

DESIGN	
DRAWN	11-30-78 CH
CHK'D.	11-30-78 DP
APP'D.	11-30-78
SCALE	DIST. CODE 00.

OPERATING DATA

I. PRESSURE RELIEF FEATURE:
PRESSURE RELIEF CONTROL (3) IS A "NORMALLY CLOSED" CONTROL THAT RESPONDS TO MAIN VALVE INLET PRESSURE CHANGES. AN INCREASE IN INLET PRESSURE TENDS TO OPEN CONTROL (3) AND A DECREASE IN INLET PRESSURE TENDS TO CLOSE CONTROL (3). THIS CAUSES MAIN VALVE COVER PRESSURE TO VARY AND THE MAIN VALVE MODULATES (OPENS AND CLOSES) MAINTAINING A RELATIVELY CONSTANT PRESSURE AT THE MAIN VALVE INLET. WHEN INLET PRESSURE IS LOWER THAN THE SET POINT OF CONTROL (3), CONTROL (3) CLOSES. THIS PRESSURIZES THE MAIN VALVE COVER CHAMBER AND THE MAIN VALVE CLOSES.
PRESSURE RELIEF CONTROL (3) ADJUSTMENT: TURN THE ADJUSTING SCREW CLOCKWISE TO INCREASE THE SETTING.

II. CLOSING SPEED CONTROL
NEEDLE VALVE (2) CONTROLS THE CLOSING SPEED OF THE MAIN VALVE. TURN THE ADJUSTING STEM CLOCKWISE TO MAKE THE MAIN VALVE CLOSE SLOWER. DO NOT CLOSE VALVE (2) COMPLETELY OR THE MAIN VALVE WILL NOT CLOSE. (SUGGESTED INITIAL SETTING OF NEEDLE VALVE IS 1/4 TO 1/2 TURN OPEN.)

III. OPTIONAL FEATURE OPERATING DATA:
SUFFIX "B" (ISOLATION VALVES) CK2 COCKS (B1) AND (B2) ARE USED TO ISOLATE THE PILOT SYSTEM FROM MAIN LINE PRESSURE. THESE VALVES MUST BE OPEN DURING NORMAL OPERATION.
SUFFIX "F" (REMOTE PILOT SENSING)
REMOTE SENSING PRESSURE IS OBTAINED FROM A POINT UPSTREAM OF THE MAIN VALVE INLET. (SENSING PRESSURE IS OBTAINED FROM THE MAIN VALVE INLET IF SUFFIX "F" IS NOT SPECIFIED).
SUFFIX "H" (ATMOSPHERIC DRAIN)
PILOT SYSTEM DRAIN LINE IS DISCHARGED TO ATMOSPHERE. (PILOT SYSTEM DRAIN LINE IS CONNECTED TO THE MAIN VALVE OUTLET BOSS IF SUFFIX "H" IS NOT SPECIFIED).
SUFFIX "S" (OPENING SPEED CONTROL)
FLOW CONTROL (S) CONTROLS THE OPENING SPEED OF THE MAIN VALVE. TURN THE ADJUSTING STEM CLOCKWISE TO MAKE THE MAIN VALVE OPEN SLOWER.

IV. CHECK LIST FOR PROPER OPERATION:
[ ] SYSTEM VALVES OPEN UPSTREAM AND DOWNSTREAM.
[ ] AIR REMOVED FROM THE MAIN VALVE COVER AND PILOT SYSTEM AT ALL HIGH POINTS.
[ ] CK2 COCKS (B1) AND (B2) OPEN (OPTIONAL FEATURE).
[ ] PERIODIC CLEANING OF STRAINER (2) IS RECOMMENDED.
[ ] NEEDLE VALVE (2) OPEN 1/4 TO 1/2 TURN.
[ ] REMOTE CONTROL LINE PROPERLY CONNECTED (OPTIONAL FEATURE).
[ ] ATMOSPHERIC DRAIN LINE PROPERLY CONNECTED (OPTIONAL FEATURE).

REVISION RECORD

LTR	DESCRIPTION	BY	DATE

CLAYTON® *automatic* VALVES

INSTALLATION/OPERATION/MAINTENANCE

HYTROL REMOTE CONTROL VALVE

GLOBE	ANGLE
Clayton **100-01**	*Clayton* **100-01**

DESCRIPTION

The Clayton Hytrol Valve is the basis for Clayton Automatic Valves. It is a hydraulically operated, diaphragm actuated, globe, or angle pattern valve. This valve consists of three major components, the body, diaphragm assembly and cover. The diaphragm assembly is the only moving part.

The body contains a seat insert that forms a tight seal with the body. The diaphragm assembly uses a diaphragm of nylon fabric bonded with synthetic rubber. A synthetic rubber disc, contained on three sides by a disc retainer, forms a seal with the valve seat when pressure is applied above the diaphragm. The diaphragm assembly forms a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure.

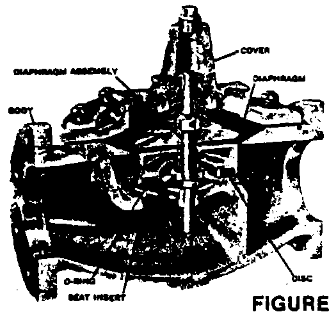


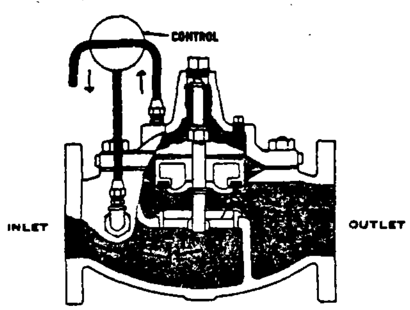
FIGURE 1

INSTALLATION

1. Before valve is installed, pipe lines should be flushed of all chips, scale and foreign matter.
2. It is recommended that either gate or block valves be installed on both ends of the Clayton Hytrol Valve to facilitate isolating the valve for preventive maintenance.
3. Place valve in the line with flow through the valve in the direction indicated on inlet plate or by flow arrows.
4. Allow sufficient room around valve to make adjustments, and for disassembly.
5. Clayton Hytrol Valves operate with maximum efficiency when mounted in horizontal piping with the cover UP, however, other positions are acceptable. Due to size and weight of cover and internal components of 6 inch valves and larger, installation with cover UP is advisable. This makes periodic inspection of internal parts readily accessible.
6. If a pilot control system is installed on the Hytrol Valve, use care to prevent damage. If necessary to remove fittings or components, be sure they are kept clean and replaced exactly as they were.
7. After the valve is installed and the system is first pressurized, vent air from the cover chamber and tubing by loosening fittings at all high points.

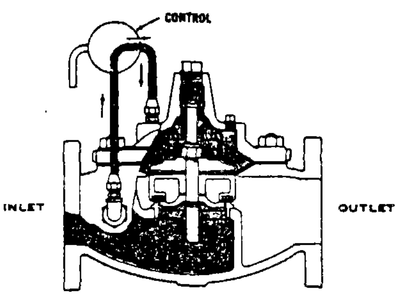
OPERATION, *OPEN-CLOSED SERVICE*

When equipped with a three way control valve the Clayton Hytrol Valve either opens wide or closes tight.



VALVE OPEN

The Clayton Hytrol Valve opens fully when there is no pressure in the cover chamber above the diaphragm, and there is at least five psi line pressure at the valve inlet.



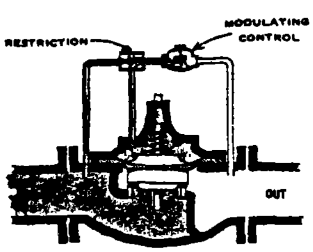
VALVE CLOSED

The Clayton Hytrol Valves close when the line pressure is directed into the cover chamber above the diaphragm. An independent operating supply may be used if its pressure is equal to, or greater than, pressure at the valve inlet.

FIGURE 2

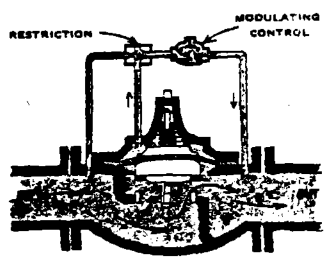
OPERATION, *MODULATING SERVICE*

Modulating action can be obtained by installing a factory designed control system to the basic Clayton Hytrol Valve. Various types of modulating control systems are available to control pressure, flow rates and liquid levels.



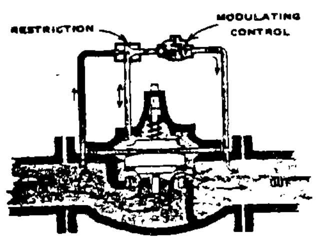
VALVE CLOSED

When the modulation control closes sufficiently to direct a great enough pressure into the cover chamber to overcome opening forces of line pressure, the main valve closes.



VALVE OPEN

When the modulating control opens to a point where more pressure is relieved from the cover chamber than the restriction can supply, cover pressure is reduced and the valve opens.



VALVE MODULATING

The main valve modulates to any degree of opening in response to changes in the modulating control. At an equilibrium point the main valve opening and closing forces hold the valve in balance. This balance holds the valve partially open, but immediately responds and readjusts its position to compensate for any changes in the controlling condition.

FIGURE 3

   CLA-VAL CO. *Newport Beach, California*

TROUBLE SHOOTING

The following trouble shooting information deals strictly with the "Hytrol Valve". This assumes that everything but the main valve itself has been completely isolated, i.e. each part of the control system is hydraulically blocked from the main valve. All trouble shooting is possible without removing the valve from the line.

SERVICE SUGGESTIONS

SYMPTOM	*PROBABLE CAUSE	REMEDY
Fails to close	Closed cocks in control system, or in main line.	Open cocks.
	Lack of cover chamber pressure.	Check upstream pressure, strainer, tubing, cocks, needle valves for restriction.
	Diaphragm damaged. (See note)	Replace diaphragm.
	Diaphragm assembly inoperative. Corrosion or excessive scale build up on valve system.	Clean and polish stem. Replace any defective part, damaged, badly eroded.
	Mechanical obstruction. Object lodged in valve.	Remove obstruction.
	Worn disc.	Replace disc.
	Badly scored seat.	Replace seat.
Fails to open	Closed isolation valves or cocks in pilot system, or in main line.	Open valves or cocks.
	Insufficient line pressure.	Check pressure.
	Diaphragm assembly inoperative. Corrosion on valve stem.	Clean and polish stem. Replace any defective part, damaged, badly eroded.

*Assuming control system is functioning properly.

NOTE: The following method will determine if there is a damaged diaphragm without removing the valve cover: Put pressure into the valve and close all control lines to the valve cover chamber. Remove a fitting on the valve cover; if there is continuous flow out of the cover chamber through this opening, the diaphragm is damaged, or the diaphragm assembly on the stem is loose.

Freedom of Movement

1. Shut off pressure to the control system. On larger valves this can be done simply by closing cocks in the control system. On the smaller valves without shutoff cocks, it is necessary to shut off the main line pressure while disconnecting and blocking off the control system.

   CAUTION: Care should be taken when doing the above since removal of pressure from the cover chamber while pressure exists in the valve body will permit the valve to open wide. This will either permit a high flow rate through the valve, or the downstream pressure will quickly increase to a point close to or equal to the inlet pressure. In some cases, this can be very harmful. Where this is the case, and there are no block valves in the system to protect the downstream piping, it should be realized that the valve cannot be serviced under pressure. Steps should be taken to remedy this situation before proceeding any further.

   Usually, there is a block valve within close proximity downstream which can be closed to prevent the high inlet pressure from getting into the downstream piping even though the Hytrol valve is permitted to go wide open. Once it is clear that a wide open valve can be tolerated, then the trouble shooting can proceed.

2. Disconnect all control lines to the valve cover and leave fittings in cover open to atomosphere.

3. With the cover vented to atmosphere and pressure in the valve body, observe the open cover tapping for signs of continuous flow. If the fluid appears to flow continuously there is a good reason to believe the diaphragm is either damaged, or it is loose on the stem. In either case, this is sufficient cause to remove the valve cover and investigate the leakage. If there is no continuous flow, you can be quite certain the diaphragm is sound and the diaphragm assembly tight.

4. If the valve has a valve position indicator, observe the indicator to see that the valve opens wide. Mark the point of maximum opening.

5. If the valve isn't equipped with an indicator, the trouble shooter should install one. This is part of the indispensable equipment the service man should have.

6. Re-connect enough of the control system to permit the application of inlet pressure to the cover. Open cock or valve so pressure flows from the inlet into the cover.

7. While pressure is building up in the cover, the valve should go closed smoothly with out any hesitations. There is a hesitation in every Hytrol valve closure, however, which can be mistaken for a mechanical bind. The stem will appear to stop moving very briefly before going to the closed position. This slight pause is caused by the diaphragm flexing at a particular point in the valve's travel and not caused by a mechanical bind of some kind.

8. When closed, a mark should be made on the indicator corresponding to the "closed" position. The distance between the two marks should be approximately .28 × valve size.

   EXAMPLE: The stroke on a 4" valve is 4 × .28 or 1.12 inches from full open to full close.

   If the stroke is very much different than that calculated, there is a good reason to believe something is mechanically restricting the stroke of the valve at one end of its travel. If the flow doesn't stop through the valve when in the indicated "closed" position, the obstruction probably is between the disc and the seat. If the flow does stop, then the obstruction is more likely in the cover. In either case, operation of the valve two or three times by alternately applying and relieving pressure is a good idea. Sometimes this will serve to dislodge a foreign object from the seat, or clear whatever is obstructing the valve movement. If this is not successful, then the cover must be removed, and the obstruction located and removed.

Tight Sealing

If the trouble-shooting to this point has disclosed no problems relative to freedom of movement or a damaged diaphragm, the only other problem of any concern is whether or not the valve shuts off tight under the conditions of operation. If it does not shut off tight, check disc and seat for wear.

MAINTENANCE

Preventive Maintenance

Clayton Hytrol Valves require no lubrication or packing and a minimum of maintenance. However, a periodic inspection schedule should be established to determine how the fluid velocity as well as the substances occurring in natural waters, such as dissolved minerals, colloidal and suspended particles, are effecting the valve. Effect of these actions or substances must be determined by inspection.

Disassembly

The Hytrol Valve inspection or maintenance can be accomplished without removal from the line. Shut off all pressure to the valve, both line, and independent operating pressure when used.

WARNING Maintenance personnel can be injured and equipment damaged if disassembly is attempted with pressure in the system.

1. After pressure has been released from the valve and cover chamber, remove the controls and tubing. Obtain a schematic of the assembly or note and sketch position of tubing and controls for reassembly.

2. Remove cover nuts (2) Figure 6 and remove cover. If the valve has been in service for any length of time, chances are the cover will have to be loosened by driving upward along the edge of the cover with a dull cold chisel. See Figure 4. When block and tackle or a power hoist is to be used to lift valve cover insert proper size eye bolt in place of the center cover plug (4) Figure 6. Pull cover straight up to keep from damaging bottom seat and stem.

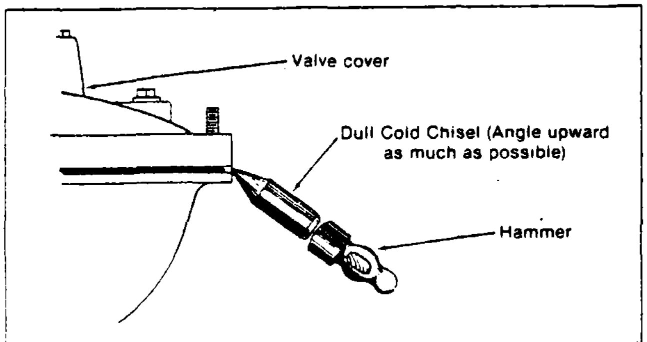


FIGURE 4

3. Remove the diaphragm and disc assembly from the valve body. With smaller valves this can be accomplished by hand, pulling straight up on the stem so as not to damage the seat or stem. On large valves, an eye bolt of proper size can be installed in the stem and the disc assembly can then be lifted with a block and tackle or power hoist.

4. The next item to remove is the stem nut. Examine the stem threads above the nut for signs of mineral deposits or corrosion deposits. If the threads are not clean, use a wire brush to remove as much of the residue as possible. Attach a good fitting wrench to the nut and give it a sharp "rap" rather than a steady pull. Usually this is sufficient to loosen the nut for further removal. On smaller valves where the entire diaphragm assembly can be removed, hold the stem in a vice equipped with soft brass jaws and following the same suggestion outlined above.

   CAUTION: DO NOT USE A PIPE WRENCH OR VICE WITHOUT SOFT BRASS JAWS ON THE UPPER OR LOWER END OF THE VALVE STEM. This practice scars the fine finish on the stem, and no amount of careful dressing can restore the stem to its original condition.

5. After the stem nut has been removed, the diaphragm assembly breaks down into its component parts quite easily. Removal of the disc from the disc retainer can be a problem if the valve has been in service for a long time. Using two screwdrivers inserted along the outside edge of the disc usually will accomplish its removal. Care should be taken to preserve the space washers (18) particularly if no new ones are available for reassembly.

6. The only part left in the valve is the seat ring which ordinarily does not require removal. If, however, it is badly worn and replacement is necessary, it can be removed. For 6" and smaller valves obtain a seat driver X109 from the factory. On 8" and larger valves, the seat is held in place by a number of flat head screws. After the screws have been removed, the seat can be loosened from the body quite easily using a piece of angle or channel iron with a hole drilled in the center. Place it across the body so a long bolt or stud can be inserted through the center hole in the seat and the hole in the angle iron. By tightening a nut an upward force is exerted on the seat. See Figure 5.

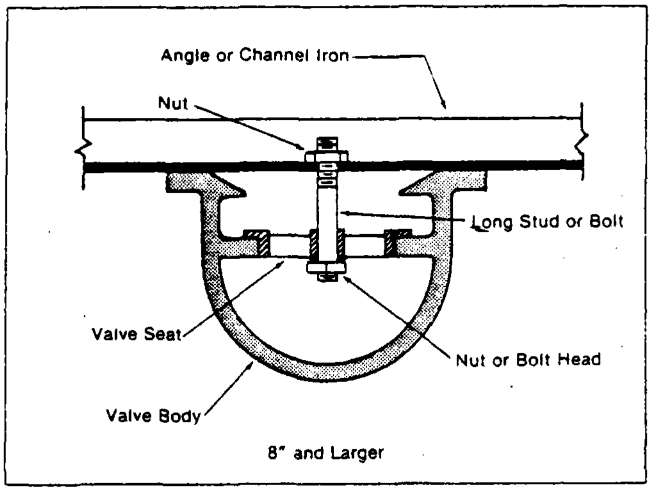


FIGURE 5

Lime Deposits

One of the easiest ways to remove lime deposits from the valve stem is to dip it in a 5-percent muriatic acid solution just long enough for the deposit to dissolve. This will remove most of the common types of deposits. If the deposit is not removed by acid, then a fine grit (400) wet or dry paper can be used with water. If the build-up of deposits on the valve stem is a consistent problem, there are stems that have been sleeved with a plastic material called Delrin that have been very successful in eliminating lime deposits that tend to form on the valve stem. These stems are available in new valves and as a replacement part for existing valves. Contact your Cla-Val Co. representative for complete details.

Inspection of Parts

After a valve has been disassembled, each part should be examined carefully for signs of wear, corrosion, or any other abnormal condition. Usually, it is a good idea to replace the resilient parts (diaphragm and disc) unless they are free of signs of wear. Any parts which appear doubtful should be replaced.

NOTE: If a new disc isn't available, the existing disc can be turned over, exposing the unused surface for contact with the seat.

Reassembly

1. Reassembly is the reverse of the disassembly procedure. If a new disc (17) has been installed, it may require a different number of spacer washers (18) to obtain the right amount of "grip" on the disc. When the diaphragm assembly has been tightened to a point where the diaphragm cannot be twisted, the disc should be compressed very slightly by the disc guide. Excessive compression should be avoided. Use just enough spacer washers to hold it firmly.

2. Make sure the stem nut is made up very tight. Failure to do so could allow the diaphragm to pull loose and tear when subjected to pressure.

3. Re-install the diaphragm assembly in the valve, and line up the diaphragm holes with the stud or bolt holes on the body. On larger valves with studs, it may be necessary to hold the diaphragm assembly up while stretching the diaphragm over the studs.

4. Put spring in place and replace cover. Make sure diaphragm is lying smooth under the cover.

5. Tighten cover nuts firmly using a cross-over pattern until all nuts are tight.

6. Re-install the pilot system and tubing exactly as it was prior to removal.

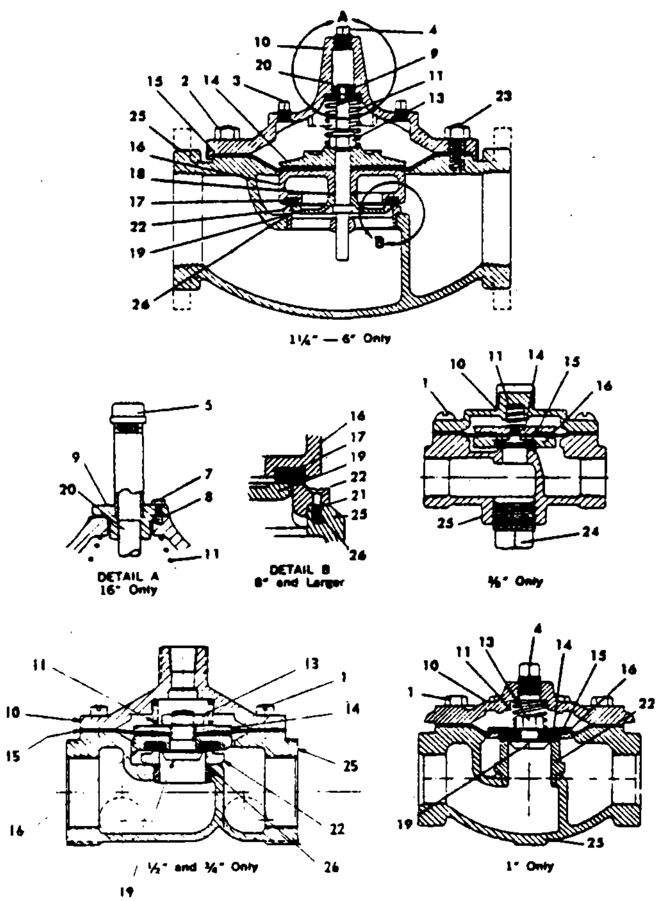


FIGURE 6

Test Procedure for Valve Assembly

There are a few simple tests which can be made in the field to make sure the valve has been assembled properly.

1. It is possible to check the diaphragm assembly for freedom of movement by inserting a rod into the threaded hole in the top of the valve stem and lifting the diaphragm assembly manually. The rod should be threaded on one end and have a "T" bar handle of some kind on the other end for easy gripping. The diaphragm assembly should move freely without any signs of sticking or grabbing. Due to the weight of the diaphragm assembly this procedure is not possible on valves larger than 10".

2. On the larger valves, the same determination can be made by very carefully introducing a low pressure (less than five psi) into the valve body with the cover vented. The diaphragm assembly sould lift easily without any jerkiness, and then settles back easily when the pressure is removed.

3. To check the valve for drip-tight closure, a line should be connected from the inlet to the cover, and pressure applied at the inlet of the valve. If properly assembled, the valve should hold tight with as low as ten psi at the inlet.

4. With the line still connected from the inlet to the cover, apply full working pressure to the inlet. Check all around the cover for any leaks. Re-tighten cover nuts if necessary to stop leaks past the diaphragm.

PARTS LIST

ITEM	DESCRIPTION
1	Cover Retaining Screw (3/8" thru 4" Sizes Only)
2	Cover Retaining Nut (6" and Larger)
3	Cover Plug
4	Center Cover Plug
5	Pipe Cap (16" Size Only)
7	Cover Bearing Screw (16" Size Only)
8 •	Cover Bearing Gasket (16" Size Only
9	Cover Bearing
10	Cover
11 •	Spring
13	Stem Nut
14	Diaphragm Washer
15 •	Diaphragm
16 • •	Disc Retainer
17 •	Disc
18 •	Spacer Washer
19	Disc Guide
20	Stem
21	Seat Screw (8" & Larger Only)
22	Seat
23	Body Stud (6" and Larger)
24	Body Plug
25	Body
26	O-Ring, Seat

• RECOMMENDED SPARE PARTS •• FOR 3/8" - 1" SIZE ONLY

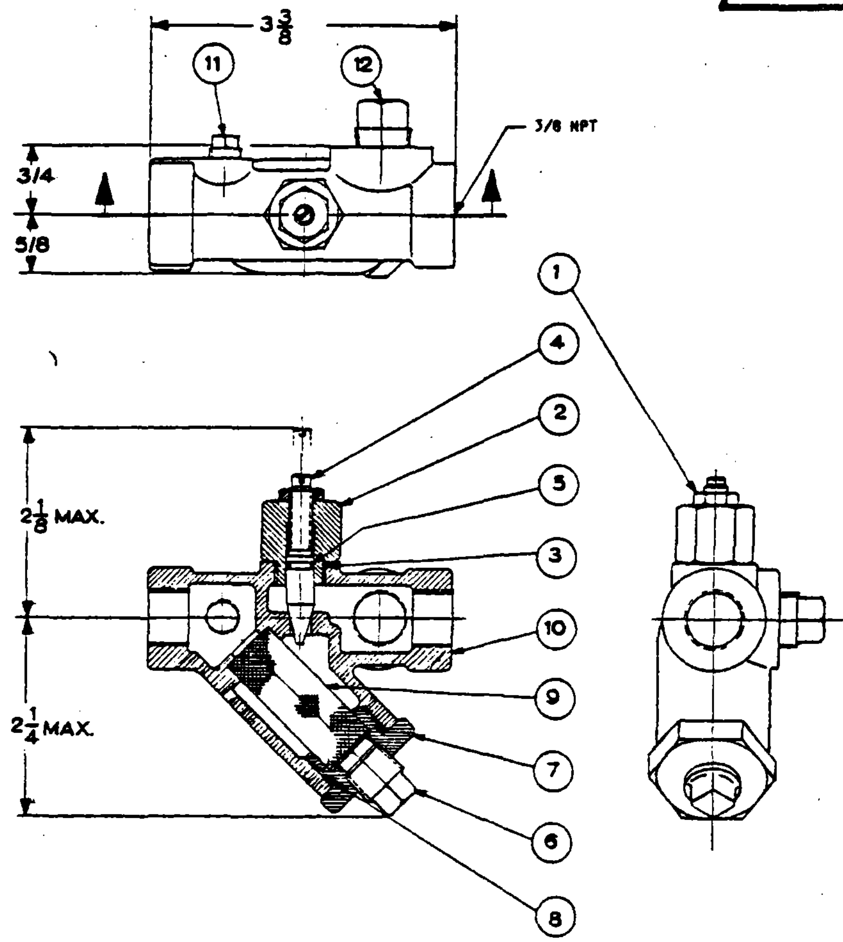
When ordering parts specify:
- All nameplate data
- Item Number
- Description
- Material
- Size

CLAYTON® *automatic* VALVES — **PARTS LIST**

STRAINER AND NEEDLE VALVE ASSEMBLY

Clayton **X-42N-2**

SIZE	STOCK NUMBER
3/8" x 3/8"	68372



ITEM	DESCRIPTION	MATERIAL	PART NO.	UNIT PRICE
1	Jam Nut—Hex	Sil Brz	67798-01	
2	Bonnet	S.S.	67910	
3	"O" Ring—Bonnet	Syn Rub	00713	
4	Stem	S.S.	67907	
5	"O" Ring—Stem	Syn Rub	00708	
6	Plug—Pipe 1/4	Brass	67847-02	
7	Strainer Plug	S. S.	67911	
8	"O" Ring—Plug	Syn. Rub.	00751	
9	Screen	Monel	68373	
10	Body	Rd Brs	67905	
11	Plug—Pipe 1/8	Brass	67660-01	
12	Plug—Pipe 3/8	Brass	67660-03	

PRICES SUBJECT TO CHANGE WITHOUT NOTICE • F.O.B. NEWPORT BEACH, CALIFORNIA — EFFECTIVE 4-15-77

When ordering parts specify:
- All nameplate data
- Item Number
- Description
- Material
- Part Number

C		CLAYTON® *automatic* VALVES	INSTALLATION / OPERATION / MAINTENANCE
		PRESSURE RELIEF CONTROL	*Clayton* CRL

See PL-CRL *on reverse side for* PART ITEM *Reference*

DESCRIPTION

The Clayton Pressure Relief Control is a direct-acting, spring-loaded, diaphragm type relief valve. It may be used as a self-contained valve or as a pilot control for a Clayton Hytrol Valve. It opens and closes within very close pressure limits.

INSTALLATION

The Pressure Relief Control may be installed in any position. The control body (7) has one inlet and one outlet port with a side pipe plug (24) at each port. These plugs are used for control plumbing or gauge applications. The inlet in the power unit body (6) is the sensing line port. A flow arrow is marked on the body casting.

OPERATION

The pressure Relief Control is normally held closed by the force of the compression spring above the diaphragm; control pressure is applied under the diaphragm.

When the controlling pressure exceeds the spring setting, the disc is lifted off its seat, permitting flow through the control.

When controlling pressure drops below spring setting, the spring returns the control to its normally closed position.

ADJUSTMENT

The Pressure Relief Control can be adjusted to provide a relief setting at any point within the range stamped on the data plate.

Pressure adjustment is made by turning the adjustment screw (9) to vary the spring pressure on the diaphragm. Turning the adjustment screw clockwise increases the pressure required to open the valve. Counterclockwise decreases the pressure required to open the valve.

When pressure adjustments are complete the jam nut (10) should be tightened and the protective cap (1) replaced. If there is a problem of tampering, lock wire holes have been provided in cap and cover. Wire the cap to cover and secure with lead seal.

DISASSEMBLY

The Pressure Relief Control does not need to be removed from the line for disassembly. Make sure that pressure shut down is accompanied prior to disassembly. If the Pressure Relief Control is removed from the line for disassembly be sure to use a soft jawed vise to hold body during work.

Refer to Parts List Drawing for item numbers.

1. Remove cap (1), loosen jam nut (10) and turn adjusting screw counterclockwise until spring tension is relieved.
2. Remove the eight screws (4) holding the cover (3) and powerunit body (6). Hold the cover and powerunit together and place on a suitable work surface.
3. Remove the cover (3) from powerunit body (6). The spring (12) and two spring guides (11).
4. Remove nut (13) from stem (19) and slide off the belleville washer (14), the upper diaphragm washer (15) and the diaphragm (16).
5. Pull the stem (19) with the disc retainer assembly (21) through the bottom of powerunit. The lower diaphragm washer (17) will slide off of stem top.
6. Remove jam nut (23) and disc retainer assembly (21) from stem. Use soft jawed pliers or vise to hold stem. The polished surface of stem must not be scored or scratched.
7. The seat (22) need not be removed unless it is damaged. If removal is necessary use proper size socket wrench and turn counterclockwise.

INSPECTION

Inspect all parts for damage, or evidence of cross-threading. Check diaphragm and disc retainer assembly for tears, abrasion, or other damage. Check all metal parts for damage, corrosion, or excessive wear.

REPAIR AND REPLACEMENT

Minor nicks and scratches may be polished out using fine emery or crocus cloth. Replace all "O" rings and any damaged parts.

When ordering replacement parts, be sure to specify parts list item number and all name plate data.

REASSEMBLY

In general, reassembly is the reverse of disassembly, however, the following steps should be observed:

1. Lubricate the "O" ring (18) with a good grade of waterproof grease, Dow Corning 44 medium grade or equal. Use grease sparingly and install "O" ring in powerunit body (6).
2. Install stem (19) in powerunit body (6). Use a rotating motion with minimum pressure to let stem pass through "O" ring.
3. Install "O" ring (5) at top of stem (19). Place lower diaphragm washer (17) on the stem with the serrated side up. Position diaphragm (16), upper diaphragm washer (15), with serrations down, and belleville washer (14), with concave side down. Secure assembly with nut (13). Make sure stem slides freely in powerunit body.
4. Position powerunit body (6) as shown on parts list drawing (top view).
5. Continue reassembly as outlined in disassembly steps 1 through 3.

SERVICE SUGGESTIONS

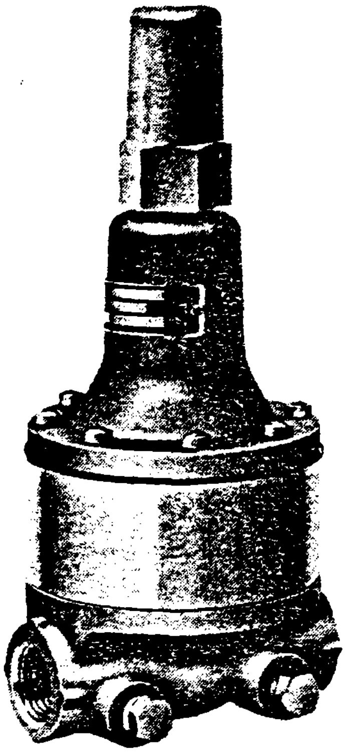
SYMPTOM	PROBABLE CAUSE	REMEDY
Fails to open.	Controlling pressure too low.	Back off adjusting screw until valve opens.
Fails to open with spring compression removed.	Mechanical obstruction, corrosion, scale build-up on stem.	Disassemble, locate, and remove obstruction, scale.
Leakage from cover vent hole when controlling pressure is applied.	Diaphragm damage.	Disassemble, replace damaged diaphragm.
	Loose diaphragm assembly.	Tighten upper diaphragm washer.
Fails to close.	No spring compression.	Re-set pressure adjustment.
Fails to close with spring compressed.	Mechanical obstruction.	Disassemble, locate and remove obstruction.

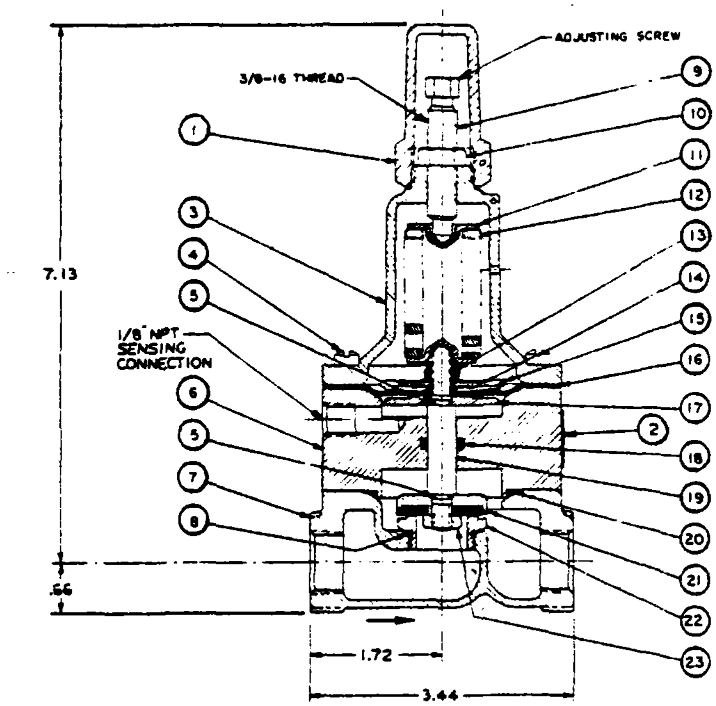
 LITHO IN U.S.A. CLA-VAL CO. *Newport Beach, California*

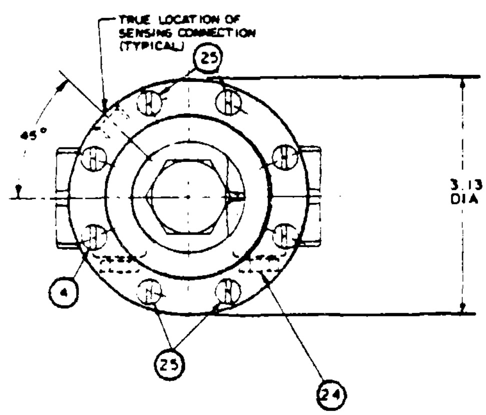
N-CRL (R1-79)

C	CLAYTON® *automatic* VALVES	PARTS LIST
	PRESSURE RELIEF CONTROL	*Clayton* CRL

STOCK NUMBERS		
SIZE	SPRING RANGE	NUMBER
½"	0 - 75 PSI	79222-01
½"	20 - 200 PSI	79222-02
½"	100 - 300 PSI	82809-01
¾"	0 - 75 PSI	79229-01
¾"	20 - 200 PSI	79229-02
¾"	100 - 300 PSI	86005-01







PARTS LIST

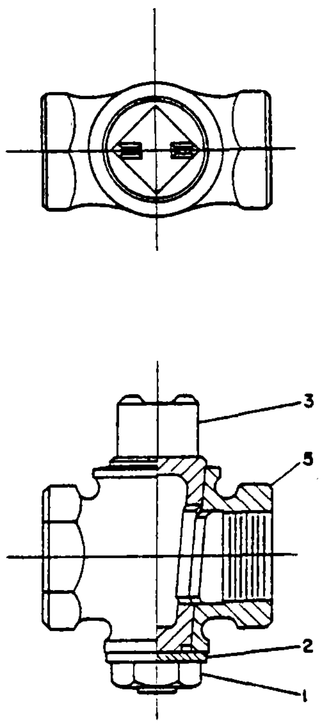
ITEM	DESCRIPTION	QTY.	ITEM	DESCRIPTION	QTY.
1	Cap	1	11	Spring Guide	2
1	Cap (100-300 PSI)	1	11	Spring Guide (100-300 PSI)	2
2	Nameplate (0-75 PSI)	1	12	Spring (0-75 PSI)	1
2	Nameplate (20-200 PSI)	1	12	Spring (20-200 PSI)	1
2	Nameplate (100-300 PSI)	1	12	Spring (100-300 PSI)	1
3	Cover	1	13	Nut	1
3	Cover (100-300 PSI)	1	14	Belleville Washer	1
4	Screw	8	15	Upper Diaphragm Washer	1
5	O-Ring	2	16	Diaphragm	1
6	Powerunit Body	1	17	Lower Diaphragm Washer	1
7	Body — ½"	1	18	O-Ring	1
7	Body — ¾"	1	19	Stem	1
8	O-Ring	1	20	O-Ring	1
9	Adjusting Screw	1	21	Disc Retainer Assembly	1
9	Adjusting Screw (100-300 PSI)	1	22	Seat	1
10	Jam Nut	1	23	Jam Nut	1
10	Jam Nut (100-300 PSI)	1	24	Pipe Plugs	2

When ordering parts specify:
- All nameplate data
- Item Number
- Description
- *Material*

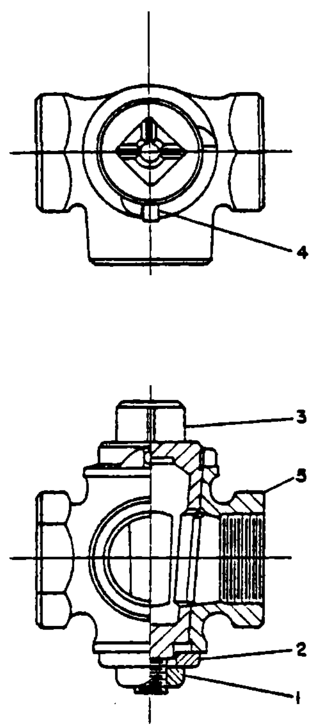
PL-CRL (R1-79) PATENTS ISSUED AND/OR PENDING LITHO IN U.S.A. CLA-VAL CO. *Newport Beach, California*

C CLAYTON *automatic* VALVES **PARTS LIST**

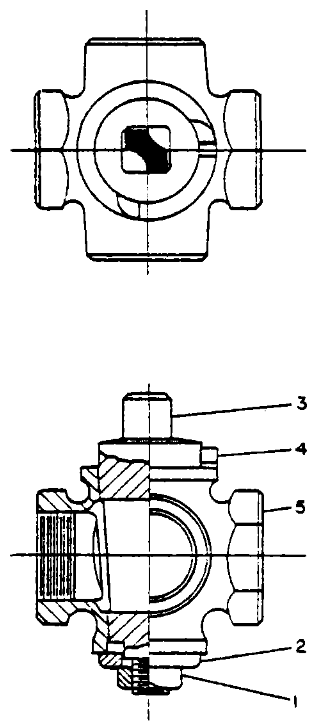
SHUTOFF COCKS – CK SERIES



CAT. NO. CK2
(2 WAY)



CAT. NO. CK3
(3 WAY)



CAT. NO. CK4
(4 WAY)

ITEM NO.	DESCRIPTION
1	Nut
2	Washer
3	Plug
4	Stop Pin
5	Body

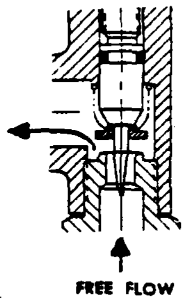
WHEN ORDERING PARTS, SPECIFY:	FORM NO. P-CK 1.2.7.130	ITEM NO.	DESCRIPTION	ALL NAMEPLATE DATA OR NOS. STAMPED ON ASSEMBLY

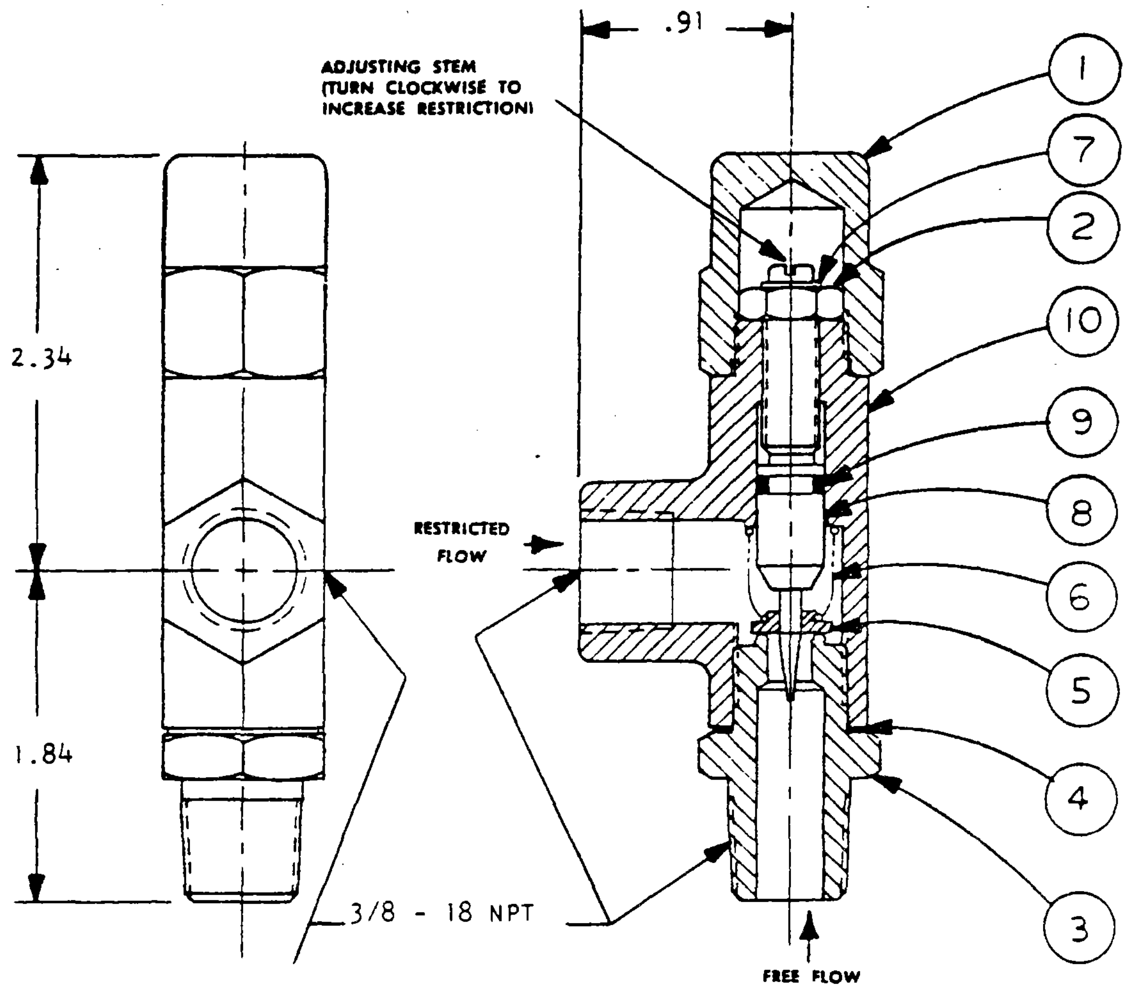
C		CLAYTON® *automatic* VALVES	PARTS LIST
		FLOW CONTROL	*Clayton* **CV** 3/8"

MATERIAL	STOCK NUMBER	FORMERLY
Bronze Body Stainless Steel Trim	97015-01A	C-5464
Stainless Steel Body and Trim (303)	97015-02J	37104
Bronze Body Monel Trim	97015-03G	37161

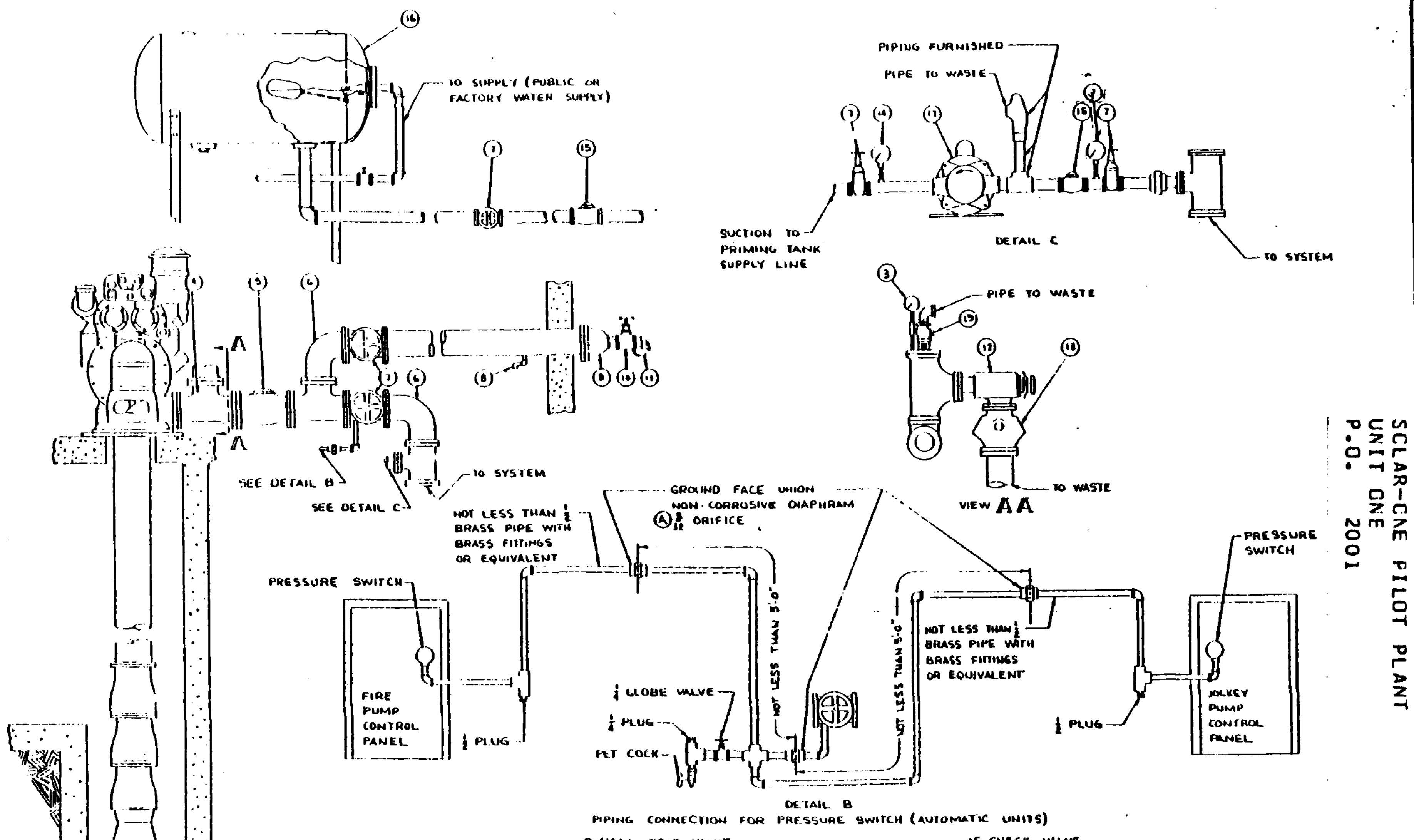
ITEM NO.	DESCRIPTION	QUAN.
1	Cap	1
2	Jam Nut	1
3	Seat	1
4 ★	Gasket	1
5 ★	Disc	1
6 ★	Spring	1
7	Snap Ring	1
8	Adjusting Stem	1
9 ★	"O" Ring	1
10	Housing Assembly	1

WITH DISC OPEN FOR "FREE FLOW"





When ordering parts specify:	• All nameplate data • Item Number	• Description • Material	• Part Number ★ Recommended Spare Parts



3 DISCHARGE GAUGE
4. DISCHARGE TEE
5 DISCHARGE CHECK VALVE
6. ELBOW
7 O.S. & Y. GATE VALVE
8 WALL DRIP VALVE
9 HOSE VALVE MANIFOLD
10 HOSE VALVES
11 HOSE VALVES CAPS & CHAINS
12 RELIEF VALVE
13 WASTE CONE (OPEN & ENCLOSED)
14 SUCTION GAUGE
15. CHECK VALVE
16 PRIMING TANK (PRIMARY PRIMING SUPPLY)
17 JOCKEY PUMP (AUTOMATIC UNITS)
18 DEPTH TUBE
19. AIR RELEASE VALVE

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SCLAR-CNE PILOT PLANT
UNIT ONE
P.O. 2001

1.2.7.132

STD. MAT'L	NOTE: DO NOT SCALE DRAWING
REFERENCE:	DRAWN BY
PATT. TIES TO:	CHECKED BY
PATTERN NUMBER	APPROVED BY
	DATE: 1-13-75
	SCALE: NONE
	C

AURORA PUMP

NAME: VERTI-LINE WET PIT FIRE PUMP ENGINE DRIVER

PART NUMBER: 0 3 2 0 3 5 0 0 0 0

Revision: B3 3-15-77 WAS 1/32

AURORA PUMP

A UNIT OF GENERAL SIGNAL

ENGINEERING DEPT.
NORTH AURORA, ILLINOIS· 60542

RIGHT ANGLE GEAR DRIVE

MODEL 125 S MFG. AMARILLO RIGHT ANGLE GEAR DRIVE,

RATIO 3:2 OR 2600 /1750 RPM WITH

NON-REVERSE RATCHET.

SOLD TO: TOWNSEND & BOTTOM, INC

F.O. # 460-65706

DATE: 6-23-80

BY: W/W

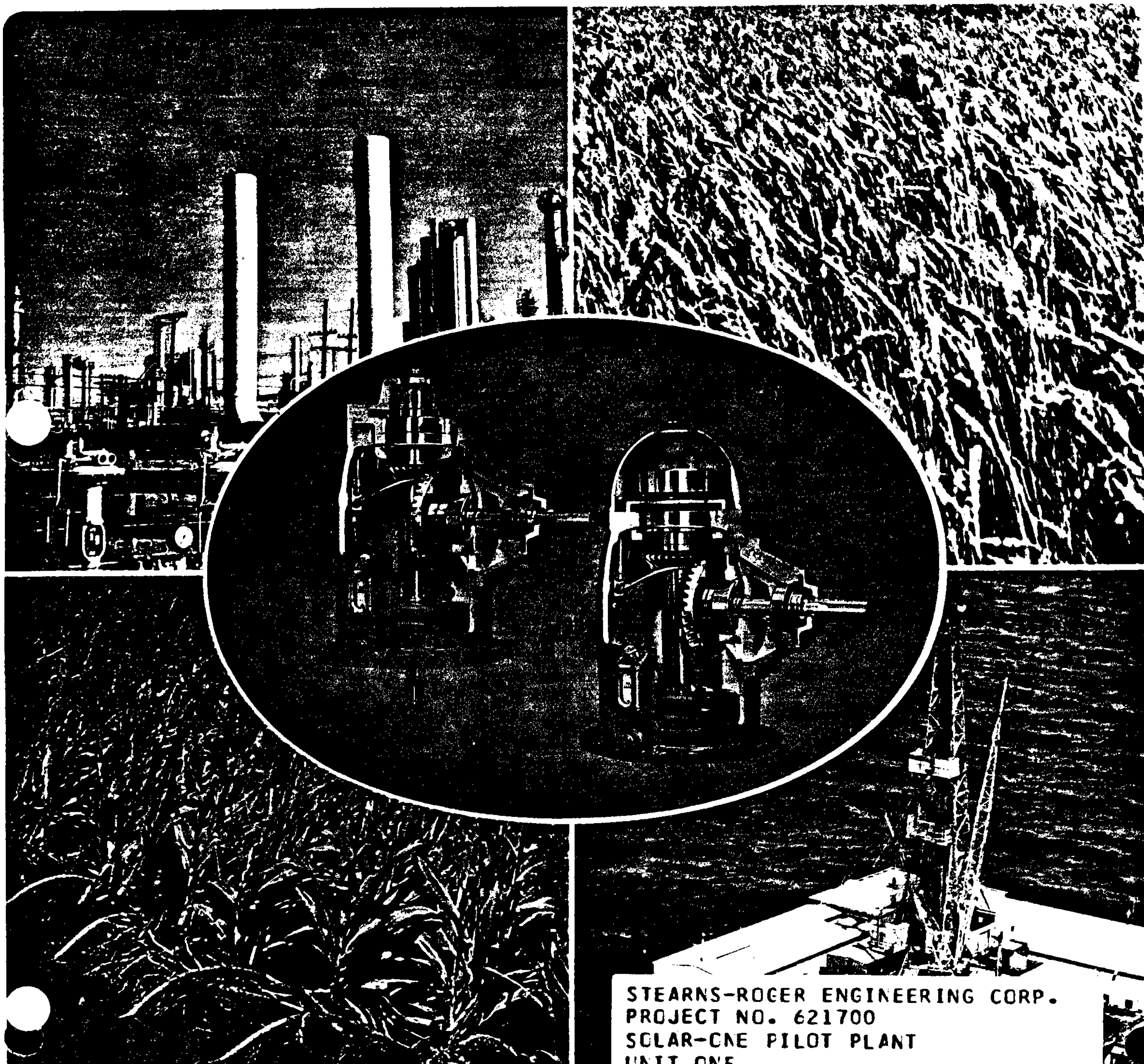
DATE: 12-10-80

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

SP-106968

amarillo

MARMON

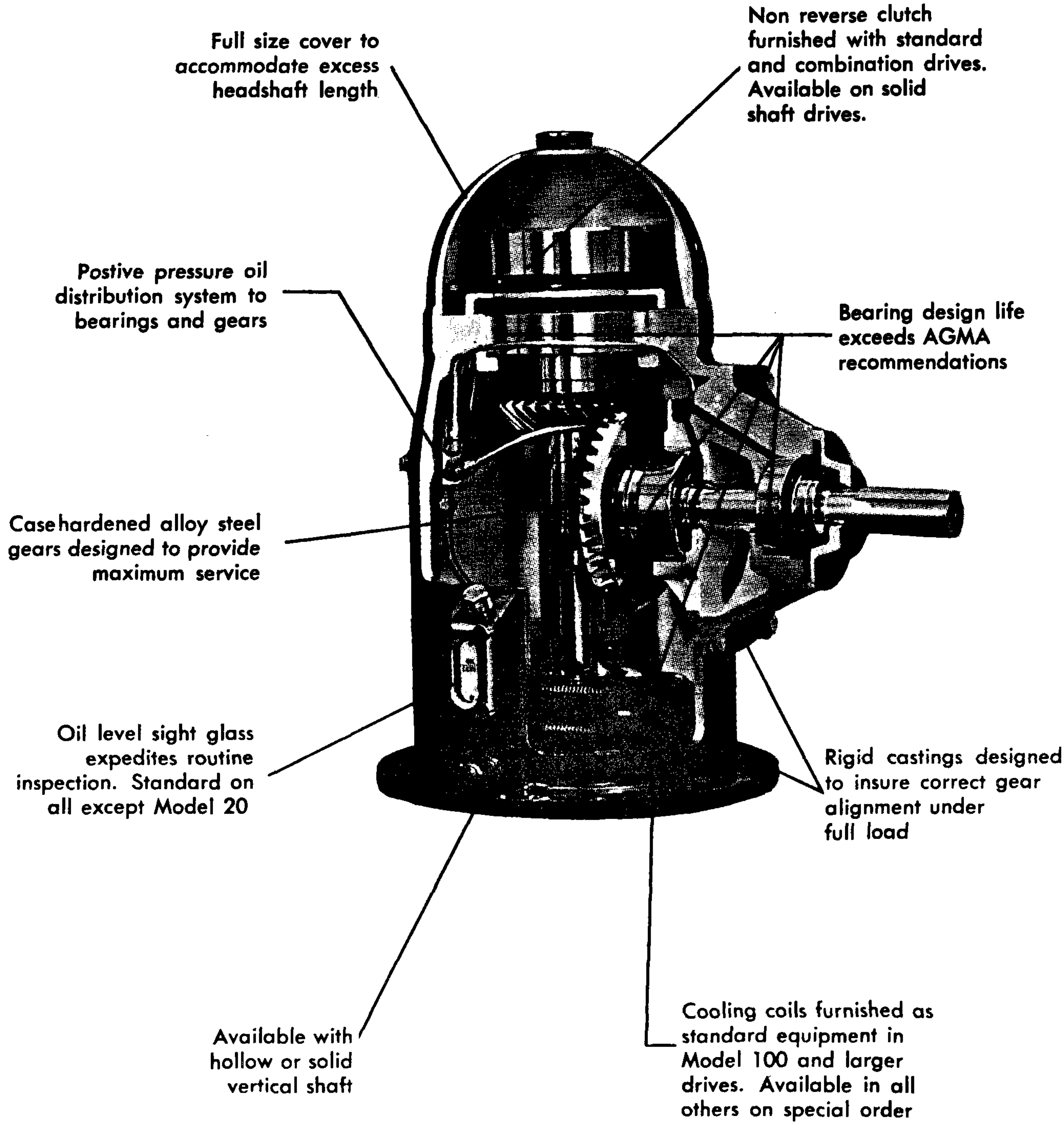


STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

1.2.7.134

AMARILLO GEAR COMPANY - P.O. BOX 1789 - 2401 SUNDOWN LANE - A/C 806 622-1273, TWX 910-898-4128 - AMARILLO, TEXAS 79105

OUTSTANDING HIGHLIGHTS OF AMARILLO'S PACE-SETTING DESIGNS



Every Drive Factory Tested Prior To Shipment To Assure Superior Performance

The Amarillo Gear Company enters the forty-fifth production year with the most adaptable selection of drives to date. Fifteen standard models are available, ranging from 20 to 1200 HP. This range of sizes, available with a wide range of ratios, provides one of the largest selections in the industry. Amarillo Right Angle Gear Drives were developed primarily for the irrigation industry as a replacement for the quarter-turn belt drives. However, greater numbers of drives for industrial applications are being presented. This widespread acceptance is a direct result of "Amarillo's" reliable, efficient and economic operation.

FM Standard Drives Are Factory Mutual Approved for Use With Vertical Fire Pumps

SELECTION OF THE PROPER DRIVE

Several factors must be considered in the selection of a right angle drive to obtain maximum performance from minimum investment. The following information is presented to assist in making your selection:

EFFICIENCY: Through the use of high quality gears and bearings, transmission efficiency ranges from 94% to 97% varying with speed, horsepower and thrust. Actual efficiency values will be furnished upon request.

GEARS: All drives are furnished with spiral bevel gears, designed in accordance with AGMA (American Gear Manufacturers Association) standards for both strength and surface durability, employing a minimum service factor of 1.50 at rated horsepower. This service factor applies to both speed increasing and speed decreasing drives.

THRUST BEARINGS:
When possible, full advantage is taken of the thrust produced by the gears to provide maximum thrust ratings. This factor, in turn, requires either a minimum external downthrust or thrust bearings arranged to handle thrust in both directions. Thrust ratings of our standard drives are listed in Tables 3 and 5. Three types of thrust bearing arrangements are offered. They are explained as follows:

TYPE SL (Limited Thrust) drives are intended for shallow setting applications or for any application that does not produce a constant downthrust while operating. These thrust bearing arrangements will also handle continuous upthrust equal to 50% of the maximum downthrust rating.

TYPE S (Standard Thrust) drives produce maximum downthrust ratings which are adequate for most deep well applications. Type S gear drives are arranged for momentary conditions of zero downthrust or upthrust. If external thrust is less than the minimum values shown in Tables 3 and 5 for other than momentary conditions, a Type SL drive or a Type SH drive with opposed thrust bearings should be selected.

TYPE SH (Heavy Downthrust) drives have stacked thrust bearings for extreme thrust conditions. Type SH gear drives are arranged for momentary conditions of zero downthrust or upthrust. If external thrust is less than the minimum values shown in Tables 3 and 5 for other than momentary conditions, contact the factory for recommendations. When Type SH drives are supplied with opposed thrust bearings, the Type S maximum thrust ratings apply.

The thrust bearing options offered in Tables 3 and 5 are adequate for most irrigation and industrial applications. Special thrust bearing arrangements can be provided for unusual conditions that are not covered by Tables 3 and 5.

MODEL DESIGNATION: The model number designates the basic horsepower rating at 1760 RPM pump speed. The number is preceded by one of the following letter designations to define the type drive:

SL Standard Hollow Shaft Drive with Limited Thrust Capacity
S Standard Hollow Shaft Drive with Standard Thrust Capacity
SH Standard Hollow Shaft Drive with Heavy Thrust Capacity
SSL Solid Shaft Drive with Limited Thrust Capacity
SS Solid Shaft Drive with Standard Thrust Capacity
SSH Solid Shaft Drive with Heavy Thrust Capacity
C Combination Drive
CS Combination Drive with Solid Vertical Shaft
D Double Drive

Example: S 60 designates a Model 60, standard vertical hollow shaft gear drive with standard thrust bearing.
SH 60 designates a Model 60, standard vertical hollow shaft gear drive with heavy thrust capacity.

All orders are processed immediately upon receipt; however, to obtain the best possible service, the following information should be supplied when ordering:

Model Number and Type
Ratio (or input and output speed)
Coupling Bore in Hollow Shaft Type
Vertical Shaft Dimensions for Solid Shaft Type
Rotation Required
Motor Base Diameter for Combination Type
Flexible Shaft and Flange Requirements

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

RATIOS AND ROTATIONS: The ratio of a drive is defined as the ratio of the horizontal input speed to vertical output speed. For example, a 2:1 ratio would have a horizontal speed of twice the vertical speed. There are four rotational schemes available as shown in figure 1, 2, 3, and 4. Figure 1 is denoted as standard rotation. Figures 2, 3, and 4 are special rotation, being manufactured only on order, and are not subject to cancellation without charge for completed parts. CW—Clockwise; CCW—Counter-clockwise.

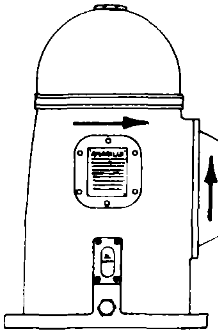


FIGURE 1
HORIZONTAL—CW
VERTICAL—CCW

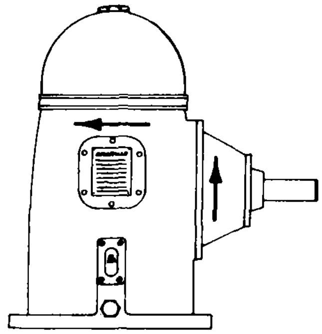


FIGURE 2
HORIZONTAL—CW
VERTICAL—CW

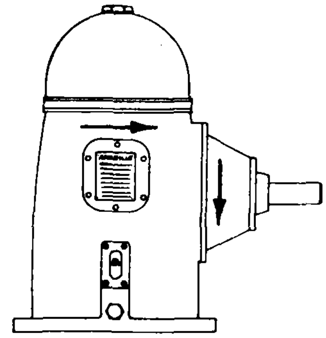


FIGURE 3
HORIZONTAL—CCW
VERTICAL—CCW

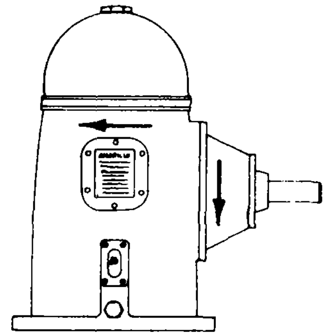


FIGURE 4
HORIZONTAL—CCW
VERTICAL—CW

RATINGS: Only bearings of major manufacturers are used in the Amarillo drives. Average bearing design life far exceeds that specified by the AGMA.

The permissible loading varies with the speed, and in borderline cases, up to 10% overloading is permitted before the warranty is voided. This overloading condition should be used with the knowledge that a corresponding reduction of 25% to 30% in bearing life may be expected.

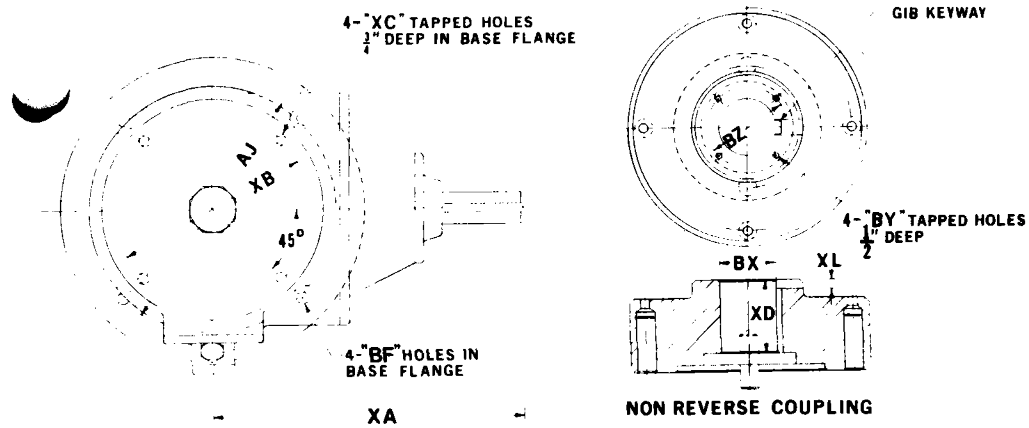
Tables 3 through 6 provide a means of rapid selection for most drive applications. The ratings given in these tables include a 1.5 service factor which is adequate for continuous operation of a deep well turbine or centrifugal pump driven by a multi-cylinder engine. Should speeds other than those listed be required, consult Table 1. Drives for special applications should be referred to the manufacturer. Our engineers will provide any necessary assistance in making your selection.

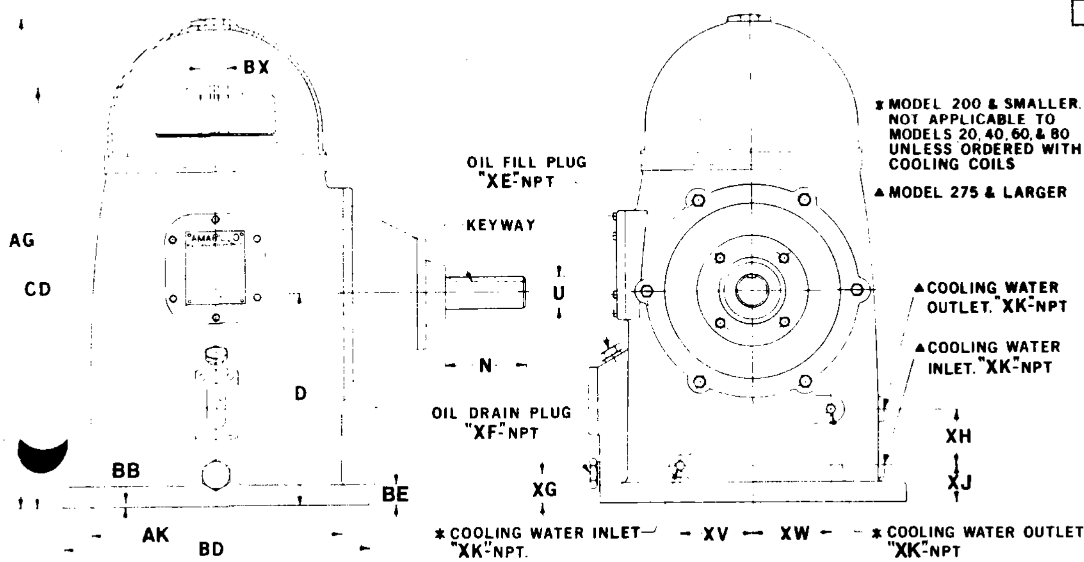
HORSEPOWER AND THRUST BEARING RATINGS
TABLE 1

Vertical Shaft R. P. M.	Percent of Rated Horsepower	Percent of Thrust Capacity	Vertical Shaft R. P. M.	Percent of Rated Horsepower	Percent of Thrust Capacity
430	37%	160%	*2000	105%	96%
580	46%	145%	*2200	111%	93%
690	52%	137%	*2400	116%	90%
720	54%	135%	*2600	122%	88%
870	61%	126%	*2800	128%	86%
960	66%	122%	*3000	133%	84%
1160	75%	115%	*3460	146%	80%
1460	88%	106%	*3600	150%	79%
1760	100%	100%			

*Cooling coils should be specified for Models 40, 60, and 80 operating with vertical speeds exceeding 1760 RPM. The factory should be consulted on Models 375 through 750 if vertical speeds exceed 1760 RPM.

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.





COUPLING DIMENSIONS
TABLE 2B

	MODEL	BX BORE' MAXIMUM		GIB KEYWAY	BY	BZ	XD	XL
		NOMINAL	ACTUAL					
*	20	1	1.001	1/4 X 1/8	0-32	1 3/8	1 5/16	9/32
	40A	1 1/4	1.251	1/4 X 1/8	1/4-20	1 3/4	1 3/4	9/32
	40B	1 1/4	1.251	1/4 X 1/8	1/4-20	1 3/4	1 3/4	9/32
	60	1 1/2	1.501	3/8 X 3/16	1/4-20	2 1/8	2	9/32
	80	1 1/2	1.501	3/8 X 3/16	1/4-20	2 1/8	2	9/32
	100	1 1/2	1.501	3/8 X 3/16	1/4-20	2 1/8	2	9/32
	125	1 11/16	1.686	3/8 X 3/16	1/4-20	2 1/2	2 1/4	9/32
**	150	2	2.001	1/2 X 1/4	1/4-20	2 1/2	3	9/32
	200	2	2.001	1/2 X 1/4	1/4-20	2 1/2	3	9/32
***	275	2 7/16	2.438	5/8 X 5/16	3/8-16	3 1/4	3	9/32
	375	2 7/16	2.438	5/8 X 5/16	3/8-16	3 1/4	3	9/32
	450	2 7/16	2.438	5/8 X 5/16	3/8-16	3 1/4	3	9/32
	600	2 7/16	2.438	5/8 X 5/16	3/8-16	3 1/4	3	9/32
	750	2 15/16	2.938	3/4 X 3/8			3 3/4	7/16

Smaller coupling bores and metric sizes are supplied as requested.

*Model 20, 1:3 ratio, maximum coupling bore 7/8".
Model 20, 1:3 ratio, not available with Fig. 2 or Fig. 3 rotation.

**Model 150, 1:3 ratio, maximum coupling bore 1-11/16".

***Model 275, 2:5 ratio, maximum coupling bore 2-3/16".

†Contact factory for maximum coupling bores for all gear drives with Fig. 2 or Fig. 3 rotation with 1:2, 2:5 or 1:3 ratio.

TABLE OF DIMENSIONS — STANDARD DRIVE
TABLE 2A

MODEL	D	N	HORIZONTAL SHAFT U			TYPE SL		TYPE S		TYPE SH		AJ	AK	BB	BD	BE	BF	XA	XB	XC	XE	XF	XG	XH	XJ	XK	XV	XW
			NOMINAL	ACTUAL	KEYWAY	AG	CD	AG	CD	AG	CD																	
20	6 3/4	2 5/8	1 1/4	1.249	5/16 X 5/32	16 1/4	13 3/4	16 1/4	13 3/4	17 1/4	14 3/4	9 1/8	8.250	3/16	10	5/8	7/16	10 7/8			3/8	3/8	15/16					
40A	8 1/2	4 3/8	1 1/2	1.499	3/8 X 3/16	21 3/4	18	21 3/4	18	23	19 1/4	9 1/8	8.250	1/4	12	13/16	7/16	15 5/8			1/2	1/2	1 1/4					
40B	8 1/2	4 3/8	1 1/2	1.499	3/8 X 3/16	21 3/4	18	21 3/4	18	23	19 1/4	14 3/4	13.500	1/4	16 1/2	13/16	11/16	15 5/8			1/2	1/2	1 1/4					
60	11 1/2	4 1/4	1 1/2	1.499	3/8 X 3/16	28	23 5/16	28	23 5/16	29 3/8	24 11/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4
80	11 1/2	4 1/4	1 7/8	1.874	3/8 X 3/16	29 1/4	24 9/16	28 1/2	23 13/16	30 1/4	25 9/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4
100	11 1/2	4 1/4	1 7/8	1.874	3/8 X 3/16	29 1/4	24 9/16	28 1/2	23 13/16	30 1/4	25 9/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4
125	11 1/2	4 1/2	2 7/16	2.436	5/8 X 5/16	30 1/4	25 1/8	29 3/8	24 1/4	31 1/8	26	14 3/4	13.500	1/4	16 1/2	3/4	11/16	18 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4
150	13 3/4	5 1/4	2 7/16	2.436	5/8 X 5/16	35 5/16	30 13/16	33 3/4	29 1/4	35 5/8	31 1/8	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	3/4	3/4	2 1/8	4 1/2	2 5/8	1/2	5	5
200	13 3/4	5 1/4	2 7/16	2.436	5/8 X 5/16	35 5/16	30 13/16	33 3/4	29 1/4	35 5/8	31 1/8	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	3/4	3/4	2 1/8	4 1/2	2 5/8	1/2	5	5
275	16	6	2 15/16	2.936	3/4 X 3/8	43 1/4	36 7/8	43 1/4	36 7/8	43 5/8	38	23	13.500	1/4	24 1/2	1 1/8	13/16	†25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4
375	16	6	2 15/16	2.936	3/4 X 3/8	43 1/4	36 7/8	43 5/8	38	46 1/8	38 1/4	23	13.500	1/4	24 1/2	1 1/8	13/16	†25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4
* 450	16	6	3 3/4	3.749	7/8 X 7/16	43 1/4	36 7/8	43 5/8	38	46 1/8	38 1/4	23	13.500	1/4	24 1/2	1 1/8	13/16	†25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4
600	18	6	3 3/4	3.749	7/8 X 7/16	48	41 3/8	50	42			23	13.500	1/4	24 1/2	1 1/8	13/16	†26 3/4	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	6	2 7/8	3/4	8 1/4	8 1/4
750	21	8	4	3.998	1 X 1/2	62 1/4	50 1/4	62 1/4	50 1/4			28 3/4	22.000	1/4	30 1/2	1 1/4	13/16	36 7/8	26	3/4-10-NC	3/4	3/4	2 15/16	6 1/4	3 5/8	3/4	8	8 1/2

* Horizontal shaft dimensions shown for Model 450 apply to ratios in Table 4 only. Consult factory for dimensions of all others.
† "XA" dimensions shown apply to ratios in Table 4 only. Consult factory for dimensions of all others.

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

TABLE 3

NOTE: Drives that are rated at 1760 RPM vertical speed **ARE NOT LIMITED** to 1760 RPM. See Table 1.

MODEL	Vertical Shaft RPM	H.P. Rating	DOWNTHRUST CAPACITY IN POUNDS — HOLLOW SHAFT — Type SL Min.	Type SL Max.	Type S Min.	Type S Max.	Type SH Min.	Type SH Max.	SOLID SHAFT — Type SSL Min.	Type SSL Max.	Type SS Min.	Type SS Max.	Type SSH Min.	Type SSH Max.	COMB. — Type C Min.	Type C Max.
20	1160	15	0	978	797	2358	797	3680	0	978	0	2358			0	2358
	1460	18	0	901	760	2173	760	3392	0	901	0	2173			0	2173
	1760	20	0	850	700	2050	700	3200	0	850	0	2050			0	2050
	3460	30	0	680	534	1640	534	2560	0	680	0	1640			0	1640
40	1160	30	0	1495	1138	3565	1138	5520	0	1495	0	3565			0	3565
	1460	35	0	1378	1055	3286	1055	5088	0	1378	0	3286			0	3286
	1760	40	0	1300	1000	3100	1000	4800	0	1300	0	3100			0	3100
60	960	39	0	2074	1490	5002	1490	7320	0	2074	0	5002			0	5002
	1160	45	0	1955	1422	4715	1422	6900	0	1955	0	4715			0	4715
	1460	53	0	1802	1331	4346	1331	6360	0	1802	0	4346			0	4346
	1760	60	0	1700	1250	4100	1250	6000	0	1700	0	4100			0	4100
80	960	52	0	3904	2085	6954	2085	11224	0	3904	0	6954			0	6954
	1160	60	0	3680	1991	6555	1991	10580	0	3680	0	6555			0	6555
	1460	70	0	3392	1846	6042	1846	9752	0	3392	0	6042			0	6042
	1760	80	0	3200	1750	5700	1750	9200	0	3200	0	5700			0	5700
100	960	66	0	3904	2101	7198	2101	11224	0	3904	0	7198			0	7198
	1160	75	0	3680	1991	6785	1991	10580	0	3680	0	6785			0	6785
	1460	88	0	3392	1856	6254	1856	9752	0	3392	0	6254			0	6254
	1760	100	0	3200	1750	5900	1750	9200	0	3200	0	5900			0	5900
125	720	68	0	5535	3135	7965	3135	12420	0	5535	0	7965			0	7965
	960	83	0	5002	2722	7198	2722	11224	0	5002	0	7198			0	7198
	1160	94	0	4715	2560	6781	2560	10580	0	4715	0	6781			0	6781
	1460	110	0	4346	2387	6254	2387	9752	0	4346	0	6254			0	6254
	1760	125	0	4100	2250	5900	2250	9200	0	4100	0	5900			0	5900
150	720	80	0	6750	3520	9180	3520	14243	0	6750	0	9180	0	14243	0	9180
	960	98	0	6100	3234	8296	3234	12871	0	6100	0	8296	0	12871	0	8296
	1160	112	0	5750	3059	7820	3059	12133	0	5750	0	7820	0	12133	0	7820
	1460	132	0	5300	2864	7208	2864	11183	0	5300	0	7208	0	11183	0	7208
	1760	150	0	5000	2700	6800	2700	10550	0	5000	0	6800	0	10550	0	6800
200	720	107	0	6750	3531	9180	3531	14243	0	6750	0	9180	0	14243	0	9180
	960	131	0	6100	3242	8296	3242	12871	0	6100	0	8296	0	12871	0	8296
	1160	150	0	5750	3072	7820	3072	12133	0	5750	0	7820	0	12133	0	7820
	1460	176	0	5300	2864	7208	2864	11183	0	5300	0	7208	0	11183	0	7208
	1760	200	0	5000	2700	6800	2700	10550	0	5000	0	6800	0	10550	0	6800
275	720	147	0	8100	3920	13973	3920	25650	0	8100	0	13973	3920	25650	CONSULT FACTORY	
	960	180	0	7320	3600	12627	3600	23180	0	7320	0	12627	3600	23180		
	1160	206	0	6900	3410	11903	3410	21850	0	6900	0	11903	3410	21850		
	1460	241	0	6360	3169	10971	3169	20140	0	6360	0	10971	3169	20140		
	1760	275	0	6000	3000	10350	3000	19000	0	6000	0	10350	3000	19000		
375	580	172	0	8700	4871	27550	4871	36250	0	8700	0	15008	4871	27550	CONSULT FACTORY	
	720	201	0	8100	4586	25650	4586	33750	0	8100	0	13973	4586	25650		
	960	246	0	7320	4209	23180	4209	30500	0	7320	0	12627	4209	23180		
	1160	281	0	6900	3979	21850	3979	28750	0	6900	0	11903	3979	21850		
	1460	329	0	6360	3702	20140	3702	26500	0	6360	0	10971	3702	20140		
	1760	375	0	6000	3500	19000	3500	25000	0	6000	0	10350	3500	19000		
450	580	207	0	8700	5583	27550	5583	36250	0	8700	0	15008	5583	27550	CONSULT FACTORY	
	720	241	0	8100	5236	25650	5236	33750	0	8100	0	13973	5236	25650		
	960	295	0	7320	4807	23180	4807	30500	0	7320	0	12627	4807	23180		
	1160	337	0	6900	4545	21850	4545	28750	0	6900	0	11903	4545	21850		
	1460	395	0	6360	4232	20140	4232	26500	0	6360	0	10971	4232	20140		
	1760	450	0	6000	4000	19000	4000	25000	0	6000	0	10350	4000	19000		
600	580	275	0	11600	6259	36250	CONSULT FACTORY		0	11600	0	15008	6259	36250	CONSULT FACTORY	
	720	321	0	10800	5885	33750			0	10800	0	13973	5885	33750		
	870	367	0	10080	5568	31500			0	10080	0	13041	5568	31500		
	960	393	0	9760	5404	30500			0	9760	0	12627	5404	30500		
	1160	449	0	9200	5109	28750			0	9200	0	11903	5109	28750		
	1460	527	0	8480	4765	26500			0	8480	0	10971	4765	26500		
	1760	600	0	8000	4500	25000			0	8000	0	10350	4500	25000		
750	580	344	0	11310	6959	36250	CONSULT FACTORY		0	11310	0	15008	6259	36250	CONSULT FACTORY	
	720	401	0	10530	6535	33750			0	10530	0	13973	5885	33750		
	870	458	0	9828	6177	31500			0	9828	0	13041	5568	31500		
	960	491	0	9516	6001	30500			0	9516	0	12627	5404	30500		
	1160	561	0	8970	5674	28750			0	8920	0	11903	5109	28750		
	1460	659	0	8268	5296	26500			0	8268	0	10971	4765	26500		
	1760	750	0	7800	5000	25000			0	7800	0	10350	4500	25000		

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

TABLE 4

NOTE: Drives that are rated at 1760 RPM vertical speed **ARE NOT LIMITED** to 1760 RPM. See Table 1.

MODEL	VERTICAL SHAFT RPM	ENGINE RPM											
		1:1	10:11	5:6	4:5	3:4	2:3	5:8	4:7	1:2	4:9	2:5	1:3*
20	1160 1460 1760 3460	1160 1460 1760 3460		967 1217 1467 2883		870 1095 1320 2595	773 973 1173 2307			580 730 880 1730			387 487 587 1153
40	1160 1460 1760	1160 1460 1760		967 1217 1467		870 1095 1320	773 973 1173		667 840 1012	580 730 880			387 487 587
60	960 1160 1460 1760	960 1160 1460 1760	864 1044 1314 1584	800 967 1217 1467	768 928 1168 1408	720 870 1095 1320	640 773 973 1173	597 721 908 1094	545 659 830 1000	480 580 730 880		398 481 605 730	320 387 487 587
80	960 1160 1460 1760	960 1160 1460 1760	864 1044 1314 1584	800 967 1217 1467	768 928 1168 1408	720 870 1095 1320	640 773 973 1173	597 721 908 1094	545 659 830 1000	480 580 730 880		398 481 605 730	320 387 487 587
100	960 1160 1460 1760	960 1160 1460 1760	864 1044 1314 1584	800 967 1217 1467	768 928 1168 1408	720 870 1095 1320	640 773 973 1173	597 721 908 1094	545 659 830 1000	480 580 730 880		398 481 605 730	
125	720 960 1160 1460 1760	720 960 1160 1460 1760	650 867 1048 1319 1590	600 800 967 1217 1467	576 768 928 1168 1408	540 720 870 1095 1320	480 640 773 973 1173						
150	720 960 1160 1460 1760	720 960 1160 1460 1760	650 867 1048 1319 1590	597 796 960 1210 1458	576 768 928 1168 1408	540 720 870 1095 1320	480 640 773 973 1173		409 545 659 830 1000	360 480 580 730 880	320 426 516 649 782	293 391 473 595 717	240 320 387 487 587
200	720 960 1160 1460 1760	720 960 1160 1460 1760	650 867 1048 1319 1590	597 796 960 1210 1458	576 768 928 1168 1408	540 720 870 1095 1320	480 640 773 973 1173		409 545 659 830 1000	360 480 580 730 880	320 426 516 649 782	293 391 473 595 717	
275	720 960 1160 1460 1760	720 960 1160 1460 1760	656 875 1058 1331 1605	623 830 1003 1263 1522	576 768 928 1168 1408	540 720 870 1095 1320	480 640 773 973 1173	450 600 725 913 1100	409 546 660 830 1000	352 470 568 715 862	318 425 513 646 778	291 388 468 590 711	CONSULT FACTORY
375	580 720 960 1160 1460 1760	580 720 960 1160 1460 1760	529 656 875 1058 1331 1605	502 623 830 1003 1263 1522	464 576 768 928 1168 1408	439 545 726 875 1105 1332	392 486 648 783 985 1188	363 450 600 725 913 1100	330 409 546 660 830 1000	284 352 470 568 715 862			CONSULT FACTORY
450	580 720 960 1160 1460 1760	580 720 960 1160 1460 1760	529 656 875 1058 1331 1605	502 623 830 1003 1263 1522	461 573 764 923 1161 1400	439 545 726 878 1105 1332	392 486 648 783 985 1188	363 450 600 725 913 1100	330 409 546 660 830 1000	284 352 470 568 715 862			CONSULT FACTORY
600	580 720 870 960 1160 1460 1760	580 720 870 960 1160 1460 1760	521 646 781 862 1041 1310 1579	486 603 729 804 972 1223 1475	461 573 692 764 923 1161 1400	432 536 648 715 864 1087 1311	383 475 574 634 766 964 1162	360 447 539 595 719 905 1091	327 406 490 541 654 823 992	285 353 427 471 569 717 864			CONSULT FACTORY
750	580 720 870 960 1160 1460 1760	565 700 846 933 1128 1421 1712	521 646 781 862 1041 1310 1579	486 603 729 804 972 1223 1475		429 533 643 710 858 1080 1302	383 475 574 634 766 963 1162		327 406 490 541 654 823 992	276 342 414 456 551 694 837			CONSULT FACTORY

* Model 20 1:3 ratio not available with Figure 2 or Figure 3 rotation.

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

TABLE 5

NOTE: Drives that are rated at 1760 RPM vertical speed **ARE NOT LIMITED** to 1760 RPM. See Table 1.

MODEL	Vertical Shaft RPM	H.P. Rating	DOWNTHRUST CAPACITY IN POUNDS													
			HOLLOW SHAFT						SOLID SHAFT						COMB.	
			Type SL		Type S		Type SH		Type SSL		Type SS		Type SSH		Type C	
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
20	1160	15	0	978	797	2358	797	3680	0	978	0	2358			0	2358
	1460	18	0	901	760	2173	760	3392	0	901	0	2173			0	2173
	1760	20	0	850	700	2050	700	3200	0	850	0	2050			0	2050
	3460	30	0	680	534	1640	534	2560	0	680	0	1640			0	1640
40	1160	30	0	1495	1138	3565	1138	5520	0	1495	0	3565			0	3565
	1460	35	0	1378	1055	3286	1055	5088	0	1378	0	3286			0	3286
	1760	40	0	1300	1000	3100	1000	4800	0	1300	0	3100			0	3100
60	960	39	0	2074	1490	5002	1490	7320	0	2074	0	5002			0	5002
	1160	45	0	1955	1422	4715	1422	6900	0	1955	0	4715			0	4715
	1460	53	0	1802	1331	4346	1331	6360	0	1802	0	4346			0	4346
	1760	60	0	1700	1250	4100	1250	6000	0	1700	0	4100			0	4100
80	960	52	0	3904	2085	6954	2085	11224	0	3904	0	6954			0	6954
	1160	60	0	3680	1991	6555	1991	10580	0	3680	0	6555			0	6555
	1460	70	0	3392	1846	6042	1846	9752	0	3392	0	6042			0	6042
	1760	80	0	3200	1750	5700	1750	9200	0	3200	0	5700			0	5700
100	960	66	0	3904	2101	7198	2101	11224	0	3904	0	7198			0	7198
	1160	75	0	3680	1991	6785	1991	10580	0	3680	0	6785			0	6785
	1460	88	0	3392	1856	6254	1856	9752	0	3392	0	6254			0	6254
	1760	100	0	3200	1750	5900	1750	9200	0	3200	0	5900			0	5900
125	720	68	0	5535	3135	7965	3135	12420	0	5535	0	7965			0	7965
	960	83	0	5002	2722	7198	2722	11224	0	5002	0	7198			0	7198
	1160	94	0	4715	2560	6781	2560	10580	0	4715	0	6781			0	6781
	1460	110	0	4346	2387	6254	2387	9752	0	4346	0	6254			0	6254
	1760	125	0	4100	2250	5900	2250	9200	0	4100	0	5900			0	5900
150	720	80	0	6750	3520	9180	3520	14243	0	6750	0	9180	0	14243	0	9180
	960	98	0	6100	3234	8296	3234	12871	0	6100	0	8296	0	12871	0	8296
	1160	112	0	5750	3059	7820	3059	12133	0	5750	0	7820	0	12133	0	7820
	1460	132	0	5300	2864	7208	2864	11183	0	5300	0	7208	0	11183	0	7208
	1760	150	0	5000	2700	6800	2700	10550	0	5000	0	6800	0	10550	0	6800
200	720	107	0	6750	3531	9180	3531	14243	0	6750	0	9180	0	14243	0	9180
	960	131	0	6100	3242	8296	3242	12871	0	6100	0	8296	0	12871	0	8296
	1160	150	0	5750	3072	7820	3072	12133	0	5750	0	7820	0	12133	0	7820
	1460	176	0	5300	2864	7208	2864	11183	0	5300	0	7208	0	11183	0	7208
	1760	200	0	5000	2700	6800	2700	10550	0	5000	0	6800	0	10550	0	6800
275	720	147	0	8100	3920	13973	3920	25650	0	8100	0	13973	3920	25650	CONSULT FACTORY	
	960	180	0	7320	3600	12627	3600	23180	0	7320	0	12627	3600	23180		
	1160	206	0	6900	3410	11903	3410	21850	0	6900	0	11903	3410	21850		
	1460	241	0	6360	3169	10971	3169	20140	0	6360	0	10971	3169	20140		
	1760	275	0	6000	3000	10350	3000	19000	0	6000	0	10350	3000	19000		
375	580	172	0	8700	4871	27550	4871	36250	0	8700	0	15008	4871	27550	CONSULT FACTORY	
	720	201	0	8100	4586	25650	4586	33750	0	8100	0	13973	4586	25650		
	960	246	0	7320	4209	23180	4209	30500	0	7320	0	12627	4209	23180		
	1160	281	0	6900	3979	21850	3979	28750	0	6900	0	11903	3979	21850		
	1460	329	0	6360	3702	20140	3702	26500	0	6360	0	10971	3702	20140		
	1760	375	0	6000	3500	19000	3500	25000	0	6000	0	10350	3500	19000		
450	580	207	0	8700	5583	27550	5583	36250	0	8700	0	15008	5583	27550	CONSULT FACTORY	
	720	241	0	8100	5236	25650	5236	33750	0	8100	0	13973	5236	25650		
	960	295	0	7320	4807	23180	4807	30500	0	7320	0	12627	4807	23180		
	1160	337	0	6900	4545	21850	4545	28750	0	6900	0	11903	4545	21850		
	1460	395	0	6360	4232	20140	4232	26500	0	6360	0	10971	4232	20140		
	1760	450	0	6000	4000	19000	4000	25000	0	6000	0	10350	4000	19000		
600	580	275	0	11600	6259	36250	CONSULT FACTORY		0	11600	0	15008	6259	36250	CONSULT FACTORY	
	720	321	0	10800	5885	33750			0	10800	0	13973	5885	33750		
	870	367	0	10080	5568	31500			0	10080	0	13041	5568	31500		
	960	393	0	9760	5404	30500			0	9760	0	12627	5404	30500		
	1160	449	0	9200	5109	28750			0	9200	0	11903	5109	28750		
	1460	527	0	8480	4765	26500			0	8480	0	10971	4765	26500		
	1760	600	0	8000	4500	25000			0	8000	0	10350	4500	25000		
750	580	344	0	11310	6959	36250	CONSULT FACTORY		0	11310	0	15008	6259	36250	CONSULT FACTORY	
	720	401	0	10530	6535	33750			0	10530	0	13973	5885	33750		
	870	458	0	9828	6177	31500			0	9828	0	13041	5568	31500		
	960	491	0	9516	6001	30500			0	9516	0	12627	5404	30500		
	1160	561	0	8970	5674	28750			0	8920	0	11903	5109	28750		
	1460	659	0	8268	5296	26500			0	8268	0	10971	4765	26500		
	1760	750	0	7800	5000	25000			0	7800	0	10350	4500	25000		

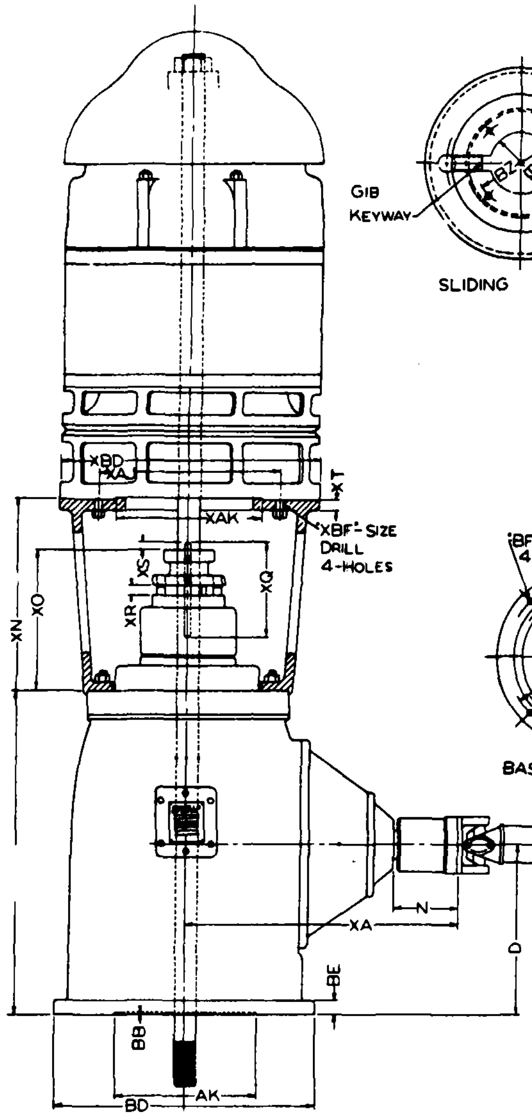
Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

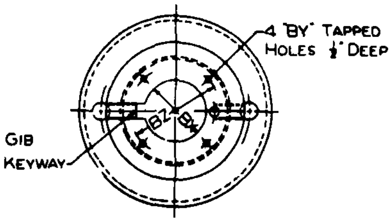
TABLE 6

NOTE: Drives that are rated at 1760 RPM vertical speed **ARE NOT LIMITED** to 1760 RPM. See Table 1.

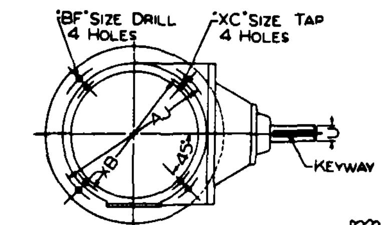
MODEL	VERTICAL SHAFT RPM	ENGINE RPM 11:10	6:5	5:4	4:3	3:2	8:5	7:4	2:1	9:4	5:2	3:1
20	1160		1392		1547	1740						
	1460		1752		1947	2190						
	1760		2112		2347	2640						
	3460											
40	1160		1392		1557	1740		2017	2320			3480
	1460		1752		1947	2190		2539	2920			4380
	1760		2112		2347	2640		3061	3520			—
60	960	1067	1152	1200	1280	1440	1544	1690	1920			2880
	1160	1289	1392	1450	1547	1740	1866	2042	2320			3480
	1460	1622	1752	1825	1947	2190	2348	2570	2920			—
	1760	1956	2112	2200	2347	2640	2831	3098	3520			—
80	960	1067	1152	1200	1280	1440	1544	1690	1920			2880
	1160	1289	1392	1450	1547	1740	1866	2042	2320			3480
	1460	1622	1752	1825	1947	2190	2348	2570	2920			—
	1760	1956	2112	2200	2347	2640	2831	3098	3520			—
100	960	1067	1152	1200	1280	1440						
	1160	1289	1392	1450	1547	1740						
	1460	1622	1752	1825	1947	2190						
	1760	1956	2112	2200	2347	2640						
125	720	797	864	900	960	1080		1267	1440			
	960	1063	1152	1200	1280	1440		1690	1920			
	1160	1284	1392	1450	1547	1740		2042	2320			
	1460	1616	1752	1825	1947	2190		2570	2920			
	1760	1949	2112	2200	2347	2640		3098	3520			
150	720	797	869	900	960	1080	1158	1267	1440		1736	2160
	960	1063	1159	1200	1280	1440	1544	1690	1920		2315	2880
	1160	1284	1400	1450	1547	1740	1866	2042	2320		2798	3480
	1460	1616	1762	1825	1947	2190	2348	2570	2920		3521	—
	1760	1949	2124	2200	2347	2640	2831	3098	3520		—	—
200	720	797	869	900	960	1080		1267	1440			2160
	960	1063	1159	1200	1280	1440		1690	1920			2880
	1160	1284	1400	1450	1547	1740		2042	2320			3480
	1460	1616	1762	1825	1947	2190		2570	2920			
	1760	1949	2124	2200	2347	2640		3098	3520			
275	720	790	833	900	960	1080	1152	1267	1440	1620	1767	2160
	960	1053	1110	1200	1280	1440	1536	1690	1920	2160	2356	2880
	1160	1272	1341	1450	1547	1740	1856	2042	2320	2610	2847	3480
	1460	1601	1688	1825	1947	2190	2336	2570	2920	3285	3584	
	1760	1930	2035	2200	2347	2640	2816	3098	3520	—	—	
375	580	636	671	725	773	870	928	1020	1183	1305	1424	1740
	720	790	833	900	960	1080	1152	1266	1467	1620	1767	2160
	960	1053	1110	1200	1280	1440	1536	1688	1958	2160	2356	2880
	1160	1273	1341	1450	1547	1740	1856	2040	2366	2610	2847	3480
	1460	1601	1688	1825	1947	2190	2336	2568	2978	3285	3584	—
	1760	1930	2035	2200	2347	2640	2816	3095	3590	—		—
450	580	636	671	725	766	859	928	1020	1183	1311	1436	1769
	720	790	833	900	951	1067	1152	1266	1467	1628	1783	2196
	960	1053	1110	1200	1269	1422	1536	1688	1958	2170	2377	2928
	1160	1273	1341	1450	1533	1719	1856	2040	2366	2623	3872	3538
	1460	1601	1688	1825	1929	2163	2336	2568	2978	3301	3615	—
	1760	1930	2035	2200	2326	2607	2816	3095	3590	—	—	—
600	580	646	692	729	766	859	928	1020	1183	1311	1436	1769
	720	802	859	905	951	1067	1152	1266	1469	1628	1783	2196
	870	969	1038	1093	1150	1289	1392	1530	1775	1967	2154	2654
	960	1070	1146	1206	1269	1422	1536	1688	1958	2170	2377	2928
	1160	1293	1385	1458	1533	1719	1856	2040	2366	2623	2872	3538
	1460	1627	1743	1835	1929	2163	2336	2568	2978	3301	3615	—
	1760	1961	2100	2212	2326	2607	2816	3095	3590	—	—	—
750	580	646	692		779	879	935	1029	1183			1771
	720	802	859		967	1091	1161	1277	1469			2198
	870	969	1038		1168	1318	1403	1544	1775			2656
	960	1070	1146		1289	1455	1548	1703	1958			2931
	1160	1293	1385		1558	1758	1871	2058	2366			3541
	1460	1627	1743		1961	2212	2355	2590	2978			—
	1760	1961	2100		2363	2667	2839	—	3590			—

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.





SLIDING CLUTCH



BASE FLANGE DRILLING

COMBINATION DRIVE

In response to the need for utmost reliability, a combination drive may be specified. This drive is normally installed with an electric motor top-mounted for constant service. In the event of power failure or motor failure the drive is simply converted for engine or turbine operation by lowering the integral sliding clutch into drive position. No additional pins or bolts are required for this conversion. These combination drives may be furnished with either solid or hollow shafts. Consult combination drive operation manual for installation instructions.

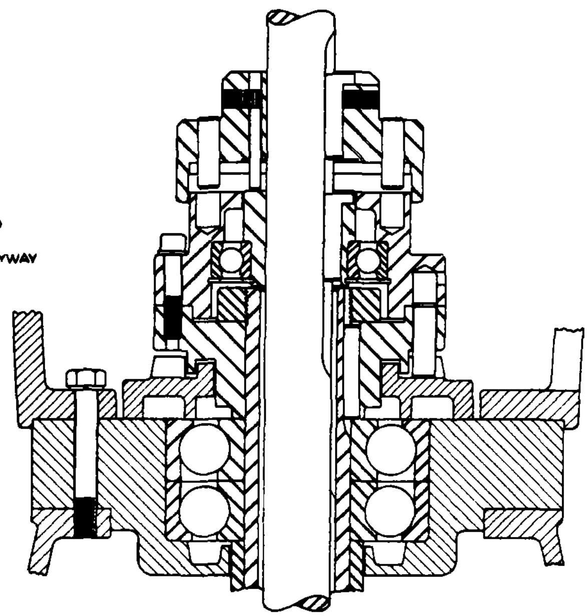

Combination Clutch — Sub-Assembly
Clutch Shown Disengaged

TABLE OF DIMENSIONS — COMBINATION DRIVE
TABLE 7

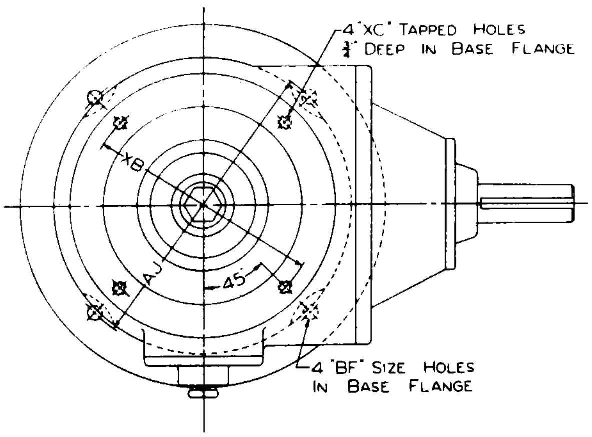
MODEL	D	N	Horizontal Shaft U			AJ	AK	BB	BD	BE	BF	XA	XB	XC	XL	XM	XN	XO	XQ	XR	XS	XT	XAJ	XAK	XBD	XBF	BX Bore Maximum
			Nominal	Actual	Keyway																						
C20	6 3/4	2 5/8	1 1/4	1.249	5/16 X 5/32	9 1/8	8.250	3/16	10	5/8	7/16	10 7/8			9/32	12 1/4	12 1/2	5 1/2	5 1/4	1/2	1 1/2	7/16					1 *
C40A	8 1/2	4 3/8	1 1/2	1.499	3/8 X 3/16	9 1/8	8.250	1/4	12	13/16	7/16	15 5/8			9/32	16 3/16	16	6 1/2	7	5/8	2	5/8					1 1/4
C40B	8 1/2	4 3/8	1 1/2	1.499	3/8 X 3/16	14 3/4	13.500	1/4	16 1/2	13/16	11/16	15 5/8			9/32	16 3/16	16	6 1/2	7	5/8	2	5/8					1 1/4
C60	11 1/2	4 1/4	1 1/2	1.499	3/8 X 3/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			9/32	20 1/4	18	7 13/16	7 3/4	3/4	2 1/4	3/4					1 1/2
C80	11 1/2	4 1/4	1 7/8	1.874	3/8 X 3/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			9/32	20 3/8	18	7 13/16	7 3/4	3/4	2 1/4	3/4					1 1/2
C100	11 1/2	4 1/4	1 7/8	1.874	3/8 X 3/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			9/32	20 3/8	18	7 13/16	7 3/4	3/4	2 1/4	3/4					1 1/2
C125	11 1/2	4 1/2	2 7/16	2.436	5/8 X 5/16	14 3/4	13.500	1/4	16 1/2	3/4	11/16	18 3/4			9/32	21 1/8	18	7 1/2	9	3/4	2 1/4	3/4					1 11/16
C150	13 3/4	5 1/4	2 7/16	2.436	5/8 X 5/16	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	9/32	25 5/8	20	9	10	7/8	2 3/4	7/8					2 *
C200	13 3/4	5 1/4	2 7/16	2.436	5/8 X 5/16	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	9/32	25 5/8	20	9	10	7/8	2 3/4	7/8					2
C275	16	6	2 15/16	2.936	3/4 X 3/8	23	13.500	1/4	24 1/2	1 1/8	13/16	† 25 1/2	14 3/4	5/8-11-NC	9/32	32 5/8	27	12	11 1/2	1 1/8	3 1/2	1					2 7/16
C375	16	6	2 15/16	2.936	3/4 X 3/8	23	13.500	1/4	24 1/2	1 1/8	13/16	† 25 1/2	14 3/4	5/8-11-NC	9/32	32 5/8	27	12	11 1/2	1 1/8	3 1/2	1					2 7/16
** C450	16	6	3 3/4	3.749	7/8 X 7/16	23	13.500	1/4	24 1/2	1 1/8	13/16	† 25 1/2	14 3/4	5/8-11-NC	9/32	32 5/8	27	12	11 1/2	1 1/8	3 1/2	1					2 7/16
C600	18	6	3 3/4	3.749	7/8 X 7/16	23	13.500	1/4	24 1/2	1 1/8	13/16	† 26 3/4	14 3/4	5/8-11-NC	9/32	34 1/4	27	12 1/4	11 1/2	1 1/8	3 1/2	1 1/8					2 7/16
C750	21	8	4	3.998	1 X 1/2	28 3/4	22.000	1/4	30 1/2	1 1/4	13/16	36 7/8	26	3/4-10-NC	7/16		30	16 1/4	15	1 3/16	4	1 1/4					2 15/16

* Model C20, ratio 1:3, maximum clutch bore 7/8"; Model C150, ratio 1:3, maximum 1-11/16". Consult factory for maximum clutch bore for Fig. 2 and Fig. 3 rotation. Model C20, 1:3 ratio, not available with Fig. 2 or Fig. 3 rotation.

** Horizontal shaft dimensions shown for Model 450 apply to ratios in Table 4 only. Consult factory for dimensions of all others.

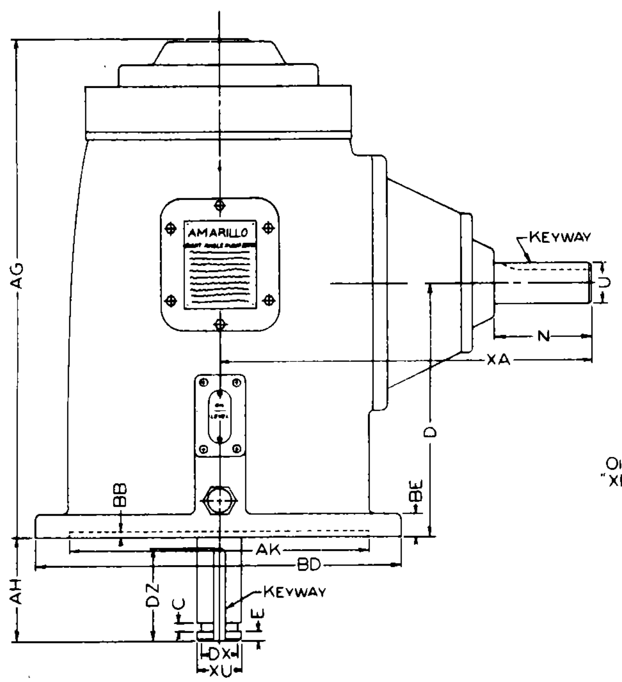
† "XA" dimensions shown apply to ratios in Table 4 only. Consult factory for dimensions of all others.

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.



SOLID SHAFT DRIVES

Amarillo Right Angle Gear Drives can be furnished as shown with Vertical Solid Shaft. See Table 3 and 5 for thrust capacity. Also available with top output shaft or with top output shaft and motor stand.



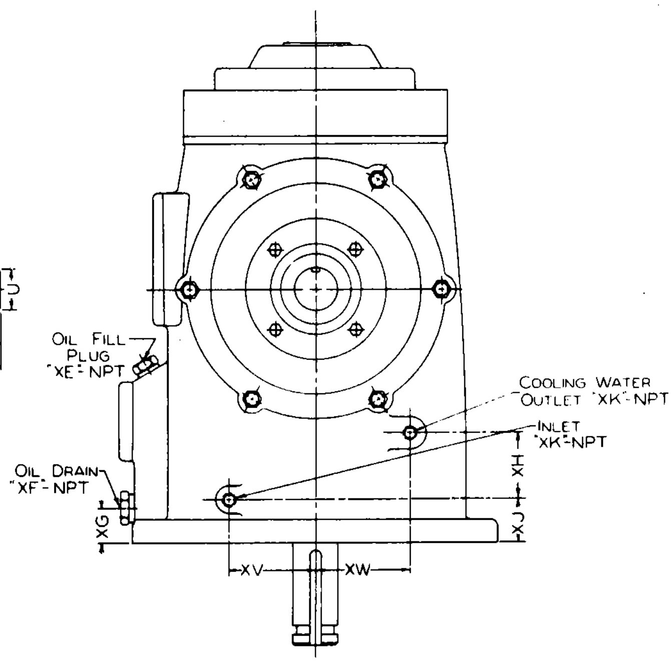


TABLE OF DIMENSIONS — SOLID SHAFT DRIVE

TABLE 8

MODEL	D	N	Horizontal Shaft U Nominal	Horizontal Shaft U Actual	Horizontal Shaft U Keyway	AG Type SSL	AG Type SS	AG Type SSH	AJ	AK	BB	BD	BE	BF	XA	XB	XC	XE	XF	XG	XH	XJ	XK	XV	XW	AH	XU Nominal	XU Actual	XU Keyway	C	E	DX	DZ
20	6 3/4	2 5/8	1 1/4	1.249	5/16 x 5/32	13 1/2	14 1/2		9 1/8	11.250	3/16	10	5/8	7/16	10 7/8			3/8	3/8	15/16						2 3/4	1	.999	1/4 x 1/8	3/8	3/8	15/16	2 1/2
40 A	8 1/2	4 3/8	1 1/2	1.499	3/8 x 3/16	18 1/2	19 3/4		9 1/8	8.250	1/4	12	13/16	7/16	15 5/8			1/2	1/2	1 1/4						4 1/2	1 1/4	1.249	5/16 x 5/32	3/8	3/8	1 1/16	4
40 B	8 1/2	4 3/8	1 1/2	1.499	3/8 x 3/16	18 1/2	19 3/4		14 3/4	13.500	1/4	16 1/2	13/16	11/16	15 5/8			1/2	1/2	1 1/4						4 1/2	1 1/4	1.249	5/16 x 5/32	3/8	3/8	1 1/16	4
60	11 1/2	4 1/4	1 1/2	1.499	3/8 x 3/16	22 5/8	24		14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4	4 1/2	1 1/2	1.499	3/8 x 3/16	3/8	3/8	1 3/16	4
80	11 1/2	4 1/4	1 7/8	1.874	3/8 x 3/16	24	25		14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4	4 1/2	1 1/2	1.499	3/8 x 3/16	3/8	3/8	1 3/16	4
100	11 1/2	4 1/4	1 7/8	1.874	3/8 x 3/16	24	25		14 3/4	13.500	1/4	16 1/2	3/4	11/16	16 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4	4 1/2	1 1/2	1.499	3/8 x 3/16	3/8	3/8	1 3/16	4
125	11 1/2	4 1/2	2 7/16	2.436	5/8 x 5/16	24	25		14 3/4	13.500	1/4	16 1/2	3/4	11/16	18 3/4			3/4	1/2	1 5/8	3	2	3/8	3 7/8	4 1/4	4 1/2	1 11/16	1.687	3/8 x 3/16	3/8	3/8	1 5/16	4
150	13 3/4	5 1/4	2 7/16	2.436	5/8 x 5/16	26 5/8	29	31 1/2	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	3/4	3/4	2 1/8	4 1/2	2 5/8	1/2	5	5	4 1/2	1 15/16	1.937	1/2 x 1/4	3/8	3/8	1 9/16	4
200	13 3/4	5 1/4	2 7/16	2.436	5/8 x 5/16	28 5/8	29	31 1/2	18 1/4	13.500	1/4	20	1 1/8	11/16	20 3/4	14 3/4	5/8-11-NC	3/4	3/4	2 1/8	4 1/2	2 5/8	1/2	5	5	4 1/2	1 15/16	1.937	1/2 x 1/4	3/8	3/8	1 9/16	4
275	16	6	2 15/16	2.936	3/4 x 3/8	34 7/8	37 1/2	35 1/4	23	13.500	1/4	24 1/2	1 1/8	13/16	25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4	5	2 3/8	2.374	5/8 x 5/16	3/8	3/8	2	4 1/2
375	16	6	2 15/16	2.936	3/4 x 3/8	34 7/8	37 1/2	35 1/4	23	13.500	1/4	24 1/2	1 1/8	13/16	25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4	5	2 3/8	2.374	5/8 x 5/16	3/8	3/8	2	4 1/2
450	16	6	3 3/4	3.749	7/8 x 7/16	34 7/8	37 1/2	35 1/4	23	13.500	1/4	24 1/2	1 1/8	13/16	25 1/2	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	4 1/2	2 3/4	3/4	7 3/4	7 3/4	5	2 3/8	2.374	5/8 x 5/16	3/8	3/8	2	4 1/2
600	18	6	3 3/4	3.749	7/8 x 7/16			38 1/2	23	13.500	1/4	24 1/2	1 1/8	13/16	26 3/4	14 3/4	5/8-11-NC	3/4	3/4	1 13/16	6	2 7/8	3/4	8 1/4	8 1/4	5	2 3/8	2.374	5/8 x 5/16	3/8	3/8	2	4 1/2
750	21	8	4	3.998	1 x 1/2		45	45 1/2	28 3/4	22.000	1/4	30 1/2	1 1/4	13/16	36 7/8	26	3/4-10-NC	3/4	3/4	2 5/16	6 1/4	3 3/8	3/4	8	8 1/2	6	2 15/16	2.936	3/4 x 3/8	1/2	1/2	2 7/16	5 1/2

* Horizontal shaft dimensions shown for Model 450 apply to ratios in Table 4 only. Consult factory for dimensions of all others.
† "XA" dimensions shown apply to ratios in Table 4 only. Consult factory for dimensions of all others.

Please see pages 12, 13 and 14 for all information on Models 1000 and 1200.

TABLE 10. MODEL 1000 POWER RATINGS*

SEE TABLE 13 FOR RATINGS OF MODEL 1000 WITH 7:4 AND GREATER DECREASING RATIO.

Vertical Shaft RPM	HP Rating	DRIVER RPM									
		1:1	5:6	4:5	3:4	2:3	4:7	1:2	6:5	4:3	3:2
580	460	593	487	464	429	383	327	276	690	784	879
720	535	736	605	576	533	475	406	342	857	973	1091
870	611	889	731	696	644	574	490	414	1036	1176	1318
960	654	981	806	768	710	634	541	456	1143	1297	1455
1160	747	1185	974	928	858	766	654	551	1381	1568	1758
1460	877	1491	1226	1168	1080	964	823	694	1738	1973	2212
1760	1000	1798	1478	1408	1302	1162	992	837			

* These ratings include a 1.5 service factor for continuous operation of a turbine or centrifugal pump driven by a multi-cylinder engine. When selection is to be made with a service factor other than 1.5 the ratings may be modified accordingly.

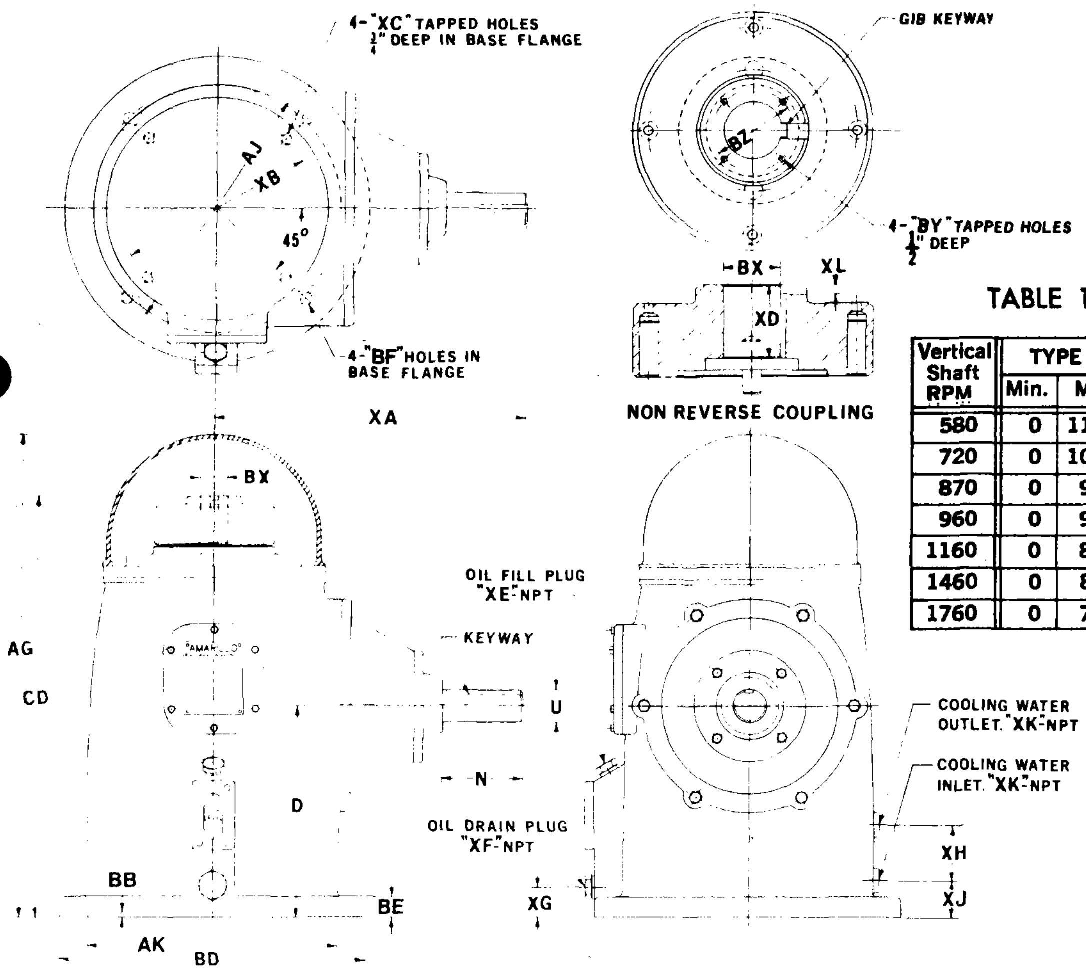


TABLE 11. THRUST RATINGS

Vertical Shaft RPM	TYPE SL		TYPE S		TYPE SH	
	Min.	Max.	Min.	Max.	Min.	Max.
580	0	11310	8374	36250	8374	46183
720	0	10530	7846	33750	7846	42972
870	0	9828	7416	31500	7416	40345
960	0	9516	7194	30500	7194	39043
1160	0	8970	6800	28750	6800	36656
1460	0	8268	6342	26500	6342	33950
1760	0	7800	6000	25000	6000	31900

TABLE 12—MODEL 1000 DIMENSIONS (Ratios Shown in Table 10 only)

MODEL	D	N	Horizonal Shaft U Nominal	Actual	Keyway	AG	AJ	AK	BB	BD	BE	BF	CD	XA	XB	XC	XD	XE	XF	XG	XH	XJ	XK	XL	BX MAX	Weight
1000	21	8	4	3.998	1 x 1/2	62 1/4	28 3/4	22.000	1/4	30 1/2	1 1/4	13/16	50 1/4	36 7/8	26	3/4-10NC	3 3/4	3/4	3/4	2 5/16	6 1/4	3 3/8	3/4	7/16	2 15/16	3000

Not for construction—Request certified prints.

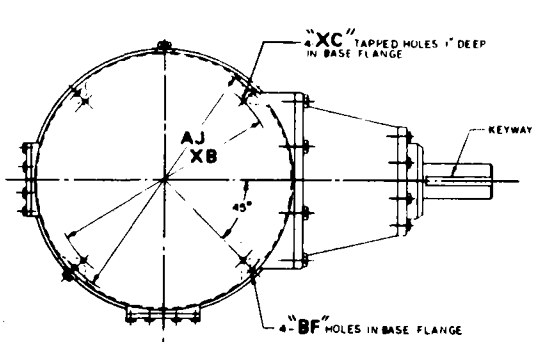
TABLE 13. MODEL 1000 POWER RATINGS*

7:4 AND GREATER DECREASING RATIOS

SEE TABLE 10 FOR OTHER RATIOS

Vertical Shaft RPM	HP Rating	DRIVER RPM						4:1		9:2		5:1	
		7:4	2:1	9:4	5:2	3:1	7:2	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM
250	255	444	509	560	619	763	882	218	1016	218	1143	201	1269
340	316	603	693	762	842	1038	1200	270	1381	270	1554	249	1726
430	373	763	876	963	1065	1313	1518	318	1747	318	1966	293	2183
580	460	1029	1181	1299	1436	1771	2047	392	2356	392	2651	362	2945
720	535	1277	1467	1613	1783	2198	2541	456	2925	456	3291	421	3655
870	611	1544	1772	1949	2154	2656	3071	521	3534				
960	654	1703	1956	2150	2377	2931	3388						
1160	747	2058	2363	2598	2872	3541							
1460	877	2590	2974	3270	3615								
1760													

* These ratings include a 1.5 service factor for continuous operation of a turbine or centrifugal pump driven by a multi-cylinder engine. When selection is to be made with a service factor other than 1.5 the ratings may be modified accordingly.



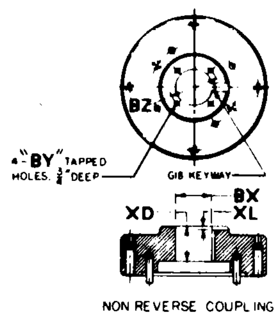


TABLE 14. THRUST RATINGS

Vertical Shaft RPM	TYPE SL		TYPE S
	Min.	Max.	
250	0	35264	
340	0	31829	
430	0	29433	
560	0	26638	
720	0	24786	Consult
870	0	23271	Factory
960	0	22520	
1160	0	21143	
1460	0	19583	
1760	0	18400	

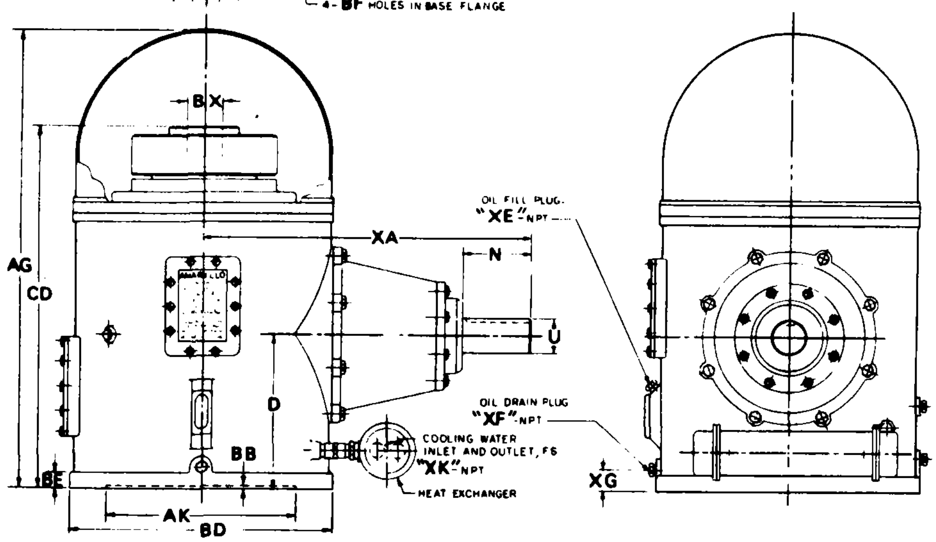


TABLE 15—MODEL 1000 DIMENSIONS (Ratios Shown in Table 13 only)

MODEL	D	N	Horizontal Shaft U			Type SL		Type S		Type SH		AJ	AK	BB	BD	BE	BF	XA	XB	XC	XE	XF	XG	XK	BX MAX	XD	XL	Weight
			Nominal	Actual	Keyway	AG	CD	AG	CD	AG	CD																	
1000	17	6	3 3/4	3.749	7/8 x 7/16	50 1/8	38 5/8	*	*	*	*	28 3/4	22.000	1/4	30 1/2	1 7/8	1 1/16	33 1/8	26	3/4-10 NC	1	1	2 1/8	1	4	3 3/4	7/16	2500

Not for construction—Request certified prints.

* Consult Factory

TABLE 16. MODEL 1200 POWER RATINGS*

Vertical Shaft RPM	1:1		4:3		3:2		7:4		2:1		5:2		3:1		4:1		5:1		6:1	
	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM	HP Rating	Driver RPM
250	306	255	320	338	306	379	369	444	349	526	313	630	309	762	278	1015	242	1268	214	1521
340	380	347	396	459	380	515	458	603	432	715	388	857	384	1036	345	1380	300	1724	265	2068
430	447	439	467	581	447	652	540	763	510	904	458	1084	452	1310	407	1745	353	2181	313	2616
580	552	593	576	784	552	879	665	1029	629	1220	564	1462	558	1768	502	2354	435	2941	386	3528
720	642	736	670	973	642	1091	774	1277	731	1514	656	1814	649	2194	584	2922	507	3651		
780	733	889	765	1176	733	1318	884	1544	835	1830	749	2192	741	2651	666	3531				
960	785	981	820	1297	785	1455	947	1703	894	2019	803	2419	794	2926	714	3896				
1160	896	1185	936	1568	896	1758	1081	2058	1021	2440	916	2923	906	3535						
1460	1053	1492																		
1760	1200	1798																		

* These ratings include a 1.5 service factor for continuous operation of a turbine or centrifugal pump driven by a multi-cylinder engine. When selection is to be made with a service factor other than 1.5 the ratings may be modified accordingly.

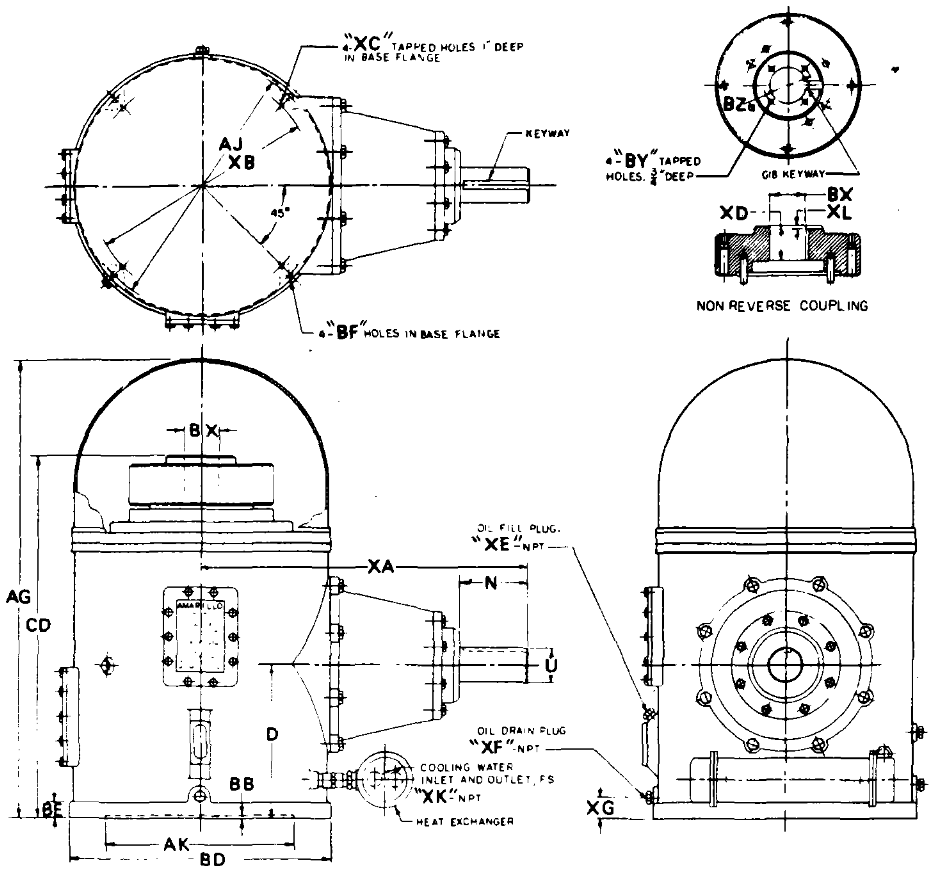


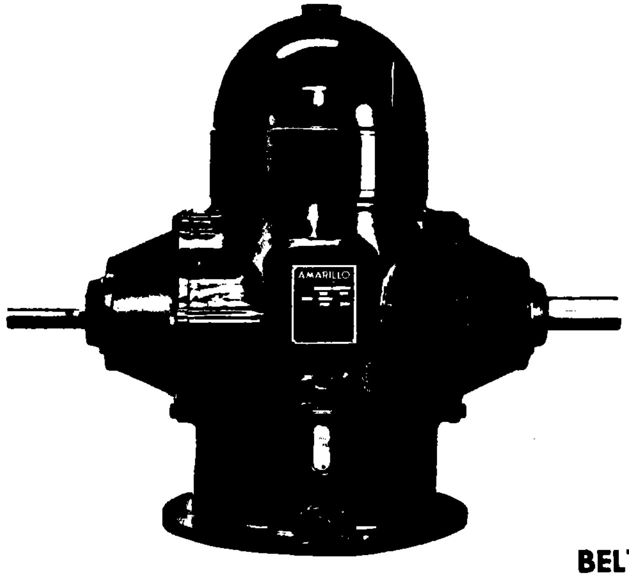
TABLE 17 THRUST RATINGS

Vertical Shaft RPM	Type SL		Type S		Type SH	
	Min.	Max.	Min.	Max.	Min.	Max.
250	0	32980	14361	44820	14361	64107
340	0	30075	13090	39840	13090	56985
430	0	28060	12115	38030	12115	54395
580	0	25590	11167	34385	11167	49180
720	0	23920	10560	32180	10560	46025
870	0	22615	9872	30610	9872	43780
960	0	22060	9680	29530	9680	42235
1160	0	20850	9103	27890	9103	39890
1460	0	19395	8486	26150		
1760	0	18400				

TABLE 18 DIMENSIONS

Model	D	N	Horizontal Shaft U			Type SL		Type S		Type SH		AJ	AK	BB	BD	BE	BF	XA	XB	XC	XE	XF	XG	XK	BX Max	XD	XL	Weight
			Nominal	Actual	Keyway	AG	CD	AG	CD	AG	CD																	
1200	18	8	4	3.998	1 x ½	54	45	59¼	50¼	59¼	50¼	28¾	22.000	¼	30½	1⅞	1 1/16	38	26	¾-10 NC	1	1	2⅛	1	4	5	7/16	3700

Not for construction—Request certified prints



AMARILLO RIGHT ANGLE DOUBLE DRIVE

This Drive may be used as a Double Engine Drive or as a Combination Drive using a horizontal electric motor and engine. When used as a Combination Drive, over-running clutches or other means should be provided for disengaging the idle driver. When used as a Double Drive with the two input loads equal, the transmission capacity is 150% of the Standard Drive, except limit Model 100 to 135 H.P., and contact the factory for capacity of Model 450 and larger drives.

BELT DRIVE

The Amarillo Right Angle Pump Drive may be used with a straight belt, either V or flat, providing the correct design of pulley is used on the Drive, so that the pull of the belt is centered approximately over the outside bearing on the horizontal shaft. In this way the drive may be advantageously used with slow speed engines. If long, heavy, or tight belts are used, it is advisable to carry the load of the belt on two pillow block bearings with a short shaft, and use a flexible drive shaft to connect the shaft to the gear drive.

OTHER SPECIAL DRIVES

Amarillo Gear Company has manufactured many specialized drives, and will be pleased to receive your inquiries regarding drive applications not covered in this catalog. Ratios not shown in Tables 4 and 6 will be quoted on request.

AVERAGE WEIGHTS and DIMENSIONS

TABLE 19

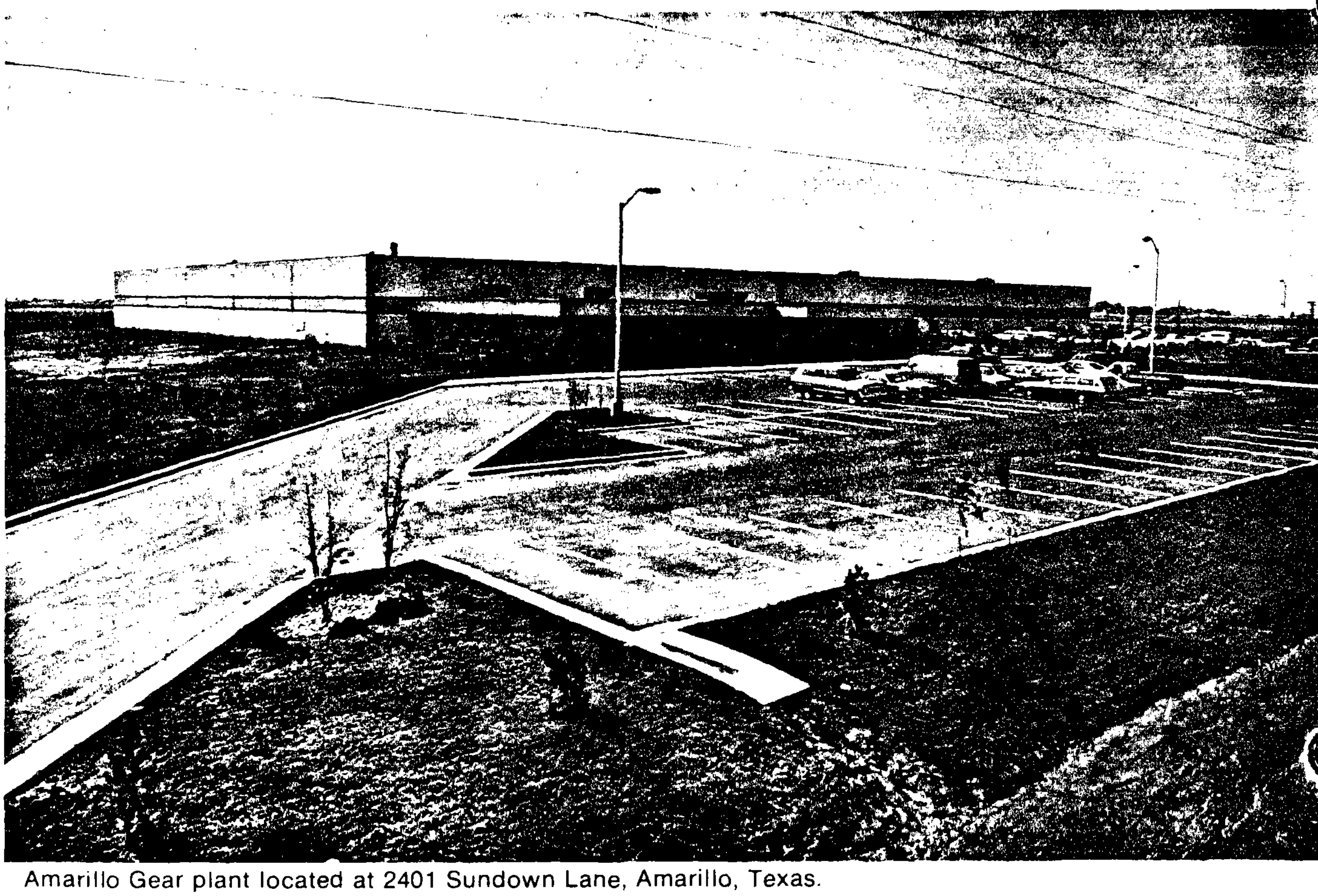
MODEL	NET WEIGHT	DOMESTIC CRATE	EXPORT BOX		EXPORT BOX DIMENSIONS (Inches)			VOLUME CUBIC FEET
			Pounds	Kilograms	Length	Width	Height	
20	108	118	145	66	22	15	20	4
40A	218	234	268	122	30	16	25	7
40B	235	256	285	129	30	20	25	9
60	350	373	415	188	30	20	30	10
80	370	393	438	199	30	20	30	10
100	375	398	443	201	30	20	30	10
125	449	468	530	240	32	20	32	12
150	680	710	791	359	36	24	39	20
200	690	720	801	363	36	24	39	20
275	1320	1450	1543	700	44	30	49	37
375	1320	1450	1558	707	44	30	49	37
450	1320	1450	1558	707	44	30	49	37
600	1800	1930	2050	930	44	30	55	42
750	3000	3250	3400	1542	58	36	72	87
1200	3700	3900	4000	1675	60	36	69	87

WARRANTY

The Amarillo Right Angle Pump Drive is guaranteed against defects in workmanship and material for a period of one year after installation when operated under normal service at rated capacity. Within the above stated period the manufacturer will replace defective parts returned transportation prepaid. The guarantee will not apply to repairs made outside the factory without the consent of the manufacturer, or to drives that have been subject to abuse, accident, neglect, or improper installation. No warranty is made in regard to bearings, trade accessories, machinery, or other articles of merchandise not manufactured by us. No responsibility will be assumed for overloading the rated capacity of the thrust bearing. (The thrust capacity of the drive should be verified by the pump manufacturer with whose equipment the drive is used.) This warranty is expressly made in lieu of any warranties otherwise implied by law.

AMARILLO GEAR COMPANY

A DIVISION OF THE MARMON GROUP, INC., (MICHIGAN)
2401 Sundown Lane, Amarillo, Texas 79105
Post Office Box 1789 806/622-1273
Cable: Amadrive TWX 910-898-4128



Amarillo Gear plant located at 2401 Sundown Lane, Amarillo, Texas.

1.2.7.149

OPERATING AND MAINTENANCE INSTRUCTIONS
FOR

AMARILLO
RIGHT ANGLE GEAR DRIVES

INSTALLATION

All units for domestic shipment by surface transportation are shipped with the proper amount and type of lubricant installed. Export or air freight shipments are shipped with initial oil fill in separate containers.

Install oil to the required level or add oil if spillage has occurred.

Inspect and clean top of pump discharge base and bottom of gear drive to assure removal of burrs or foreign material that might cause misalignment.

Install gear drive on discharge base and slide non-reverse clutch over headshaft. The non-reverse clutch should fit on the headshaft and engage the drive sleeve or drive nut **without springing** the headshaft. Lubricate the headshaft threads and bottom of the adjusting nut before raising the pump impellers.

Remove rust preventive from shaft extension and clean thoroughly. Install coupling half or flange. Hammering or mechanically forcing the coupling on the shaft can damage the bearings or disturb the setting of the gears and is not permissible. Interference fits are permissible if the coupling can be heated for installation and fitted without hammering or mechanically forcing on the gear drive shaft. Check runout of aligning surfaces on both coupling halves before installing connecting members.

When a flexible drive shaft is to be used, see installation instructions on the following page.

Align driver with gear drive to obtain parallel and angular alignment within limits specified by coupling or drive shaft manufacturer. Incorrect alignment will void the warranty on the Amarillo Right Angle Gear Drive.

Excessive noise and vibration in a new gear drive is almost always an indication of a poor installation as all drives are tested at the factory. Failure to correct the installation can result in damage to the pump and gear drive. Our warranty will not apply unless the drive is properly installed. Proper installation includes alignment of power unit, right angle drive and pump. It is also necessary to provide an adequate foundation for the pump and engine and a positive method of preventing the power unit from shifting to assure that alignment will be maintained.

LUBRICATION

Use only rust and oxidation inhibited (R & O) gear oils in accordance with American Gear Manufacturers' Association (AGMA) Standard 250.03 dated May, 1972. For general operating conditions, AGMA lubricant number and corresponding viscosity range should be as shown below. Contact factory for specific lubricant recommendations for operation under extremely hot or cold ambient conditions.

Gear drives operating in very cold weather must be provided with an oil that has a viscosity which is low enough to allow the oil to flow through the lubrication lines. An oil flow test valve may be installed by replacing the pipe plug located to the rear of the name plate with a suitable valve. Be sure to provide some method of preventing the valve from vibrating open during the operation of the drive. Oil must flow through this valve immediately upon start up, otherwise, the bearings and gears will not be properly lubricated. For consistent cold weather starting, a lube oil heater may be required. Contact factory for recommendations for lube oil heaters if needed.

TABLE 1 AGMA LUBRICANT NUMBER

MODEL NUMBER	AMBIENT TEMPERATURE	
	15° to 60° F. (−9° to 16° C)	50° to 125° F. (10° to 52° C)
20 Through 200	2	3 - 4
*275 Through 1500	4	5

*Lubricant for models 275 and larger should be selected to have a viscosity of 150 SSU at the operating temperature. To determine the operating oil temperature, measure the oil sump temperature with a thermometer after the drive has been operating for four hours or longer. AGMA lubricant number 5 is adequate for an operating temperature range of 160° to 180° F. (71° to 82°C).

AMARILLO GEAR COMPANY
A DIVISION OF THE MARMON GROUP, INC., (MICHIGAN)
Post Office Box 1789
Amarillo, Texas 79105
806/622-1273 Cable: Amadrive
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TABLE 2 TYPICAL LUBRICANTS

AGMA LUBRICANT NUMBER	2	3	4	5
Viscosity Range, SSU at 100° F. cSt at 37.8° C	284-347 62-75	417-510 90-110	626-765 135-165	918-1122 198-242
Amalie	Gearhead Oil #300	Gearhead Oil #500	-----	-----
Atlantic Richfield Company	Duro 68	Duro 100	Duro 150	Duro 220
Chevron Oil Company	OC Turbine Oil 68	OC Turbine Oil 100	OC Turbine Oil 150	OC Turbine Oil 220
Cities Services Oil Company	Pacemaker 68	Pacemaker 100	Pacemaker 150	-----
Continental Oil Company	Dectol 68 R&O	Dectol 100 R&O	Dectol 150 R&O	Dectol 220 R&O
Exxon Company	Teresstic 68	Teresstic 100	Teresstic 150	Nuto 220
Gulf Oil Corporation	Harmony 68	Harmony 90	Harmony 150 D	Harmony 220
Mobile Oil Company	DTE Oil Heavy Medium	DTE Oil Heavy	DTE Oil Extra Heavy	DTE Oil BB
Phillips Petroleum Company	Magnus 68	Magnus 100	Magnus 150	Magnus 220
Shell Oil Company	Turbo 68	Turbo 100	Turbo 150	Turbo 220
Sun Oil Company	Sunvis 754	Sunvis 764	Sunvis 775	Sunvis 790
Texaco Inc.	Regal 68 R&O	Regal 100 R&O	Regal 150 R&O	Regal 220 R&O

List of brand names is for purpose of identifying types and is not to be construed as exclusive.

CHANGE INTERVAL

Change oil at least every 1000 to 1500 hours of operation. If drive is operated intermittently less than 1000 hours in a season run of two or three months, change oil at the end of that period of operation to eliminate water formed in the gear case due to condensation. Frequency of change will depend upon the rate of water condensation in the drive. Drives operated in climates with hot days and cool nights will accumulate moisture more rapidly than drives operated at constant temperatures. More frequent oil changes are necessary for units which operate with an oil temperature above 180° F. (82° C). The oil should be changed after every 500 to 700 operating hours under these conditions. Contact factory for special lubrication procedures when the operating oil temperature exceeds 200° F. (93° C).

To drain the oil, remove the drain plug in the base flange. Refill at filler plug, which is located directly below name plate. If the drive is equipped with sight gauge, fill to level indicated. If the drive does not have a sight gauge, the oil level is one half inch below the top of the filler hole.

TABLE 3 OIL CAPACITY

MODEL		LITERS
20	1½ Quarts	1½
40	4 Quarts	4
60, 80, 100	9 Quarts	8½
125	9 Quarts	8½
150, 200	4 Gallons	15
275, 375, 450	11 Gallons	42
600	12 Gallons	45
750	17 Gallons	64
1000 A	15 Gallons	57
1000 G	17 Gallons	64
1200	18 Gallons	72
1500	18 Gallons	72

Older drives with water jackets will require less oil.

COOLING

Amarillo Gear Drive Models 100, 125, 150, 200, 275, 375, 450, 600 and 750 are assembled with cooling coils as standard equipment. Models 1000 A, 1200 and 1500 are assembled with an external shell and tube heat exchanger. Cooling coils are available on special order in model 40, 60 and 80. The oil is cooled by circulating water through the coils or the tube side of the heat exchanger. Cooling water is piped from a service connection on the discharge head of the pump to the lower cooling water connection on the gear drive. The upper connection is then piped to a spillway or back into the well casing. If there is not sufficient pressure, the water can be started by siphoning through the drive.

The operating temperature of the drive will depend on many factors. Water cooling should always be used if the operating oil temperature exceeds 180° F. (82° C) and the drive is to be operated for periods greater than eight hours per day. Water cooling will usually be required on model 100 and larger drives. Smaller drives may require water cooling if speeds are over 1760 rpm or if they are exposed to high room temperatures, limited air circulation, direct rays of the sun or other external sources of heat.

Table 4 is the coolant flow required when fresh water at 70° F. (21° C) is used and other operating conditions are normal.

TABLE 4

MODEL	GALLONS PER MINUTE	LITERS PER MINUTE	MODEL	GALLONS PER MINUTE	LITERS PER MINUTE
40	1	3	375	5½	21
60	1	3	450	6½	25
80	1	4	600	9½	36
100	1½	6	750	11	42
125	2	8	1000	11	42
150	2½	9	1200	12	45
200	3	11	1500	13	49
275	4	15			

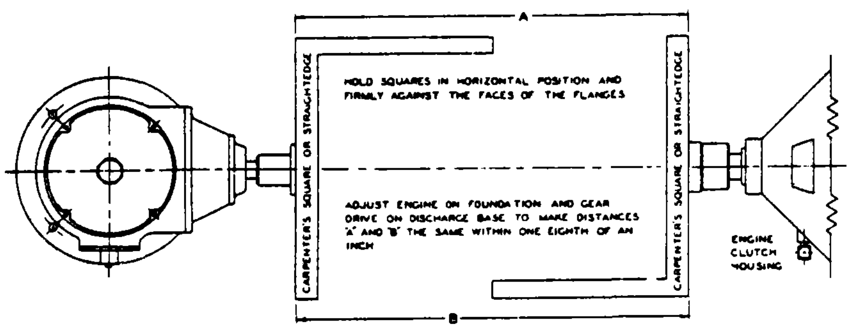
NON-REVERSE CLUTCH INSTRUCTIONS

The four enclosed pins are for the non-reverse clutch. They are to be placed in the drilled holes in the clutch if non-reverse protection is desired, or they can be left out if non-reverse protection is not needed. Pins and holes must be clean and free of oil so that the pins will fall freely. **Drives used in fire pump applications must be provided with anti-reverse mechanism. The anti-reverse is not to be disabled for these applications.**

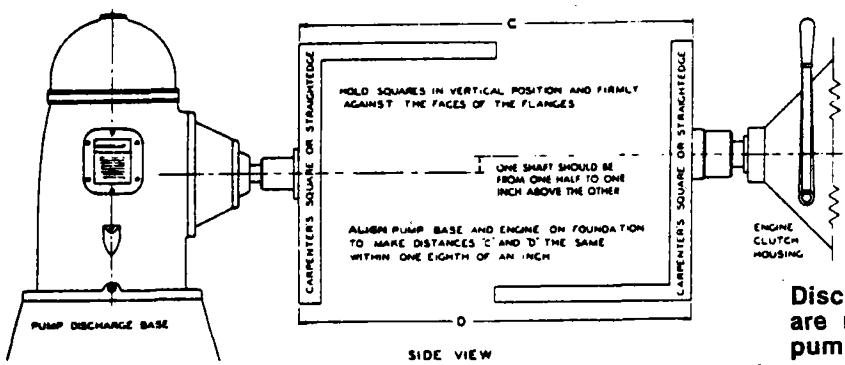
The non-reverse protection is not guaranteed. Settings of over 400 feet (122 meters) deep will require special procedures and in some cases the pin and ratchet type non-reverse will not work. Consult supplier for the proper procedure to follow in shutting down the well. **Drives used in fire pump applications must be provided with anti-reverse mechanism. The anti-reverse is not to be disabled for these applications.**

The gear drive may be damaged by accidental shock engagement of the non-reverse. This can be caused by the engine backfiring with the clutch engaged or by the pump starting to backspin before the pins engage the ratchet. Check the gear drive carefully after any shock engagement of the non-reverse. On some models the driving nut could unscrew from the hollow shaft. If this happens the nut must be tightened before resuming operation. **Drives used in fire pump applications must be provided with anti-reverse mechanism. The anti-reverse is not to be disabled for these applications.**

FLEXIBLE DRIVE SHAFT INSTALLATION INSTRUCTIONS



TOP VIEW



SIDE VIEW

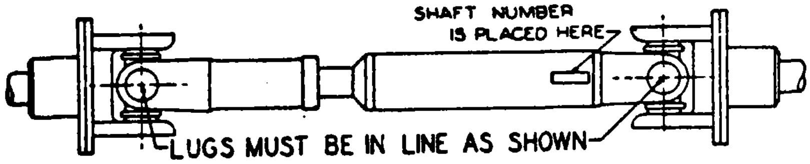
Disconnecting clutches are not allowed on fire pump applications.

Check the universal joints to see that they work freely before installing the drive shaft. The drive shaft should fit into the recess machined in the flange face without using the bolts to force it in. Never use a flange that has been damaged by direct hammering on its face.

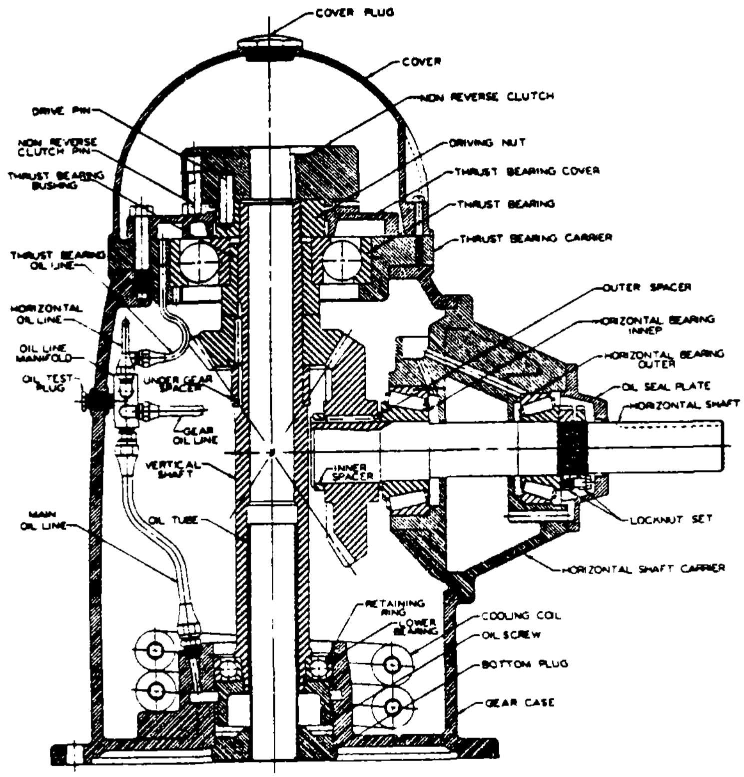
The engine and gear drive shaft need not line up axially but they must be parallel within one degree. A simple positive method of checking alignment before installing the drive shaft is illustrated above. Two carpenter's squares or straight edges of equal length and a steel tape will be the only equipment required.

Lubricate the drive shaft before using and then every 200 to 500 hours with 140 SAE straight mineral oil or low solid content grease. Use the following lubricants or equal:

Journal Crosses:	Oil - Texaco PASR-629 Grease - Shell Alvania EP #2
Sliding Splines:	Texaco Marfac E.P. #1



When installing flexible shafts, be sure that joints are assembled with lugs in the same plane as shown. If lugs are not as shown, unequal acceleration occurs in the joints and vibration and knocking develop. Allow for slip movement in each direction.



Manufactured by

AMARILLO GEAR COMPANY

AMARILLO, TEXAS

WARRANTY

The Amarillo Right Angle Gear Drive is guaranteed against defects in workmanship and material for a period of one year after installation when operated under normal service at rated capacity. Within the above stated period the manufacturer will replace defective parts, returned transportation prepaid. The guarantee will not apply to repairs made outside the factory without the consent of the manufacturer, or to drives that have been subject to abuse, accident, neglect, or improper installation. No warranty is made in regard to bearings, trade accessories, machinery, or other articles of merchandise not manufactured by us. No responsibility will be assumed for overloading the rated capacity of the thrust bearing. (The thrust capacity of the drives should be verfied by the pump manufacturer with whose equipment the drive is used.) This warranty is expressly made in lieu of any warranties otherwise implied by law.

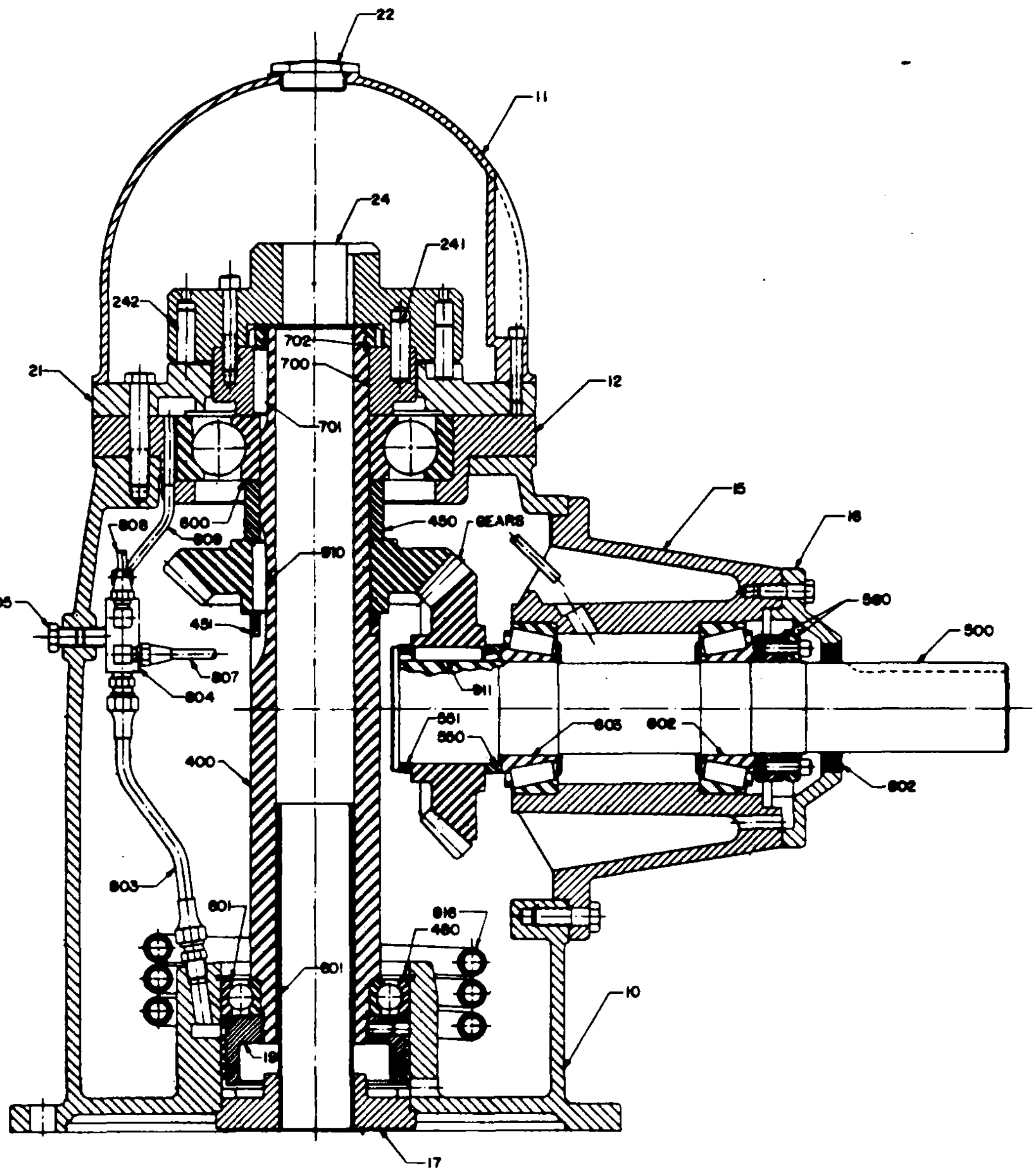
MODEL 125 PARTS LIST

BE SURE TO GIVE SERIAL NUMBER OF DRIVE WHEN ORDERING PARTS

Part No.	Model 125	Description
10	x	P10M Gear Housing
11	x	P11B Cover
12	x	P12ER Thrust Bearing Carrier
15	x	P15M Horizontal Shaft Carrier
16	x	M16TFS Oil Seal Plate
17	x	P17M Bottom Plug
18	x	E18 Inspection Plate
19	x	P19M Oil Screw
	x	P19M Oil Screw for Special Rotation
21	x	P21RM Thrust Bearing Cover
	x	P21RM Thrust Bearing Cover for Special Rotation
22	x	E22 Cover Plug
24	x	P24RM Non Reverse Clutch
242	x	Set Non Reverse Clutch Pins
400	x	Vertical Shaft
	x	Vertical Shaft for Special Rotation
450	x	Vertical Spacer
451	x	Under Gear Spacer
480	x	Retaining Ring
500	x	Horizontal Shaft
	x	Horizontal Shaft for Ratios 3:2, 7:4, 2:1
550	x	Horizontal Outer Spacer
551	x	Horizontal Inner Spacer
560	x	Locknut Set
600	x	7415BG Vertical Shaft Thrust Bearing
601	x	6215 Vertical Shaft Lower Bearing
602	x	JH211710/JH211749 Horizontal Shaft Outer Bearing
603	x	JH211710/JH211749 Horizontal Shaft Inner Bearing
700	x	Driving Sleeve
701	x	Driving Sleeve Key
702	x	N-14 Driving Sleeve Locknut
801	x	Oil Tube
802	x	Oil Seal

Part No.	Model 125	Description
803	x	Main Oil Line
804	x	Oil Line Manifold
807	x	Gear Oil Line
808	x	Horizontal Carrier Oil Line
809	x	Thrust Bearing Oil Line
816	x	Cooling Coil
910	x	Vertical Shaft Gear Key
911	x	Horizontal Shaft Gear Key
	x	Set Gear Case Gaskets
	x	Set Oil Level Gauge Gaskets
	x	Oil Level Gauge Glass
		LIGHT THRUST
	x	P12S2M Thrust Bearing Carrier
	x	P21RM(7315) Thrust Bearing Cover
	x	Vertical Shaft
	x	1 Pair 7315BG Opposed Vertical Shaft Thrust Bearings
		HEAVY THRUST (STACKED BEARINGS)
	x	P12SER Thrust Bearing Carrier
	x	Vertical Shaft
	x	1 Pair 7415BG Vertical Shaft Thrust Bearings
		COMBINATION PARTS
	x	P12S2M Thrust Bearing Carrier
	x	P21RM(7315) Thrust Bearing Cover
	x	Vertical Shaft
	x	1 Pair 7315BG Vertical Shaft Thrust Bearings
	x	6212-2RS Steady Bearing
3468	x	Sliding Clutch
3469	x	Bearing Bushing
3470	x	Driving Sleeve Cover
3471	x	Non Reverse Clutch
	x	P35C Motor Stand, 16½"
	x	P35C Motor Stand, 20"
	x	P35C Motor Stand, 24½"

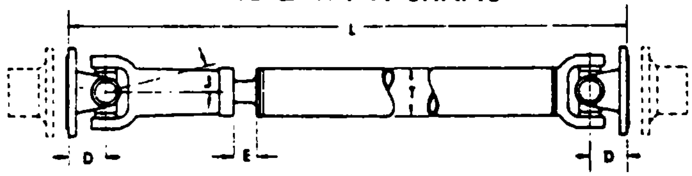
GEARS – SOLD IN SETS ONLY.


22
11
24
241
242
702
700
21
12
701
15
600
808
809
450
GEARS
16
810
805
451
560
500
807
804
811
561
560
603
602
400
602
803
601
816
480
601
19
10
17

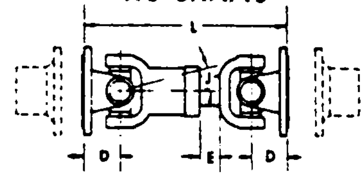
MODEL S125

DIMENSIONAL SPECIFICATIONS

WL & WV-A SHAFTS



WS SHAFTS

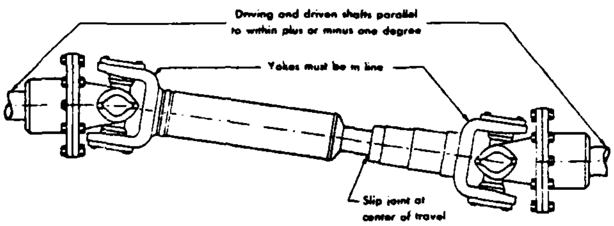


DIMENSION	WL and WV-A SHAFTS											
	SIZE	27	31	37	41	48	55	61	71	81	88	91	95
L—Std. lengths, inches		24,36,48	24,36,48	24,36,48	24,36,48	24,36,48	24,36,48	36.48	48	48	48	48	None
—Minimum possible		15 1/4	15 1/4	16 3/4	17 1/2	16 3/4	17	25 1/8	24 1/4	26 7/16	27 3/8	30 3/8	46 9/16
T—Tube diameter & wall		2 1/2x.083	2 1/2x.083	3x.083	3 1/2x.083	3 1/2x.083	3 1/2x.095	3 1/2x.134	4x.134	4 1/2x.134	4 1/2x.259	4 3/4x.250	5 1/4x..375
D—Joint center to face		1 3/8	1 3/8	1 9/16	1 13/16	2	2	2 3/4	3	3 3/8	3 1/2	4 1/4	8 5/8
E*—Lengthens or shortens		1 9/16	1 9/16	1 13/16	1 11/16	1 1/4	1 1/4	2 7/16	1 15/16	1 11/16	1 3/4	1 1/2	2 1/2
J—Max. clearance angle		20°	20°	20°	20°	22°	22°	26°	22°	30°	22°	15°	20°
—Preferred work angle		1° to 8°	1° to 8°	1° to 8°	1° to 8°	1° tc 8°	1° to 8°	1° to 8°	1° to 8°	1° to 8°	1° to 8°	1° to 8°	1° to 8°
Wt. uncrated 48" shaft		17#	18#	24#	27#	32#	42#	56 1/2#	80#	108#	175#	198#	417#
Add or subtract per ft.		2.1#	2.1#	2.6#	3#	3#	3.5#	4.8#	5.5#	6.1#	11.8#	12.02#	29.4#

*Shafts will lengthen or shorten by "dimension E" giving a total movement of 2E. Length "L" is with slip joint in its mid position.

INSTALLATION INSTRUCTIONS

DRIVER & DRIVEN SHAFTS MUST BE PARALLEL and YOKES MUST BE IN LINE

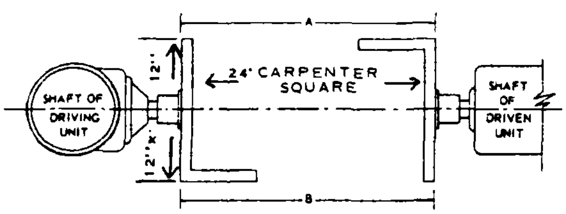


Drive and driven units need not line up axially, but they MUST be parallel to one another within *plus or minus one degree.* Theoretically, shafts should be offset slightly so that bearings will rotate, but experience has shown that there is sufficient deviation in most installations so that bearings will creep and distribute the wear.

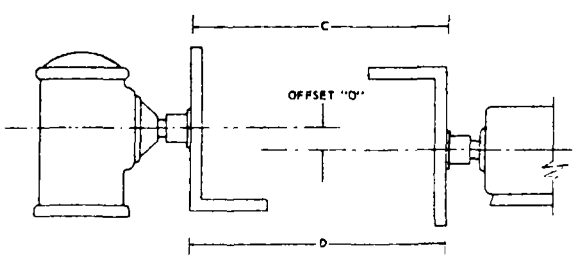
MAXIMUM WORKING ANGLE depends on RPM. See page 15 for details.

The following illustrations show a simple method to secure parallelism of shafts. Just use two steel carpenter squares.

TOP VIEW (1) Set driving and driven shafts horizontal with spirit level. (2) Line up with stretched wire. (3) With midpoint of squares at center of flanges as shown, dimensions "A" and "B" must be equal to within *1/8" for WL standard and 1/16" for WS shafts.*



SIDE VIEW Driving and driven units can be set in line or with offset as required by the installation. In illustration below, units have a slight vertical offset. Using steel squares as above, "C" and "D" must be equal to *1/8" for WL standard & 1/16" for WS.*

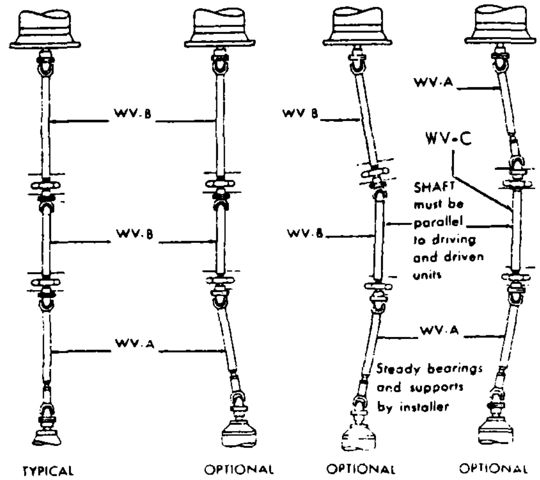


For a typical installation we recommend for simplicity that offset "O" be not more than 3-1/4 inches for 24 inch lengths, not more than 5 inches for 36 inch lengths, not more than 6-1/2 inches for 48 inch lengths, etc.

VERTICAL INSTALLATIONS require the same fundamentals of parallelism and yoke alignment as are shown at the left. In addition, the bearing stub of WV-B shafts and the slip joint of WV-A should be at the lower end in each case as shown below.

If total shaft weight exceeds 250 lbs., either a flange with taper bore and nut or a straight bore flange and two set screws should be used on the unit which supports this weight.

Watson shafts can be set in line or offset as shown:



Steady bearings should be self-aligning. Installation using WV-C shaft is useful in missing obstructions. The center line of WV-C must be parallel to center of line of driving and driven units to within one degree.

STEADY BEARING SUPPORTS must have enough rigidity to avoid vibration. In our experience, this problem has not been serious. Observe the following:

Keep spans short as possible.
Make end connections rigid.
Use rigid beam and install so that the principal section modulus opposes the horizontal forces.

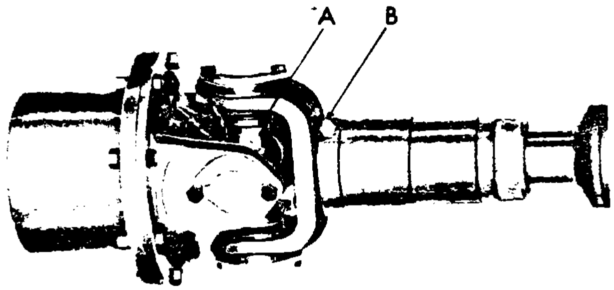
FOUNDATIONS for all installations must be adequate, since most power units will vibrate to some extent. Proper steel beam or concrete foundations—with hold-down bolts are necessary to maintain alignment and to eliminate damaging vibrations. Inadequate foundations will void guarantee.

SERVICE INSTRUCTIONS

LUBRICATION of Watson Shafts is simple and easy. Two areas, "A" and "B", should be lubricated every 500 hours of normal service or every 200 hours of continous service as follows:

AREA "A"—Journal crosses: Use Texaco P.A.S.R.-629, Gulf No. 188, Socony Gargoyle Viscolite SS or similar lubricants. If lubricant sealing problems develop, use any good grade E.P. No. 2 Grease such as Shell Alvania E.P. No. 2 or Texaco Marfac H.D.E.P. No. 2. When adding lubricant be certain that it appears at all four bearing seals to assure removal of dirt and contaminents. The bearing seals should relieve lubricant with a "pop" at about 80 PSI. Apply force or torque by hand to the joint, while lube gun pressure is being applied, to encourage lubricant relief.

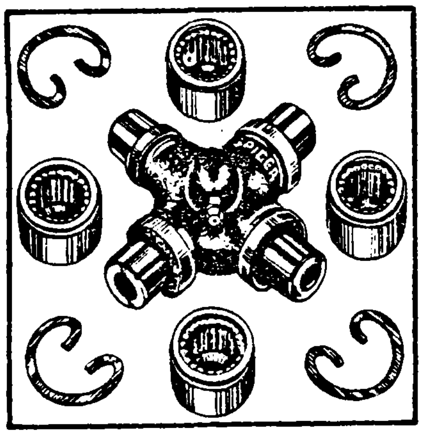
AREA "B"—Sliding Splines: Any good grade of long fibre grease is preferred, expecially an extreme pressure (E.P.) type. Spline lubricants found to be satisfactory are Texaco Marfac No. 1 E.P., Texaco Marfac "0" E.P., Mobile Grease, Special No. 53-030 and Texaco All Temp. No. 1992.



BEARING REPLACEMENT

Never disassemble the needle bearings from their yokes unless it is necessary to replace the cross and bearing set. To inspect, remove the shaft and test bearings by moving the flange yoke in all angular positions to roll the needles.

If the action of all four bearings is smooth, replacement is not necessary. If the action is rough or uneven, replace the entire cross and bearing set. See instructions below for both Snap-Ring and Bearing-Cap construction.



DISASSEMBLY—SNAP-RING TYPE

Tap one end of the bearing lightly to remove pressure on the snap-ring. Remove the snap-ring with pliers; repeat procedure for opposite bearing. Then drive with a soft drift on one bearing to push the opposite bearing through its yoke. Remove the exposed bearing, turn the joint over, and remove the first bearing by driving on the exposed end of the journal cross. Repeat this operation for the other two bearings.

ASSEMBLY—SNAP-RING TYPE

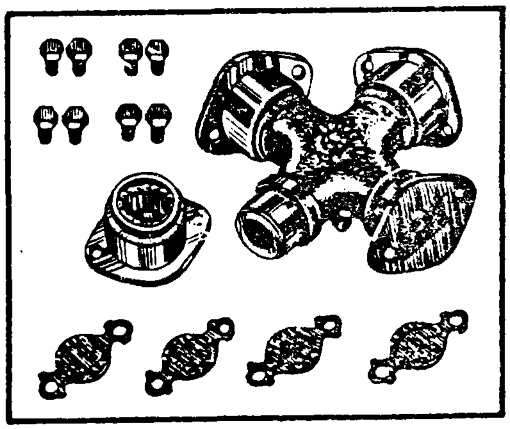
Remove the bearings from the new cross assembly, holding the cups so that the needles do not fall out. Position the cross in one yoke. Position one bearing cup with its needles in the yoke and insert the journal of the cross into this bearing. Press bearing into yoke. Repeat for opposite bearing. If press is not available, use a vise. NEVER hammer on new bearings. Install snap-rings and repeat operation for other two bearings.

DISASSEMBLY—BEARING-CAP TYPE

Bend down the tabs on the lock-plates, remove the lock-plate capscrews, and remove the lock-plates. Clamp the flange yoke in a vise with its lugs horizontal. Tap on the top of the joint to start the top bearing out. Pull this bearing. Start the lower bearing by driving on the exposed end of the journal cross. Pull the lower bearing. Then remove from vise, turn 90 degrees, reclamp in vise, and repeat operation for other two bearings.

ASSEMBLY—BEARING-CAP TYPE

Install the new cross and bearing set, following exactly the same procedure as used with the snap-ring type. Install the lock-plates and capscrews. Bend the tabs of the lock-plates up to lock the capscrews.



SAFETY AND WARRANTY

"We recommend the use of shaft guards to protect personnel from contact with rotating drive shafts or to contain the shaft in the event of failure."

"H. S. Watson Company agrees to repair or replace without charge, f.o.b. our factory, or at our option allow credit for, any portion of a product which proves to be defective in material or workmanship within a period of 180 days from the date the product is placed in service. Products claimed to be defective must be held for our shipping instructions and no claim will be allowed unless we have had a reasonable opportunity to examine the products. WE MAKE NO WARRANTY AS TO MERCHANTABILITY OR AS TO FITNESS OF PRODUCTS FOR A PARTICULAR PURPOSE OR AS TO THE RESULTS TO BE OBTAINED FROM THEIR USE BY PURCHASER OR OTHERS. We make no warranties, express or implied, statutory or otherwise." 1.2.7.158

SHAFT & FLANGE INSTALLATION:

HORIZONTAL APPLICATIONS:

All STOCK flanges are bored with a plus .001 - minus .000 'erance and should be a slip fit over the output and input ıfts. Align the key-ways in both the flange and shaft and ntly tap flange on. Tighten set screws in the flange and install drive shaft.

In some installations, it is preferred that the flanges be SPECIAL ordered with the bore machined UNDERSIZE, creating an interference fit.

If the flanges are UNDERSIZE, we recommend the following procedure:

1. Heat the flange with a torch allowing the bore to expand.
2. Align the keyways in both the flange and shaft.
3. Slide the flange over the shaft and allow the flange to cool.

CAUTION: DO NOT attempt to hammer on an undersize flange without heat. This may permanently damage the thrust bearings in either the driver or driven equipment.

VERTICAL APPLICATIONS:

In vertical applications most of the shafting weight is supported from the upper connecting flange. We RECOMMEND that when a drive shaft or multiple drive shaft installation weighs over 150 lbs. it should be supported in one of the following ways:

1. Ordering flanges with an extra set screw 90° from the keyway. (Do not use with drive shafts weighing over 300 lbs.)
2. Ordering SPECIAL bored flanges with the bore machined UNDER-SIZE (refer to above for proper installation of UNDERSIZE FLANGES).
3. Ordering flanges with a counter bore for a split ring adapter.
4. Ordering flanges with a taper bore and nut (consult with motor manufacturer).

In multiple installations, start with the upper most 'B' section of shafting:

1. Laying the 'B' section out on the floor, slide the steady bearing over the neck of the 'B' stub followed by the tapered 'B' FLANGE, NUT & COTTER PIN. Note: steady bearings must be self-aligning type.
2. Attach universal end of shafting to upper connecting flange, using bolt, nut & lockwasher supplied.
3. Attach STEADY BEARINGS to support beams.
4. Repeat steps 1 thru 3 for each 'B' section.
5. The bottom or "A" section is installed with the SLIP JOINT mounted to the connecting FLANGE on the pump.

NOTE: Make sure that the EARS on the YOKES are in line after assembly. Refer to drawing on Page 15.

LUBRICATION:

There are only three major components that need to be lubricated:

1. Universal joint (Note: In some series, the universal joint is a lube for life bearing which never requires lubrication).
2. Sliding splines in the Slip Joint.
3. Steady bearings.

It is recommended that the UNIVERSAL JOINTS and STEADY BEARINGS be lubricated with Shell Alvania EP-2 or equivalent for speeds over 500 RPM and SAE 140 to 250 oil for speeds under 500 RPM.

The SLIDING SPLINES in the SLIP JOINT should be lubricated with any good grade of long fiber grease such as Texaco Marfac "O" E.P.

When adding lubricant be certain that it appears at all four bearing seals to assure removal of dirt and contaminents. The bearing seals should relieve lubricant with a "pop" at about 80 PSI.

Bearings should be lubricated every 500 hours of normal service or every 200 hours of continuous service.

BOLT SPECIFICATIONS

Bolt Size	Series Used On	Wrench Torque	Grade
3/8-24NF x 1 1/4	27-31-61-71	30 lbs. ft.	5
7/16-20NF x 1 1/4	37-41	48 lbs. ft.	5
7/16-20NF x 1 1/2	81	48 lbs. ft.	5
1/2-20NF x 1 1/2	48-55	76 lbs. ft.	5
5/8-18NF x 2	88-91	155 lbs. ft.	8
3/4-16NF x 2 1/2	95	274 lbs. ft.	8
7/8-14NF x 3 1/2	205	439 lbs. ft.	8
1-8NF x 4	215	686 lbs. ft.	8

TROUBLE SHOOTING GUIDE

PROBLEM	CAUSE	SOLUTION
VIBRATIONS	1. Operating in or near the critical or half-critical speed. Refer to page 10	Reduce speed or rework using special tubing.
	2. Ears on yoke are not in line with each other. See drawing on page 15.	Disassemble and align yokes.
	3. Drive shaft may be out of balance due to shafting being bent during shipment or not originally balanced.	Return for straightening and balancing.
	4. Bearings in the U-joint or steady bearing wore out.	Replace bearing.
	5. U-joints are stiff due to damaged bearing.	Replace bearing.
	6. Pilots not seated at con. flange or "B" shaft connections.	Reseat flanges.
	7. If operating in conjunction with a reciprocating engine, a torsional problem may exist.	A torsional analysis should be performed.
	8. Steady bearings are not self-aligning and are binding.	Replace.
	9. Thrust bearings binding up in either the driver or driven equipment.	Replace bearings.
	10. Exceeding recommended angular misalignments.	Reduce angle.
	11. Input and output shafts are not parallel.	Shim if necessary.
FLANGES SLIPPING OFF SHAFT	1. Exceeding weight limitations for stock bored flanges.	Add additional set screw.
	2. Set screw not tightened.	Tighten set screw.
PREMATURE FAILURE OF BEARING	1. Lack of proper maintenance.	See lubrication recommendations.
	2. Exceeding recommended angular misalignment or Max. RPM.	Reduce either or both.
	3. Excessive vibrations (See vibration sec. above)	See above.
	4. Shafting under specified.	Refer to Page 8 & 9

AURORA PUMP

A UNIT OF GENERAL SIGNAL

ENGINEERING DEPT.
NORTH AURORA, ILLINOIS· 60542

DIESEL ENGINE AND ACCESSORIES

FIRE PUMP F.O.# 4GO-65706

MODEL V-378-F2 UL LISTED

FM APPROVED 24 VOLT NEG GROUND

DIESEL ENGINE FOR AUTOMATIC OPERATION

W/THE FOLLOWING ACCESSORIES:

2 FLEXIBLE METAL HOSES

1 SET OF ENGINE MANUALS 8 EXTRA

4 BATTERIES W/ACID - 12 VOLTS

2 BATTERIES RACKS

4 BATTERIES CABLES SETS

2 FLEXIBLE EXHAUST CONNECTOR

2 ADAPTER FITTING

2 ~~COMMERCIAL~~ RESIDENTIAL CLASS MUFFLER

1 SET 1¼" HEAT EXCHANGER PIPING W/

SOLENOID VALVE

1-120 GAL FUEL TANK

1 SET FUEL TANK FITTINGS W/ GAUGE

1 KIM START IMMERSION HEATER

1 KIM START PRESSURE SWITCH

1 KIM START THERMOSTAT

BY: WJW

DATE :

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

SP-106968

AURORA PUMP
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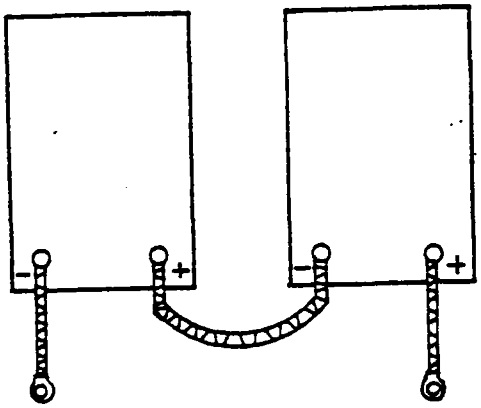
NORTH AURORA, ILLINOIS· 60542

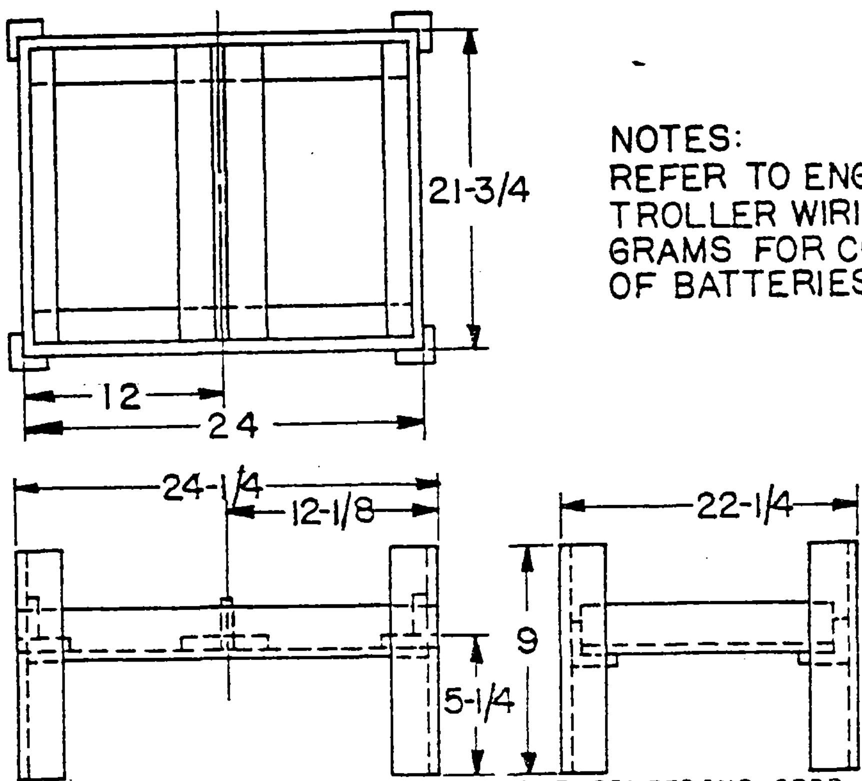
BATTERIES & RACKS



24 VOLT NEGATIVE GROUND (4)
CUMMINS

~~N-855-F~~	~~V-378-F1~~
~~NT-855-F1~~	V-378-F2
~~NT-855-F2~~	~~V-504-F1~~
~~VT-1710-F~~	~~V-504-F2~~

CABLE PART NO.	CABLE QTY.	CABLE LGTH.	CABLE TYPE & SIZE
916-0040-999	2	1 FT.	SAE J558A TYPE SGT 2/0 GA.
916-0041-999	2	5 FT.	
916-0042-999	2	5 FT.	



NOTES:
REFER TO ENGINE CONTROLLER WIRING DIAGRAMS FOR CONNECTION OF BATTERIES

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P.O. 2001

SP-10a968

AURORA PUMP

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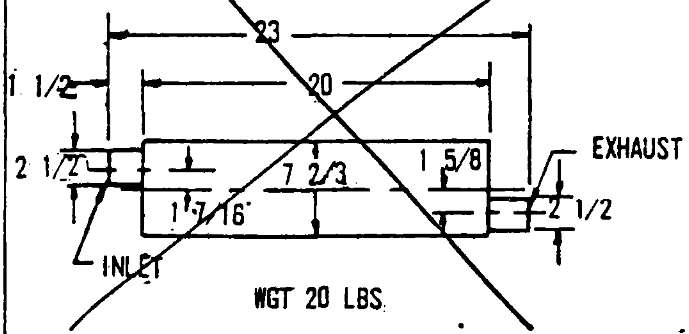
ENGINEERING DEPT.
NORTH AURORA, ILLINOIS· 60542

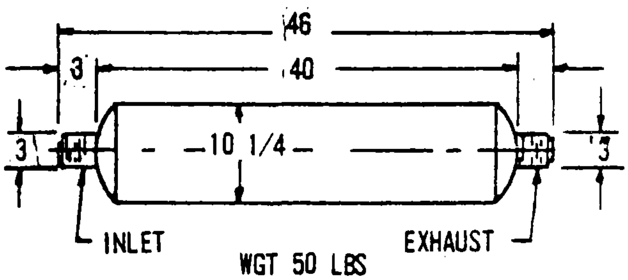
MUFFLER

ENGINE MODELS

~~V-378-F1~~
~~V-378-F2~~
DONALDSON-SLOTTED

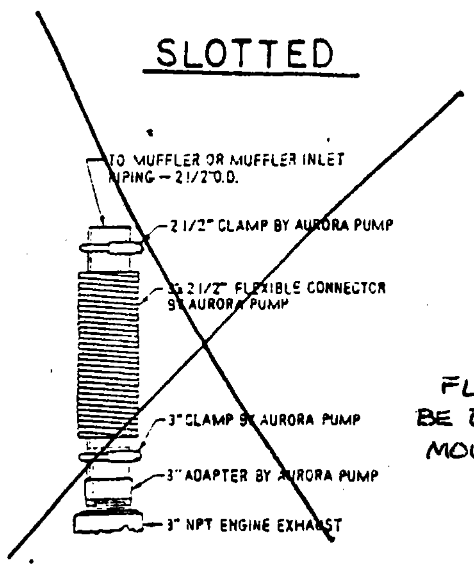


~~V-378-F1~~ V-378-F2
~~V-504-F1~~
~~V-504-F2~~ BELOW 157 HP
MAXIM-THREADED



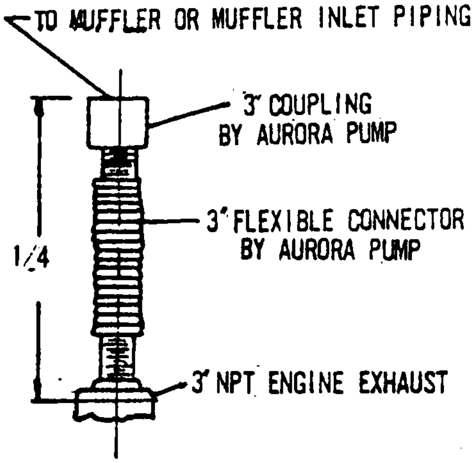
INSTALLATION

SLOTTED



FLEXIBLE CONNECTOR MAY BE BENT 90° FOR VERTICAL MOUNTING OF MUFFLER

THREADED



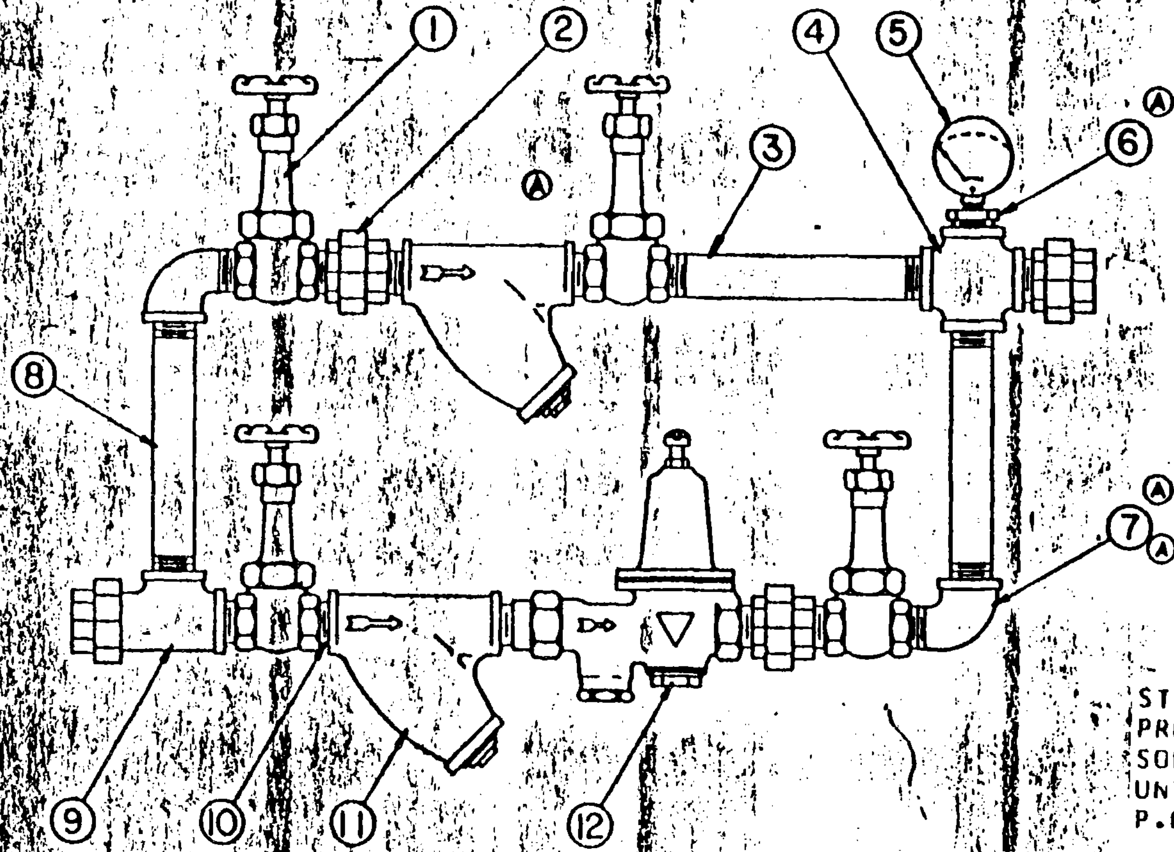
NOTES: PIPING BETWEEN ENGINE AND MUFFLER SHOULD NOT EXCEED TWENTY PIPE DIAMETERS AND SHOULD BE SHORTER IF POSSIBLE

NO MORE THAN FOUR FEET OF UNSUPORTED PIPE AND FLEXIBLE CONNECTOR MAY BE ATTACHED TO THE ENGINE

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

8-21-75

SP-10694-5



ITEM	QUAN	DESCRIPTION
1	4	GATE VALVE
2	3	MALE X FEMALE UNION
3	1	PIPE (CUT TO LENGTH REQ'D)
4	1	CROSS
5	1	PRESS. GAUGE
6	1	REDUCING BUSHING
7	2	90° STREET ELBOW
8	2	PIPE
9	1	TEE W/INTEGRAL UNION
10	6	CLOSE NIPPLE
11	2	Y STRAINER WITH PLUG
12	1	PRESSURE REDUCING VALVE,

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

1.2.7.163

LET	ZONE	DATE	REVISION	BY	CK'D	LET	ZONE	DATE	REVISION	BY	CK'D
M						F					
L						E					
K						D					
J						C					
H						B					
G						A	3B	6-2-77	ADD STRAINER AND VALVE ECN 0710	PD	[illegible]

STD. MAT'L:
REFERENCE:
PATT. TIES TO:
PATTERN NUMBER

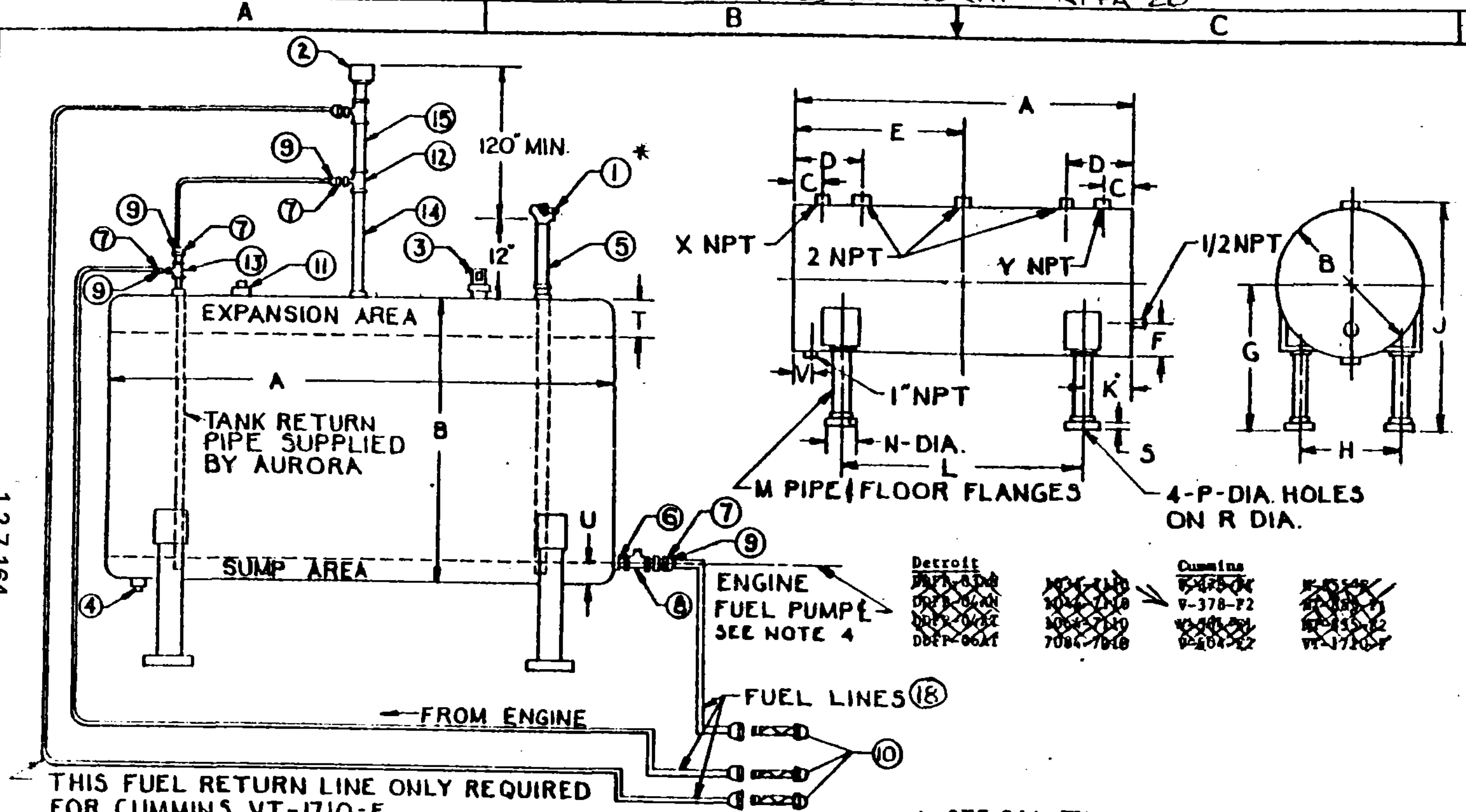
NOTE: DO NOT SCALE DRAWING
DRAWN BY
CHECKED BY
APPROVED BY
DATE
SCALE: NONE
ROUGH WEIGHT
B

AURORA PUMP
A UNIT OF GENERAL SIGNAL

NAME ENGINE COOLING WATER BY-PASS FOR VERTI-LINES
PART NUMBER 2950001451

FORM A-40013 8-72

* FLASH ARRESTOR NOT REQUIRED ON FILL CAP — NFPA 20



No.	Qty.	Description
		(Furnished by Aurora)
1	1	Fill cap with provisions for padlock
2	1	Flash arrestor - 2" NPT
3	1	Fuel gauge - 2" NPT
4	1	Pipe plug for drain - 1" NPT
5	1	Fill tube
6	1	Close pipe nipple - ½" NPT
7	4	Tube nuts for 5/8" O.D. tube
8	1	Stop cock valve - ½" NPT with provision for padlock
9	4	Flared tube fittings 5/8" O.D., ½" NPT
10	-	Flexible hose furnished (18" APPROX) with engine, with 7/8-14 UNF thread and engine fitting
11	1	Pipe plug - 2"
		(Furnished by others)
12	1	Pipe tee - 2x2x½
13	1	Pipe tee - ½x½x½
14	1	vent pipe - 2"
15	1	upper vent piping - 2"
16	1	24' of 2" ø PIPE - FILL & VENT
17	6	2" ø 90° ELLS - FILL & VENT
18		FUEL LINES

Notes

1. Tank must be installed in accordance with local building codes and specifications.
2. Arrange tank as close as possible to engine.
3. Pitch tank toward drain ½" per foot.
4. Fuel pump and tank outlet to be on same center line. A foundation may be required for fuel tank.
5. Fuel lines, tees and upper vent piping by McLENOZE PUMP & EQUIP.

THIS FUEL RETURN LINE ONLY REQUIRED FOR CUMMINS VT-1710-F

*-275 GAL. TANK IS OBROUND 27x44

TANK SIZE	USABLE VOLUME	A	B	C	D	E	F	G	H	J	K	L	M	WT LBS.	N	P	R	S	T	U	V	X	Y
120 GAL	104 GAL.	60	24	6	12	30	3	24	17	36	8	44	1-1/2	325	4-1/2	5/16	3-1/2	3/8	3	3	3	3/4	2-1/2
180 GAL	162 GAL.	60	30	6	12	30	3	27	23	42	8	44	1-1/2	415	4-1/2	5/16	3-1/2	3/8	3	3	3	3/4	2-1/2
275 GAL	243 GAL.	60	*	4	17	30	3	30	21-1/2	53	7½	45	1-1/2	250	4-1/2	5/16	3-1/2	3/8	3	3	2	2	2
320 GAL	285 GAL.	72	36	12	24	36	3	30	25-1/2	48	9	54	2	590	5-1/2	5/16	4-1/4	13/32	3	3	3	3/4	2-1/2
560 GAL	502 GAL.	72	48	12	24	36	3	36	34	60	9	54	2	825	5-1/2	5/16	4-1/4	13/32	3	3	3	3/4	2-1/2

LTR	ZONE	DATE	REVISION	BY	CK'D	LTR	ZONE	DATE	REVISION	BY	CK'D
M						F					
L						E					
K						D					
J						C					
H						B					
G						A					

FORM A-40013 6-72

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001

STD. MAT'L:
REFERENCE:
PATT. TIES TO:
PATTERN NUMBER

NOTE: DO NOT SCALE DRAWING
DRAWN BY MT
CHECKED BY
APPROVED BY
DATE 11-7-79
SCALE: NO
ROUGH WEIGHT

B

AURORA PUMP
A UNIT OF GENERAL SIGNAL

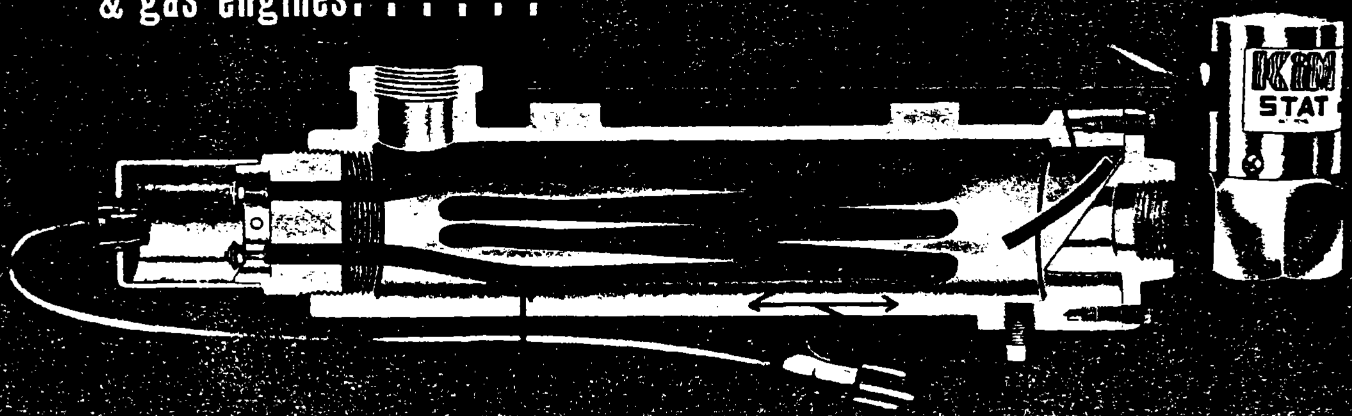
NAME FUEL PIPING DETAILS
PART NUMBER 295 0001 447

1.2.7.164

STOP WINTER DAMAGE

to your diesel & gas engines. . . . . .

Learn the secret of protecting your engines against damaging effects of cold starts and destructible effects of cold weather! 90% of all engine wear is caused by low water jacket temperatures. Preventative maintenance means more profit $ $.



How Kim Hotstart saves you $ $ $

1. Maintains Operating Temperature in engine
2. Stops destructive condensation
3. Reduces costly engine wear
4. Saves fuel
5. Saves warm-up time
6. Insures immediate defrosting
7. Prolongs battery life
8. Eliminates heated terminals
9. Factory Guarantee

MANUFACTURER'S WATTAGE RECOMMENDATIONS FOR VARIOUS TEMPERATURES UNDER NORMAL CONDITIONS

RED—for GAS ENGINES BLACK—for DIESEL ENGINES

To maintain optimum operating temperatures use:
3 Watts/Cu. In.......to -20°F
5 Watts/Cu. In. Below -20°F

Desired Temperatures	Gas Engines of 1 & 2 Cylinders	Gas Engines up to 350 Cu. In. Displacement	Gas Engines of 350-600 Cu. In. Displacement Diesel Engines of 2 & 3 Cylinders and Small 4 Cylinders	Gas Engines of 600-800 Cu. In. Displacement Diesel Engines of 4 Cylinders	Gas Engines of 800-1200 Cu. In. Displacement Diesel Engines of 6 Cylinders	Gas Engines Over 1200 Cu. In. Displacement Automotive Diesel Engines of 7-12 Cylinders	Large Industrial and Locomotive Engines
60°F	500	750	1000 1000	1500 1500	2000 2000	5000 4000	6000
60°F to 80°F	500	750	1000 1000	1500 1500	2000 2000	6000 4000	6000
80°F to 100°F	500	750	1000 1000	2000 2000	2500 2500	6000 4000	9000
100°F to 120°F	500	750	1000 1000	2000 2000	2500 2500	9000 4000	9000
120°F to 140°F	500	750	1000 1000	2000 2500	4000 2500	9000 4000	12000
140°F to 160°F	750	1000	1500 1500	2500 2500	4000 2500	9000 4000	12000
160°F to 180°F	750	1000	1500 1500	2500 2500	4000 4000	12000 4000	12000

Specification Chart on Reverse Side

KIM Hotstart®

KIM HOTSTART MANUFACTURING CO.
Telephone 509-534-6171, Box 42, Spokane, Washington 99210
Please send literature and name of local dealer

Name STEARNS-RCGER ENGINEERING CCRP.
Company PRCJECT NC. 6217C0
SCLAR-CNE FILCT PLANT
Address LNIT CNE
P.C. 2C01
1.2.7.165 City Zip Code

KIM HOTSTART SPECIFICATIONS

	Model WJ 110	WJ 220	Model JR 110	JR 220	Model A 110	A 220
''ts ±10%	115	230	115	230	115	230
s	500	500	750	750	1000	1000
ıs	4.2	2.1	6.5	3.2	8.7	4.5
..iring	#16-3	#16-3	#16-3	#16-3	#16-3	#16-3
Diameter	3½"	3½"	3½"	3½"	3½"	3½"
Length	13¾"	13¾"	13¾"	13¾"	13¾"	13¾"
Weight (pounds)	5	5	5	5	5	5
Carton Packing	12 units	12 units	12 units	12 units	12 units	12 units

	Model LB 110	LB 220	Model MB 110	MB 220	Model BC 110	BC 220	Model E 220
Volts ±10%	115	230	115	230	115	230	230
Watts	1500	1500	2000	2000	2250	2500	4000
Amps	13.05	6.78	16.6	8.3	19.5	10.8	17.4
Wiring	#16-3	#16-3	#14-3	#16-3	#14-3	#16-3	#14-3
Diameter	3½"	3½"	3½"	3½"	3½"	3½"	4½"
Length	17½"	17½"	17½"	17½".	17½"	17½"	19"
Weight (pounds)	6½	6½	6½	6½	6½	6½	9
Carton Packing	9 units	9 units	9 units	9 units	9 units	9 units	9 units

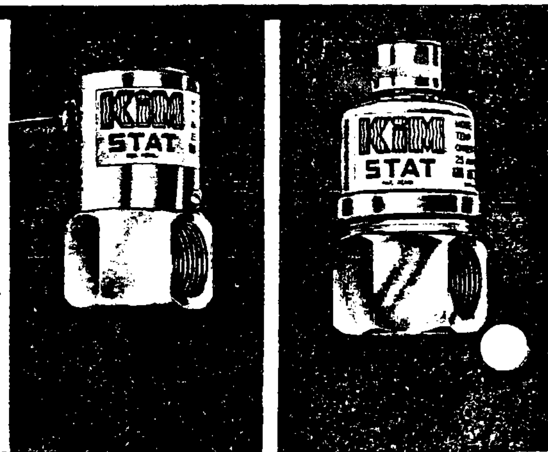
All models will operate on AC or DC (25, 50 or 60 cycle). Be sure to specify voltage required. **ALL MODELS AVAILABLE IN EXPLOSION PROOF DESIGN.**

KIM®-Stat

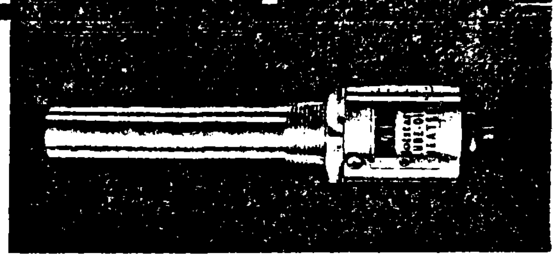
ELECTRIC THERMOSTATIC CONTROL FOR LIQUIDS

Choose from these Kim-Stat models to fit your particular requirements.

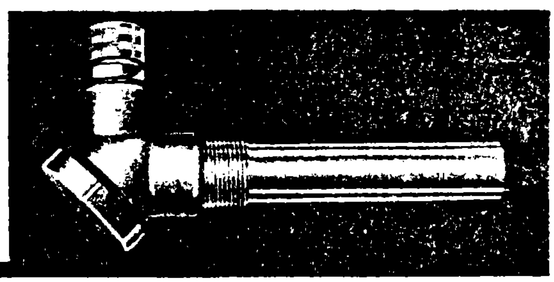
STANDARD MODEL	EXPLOSION PROOF MODELS	ON	OFF	AMPS	WEIGHT POUNDS
.S 810	KS 810EP	80° F	100° F	25 115/230	1
KS 1012	KS 1012EP	100° F	120° F	25 115/230	1
KS 1214	KS 1214EP	120° F	140° F	25 115/230	1
KS 1416	KS 1416EP	140° F	160° F	25 115/230	1
KS 1618	KS 1618EP	160° F	180° F	25 115/230	1



KIM® Lube Oil Heater



MODEL	WATTS	VOLTS ± 10%	AMPS.	W.S.I.	PROBE LENGTH	THREAD SIZE *	GALS. OF LUBE OIL	WGT. LBS.
OL61515	150	115	1.3	6.5	4⅞	1" NPT	1 to 5	1½
OL61515EP*	150	115	1.3	6.5	4⅞	1" NPT	1 to 5	2½
OL61523	150	230	.65	6.5	4⅞	1" NPT	1 to 5	1½
OL61523EP*	150	230	.65	6.5	4⅞	1" NPT	1 to 5	2½
OL6315	300	115	2.6	13.0	4⅞	1" NPT	5 to 15	1½
OL6315EP*	300	115	2.6	13.0	4⅞	1" NPT	5 to 15	2½
OL6323	300	230	1.3	13.0	4⅞	1" NPT	5 to 15	1½
OL6323EP*	300	230	1.3	13.0	4⅞	1" NPT	5 to 15	2½
OL6615	600	115	5.2	26.0	4⅞	1" NPT	15 to 30	1½
OL6615EP*	600	115	5.2	26.0	4⅞	1" NPT	15 to 30	2½
OL6623	600	230	2.6	26.0	4⅞	1" NPT	15 to 30	1½
OL6623EP*	600	230	2.6	26.0	4⅞	1" NPT	15 to 30	2½



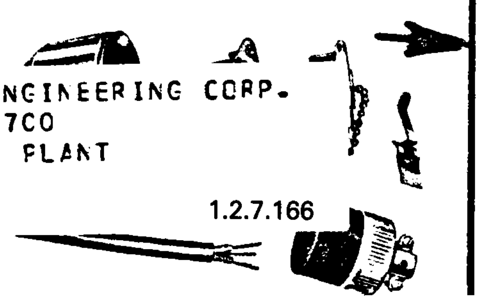
''USH MOUNTING KIT

PART [...]
WJ11

STEARNS-RCGER ENGINEERING CORP.
PRCJECT NC. 6217CO
SCLAR-CNE FILOT PLANT
UNIT CNE
P.C. 2C01

PART
WJ220, JR:

PART ... for Models
BC220 and E220



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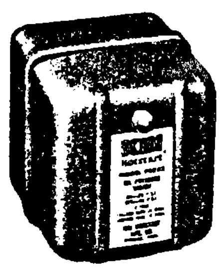
OIL PRESSURE SWITCH

Part No. PS-252
For automatic cut-off on standby equipment.
Two Pole
115/230 Volts—25 Amps.
440/550 Volts—15 Amps.



V-378-F2

Cummins Diesel Model V-378-F1 Fire Pump engine with the following standard equipment.

Clockwise rotation when viewed from end opposite stub shaft.

STANDARD EQUIPMENT

Cooler, Lubricating Oil; Tubular type, jacket water cooled.

Cleaner, Air: 10" diameter, dry type, mounted.

Electrical Equipment: 24 volt negative ground system. 24 volt starting motor; 24 volt, 20 ampere alternator; voltage regulator; manually operable contactors; junction box with enclosed terminal strip.

Filters: Lubricating oil, full flow replaceable paper element type, mounted. Fuel, paper element throwaway type mounted.

Flywheel: Machined for stub shaft mounting.

Water Temperature Switch: Provides signal to activate alarm (not included) for high water temperature.

Housing, Flywheel: SAE No. 2 with industrial supports.

Manifold, Exhaust: Dual, water cooled with outlet horizontal to rear.

Pan, Oil: Cast, aluminum, rear sump type, 3 U.S. gallon capacity. Provision for oil heater.

Panel, Instrument: Mounted. Includes ammeter, tachometer, hourmeter, water temperature gauge, lubricating oil pressure gauge, circuit breaker.

Pump, Coolant: Belt driven, centrifugal type.

Stubshaft: Mounted on flywheel.

Support, Engine: Pedestal type, front and rear.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

TECHNICAL

DATA FROM THE AURORA PUMP DIVISION

CUMMINS DIESEL WRITE UP SPECS

8420/157/000

Cummins Diesel Model V-378-F1 Fire Pump Engine with the following standard equipment.

Corrosion Resistor: Mounted, checks rust and corrosion, controls acidity and removes impurities from coolant.

Damper Vibration: Rubber Isolator.

Exchanger, Heat: Tubular type.

Governor: Mechanical flyball, mechanical variable speed type.

Guard, Belt and Damper Shield: Protection from alternator, accessory drive, and water pump belts and vibration damper.

Overspeed Switch: Mounted, overspeed shutdown with manual reset, stop crank contacts.

Water Jacket Heater: Kim Hotstart Model BS010. Pre-heater, 115 volt, 2500 watt.

Thermostat: Kimstart Model KS1012, 115/230 volt.

Oil Pressure Switch: Kim Hotstart Model PS252, 115/230 volt.

Flexible Metal Hoses: Inlet 428 0031 000 Return 428 0036 000 Hoses installed on engine with 7/8-14 UNF-45° Tip, Male fitting attached on line end of hoses.

Operation and Parts Manuals: One set.

NOTE: See Aurora Spec sheet 842 0157 000 for engine options and accessories.

842/0157/000

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

PREPARED BY WH	DATE 12-6-79	1.2.7.168	A
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AURORA PUMP
A UNIT OF GENERAL SIGNAL CORPORATION
AURORA · ILLINOIS

1. Oil Heater

For Engine Models V-378-F1, V-378-F2, V-504-F1 and V-504-F2 - Kim Hotstart Model OL41515, 115 volt, 150 Watt.

For Engine Models N-855-F, NT-855-F1 and NT-855-F2 - Kim Hotstart Model OL4315, 115 volt, 300 Watt.

For Engine Model VT-1710-F - OL 6315, 230 volt, 300 Watt.

2. Additional Operation and Parts Manuals.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

PREPARED BY WH	DATE 12-6-79	A	AURORA PUMP A UNIT OF GENERAL SIGNAL CORPORATION AURORA · ILLINOIS
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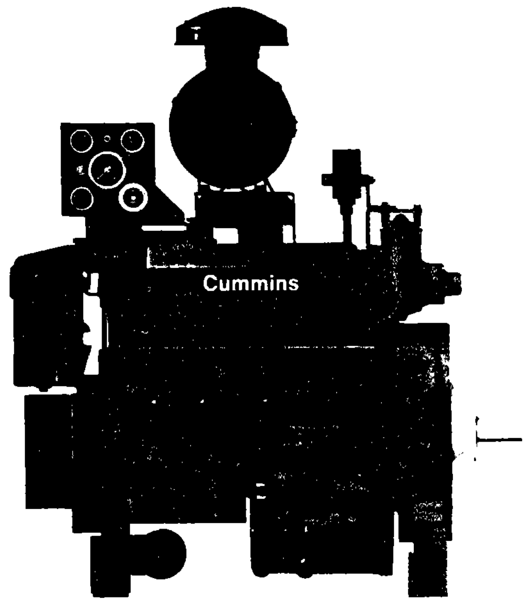
Cummins Diesel V-378-F2



Specifications

		Metric
Number of Cylinders	**6**	**6**
Bore and Stroke	**4 in. x 3¾ in.**	**117 x 95 mm**
Piston Displacement	**378 cu. in.**	**6.2 L**
Operating Cycles	**4**	**4**
Crankcase Oil Cap.	**3.75 U.S. gals.**	**14 L**
Engine Coolant Cap.	**7.4 U.S. gals.**	**28 L**
Net Weight, with Std. Accessories, Dry	**1665 lbs.**	**756 kg**

Specific ratings are shown on rear page.

Design Features

Bearings: Replaceable, precision type, steel backed inserts. Five main bearings, 3.5 in. (89 mm) diameter. Connecting rod bearings 2.8 in. (70 mm) diameter.

Camshaft: Single camshaft precisely controls valve and injector timing. Lobes are induction hardened for long life. Five replaceable precision type bearings 2.0 in. (51 mm) diameter.

Camshaft Followers: Induction hardened, roller type for long cam and follower life.

Connecting Rods: Drop forged, I-beam section 6.0 in. (153 mm) center to center length. Rifle drilled for pressure lubrication of piston pin. Rod is tapered on piston pin end to reduce unit pressures.

Cooling System: Belt driven centrifugal pump. Large volume water passages provide even flow of coolant around cylinder liners, valves, and injectors. Modulating by-pass thermostat regulates coolant temperature. Spin-on corrosion resistor checks rust and corrosion, controls acidity, and removes impurities.

Design Features Continued

Crankshaft: High tensile steel forging with induction hardened fillets and journals. Fully counterweighted and balanced.

Cylinder Block: Alloy cast iron with removable wet liners. Cross bolt support to main bearings cap provides extra strength and stability.

Cylinder Heads: Alloy cast iron. Each head serves three cylinders. Drilled fuel supply and return lines. Valve seats are replaceable corrosion resistant inserts. Valve guides and cross head guides are replaceable inserts.

Cylinder Liners: Replaceable wet liners dissipate heat faster than dry liners and are easily replaced without reboring the block.

Fuel System: Cummins exclusive low pressure PT™ system with wear compensating pump and integral dual flyweight governor. Camshaft actuated fuel injectors give accurate metering and timing. Fuel lines are internal drilled passages in cylinder heads. Spin-on fuel filter.

Gear Train: Timing gears and accessory drive gears are induction hardened spur gears driven from crankshaft and located at rear of block.

Lubrication: Large capacity gear pump provides pressure lubrication to all bearings. All pressure lines are internal drilled passages in block and heads. Oil cooler, full-flow filters maintain oil condition and maximize oil and engine life.

Pistons: Aluminum alloy, cam ground and barrel shaped to compensate for thermal expansion assures precise fit at operating temperatures. CeCorr™ grooved skirt finish provides superior lubrication. Two compression and one oil ring.

Piston Pins: Full floating, tubular steel retained by snap rings. 1.4 in. (36 mm) diameter.

Valves: 1.6 in. (41 mm) diameter poppet type intake and exhaust valves. Wear resistant face on exhaust valves.

Standard Equipment

Air Cleaner: 10 in. (254 mm) diameter, dry type, mounted.

Belt and Damper Shield Guard: Protection from alternator, accessory drive, and water pump belts and vibration damper.

Coolant Pump: Belt driven, centrifugal type.

Corrosion Resistor: Mounted, checks rust and corrosion, controls acidity, and removes impurities from coolant.

Electrical Equipment: 24 volt negative ground system. 24 volt starting motor; 24 volt, 18 ampere alternator; voltage regulator; manually operable contacters; junction box with enclosed terminal strip.

Engine Support: Pedestal type, front and rear.

Exhaust Manifold: Water cooled.

Filters: Lubricating oil, full flow replaceable paper element, mounted. Fuel, paper element throwaway type, mounted.

Flywheel: Machined for stub shaft mounting.

Flywheel Housing: SAE No. 2 with industrial supports.

Governor: Mechanical flyweight, mechanical variable speed type.

Heat Exchanger: Tubular type, aluminum bronze.

Instrument Panel: Mounted. Includes ammeter, circuit breaker, water temperature gauge, tachometer, lube oil pressure gauge, hourmeter.

Lubricating Oil Cooler: Tubular type, jacket water cooled.

Oil Pan: Cast aluminum, rear sump type, 3 U.S. gallon (11.4 liter) capacity. Provision for oil heater.

Oil Pressure Switch: Provides signal to activate alarm (not included) for low oil pressure.

Overspeed Switch: Mounted, overspeed shutdown with manual reset, stop crank contacts.

Stubshaft: Mounted on flywheel.

Vibration Damper: Rubber isolator.

Water Jacket Heater: Mounts under oil pan. 115 volt, 2500 watt.

Water Temperature Switch: Provides signal to activate alarm (not included) for high water temperature.

Optional Equipment

Oil Heater: Mounted in pan.

LISTED AGENCY RATINGS

Underwriters' Laboratories:
119 HP @ 2400 RPM
127 HP @ 2600 RPM
132 HP @ 2800 RPM
135 HP @ 3000 RPM
137 HP @ 3300 RPM

Factory Mutual:
113 HP @ 2400 RPM
120 HP @ 2600 RPM
125 HP @ 2800 RPM
128 HP @ 3000 RPM
130 HP @ 3300 RPM

Underwriters' Laboratories of Canada:
119 HP @ 2400 RPM
127 HP @ 2600 RPM
132 HP @ 2800 RPM
135 HP @ 3000 RPM
137 HP @ 3300 RPM

The agency-approved horsepower ratings shown are already derated for fire pump service and available for driving the fire pump at SAE standard J816b conditions of 500 ft. (150 m) (29.38 in. Hg or - 746 m Hg), and 85° F., 29.4° C. intake air temperature. The only additional deration necessary is for higher ambient temperatures and elevations as follows: 3% for each 1000 feet above 500 feet and 1% for each 10 degrees above 85°F. in accordance with National Fire Association Pamphlet No. 20.

Installation Considerations

Maximum raw water pressure must not exceed 50 PSI. Minimum acceptable raw water flow at 90°F. raw water temperature and 100°F. ambient air temperature should be at least 32 G.P.M. at the 3300 RPM listed rating.

Ventilation air required for engine combustion is 315 CFM at 3300 RPM rating. This is for engine air combustion only and does not take into consideration additional air required for normal room cooling.

Listed under Underwriters' Laboratories, Inc., reexamination service for fire protection applications.

Listed by Associated Factory Mutual Fire Insurance Companies for fire protection applications.

Listed under Underwriters' Laboratories of Canada reexamination service for fire protection applications.

Cummins has always been a pioneer in product improvement. Thus specifications may change without notice. Illustrations may include optional equipment.

Cummins Engine Company, Inc., Columbus, Indiana 47201

Bulletin 3380299 Litho in USA 6-80

CUMMINS ENGINE COMPANY, INC.

Engine Data Sheet

Fire Pump Engine Model: V-378-F2 **Date:** June, 1980 **Data Sheet:** DS-3606-A
(for listed/approved ratings see tabulation)

General Engine Data

Type:	4 Cycle;90°Vee;6 Cylinder
Aspiration:	Natural
Bore — in. (mm)	4.625 (117)
Stroke — in. (mm)	3.75 (95)
Displacement — in.³ (litre)	378 (6.2)
Compression Ratio:	17.0:1
Valves per Cylinder: — Intake	2
— Exhaust	2
Engine Weight & Center of Gravity (With Standard Accessories)	
Reference Installation Diagram	556892
Dry Weight — lb. (kg)	1665 (756)
Wet Weight — lb. (kg)	1763 (800)
C.G. Distance From F.F.O.B. — in. (mm)	10.7 (272)
C.G. Distance Above ℄ Crankshaft — in. (mm)	4.3 (109)
Maximum Allowable Bending Moment @ Rear Face of Block — lb.-ft. (N•m)	1000 (1 350)

Air Induction System

Maximum Allowable Temperature Rise Between Ambient Air and Engine Air Inlet (Ambients 32°F [0°C] to 100°F [38°C]) — °F (°C)	30 (15)
Maximum Allowable Intake Restriction With a Dirty Air Filter Element — in. H_2O (mm H_2O)	20 (500)
Part Number of Standard Air Filter Element (Dry Type)	555084

Lubrication System

Oil Pressure @ Rated Speeds — PSI (kPa)	45–70 (310–480)
Oil Flow @ Maximum Rated Speeds (Nominal) — U.S. GPM (litre/s)	25 (1.6)
Oil Pan Capacity (High — Low) U.S. gal. (litre)	3–2.25 (11–8.5)
Full Flow Lube Oil Filter Capacity — U.S. gal. (litre)	3.75 (14)
Part Number of Standard Oil Pan	553496
Part Number of Standard Oil Filter Element	LF-613

Application Note: When ambient temperatures will be lower than 70°F (21°C) an oil heater is required. The recommended heater wattage for this engine is 150 down to 40°F (4°C).

Cooling System

Heat Exchanger Cooled (Shell & Tube Type)	
Part Number of Tube Bundle	653747
Raw Water Working Pressure Range at Heat Exchanger — PSI (kPa)	50 (345) (Maximum)
Recommended Minimum Water Supply Pipe Size to Heat Exchanger (Reference Only) — in. (mm) dia.	1 (25)
Recommended Minimum Water Discharge Pipe Size From Heat Exchanger (Reference Only) — in. (mm) dia.	1.25 (30)
Coolant Water Capacity (Engine Side) — U.S. gal. (litre)	7.4 (28)
Standard Thermostat — Type	Modulating
— Range — °F (°C)	170–185 (77–85)
Minimum Raw Water Flow with Water Temperatures to 90°F (32°C) — U.S. GPM (litre/s)	32 (2.0)

Note: Minimum raw water requirement is based on water flow required to minimize tube fouling in the heat exchanger tube bundle.

A jacket water heater is mandatory on this engine. The recommended heater wattage is 1500 down to 40°F (4°C).

Exhaust System

Maximum Allowable Back Pressure Imposed by Piping & Silencer — in. Hg (mm Hg)	3 (75)
Exhaust Pipe Size Normally Acceptable — in. (mm) dia.	2.5 (65) Twin 3 (75) Single

Fuel System

Supply Line Size — in. (mm)	0.500 (15) I.D. Tube
Drain Line Size — in. (mm)	0.500 (15) I.D. Tube
Maximum Fuel Line Length Between Supply Tank & Fuel Pump — ft. (m)	40 (12)
Maximum Fuel Height Above ℄ Crankshaft — in. (mm)	80 (2 030)
Part Number of Standard Fuel Filter	156171
Part Number of Standard Fuel Filter Element	FF–105–D
Maximum Allowable Restriction to Fuel Pump With Dirty Filter — in. Hg (mm Hg)	8.0 (200)
Maximum Allowable Return Line Restriction — in. Hg (mmHg)	4 (100)

Electrical System

Battery Voltage	24	
Battery Cable Size (Maximum Cable Length Not to Exceed 10 ft. (3.0 m) AWG)	00	
Wiring for Automatic Starting (Negative Ground)	Standard	
Alternator (Standard) 24 Volt, Internally Regulated — Ampere		
Manually Operable Contactors	Standard	
Minimum Recommended Battery Capacity —	*Amp-hr.*	*0°F CCA*
70°F (21°C) Minimum Temperature	100	450
32°F (0°C) Minimum Temperature	150	640
Reference Wiring Diagram Number	218147	

Performance Data

All data is based on the engine operating with fuel system, water pump, lubricating oil pump, air cleaner, and alternator; not included are compressor, fan, optional equipment and driven components. Data is based on operation at SAE standard J816b conditions of 500 feet (150 m) altitude (29.00 in. [736 mm] Hg dry barometer), 85°F (29°C) intake air temperature and 0.38 in. (9.6 mm) Hg water vapor pressure, using No. 2 diesel or a fuel corresponding to ASTM D2. **All data is subject to change without notice.**

Altitude Above Which Output Should be Limited — ft. (m)	500' (150m)
Correction Factor per 1000 ft. (300 m) above Altitude Limit	3%
Temperature Above Which Output Should be Limited — °F (°C)	85 (29)
Correction Factor per 10°F (11°C) Above Temperature Limit	1% (2%)

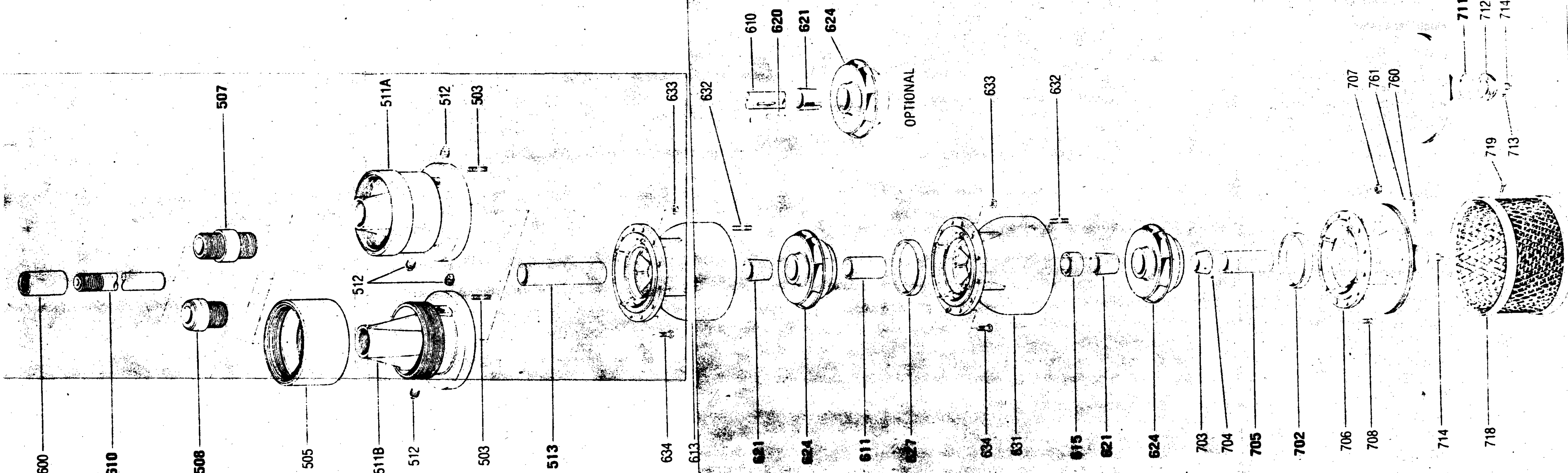
Listed/Approved Ratings BHP (kW)	Speed RPM	Ventilation Air Req'd. For Combustion CFM (litre/s)	Heat Rejection to Cooling Water BTU/min. (kW)	Heat Rejection to Ambient Air* BTU/min. (kW)	Exhaust Gas Flow CFM (litre/s)	Exhaust Gas Temp. °F (°C)	Fuel Consumption gal./hr. (litre/h)
			UL LISTED RATINGS				
137 (102)	3300	331 (157)	5513 (97.0)	639 (11.2)	809 (381)	895 (480)	7.4 (28.0)
135 (100)	3000	310 (147)	5408 (95.1)	587 (10.3)	756 (356)	885 (474)	6.8 (25.7)
132 (98)	2800	299 (141)	5355 (94.2)	587 (10.3)	725 (342)	885 (474)	6.8 (25.7)
127 (94)	2600	284 (134)	4883 (85.9)	553 (9.7)	693 (327)	885 (474)	6.4 (24.2)
119 (88)	2400	273 (129)	4830 (85.0)	544 (9.6)	662 (312)	870 (466)	6.3 (23.8)
			FM APPROVED RATINGS				
130 (97)	3300	315 (149)	5250 (92.3)	500 (8.8)	770 (363)	890 (477)	7.4 (28.0)
128 (95)	3000	295 (139)	5150 (90.5)	400 (7.0)	720 (340)	880 (471)	6.8 (25.7)
125 (93)	2800	285 (135)	5100 (89.7)	400 (7.0)	690 (326)	880 (471)	6.8 (25.7)
120 (89)	2600	270 (127)	4650 (81.7)	400 (7.0)	660 (312)	880 (471)	6.4 (24.2)
113 (84)	2400	260 (123)	4600 (80.9)	400 (7.0)	630 (297)	865 (463)	6.3 (23.8)

*Does not include exhaust piping.

Fire Pump Engine Model: V–378–F2
Data Sheet No.: DS–3606–A
Date: June, 1980
Bulletin No.: 3383350

CUMMINS ENGINE COMPANY, INC., Columbus, Indiana 47201

AURORA 1110-1120 SERIES
REPAIR PARTS LIST
PUMP BOWL ASSEMBLY
WITH BASKET STRAINER



BOLD FACE PIECE NUMBERS INDICATE RECOMMENDED SPARE PARTS

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

AURORA PUMP
A UNIT OF GENERAL SIGNAL

1.27.174 320 8005 000

M-20

INSTALLATION & OPERATING INSTRUCTIONS

CLOSE COUPLED VERTICAL TURBINE PUMPS

1.2.7.175

OPEN LINESHAFT CONSTRUCTION

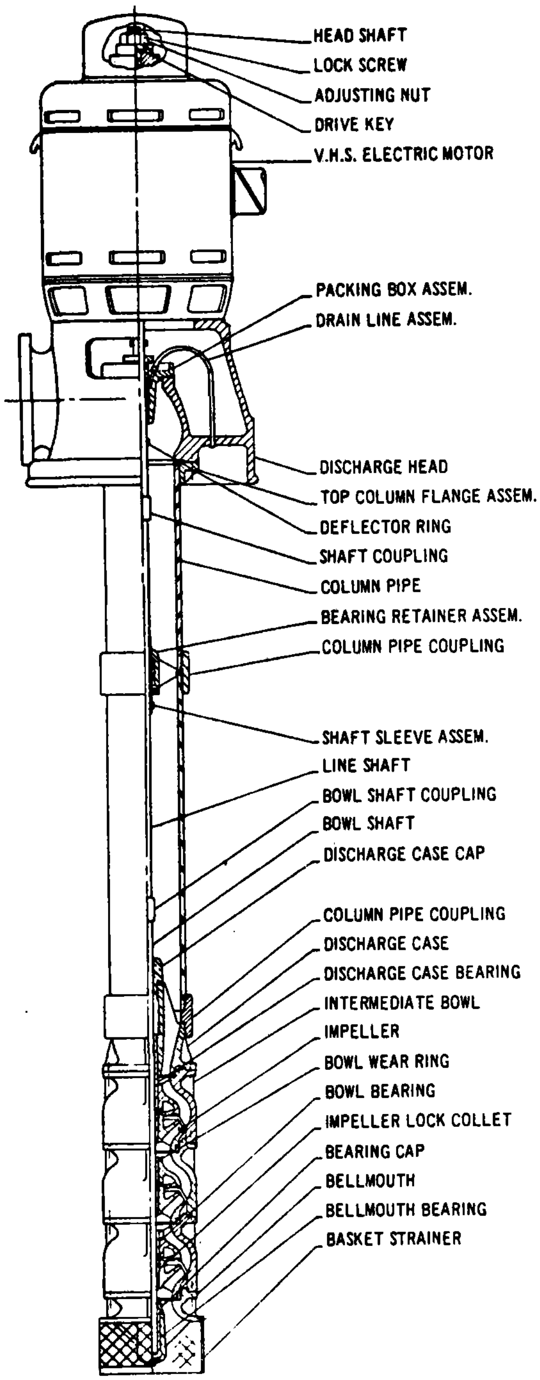


Fig. 1

ENCLOSED LINESHAFT CONSTRUCTION

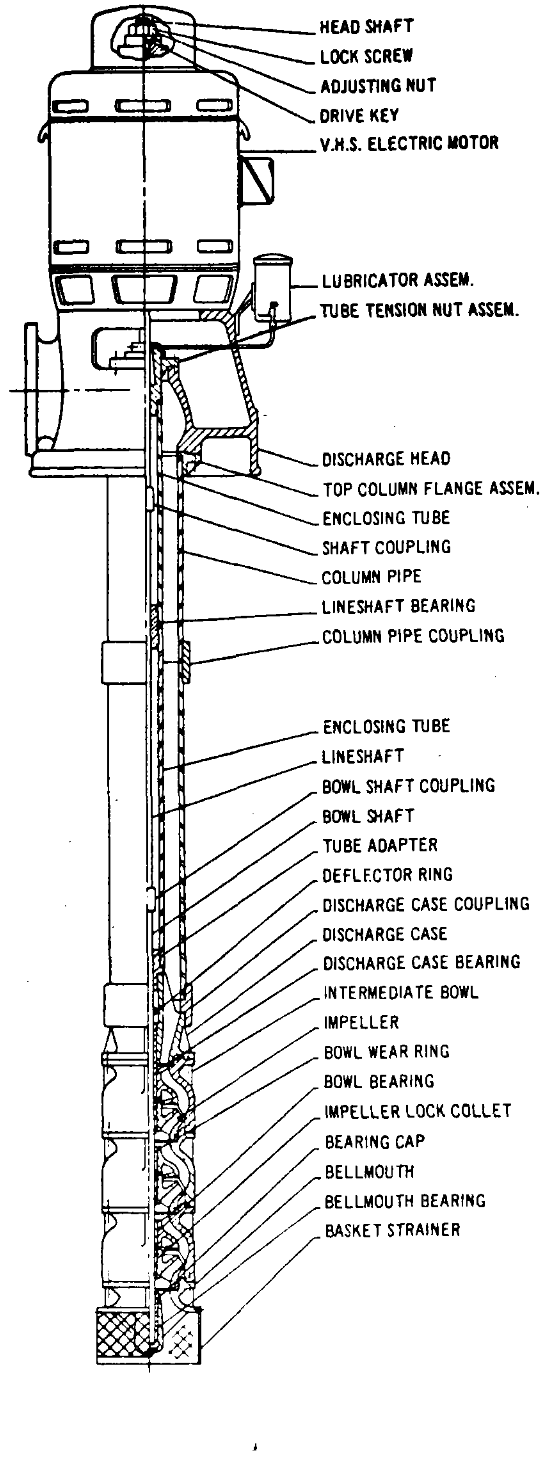


Fig. 2

INSTRUCTIONS FOR THE INSTALLATION AND CARE
OF LAYNE & BOWLER VERTI-LINE PUMPS

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SECTION 1

INTRODUCTION

The satisfactory operation of the vertical turbine pump is dependent upon careful and correct installation and maintenance of the equipment. Because of the variations in installation requirements, the following instructions must of necessity be rather general in tone. The installer and maintenance man must use sound judgement to adapt the methods outlined to the conditions existent for each particular installation.

General assemblies of Layne & Bowler Vertical Turbine Pumps are shown in Figs. 1 and 2 with the component parts properly identified. This nomenclature will be used as a reference throughout these instructions. It must be understood that these are typical illustrations and may not conform in complete detail to the equipment as furnished. Please refer to any drawings that have been prepared for this specific installation and become thoroughly familiar with the construction of the pump in question before attempting to assemble, install, dismantle, or do repair work on the unit.

This type of equipment is often furnished with optional features at the specification of the user. Most of the available options will be described in this booklet. Please refer to those sections applicable to the construction of your unit, disregarding those that do not apply.

Close coupled vertical turbine pumps are usually shipped assembled and proper instructions for the handling of this type of machine will be presented here first. For equipment of a length too inconvenient to ship completely joined, the bowl unit and discharge head are assembled individually at the factory while the column parts may be shipped as components for job site assembly as suggested later in the following instructions.

If there is any doubt or question during the process of installation or operation, contact the factory or your nearest Layne & Bowler representative at once.

SECTION 2

PRELIMINARY PRECAUTION

Examine the installation site carefully before starting work.

If piping is already in place, make sure that it has been completely cleared of sand, silt, gravel, chips, or foreign material of any sort. If pump is to be installed in a sump, be sure sump has been cleared of debris and is equipped with provisions to prevent entrance of any more foreign material. The sump itself including inflow channel and pump mounting structure must be of a design adequate for the equipment to be installed. This consideration is the responsibility of the user.

During all steps of installation, care must be used to prevent strains from being imposed upon pump parts which might cause bending or misalignment of column or shafting. This also applies to piping connections.

If any parts are protected with permanent coatings, extreme care in handling will be necessary to prevent damage to coating. This might include such precaution as gloves for wrenches, etc. If coating is damaged, it should be repaired before installation is completed.

SECTION 3

PUMP FOUNDATION

A suitable pump foundation should always be provided, preferably of solid concrete construction. If this is not practical, adequate beams or timbers may be used. With a suction cased pump, the foundation will of course be under the vessel flange and the pump head will mount directly to the vessel flange.

The pump foundation must be built to carry the weight of the entire pump full of liquid and should be of a design to withstand and prevent any undue vibration. If the pump is mounted on beams, the beams should be heavy enough to prevent spring action between spans, also with lateral bracing to prevent side motion.

Pump foundation or mounting structure is not to be considered part of the pump and will be the responsibility of the user.

SECTION 4

SUCTION VESSEL

If pump is a suction cased booster, suction vessel may have been furnished with pump or may have been procured from another source. In either event, vessel should be lowered into its pit, leveled, and grouted in place, following which nuts may be tightened on anchor bolts.

It is important that vessel be set with machined portion of top flange perfectly level. Vessel bolt holes must be located so that suction and discharge nozzles are in proper orientation for jobsite piping.

In some installations, concrete is poured around outside of vessel after positioning. In other instances, vessel may be set in ground with a higher water table. In these or similar situations, proper measures must be taken to prevent vessel from floating out of position. This may be done by any suitable means, including firm anchoring and bracing, or vessel itself may be filled with water to eliminate its buoyancy.

Following installation of vessel, and during installation of pump, it will be necessary to provide protection for machined surface of vessel flange.

Typical assemblies of this type are shown in Fig. 3 and 4.

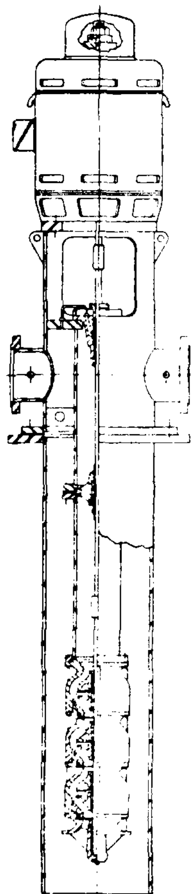

Fig. 3

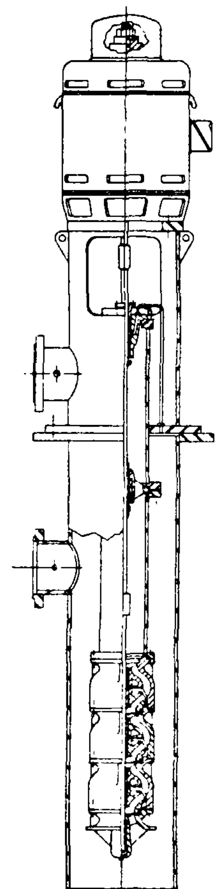

Fig. 4

SECTION 5

INSTALLATION EQUIPMENT

Required installation equipment will of course depend upon type and size of pump to be installed. Although portable derricks or tripods are sometimes used, a properly designed pump setting rig (See Fig. 5) or construction crane is recommended. The lifting device must be of sufficient height to allow the load hook to be raised about two feet higher than total length of unit if it is desired to handle the complete assembly.

Depending upon complexity of installation, following miscellaneous tools may be required:

Wooden friction blocks or steel clamps (Fig. 6)
Steel column lifting elevators of approved type and of proper size for the pump column (Fig. 6)
Cable sling approximately 10 feet long of adequate size for the loads involved
Two chain tongs
Two medium size pipe wrenches
Twelve foot length of 3/4" rope
Ordinary set of mechanics tools
Wire brush
Paint brush
A good grade of pipe joint compound
Gasoline, distillate or kerosene

If equipment is to be oil lubricated, provide at least one gallon of SAE #10 mineral oil with proper additives or a good turbine oil such as Standard Oil O.C. Turbine Oil #9.

If mating stainless steel parts are to be joined, particularly with threads, a lubricant containing molybdenum disulphide or some equally effective anti-galling compound should be provided and used per manufacturer's directions.

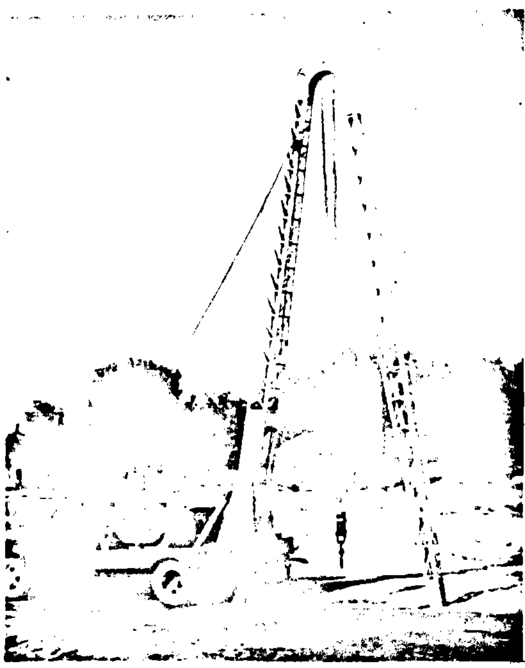

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Fig. 5

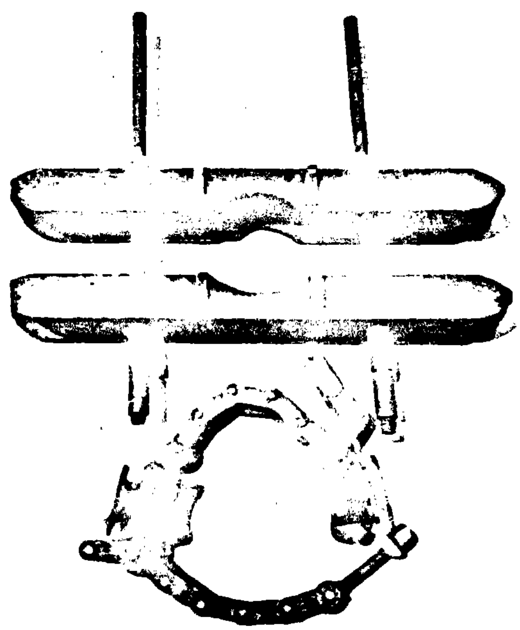


Fig. 6

SECTION 6

UNLOADING AND PREPARATION FOR INSTALLATION

Uncrate parts and inspect carefully to be sure nothing was damaged in shipment. Check in detail condition of any shafting. If any part of equipment or crating has been damaged or broken in shipment, please report immediately to factory and to transportation company involved, with full particulars, confirming all verbal understandings by letter. Do not accept shipments showing damage. Do not sign for incomplete shipments.

If pump is shipped assembled, see Section 7. If not, continue with this section.

If pump is shipped unassembled, clean all column and coupling threads of any slushing compound or foreign particles with wire brush. Keep threads clean at all times and use care in making up screwed joints to avoid cross threading and damage to threads. Use Permatex No. 2 Gasket and Thread Compound on all column joints and flanged pipe connections during installation.

If pump has been shipped in components, lay out column pipe and bowl assembly on suitable timbers or staging to keep all material out of dirt. Coupling ends should be located toward mounting position. Clean all threads thoroughly and apply joint compound with paint brush as they are installed. Inner column assembly consisting of shafting and/or tubing with lineshaft bearings will have been preassembled at the factory into proper lengths to match the column pipes. If furnished, tube faces should be inspected to see that they are free from burrs or nicks and are wiped clean. Sections of tubing which have been assembled at factory should be checked for tightness by installer at jobsite.

Examine lineshafting to make sure that it is straight, care being taken not to bend shafts or damage threads. Do not lay shafting lengths on ground or where they may be walked on or run over. KEEP THEM STRAIGHT. They must be placed on timbers and all rust preventive oil or slushing compound should be washed off with gasoline, distillate or solvent. Exercise great care in jobsite handling because, due to its length, a shaft can easily be sprung or bent. Any length that is bent should not be used. Keep shaft and tube ends covered until they are ready to be installed.

All other parts should be cleaned and laid out on a clean surface in the order in which they will be used. Check against packing list to be sure that none are missing.

Insert each length of intermediate shafting into the assembled enclosing tubes if furnished or into the column pipe if pump is of open lineshaft construction without tubing. Tube and shaft assembly, if furnished, should similarly be inserted into column pipe sections. Place with projecting lineshaft bearing and column coupling pointed toward the mounting position. See Figs. 7 and 8.

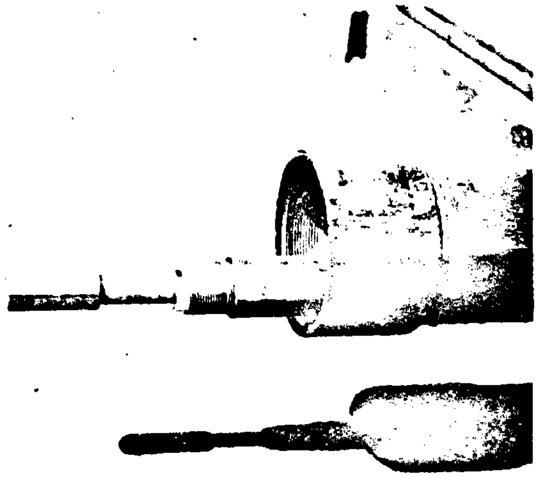


Fig. 7

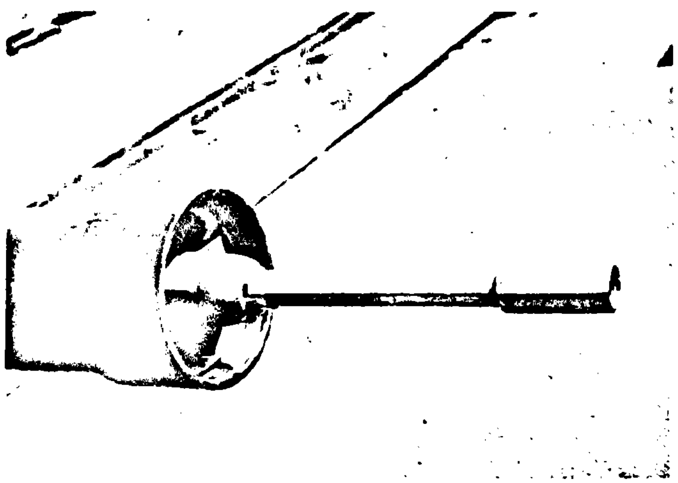


Fig. 8

SECTION 7

INSTALLATION OF FACTORY ASSEMBLED UNITS

Clean mounting structure at pump location. If this is a suction cased pump, clean top flange of vessel and install gasket or O ring as provided. Clean bottom face of discharge head mounting base or flange.

Raise entire unit as shipped to a vertical position, using proper lifting lugs, (Fig. 9), taking care not to put strain on column or any exposed shafting. Install assembled unit in a plumb vertical position with full contact base to mounting surface. Assemble base or flange mounting bolts and/or nuts.

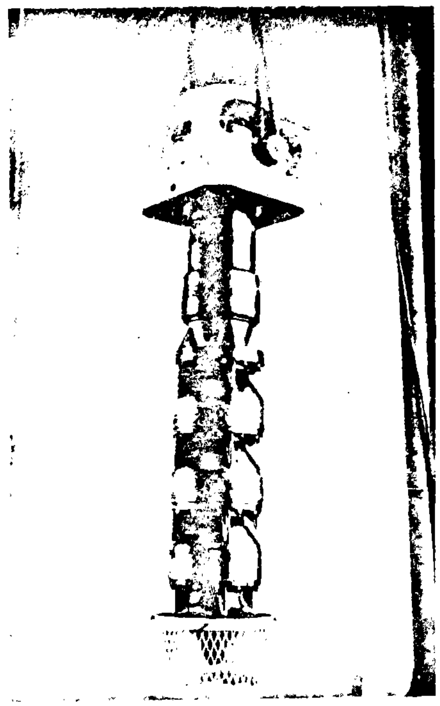


Fig. 9

If driver is of vertical solid shaft construction, refer to procedures outlined in Section 10D. If driver is of vertical hollow shaft construction, continue with this section.

Clean all mounting surfaces and lower driver into position atop its mounting structure, fastening with capscrews as provided. Remove canopy and drive coupling, illustrated in Fig. 10. Check level indicators for amount of oil or grease in driver bearings. Do not add grease without first opening grease relief plugs, as high pressure might ruin grease seals. In general, lubrication instructions will be furnished with driver and these instructions should be followed implicitly.

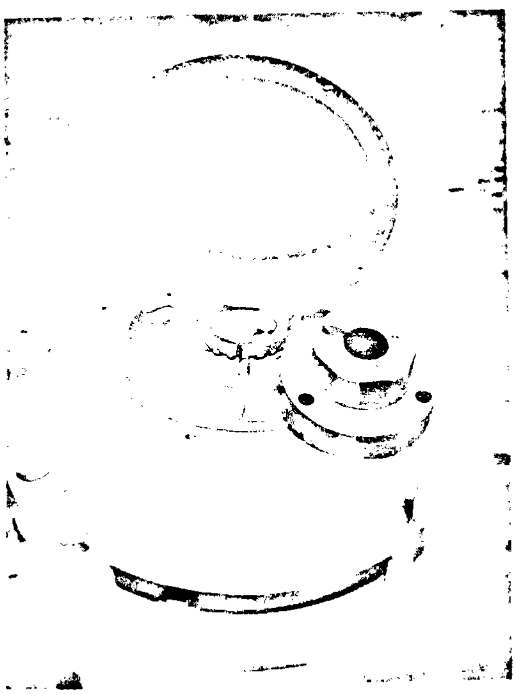


Fig. 10

On electric motor driven units of hollow shaft construction, connect motor terminals to leads in starter panel. CAUTION: Do not work on pump, motor, wiring, or other components of system without first opening main breaker or pump disconnect switch. Since many electric motors will be furnished as dual voltage machines, it is important that proper connections be made to suit voltage of power source. Therefore, check power source and motor instruction nameplate for proper method of connecting motor terminals.

Energize starter panel and buzz-start motor by switching it very quickly on and off, observing for proper rotation and inspecting to see that it spins freely and is in balance. Motor must run counterclockwise when viewed from the top. If rotation is clockwise, interchange any two motor connections on three phase motors. On single phase motors, follow manufacturer's instructions. After reconnection, again buzz-start the motor to check rotation. Make absolutely sure that it will drive the pump in a counterclockwise direction before making connection to pump shaft. De-energize panel at main breaker or pump disconnect switch before continuing.

Assemble headshaft, sliding it down through packing box or tube connector, snapping it to firm butt against pump shaft. If possible, hold shaft coupling by reaching through pump discharge opening if first joint is located below the head. Remember shaft threads are left hand. It may be necessary to loosen packing box gland to facilitate installation of top shaft.

Slide drive coupling over headshaft into place on driver. It should have a sliding fit and should be firmly seated in its proper position on top of driver without tendency to hang up as it is lowered into position or rotated. It must sit perfectly flat and without cocking. File, dress, and scrape if necessary to obtain proper assembly. Remove coupling.

Try drive key in headshaft keyway and coupling keyway. Make sure that this is also a sliding fit. Reassemble coupling in place on driver and insert key. Do not force key in place. Dress the key NOT THE KEYWAY until a free but not loose fit has been obtained. Top of key must be below adjusting nut seat when in place.

Thread adjusting nut onto headshaft, remembering shaft threads are left hand. Raise shaft about one half turn off bottom. Assemble lock screw through adjusting nut, threading it into nearest tapped hole in drive coupling. See Fig. 11.

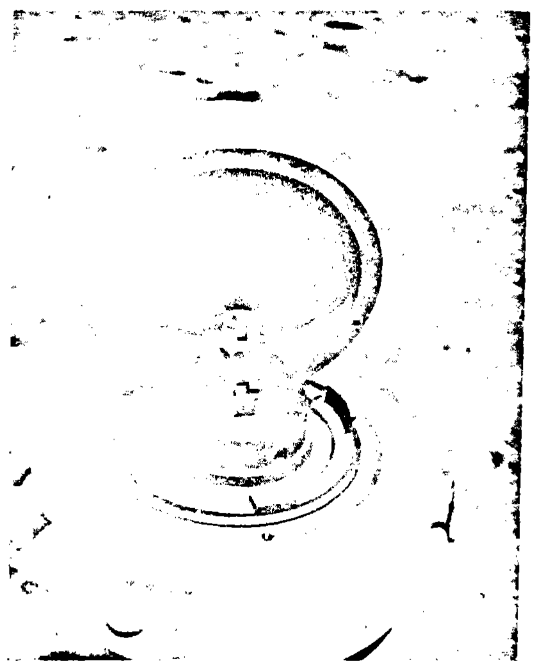


Fig. 11

If packing box is furnished, see Section 10A. Fill packing box grease cup with standard water pump grease if not already done. Lubricate as required. Connect drain lines from top of packing box flange, draining to convenient location.

If pump is of normal oil lubricated design, examine oil reservoir and oil feed line, making sure they are clean. See also Section 10B for details of enclosing tube connection, which will already have been made up at factory. Connect lubricating system as described in Section 10B. Fill oil reservoir, using oil as described earlier. Adjust lubricator valve to permit oil to drip at a rate of approximately one drop per second. For solenoid operated lubricators, this adjustment can only be made with solenoid energized, which may not occur until time of startup.

It is also advisable to apply a few drops of oil at top of tubing connector with an oil can. Reservoir and connections are shown in place in Fig. 12.

If any other system of pump lubrication has been furnished, refer to Section 10 for proper procedures or to any special instructions which may have accompanied the shipment of your pump. If pump incorporates a mechanical seal, again refer either to Section 10C or to special instructions included with shipment.

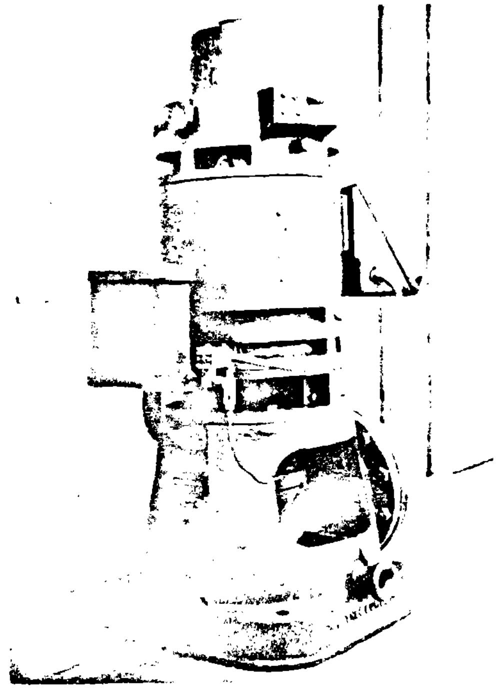


Fig. 12

Connect discharge manifold to pump without straining or distortion of any kind. Any other piping, including suction pipe to a "T" type head or to a suction vessel, must be assembled without strain being imposed on the pump in any way.

With a suction cased pump, remove vent plugs on suction and discharge. Open system suction line valve and flood pump. When as much air as possible has been released and liquid is above first stage of bowl assembly or as high above that as possible, open system discharge valve the equivalent of two turns of the wheel minimum. Replace vent plugs.

With sufficient submergence over suction or with adequate NPSH available, pump is now ready to start. However, read through these instructions completely to establish procedure for any optional items before starting pump.

SECTION 8

INSTALLATION OF UNASSEMBLED UNIT

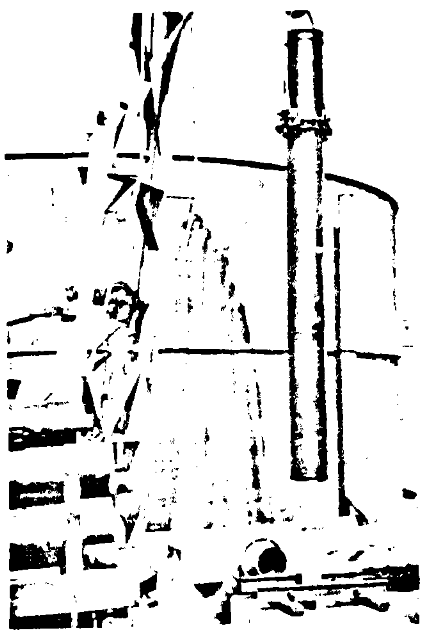


Fig. 13

Vertical turbine pumps of overall length less than 15 feet are almost invariably assembled complete at the factory less the driver. Equipment of overall length from 15 feet to 25 feet may or may not be shipped preassembled, depending upon a number of factors. Any units in excess of 25 feet overall length will invariably be shipped as components for jobsite assembly. The bowl unit and the discharge head will be assembled individually at the factory. Column components, driver, and other miscellaneous parts will then be shipped as separate items for jobsite assembly as suggested in this section.

Refer to Section 6 for preparation and location of parts prior to attempting the installation. Refer to Section 5 for suggested installation equipment.

Set pipe clamps over installation position and open up wide enough for suction pipe and/or strainer to pass through. If a suction assembly has been furnished, raise as shown in Fig. 13 with elevator assembly, lowering into position through opening in clamps. Clamp suction pipe at least two feet below coupling end so that pressure from clamp will not distort threads. Take care while raising suction assembly into vertical position to be sure that strainer (if supplied) is not damaged during this operation.

(a) OPEN LINESHAFT CONSTRUCTION

Examine bowl assembly carefully. Make sure that bowl assembly discharge case coupling is tightly butted in place and that all stage connecting nuts have been taken up securely. Examine bypass ports in discharge case to make sure that they are properly plugged. See Fig. 14. Raise bowl assembly as illustrated in Fig. 15, suspend directly over installation position and screw or bolt bowl unit onto pipe as required, making a tight joint. If no suction pipe is used, strainer may be assembled onto suction case before raising bowl assembly, but

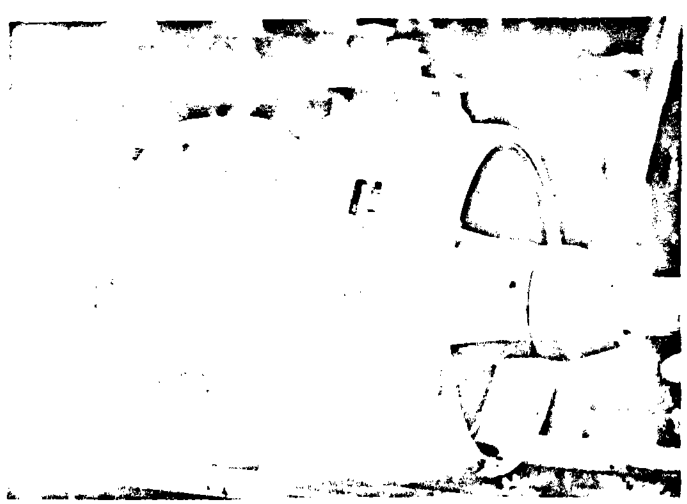


Fig. 14

care must be taken to prevent damage to strainer while raising to vertical position.

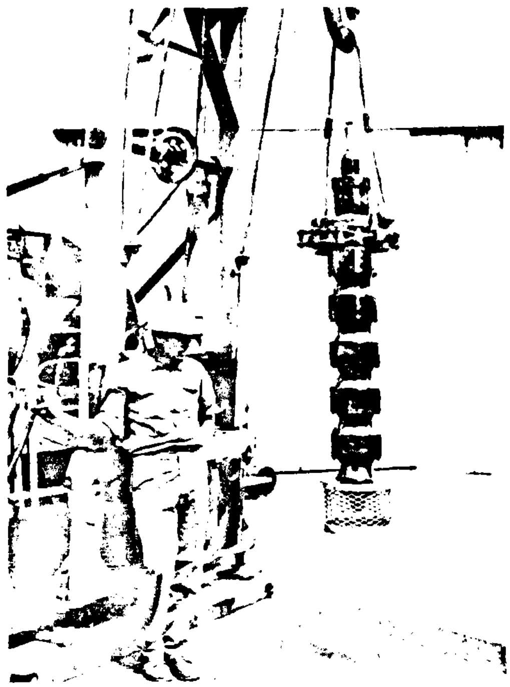


Fig. 15

Raise unit and remove clamps from suction pipe, then lower strainer, suction pipe, and bowl assembly as shown in Figs. 13 and 15. If two sets of elevators are used, column clamps can be tightened and assembled unit may then be lowered until elevator rests on clamp, Fig. 16. Clean and inspect all exposed threads and faces. Under no circumstances should the bowl assembly be lifted or handled by the pump shaft.

Bottom column pipe section will be marked as such. Attach elevators to this pipe immediately below column coupling. Use hemp rope and throw timber hitch around pipe about one foot from threaded end away from mounting position, double half hitch around shaft on top of threads to prevent slipping. This is illustrated in Fig. 16 and 17. Although other methods are acceptable, it is preferred that shaft coupling be on length of shafting already assembled as in Fig. 16 so that shaft is lowered into coupling much the same as pipe joint is made.

Crown block and load hook must be located exactly above center of installation position so that various components may be lowered and assembled true. Hoist column section in place above bowls as in Fig. 16. It will be necessary that free end of tail rope be held taut to prevent slipping on shaft. A soft board or pipe dolly should be laid out for end of column pipe to slide in on, so that threads will not be damaged as section is being raised.

Fig. 16

Fig. 17

Clean all threads and inspect shaft ends to be sure there are no burrs or dirt adhering to faces. Paint shaft threads with thread lubricant. Inspect and clean shaft coupling and assemble it as described. Lower column assembly and couple shaft, remembering that shaft thread is left-hand. Make sure that shaft ends are solidly butted together but do not use undue force in tightening

Fig. 18

See Fig. 18. Lock shafts tightly with two small pipe wrenches, using one wrench on shaft coupling and the other on shaft just above threads. Wrench handles should be parallel when final tightening is made to prevent pulling shaft off center. If available, it is even better practice to use a shaft wrench rather than a pipe wrench. Do not allow coupling to ride up on "last scratch" or imperfect thread, as this will tend to cock the coupling and create misalignment. Both shafts should show same amount of threads above and below coupling, indicating that shaft butt is in exact center of coupling. If force is required, look for damaged or dirty threads. Forcing threads may cause misalignment.

It is advisable to stuff sacking into discharge case or lower section of column pipe while assembling other parts. This will prevent dropping foreign material, tools, or parts into pump. If something is dropped in pump it must be removed before continuing installation. This could require returning everything to surface, and it can thus be seen that some form of cover is indicated. Remove sacking or cover before making up pipe joint.

Lower column pipe. Clean threads, apply lubricant, and screw up tightly with chain tongs, making absolutely sure that column joints butt solidly, metal to metal. These threads are right-hand. Start threads carefully to prevent cross-threading. In tightening column pipe joints, place one set of chain tongs on coupling and another on column pipe. Do not depend on friction clamps to hold lower section for tightening.

Fig. 19

To repeat, it is important that pipe ends butt solidly against mating parts. For flanged column, refer to Section 10F.

Raise entire unit sufficiently to remove holding clamp. Lower assembly until elevator clamp then rests on friction blocks as shown in Fig. 16. At this point, an inspection should be made to insure that shaft stands in center of pipe or that very slight pressure will center it.

Wipe all oil or grease from upper end of lineshaft down to and including journal area. Bearing retainer assembly may now be placed over projecting end of lineshaft with open end down as illustrated in Fig. 19. With threaded column, bearing retainer assembly is screwed into column coupling tightly against end of column pipe below, using hollow socket wrench provided with shipment. Obviously, this must be done before starting to screw next column pipe into coupling. Shaft should now stand freely in center of bearing retainer without binding against side. Do not force shaft to center with bearing retainer. If shaft bears heavily to one side and bearing retainer is not cross threaded, column and shaft should be pulled up again, removed and inspected for misalignment. Never continue with installation if shaft does not center freely at bearing retainer. This indicates a misaligned column pipe or bent shaft which will eventually cause trouble.

For flanged column, bearing retainer is merely set into a recess in the flange and flanged joints are then made up with nuts and bolts. All other instructions still apply.

If all is centered properly at this time, proceed with installation of next column section. Repeat this installation procedure with all additional sections, remembering that pipes and shafts must butt solidly in center of each joint.

If lineshaft is furnished with sleeves at journal points, inspect to see that sleeve journal falls properly within the bearing location. Any attaching collet or projecting part must clear bearing retainer by approximately one inch minimum so that, when shaft is raised for impeller adjustment, no interference occurs at journal points. In applying thread lubricant to shaft threads, prevent lubricant from contact with rubber bearing in bearing retainer.

Top column pipe section is generally shipped without couplings on either end and will be marked as to its position in pump. Since this section will normally be of different length than intermediate joints, it is important that it be assembled in correct location.

Top column flange will be shipped loosely assembled to discharge head. Remove nuts attaching flange to head and remove flange from its position in bottom of head, taking care to protect gasket during this operation. Top column flange may now be threaded onto top end of top column pipe as pump hangs in position. To facilitate turning flange, two long bolts may be inserted through flange holes so that a bar may be used to tighten flange onto pipe as seen in Fig. 20. As in any pipe joint, it is important that top pipe make a solid butt against shoulder of flange. Clean face of flange and put a light even coating of grease on machined surface. Place gasket very carefully upon this surface.

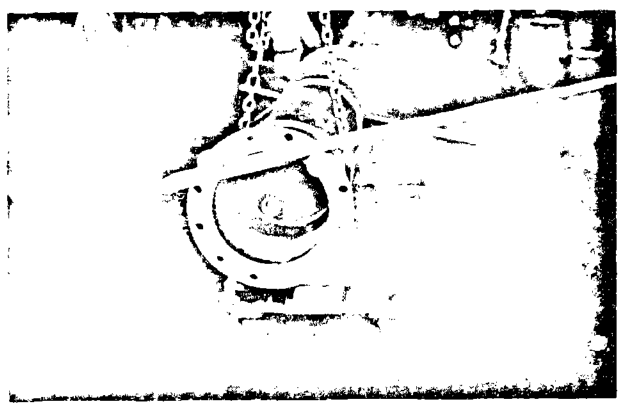


Fig. 20

Clean bottom face of discharge head, including all machined surfaces. Coat these surfaces with a very light even coating of grease.

Lower head carefully into position on top of column flange, making sure centering registers are fully engaged and that outer flange face

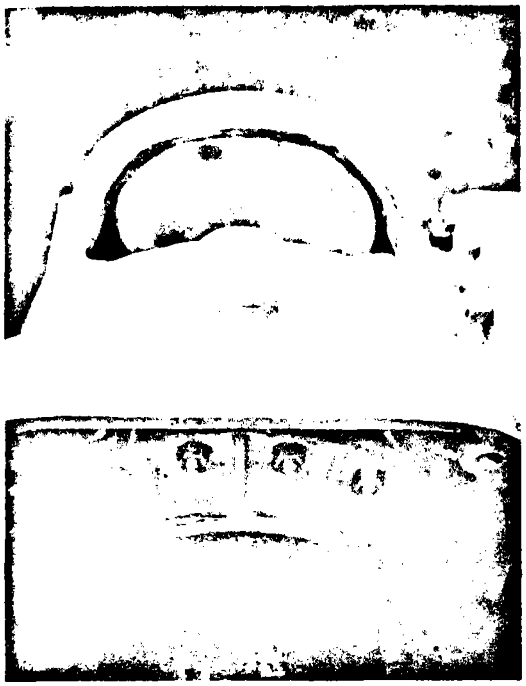


Fig. 21

seats firmly, evenly, and with no cocking. Assemble and tighten nuts uniformly on studs. See Figure 21.

See Section 10A for details of normal packing box. For any other options, see other portions of Section 10 or other special instructions furnished with job.

Clean mounting structure and make sure it is level. If pump mounts on a sealed surface, install gasket or O ring. Lower entire unit carefully to final installed position and assemble base or flange mounting bolts and/or nuts.

Proceed at surface from this point as described in Section 7.

(b) ENCLOSED LINESHAFT CONSTRUCTION

Enclosed lineshaft parts are assembled in a manner similar to that used for open lineshaft construction, except that there will also be enclosing tube to handle. Again examine bowl assembly carefully to make sure that bowl assembly discharge case coupling is tightly butted in place and that all stage connecting nuts have been taken up securely. Inspect bypass ports in discharge case to make sure that they are properly open and not plugged in any way. See Section 10G and Section 10H for possible exceptions. Remove shaft protector pipe by unscrewing from bowl assembly tube adapter. See Fig. 22 for illustration for bowl assembly.

After attaching elevators to column pipe immediately below column coupling, use hemp rope to throw timber hitch around pipe about one foot from threaded end away from installation position, then apply double half hitch around tubing section, and double half hitch around shaft on top of threads to prevent slipping. This is illustrated in Fig. 23 and 24.

As described earlie- hoist column section into place above mounting position as illustrated in Fig. 24. It will be necessary that free end of rope be held taut to prevent slipping on shaft. A soft board or pipe dolly should be laid out for end of column pipe to slide in on so that threads will not be damaged during raising of section.

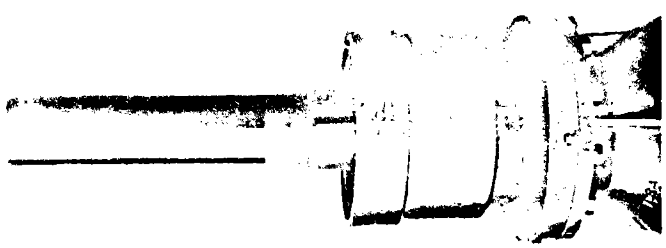


Fig. 22

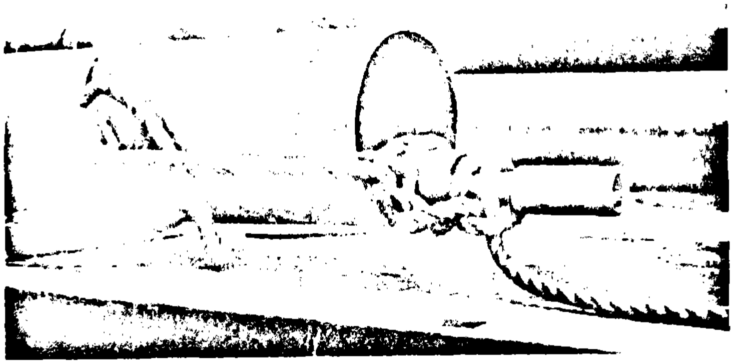


Fig. 23

Fig. 24

Clean all threads and inspect shaft ends and enclosing tube faces to be sure that there are no burrs or dirt adhering to faces. Paint shaft and tube threads with thread lubricant. Inspect and clean shaft coupling, which will usually be found in boxed parts, and assemble it as described.

Lower column assembly and couple shaft, remembering that shaft thread is left hand. Make sure that shaft ends are solidly butted together but do not use undue force in tightening. See Fig. 25. Lock shafts tightly with two small pipe wrenches, using one wrench on shaft coupling and the other on shaft just above threads. Wrench handles should be parallel when final tightening is made to prevent pulling shaft off center. If available, it is even better practice to use a shaft wrench rather than a pipe wrench. Do not allow coupling to ride up on "last scratch" or imperfect thread, as this will tend to cock the coupling. Both shafts should show same amount of threads above and below coupling, indicating that shaft butt is in exact center of coupling. If force is required, look for damaged or dirty threads. Forcing threads may cause misalignment.

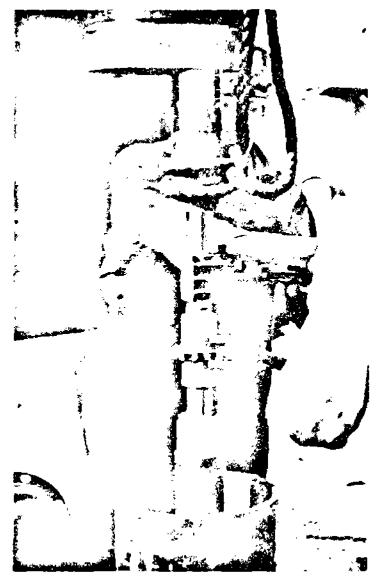


Fig. 25

Lower enclosing tube and thread it onto tube adapter at top of bowl assembly, tightening it with pipe wrench or small chain tong. These are right hand threads. On following tube sections, two wrenches or small chain tongs should be used, one holding lower tube stationary and the other to tighten upper section into place onto projecting lineshaft bearing. In all cases, wrenches must be held parallel for final tightening.

It is advisable to stuff sacking into discharge case or lower section of column pipe while assembling shaft and tube. This will prevent dropping foreign material, tools or parts into pump. If anything is dropped into pump, it must be removed before continuing installation. This could require returning everything to surface and it can thus be seen that some form of cover is indicated. Remove sacking or cover before making up pipe joint.

Lower column pipe. Clean threads, apply lubricant and make up tightly with chain tongs, again taking care that column joints butt solidly, metal to metal. Start threads carefully to prevent cross threading. In tightening column pipe joints, place one set of chain tongs on coupling and another on column pipe. Do not depend on friction clamps to hold lower section for tightening. Make sure that pipe ends butt solidly.

These threads are also right hand. For flanged column, refer to Section 10F.

Raise entire unit sufficiently to remove holding clamps. Lower assembly until elevator clamps again rest on friction blocks as shown in Fig. 24. Remove lineshaft bearing from projecting oil tube and pour into tube not more than one half pint turbine oil as described earlier. Replace lineshaft bearing using half the bearing threads, allowing half the lineshaft bearing to project out of tube to connect with next joint. At this time, position of tubing and column pipe should be observed so as to make sure it is centered. If all is centered properly at this time, proceed with installation of column section. Repeat this installation procedure on all additional sections.

Top column pipe section is generally shipped without couplings on either end and will be marked as to its position in pump. Top column pipes over 5 feet in length will usually have pads welded on about 20 inches from top end. These pads are to assist in installation work and are used for back-up to elevators or clamps when lifting assembly.

Shaft enclosing tube to be assembled in top column parcel will usually consist of three sections, one of which is a standard 5 foot joint. The other two are shorter lengths of tube. Length of tube connector at top of this tube section has been established to provide about 3 inches of adjustment at head, far more than usually required with short setting pumps.

Top lineshaft may also be of different length than standard 10 foot joints. It will have been designed to terminate at a predetermined point with respect to top column flange.

Make up top section as if it were an intermediate section of column assembly, except that pipe will not have a coupling at top. The long tube connector should be made up as a tubing joint before the discharge head is set down. See Section 10B. This is to permit use of back up tongs on tube while making up a tight joint with connector. If lock collar is furnished, it should be assembled on connector at this time but set screws should be left loose.

Top column flange will be shipped loosely assembled to discharge head. Remove nuts attaching flange to head and remove flange from its position in bottom of head, taking care to protect gasket during this operation. Top column flange may now be threaded onto top end of top column pipe as pump hangs in position. To facilitate turning flange, two long bolts may be inserted through flange holes so that a bar may be used to tighten flange onto pipe as illustrated in Fig. 20. As in any pipe joint, it is important that top pipe make a solid butt against shoulder of flange. Clean face of flange and put a light even coating of grease on machined surface. Place gasket very carefully upon this surface.

Clean bottom face of discharge head, including all machined surfaces. Coat these surfaces with a very light even coating of grease.

Lower head carefully into position on top of column flange, making sure centering registers are fully engaged and that outer flange face seats firmly, evenly, and with no cocking. Assemble and tighten nuts uniformly on studs. See Figure 21.

See Section 10B for details of normal enclosing tube connection. For any other optional features, see other applicable portions of Section 10 or other special instructions furnished with job.

Clean mounting structure and make sure it is level. If pump mounts on a surface to be sealed, place gasket or O ring in position. Lower entire unit carefully to final installed position and assemble base or flange mounting bolts and/or nuts. See Figure 26.

Proceed at surface from this point as described in Section 7.

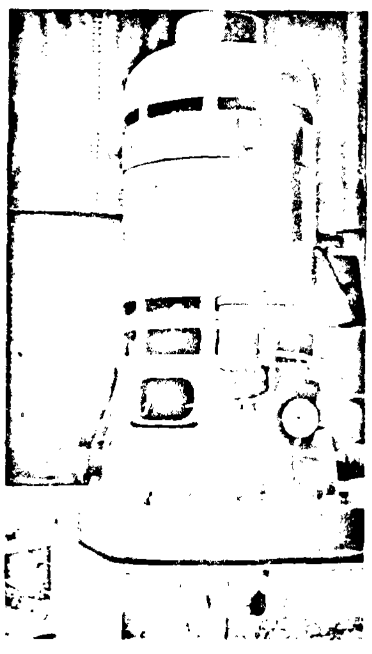


Fig. 26

SECTION 9

PUMP ADJUSTMENT PROCEDURE

The perihedral seal on enclosed impellers provides two sealing surfaces. The cylindrical seal or skirt on lower end of impeller is generally adequate for most installations. It is simplest to adjust and should be used as the only seal, unless it becomes badly worn. An enclosed impeller is shown in Fig. 27.

Fig. 27

These instructions are intended to cover pumps of minimum overall length to settings not in excess of 40 feet. Therefore, initial adjustment is not too critical and impellers may be set at approximate center of their possible travel. Adjust pump by turning adjusting nut on the left-hand shaft threads so that impellers just come off their seats. This is break-free point and should be marked, nut to drive coupling. Then, by continuing to turn adjusting nut raising shaft until impellers contact top of impeller cavity in bowl, upper limit of impeller adjustment is established and should be marked, again nut to drive coupling. Number of turns of adjusting nut between the two marks should be recorded and nut should be backed off from its upper position half the total number of turns registered above. This should locate impellers in approximately the center of impeller cavity in bowl.

If, after a period of time, the cylindrical seal has become worn, the wear compensation feature of the perihedral seal can be brought into use. The seal under these conditions is established between upper or horizontal face of bowl seal ring and lower horizontal face of impeller shoulder, as illustrated in Fig. 28. Again, adjust pump to break-free point. Raise shaft further one-third turn of adjusting nut. Run pump and, by checking power and/or capacity, determine that capacity has been increased. Make a record of power and capacity and stop the pump. Lower impellers an amount not to exceed one-sixth turn and start pump again. If faces of seal are rubbing, a slight vibration will be felt. A moderate increase in power and capacity indicates impellers are not dragging. An increase in power without increase in capacity indicates these faces are rubbing. Under these conditions, if power increase is moderate and vibration slight impellers will rub

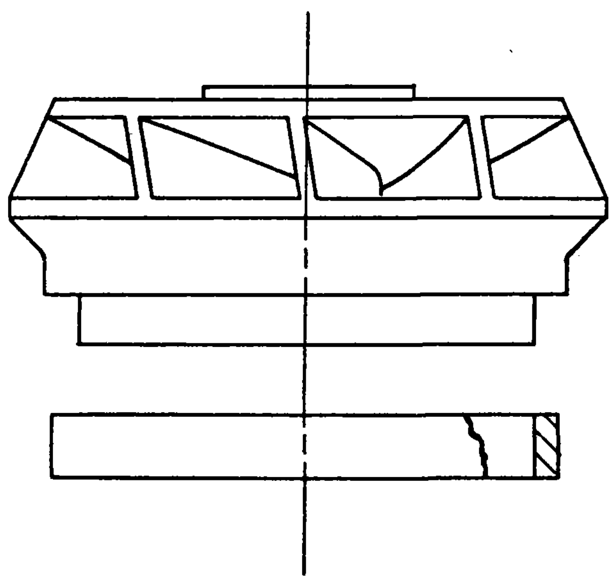


Fig. 28

free after a short period of time. This type of operation will probably be characterized by a fluctuation in power such as might be shown with an ammeter. If pump vibrates obviously and power increase is great, raise impellers until condition is relieved.

Semi-open impellers must be adjusted in same manner as described above for lateral faces of perihedral seal. However, it must be remembered that, with semi-open impellers, as illustrated in Fig. 29, accuracy of initial adjustment is much more critical at the very beginning of operation inasmuch as there is no cylindrical seal.

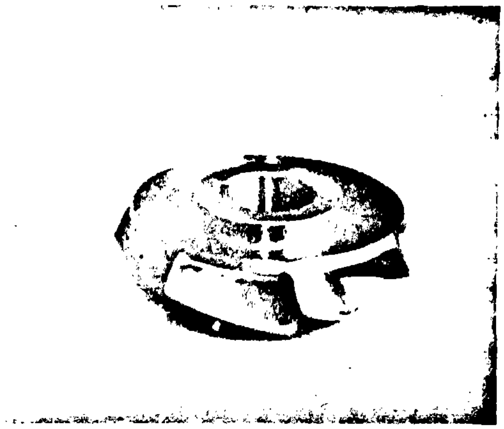


Fig. 29

It should be noted that hydraulic downthrust increases with any increase in operating pressure. While shaft elongation on close coupled and very short pumps is minimal, it must be remembered that some deflection will occur, however minor. Pumps that must be subjected to varying operating heads should be adjusted with respect to the highest head to avoid excessive dragging of impellers under these conditions.

SECTION 10

OPTIONAL FEATURES AND SPECIAL INSTRUCTIONS

Examine this section as outlined in the table of contents for those features applicable to the equipment in question. Also check shipment for any special instructions and/or drawings that have been included to cover items not described in this booklet.

(a) Packing Box

If a packing box has been furnished, as is the normal case with short coupled open lineshaft industrial equipment, it will usually be shipped assembled in its proper position in discharge head or driver pedestal. Normal packing box assembly will usually include packing container item 111-15, at extreme lower end of which is a bushing or throttle sleeve item 111-18. Immediately above this are assembled a given number of packing rings item 111-20, then a lantern ring item 111-17 positioned so as to allow leakage into proper drain port, then more packing rings and, at the top, a two piece gland item 111-16 which can be removed without disturbing shaft. Ordinarily, a gasket item 115 seals housing flange to head, although an O ring may sometimes be used. Housing is secured in position with capscrews item 114. See Fig. 30.

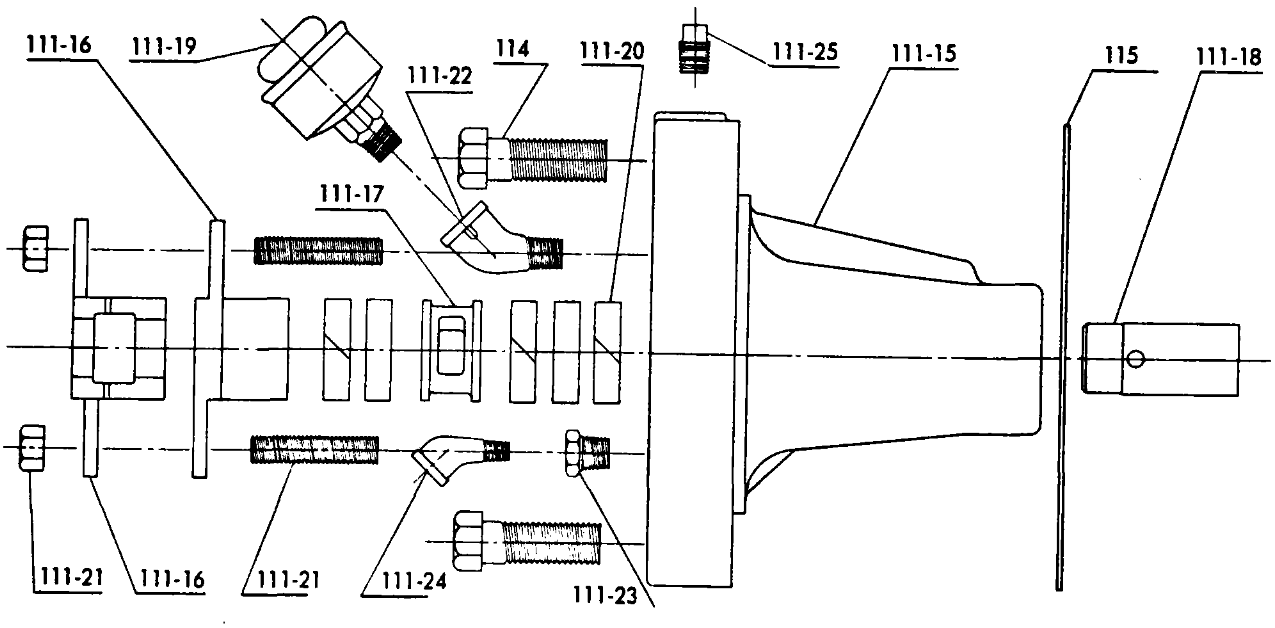


Fig. 30

When assembling headshaft as described in Section 7, packing gland nuts item 111-21 should be loosened so that shaft threads will not drag excessively on packing rings as shaft passes through box. After assembly of headshaft, packing gland nuts should be tightened initially only finger tight.

Grease cup item 111-19 should be filled with standard water pump grease. A small amount should be forced down into bushing area before starting pump. Periodic injection of grease by turning top of grease cup will add life to journal area and packing. When empty, refill grease cup with same type of grease as originally supplied.

Drain lines from drain port item 111-24 and flange lip are to be connected and routed to some convenient drainage location.

At time of first operation, start pump and run for 10 to 15 minutes. Let pump leak at least 100 drops per minute during first operation. If leakage slows down, loosen gland nuts to keep leak rate constant. Gland temperature should level off, and then drop slightly toward the end of 15 minute operation. Gland nuts may then be drawn up about one sixth turn every five minutes until leakage is minimized. If, during this operation, gland heats up so that it will vaporize water, back off gland nuts and repeat run-in procedure as described until temperature stays down after gland nuts are retightened.

During first four or five hours of operation, packing gland should be gradually tightened as packing becomes broken in and formed to completely fill chamber. If it can be tolerated, a small trickle allowed to come through box during this breaking in period will result in a better packed box. During this time, frequent checks should be made to insure that box is not overheating. Should box become overheated, slackening off on the gland nuts may be all that is needed, as described above. Should overheating continue, check to be sure bypass is open and fluid is passing through it.

In repeated tightening of gland nuts as packing wears, packing will also be compressed in packing chamber, lowering gland into chamber. Additional rings may be installed as required to compensate, but not more than two additional rings of packing should be inserted above lantern ring, as otherwise drain port will be blocked. After adding any rings, check drain port to see that it has not become plugged.

To repack, old packing must be removed by means of packing hooks, cleaning out chamber thoroughly. Lantern ring item 111-17 is provided with two #10-24 tapped holes at 180° apart in the upper face. Thus, it may be lifted from box by means of two #10-24 x 3-1/2" or longer machine screws or similar means. Gland item 111-16 may be removed completely because of its split design and lantern ring may be held up out of the way during repacking by means of a couple of turns of string tied around shaft.

At time of repacking, check shaft alignment and surface finish. Finish should be smooth, without burrs or scratches. Avoid shaft runouts over .005". Packing may be butt or diagonal cut, with the latter preferred.

It is recommended that die formed rings be used for repacking, naturally of same size as original parts. If rings are cut and fit at jobsite, length of rings should be such that ends just meet when packing is wrapped around shaft. Joint in rings should be located 90° to 180°

from joints in rings immediately above and below it in box. Packing rings may be flattened slightly to aid in starting into box.

In packing a new pump before driver is assembled, a short piece of pipe passed over headshaft can be used to press individual rings down into box and tamp them firmly into place. This expedient is not possible after driver has been installed, however, although a split tube may be used in a similar manner.

Insert three rings of packing into bottom of packing chamber, or whatever number is required to bring top of packing up to bottom of drain port. Put these rings in individually, one by one. Before reinstalling lantern ring, check to see that port through box has not been plugged by packing or other material. This can be done by means of wire run through drain port into packing chamber.

Lantern ring may now be placed above first set of packing rings item 111-20. It is by means of this lantern cage that pressure is relieved from top rings of packing, any fluid seepage being returned to atmosphere or suction through drain port in drain line tubing. Also, be certain to install lantern ring with the 10-24 tapped holes facing upward as these are used for removal when repacking box.

Install necessary additional rings of packing one by one above lantern cage as required to obtain proper location of gland. Gland may now be reinstalled and gland nuts may be reassembled on studs but they should not be tightened at this time. Follow run-in procedure as described earlier in this section.

Packing box as described is a normal design for intermediate pressure service. For higher pressures, similar construction is used except that more lantern rings, more packing rings, and possibly more drain lines will be incorporated into the design. Material of packing may vary according to service and pressure and this should be checked before attempting to repack. Material for repacking should be identical to that shipped in the original installation.

A packing box assembly properly adjusted is a most suitable and practical sealing device, requiring only nominal skills and instruction to maintain. It should be packed quite loosely when first starting pump, with fairly free leakage. Gland nuts may then be taken up evenly and gradually, preferably with fingers, until proper control of leakage rate is obtained. It should be emphasized that packing should never be run too tight or without minor leakage since it is possible otherwise to generate extreme heat, consume excess power, wear or score journals, and destroy packing itself. A regular maintenance program will insure trouble free service with a properly designed unit.

(b) Enclosing Tube Head Connection

If pump is of enclosed lineshaft construction, parts for connecting enclosing tube and lubrication system as discharge head or driver pedestal will usually be shipped assembled in head. Before making up top inner column assembly, remove these parts, which are illustrated in

Fig. 31, from their assembled position and lay them out separately on a clean surface.

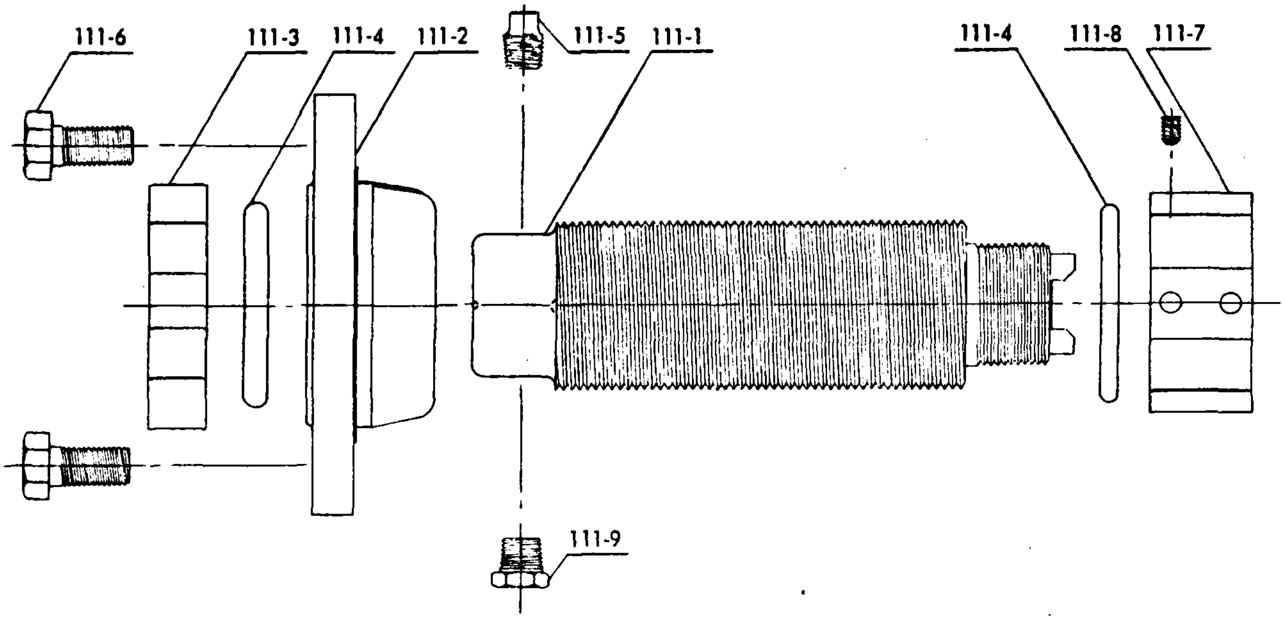


Fig. 31

After making up lengths of tubing that comprise top inner column assembly, together with any shafting to be assembled therein, the long tube connector item 111-1 should be made up as an additional joint at top end. Use back up tongs on tubing while making a tight joint with connector. If a lock collar item 111-7 is furnished, it should be assembled on connector at this time, but set screws item 111-8 should be left loose.

After top column joint is completely assembled as described before discharge head may be installed and the job completed to this point according to the instructions in Section 8b. With head in place and pump resting properly on its foundation, the long threaded tube connector should project up through and in the exact center of the hole provided in the head or mounting pedestal for this purpose.

Examine and clean threads, bore, and faces of tube tension nut, item 111-2. Inspect mating face in discharge head for any burrs, rough spots, or projections, particularly at location of tapped holes. Apply thread lubricant. Thread tube tension nut down over connector and into position. It may be necessary to remove pipe bushing and plug items 111-5 and 111-9 from ports at top of tube connector to do this.

It should be possible to run tube tension nut down until it is seated against mating face in head by hand. Inspect to see that centering register is properly engaged. At this point, tighten tension nut with a tube tension nut wrench until weight of tube is well supported. With all tubing joints solidly butted and with tension nut seated firmly in discharge head, apply enough additional tension to tubing to rotate tension nut to next matching hole in flange. Tension nut flange must seat firmly in its location in discharge head or driver pedestal in order to prevent leakage through top of elbow. Put thread lubricant on capscrews item 111-6, place them in tension nut flange and thread them firmly in position in discharge head assembly.

If a lock collar has been furnished, back it down on connector far enough to insert packing ring item 111-4. Then screw collar up on connector until it butts against bottom of tension nut. Back collar off slightly until set screws line up with first keyway in connector. Tighten set screws securely reaching through discharge opening in head.

Second packing ring item 111-4 may now be laid in place in chamfer top of tension nut around connector. Care must be taken to see that ring remains properly seated as tubing locknut item 111-3 is assembled and tightened with chamfered face down. Tightening locknut for last two or three turns may be accomplished with a spanner wrench or by tapping nut using a block of wood and hammer. Never tap nut around with a metallic object. Tubing joint is not complete and pipe bushing and plug may be reassembled in ports in position most convenient for oil line from reservoir.

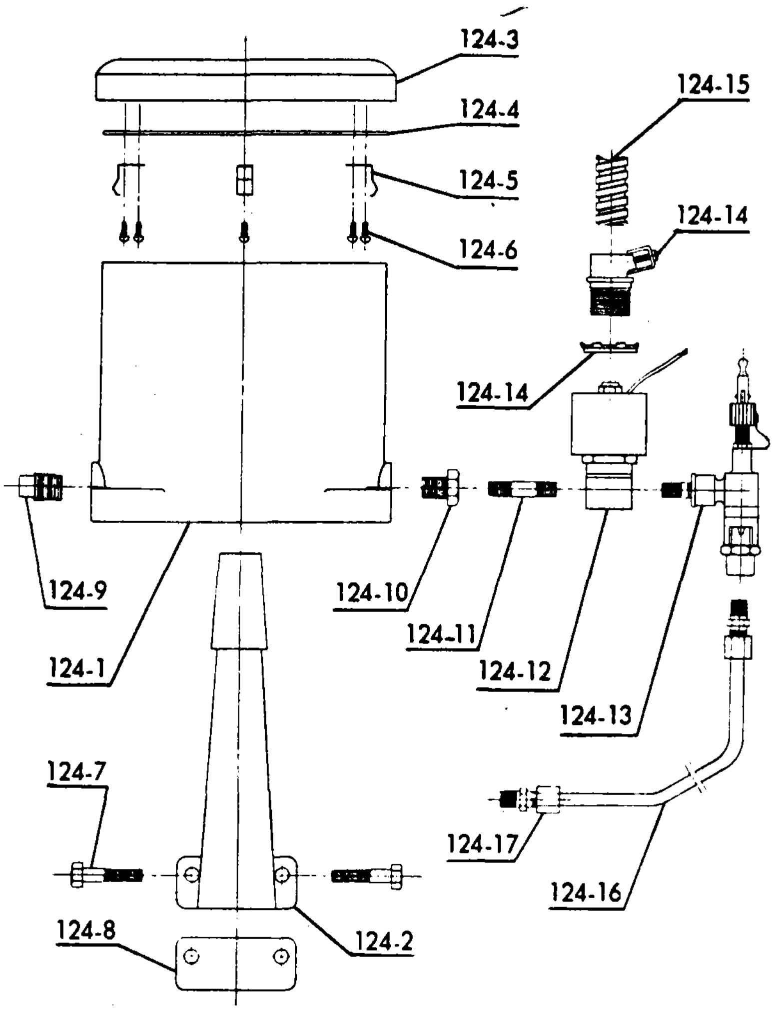


Fig. 32

Examine oil reservoir and oil feed line, making sure that they are clean. Fig. 32 shows parts involved. Attach bracket item 124-2 to driver pedestal using capscrews 124-7, placing dampener gasket 124-8 between bracket and mounting surface. Reservoir item 124-1 will slide on wedge end of bracket. Bushing 124-10 must be located on that side of reservoir most convenient to bring out oil line to tube connector. It may be necessary to interchange bushing and plug item 124-9 to accomplish this.

If lubricator is automatic, assemble pipe nipple item 124-11, solenoid operated valve item 124-12, and manual feed regulator valve item 124-13 in relative positions shown. If lubricator is not automatic, pipe nipple and solenoid operated valve will not be furnished; manual feed regulator is then to be assembled directly into bushing item 124-10. Keep cover assembly item 124-3 on reservoir at all times to keep foreign material out of container.

Connect up lubricating system as illustrated in Fig. 33, using tube item 124-16 and fittings item 124-17. Fill oil reservoir using oil as described earlier. Adjust lubricator valve 124-13 to permit oil to drip at a rate of approximately one drop per second. With solenoid operated lubricators, complete electrical connections to valve. Remove pipe plug at top of tubing connector and fill upper cavity with oil just before first start. This will insure an adequate supply of oil at each bearing for first start.

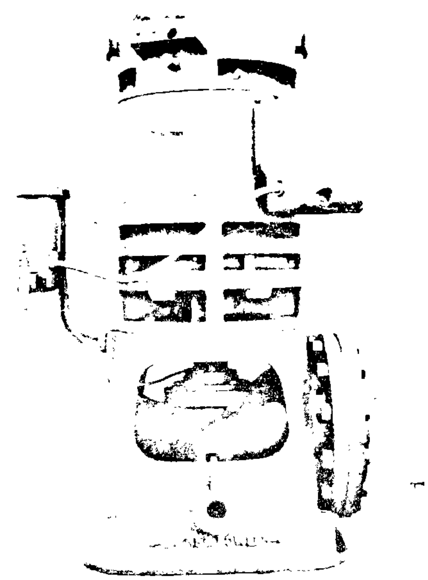


Fig. 33

Before first start, verify that oil reservoir is full and lubricant can flow freely into enclosing tube. Then start pump. Be sure oil continues to flow into pump during running time. It may be found necessary to apply a small amount of oil from an oil can at point where shaft emerges from tubing in discharge head. This should only be necessary during first few minutes of operation.

After logging about 1/2 hour running time, adjust flow on manual lubricator to about 30 drops per minute and operate at this flow rate for first 20 operating hours. Unless solenoid control is furnished, shut off manual lubricator during idle periods. After running about 20 hours, reduce oil flow rate to an amount between 8 and 10 drops per minute for permanent operation.

(c) Mechanical Seal

Mechanical seals may be furnished in a variety of types and sizes, depending upon conditions of service. Therefore, this manual can only cover a general description, together with certain procedures common to all seals. Please refer to specific instructions furnished with the shipment before operating the pump or handling the seal in any way.

A mechanical seal used in a vertical turbine pump is a face type seal. Regardless of service and rating, it attains its closure between two spring loaded sealing surfaces, one rotating with the shaft and one stationary in the housing. Basic design concepts depend upon the presence of a film of liquid on these sealing faces for lubrication, just as is necessary in plate bearings.

Therefore, before starting up a pump equipped with mechanical seals, it is imperative to insure that the seal housing contains liquid so that faces will not overheat, wear or gall. This will necessitate bleeding air or vapor out of the seal area as well as admitting fluid to the pump before start-up. In the case of a vessel pump, the suction cavity must be vented of air or vapor and filled with liquid. Starting a seal dry can cause immediate malfunction. Fluid supply must be constant to insure complete filling of the critical cavities under all operating conditions. An intermittent flow into the seal area must be avoided, whether resulting from adverse suction conditions, flashing of volatile fluids, or whatever cause.

The seal assembly, in certain environments, may require external cooling or heating for proper operation. Bypass or recirculating provisions may be necessary also. Where solids in solutions may precipitate out, a clean liquid flush will protect the seal. Same precaution will assist when dealing with solids in suspension, although abrasive particles are extremely destructive to almost any arrangement. Under such conditions, the use of a filter or separator is recommended. It is important to preserve and maintain a film of CLEAN liquid between the sealing faces.

The presence of a mechanical seal must be considered even before pump start up. In checking driver rotation, for instance, the shaft should not be connected to the driver since the system may be devoid of fluid at this time. In addition, the seal assembly cannot be adjusted until the pump shaft has been placed in its proper adjustment axially, which may not take place until immediately before start up.

Consideration of the seal must even be carried to conditions extant when the pump is NOT operating. In some systems, for instance, the pump is subjected at all times to high suction pressure. The shaft then becomes a piston and, with no downward thrust to oppose axial motion, tends to force upward opening the seal, allowing undesirable leakage. When the pump is started and hydraulic thrust forces the shaft down again, the seal faces may come together hard enough to break the film and cause damage. Therefore upthrust protection is absolutely necessary in such cases and will be provided at the factory if the driver is furnished as part of the pump order. If the driver is obtained and furnished by the user, he must make sure that this protection is included in whatever driver he may install. Solid shaft driver is preferred for use with mechanical seals. If hollow shaft driver is used, it should have a centralizing bushing at bottom of hollow shaft.

It is recommended that a thorough review be given to any detailed instruction accompanying this shipment, particularly those furnished by the seal manufacturer. It is also recommended that pumps equipped with seals be started or turned over once a day if not in continuous operation.

(d) Flanged Adjustable Coupling

After installation of all pump components through discharge head, including shaft seal parts, assembly of flanged shaft coupling must be commenced before setting driver in place. Check and clean all coupling parts before attempting assembly. Flange mating faces must be flat and free from any burrs, nicks, dents, defects or foreign material. If parts are matchmarked, assemble accordingly. Refer to Fig. 34, which illustrates spacer type coupling, assembly of flanged coupling without spacer is similar.

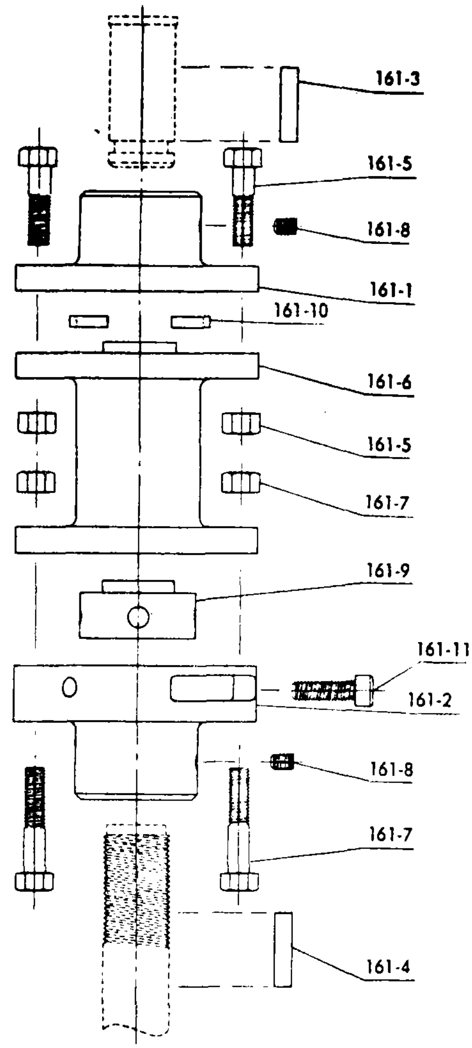


Fig. 34

Inspect and clean pump shaft threads, painting lightly with good thread lubricant. Insert key item 161-4 in pump shaft keyway and slip pump shaft coupling item 161-2 well down over shaft, flange face up, leaving shaft threads projecting above coupling. Screw adjusting nut item 161-9 onto pump shaft with rimmed end up, turning counterclockwise until pump shaft protrudes through threaded portion of nut by at least two threads.

Set driver on beams or blocks on discharge head or pedestal with ample clearance between driver shaft and pump shaft. Secure driver firmly against torque with chain or cable restraints. Connect motor and energize to check rotation, which must be counterclockwise when viewed from top. See Section 7. Stop Motor.

Insert key item 161-3 in driver shaft keyway and slip driver shaft coupling item 161-1 up onto driver shaft, flange face down. With flange above driver shaft ring groove, insert both halves of thrust collar item 161-10 into groove and slide coupling back down on shaft until it rests firmly on thrust collar, retaining collar halves in place in coupling recess. Assemble and tighten setscrew item 161-8 securely. Remove blocks and lower driver onto its mounting flange, seating it firmly. Assemble fasteners loosely but do not tighten. If necessary, dress keys to a sliding but not loose fit. Do not file keyways.

If coupling is furnished with spacer spool item 161-6, clean spacer flange faces, then assemble spacer between driver shaft coupling and pump shaft coupling flange faces. Allow spacer lower flange face to rest upon pump shaft coupling item 161-2 flange face. Insert flange bolts item 161-5 in driver coupling and spacer upper flange and tighten nuts item 161-5 by hand until they are snug against flange. Use a light oil on machine bolt threads.

With impellers firmly seated in bowls, screw adjusting nut 161-9 up on pump shaft by turning clockwise until its outer shoulder is spaced approximately .030 inches to .060 inches below face of driver coupling flange or spacer lower flange, if spacer is provided. Pull pump coupling up and insert flange bolts item 161-7 through both coupling flanges. Assemble nuts item 161-7 and run up by hand until they are snug, using a light machine oil on the bolt threads. CAUTION: Use only bolts and nuts furnished with pump.

With all nuts drawn up and with flanges meeting evenly both at faces and at outer circumferences, put all bolts under uniform tension, using torque wrench if available. Five hundred inch pounds will be sufficient torque; i.e., a 50 pound pull on a 10 inch wrench, etc. Make sure pump shaft key is flush with coupling hub and tighten setscrew item 161-8 securely.

Pump is now set so that impellers are about .030 inches to .060 inches off endseal seats. Any desired adjustment may now be obtained by rotating adjusting nut on shaft with a 1/2 inch bar inserted into adjusting nut holes through pump shaft coupling slot. Accurate settings are best accomplished by lowering impellers to bottom, turning nut clockwise, then raising to desired position by turning nut counterclockwise. When proper adjustment is obtained (.020 inches to .120 inches, depending on pump), move adjusting nut slightly until nearest hole lines up with tapped hole in outer circumference of pump coupling flange. Insert socket head capscrew item 161-11 making certain that it projects into adjusting nut hole, then tighten securely.

Coupling is now completely assembled and locked. Tighten motor fasteners firmly. See that pump turns freely by hand. Follow motor lubrication instructions before operating.

(e) Flanged Non-Adjustable Shaft Coupling (Two-Piece Flanged Coupling for Combination Gear Drive)

Two-piece flanged coupling may be installed after assembly of discharge head, packing box component parts, headshaft and adjusting nut. Lower gear drive and yoke onto mounting flange and fasten into place. See Fig. 35 for coupling design.

Clean headshaft and headshaft coupling threads thoroughly and paint with a good thread lubricant. Clean coupling flange face and screw coupling onto head shaft, flange face up. Shaft face may be .005 to .100 below flange face but must not project beyond flange face. Line up keyways, insert key and tighten set screw firmly.

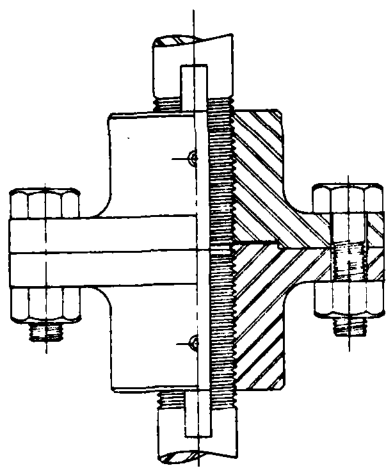


Fig. 35

After cleaning driver shaft threads, clean driver shaft coupling threads and flange face. Paint driver shaft and coupling threads with thread lubricant. Screw coupling onto driver shaft, flange face down. Shaft face may be recessed .005 to .100 into coupling but must never project beyond flange face. Line up keyways, insert drive key and tighten set screw firmly.

Raise motor, insert driver shaft into driver hollow shaft with driver coupling flange facing down. Thread on driver shaft adjusting nut to lock shaft in position in motor while lowering motor onto gear drive yoke. Lower driver onto gear drive yoke and fasten into place.

Insert bolts and screw on hex nuts by hand until snug against flange, using a light oil on machine bolt threads. After all nuts are drawn up and flange coupling meets evenly, put all machine bolts under uniform tension, using a torque wrench if available.

Installation of adjusting nut, adjustment of impellers, etc., can be completed as suggested in previous operating instructions, using applicable sections.

(f) Flanged Column Pipe Open Lineshaft Construction

Refer to Fig. 36 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling flanged column. See also Section 6 and Section 8a.

Clean all column flanges, centering fits, and contact surfaces thoroughly of any slushing compound or foreign particles with wire brush, then wash flange faces clean, using distillate or kerosene. It is very IMPORTANT that column flange centering fits and contact surfaces are clean and free from burrs, as this could cause misalignment and rough operation. Separate top and bottom column sections from intermediate column sections. These pieces are stencilled "Top Column" and "Bottom Column" at factory for easy identification at jobsite. Upper flange on top column section and lower flange on bottom column section may have different centering fits and bolt circles than intermediate column flanges for adaptation to discharge head and to discharge case or bowl flanges.

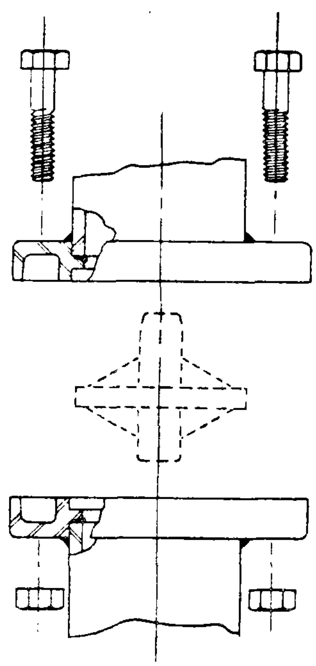


Fig. 36

Before raising column pipe into place, insert drive shaft into column and snub with a rope hitch. Raise column and shaft into position. Handle very carefully to prevent damaging lineshaft. Section 8a describes this operation generally, except for pipe flanges.

Check discharge case flange for tightness. Clean centering fit and contact surfaces on both discharge case and column flanges thoroughly. Place flange gasket onto discharge case flange face, lower suspended column pipe, guiding column so that column flange slips down over projecting male fit on discharge case. Tighten nuts evenly. Use thread lubricant on bolt threads. Bolted flanges must be tight enough to support weight of pump assembly and hold liquid pressure.

Use same type of pipe elevators and wooden clamp blocks that are used for screwed column. Before raising column section, insert bolts into column flange holes, thread end down, place elevator in position with elevator rim located to leave wrench room for nuts. At same time, take care to avoid chafing sling on flange or creating pull-off forces.

Intermediate flanged column joints are made up in same manner except that bearing retainer is installed in centering fit at each flange joint. Clean centering fits, contact faces, and bearing retainer rim thoroughly before assembling. Wipe upper end of shaft down beyond journal point free of oil or grease.

Before lowering bearing retainer into place, make sure shaft stands in center of pipe or that very slight pressure will center it. Bearing retainer is now placed over projecting end of lineshaft with open end down and into annular centering recess in column flange. Retainer rim forms a centering ring for column pipe flanges and also forms a gasket for flange joint. Shaft should now stand freely in center of bearing retainer without binding against side.

Lower next section of flanged column pipe, with its length of drive shaft supported inside by a rope hitch, onto projecting half of retainer rim. Be very careful not to damage retainer rim.

Tighten nuts evenly all around, first lightly setting up opposite bolts, then applying greater torque all around until all bolts are tightened evenly. If available, use a torque wrench which indicates amount of foot-pound torque applied to each bolt.

Refer to previous instructions included in this manual for installing and assembling lineshaft, making up lineshaft coupling, etc.

Repeat this installation procedure and precaution through entire length of column. Return to Section 8a for procedure at top joint and discharge head.

(g) Flanged Column Pipe Enclosed Lineshaft Construction

Refer to Fig. 37 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling flanged column. See also Section 6 and Section 8b.

Clean all column flanges, centering fits, and contact surfaces thoroughly of any slushing compound or foreign particles with wire brush, then wash flange faces clean, using distillate or kerosene. It is very IMPORTANT

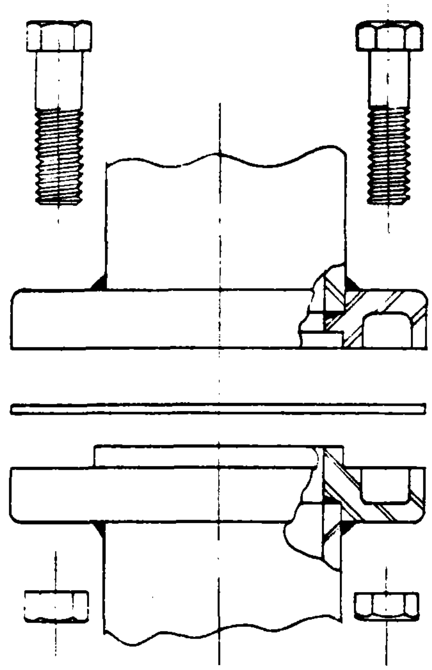


Fig. 37

that column flange centering fits and contact surfaces are clean and free from burrs, as this could cause misalignment and rough operation. Separate top and bottom column sections from intermediate column sections. These sections are stencilled "Top Column" and "Bottom Column" at factory for easy identification at jobsite. Upper flange on top column section and lower flange on bottom column section may have different centering fits and bolt circles than intermediate column flanges for adaptation to discharge head and discharge case flanges.

Before raising flanged column pipe into position, drive shaft and enclosing tube should be placed into column and snubbed with a rope hitch. Raise column, enclosing tube and lineshaft into position. Handle very carefully to prevent damaging enclosing tube and lineshaft. Section 8b describes this operation generally, except for pipe flanges.

Check discharge case flange for tightness. Clean centering fit and contact surfaces on both discharge case and column flanges thoroughly. Place flange gasket onto discharge case flange face, lower suspended column pipe, guiding column so that column flange slips down over projecting male fit on discharge case. Tighten nuts evenly. Use thread lubricant on bolt threads. Bolted flanges must be tight enough to support weight of pump assembly and hold liquid pressure.

Use same type of pipe elevators and wooden clamp blocks, that are used for screwed column. Before raising column section, insert bolts into column flange holes, place elevator in position with elevator rim up against bolt heads, thus holding them in place. This procedure must leave wrench room. At same time, take care to avoid chafing sling on flange or creating pull-off forces.

Intermediate flange column joints are made up in same manner. Clean centering fits and contact surfaces on both intermediate column flanges thoroughly, then place flange gasket onto flange face. Lower next section of flanged column pipe, with its length of enclosing tube and lineshaft supported inside by a rope hitch, guiding column so that column flange slips down over projecting male fit on column flange below.

Tighten nuts evenly all around, first lightly setting up opposite bolts, then applying greater torque all around until all bolts are tightened evenly. If available, use a torque wrench which indicates amount of foot-pound torque applied to each bolt.

Refer to previous instructions included in this manual for installing and assembling lineshaft, making up lineshaft couplings, enclosing tube, etc.

Repeat this installation procedure and precaution through entire length of column. Return to Section 8b for procedure at top joint and discharge head.

(h) External Source of Water Lubrication

Refer to Fig. 38 and to any assembly drawing which is included with these instructions to become thoroughly familiar with the construction before assembling the tube tension/packing head assembly.

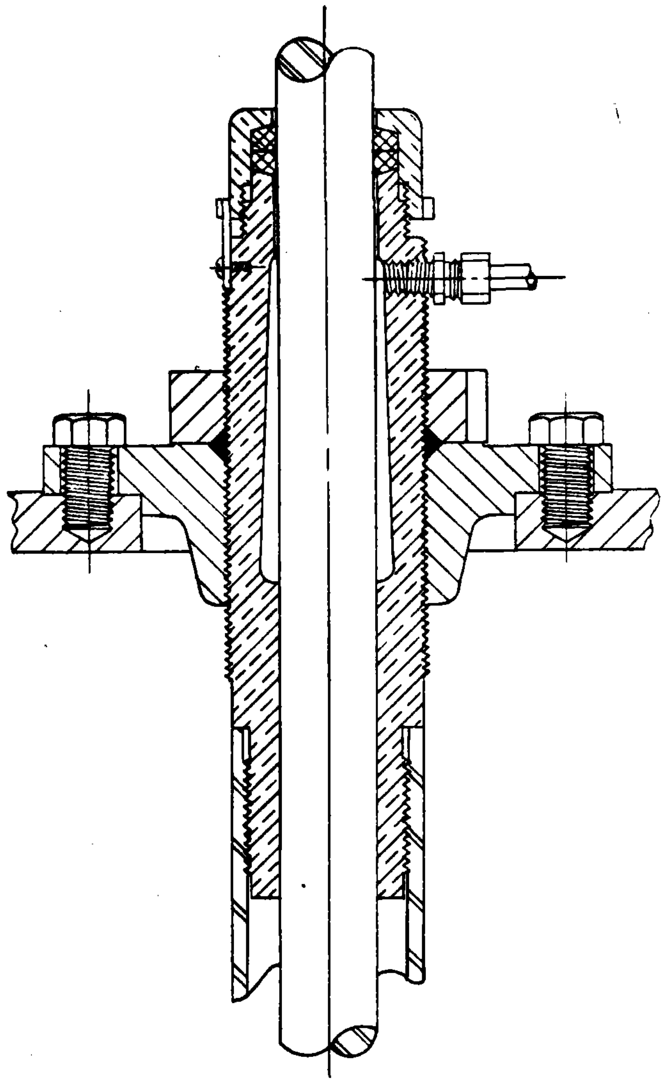


Fig. 38

Installation and assembly of tube connector, tubing tension nut, and tubing locknut is the same as described in Section 10b with additional instruction as follows:

After installation of tube connector and component parts, clean tube connector and packing gland threads. Apply thread lubricant. Length of packing rings should be such that ends just meet when packing is wrapped around shaft. Joint in ring should be located 180° from joint in ring above or below it. Packing may be flattened slightly to aid in starting gland over packing rings. Each ring should be coated thoroughly with lubricating grease before installation.

Place packing rings upon camfered face, and screw packing gland into tubing connector. Packing gland should be tightened initially only finger-tight at this time. During first two or three hours of operation, packing gland should be gradually tightened, as packing becomes broken in or formed to fill packing gland chamber. At no time should gland be tightened more than just barely enough to prevent leakage. In fact, minor leakage is desirable. During this time, frequent checks should be made to insure that gland is not overheating. Should gland become overheated, slacking off gland may be all that is needed.

Place lock strap in position and tighten lock strap screw firmly. Connect lubrication line to tubing connector port.

For most installations, 3 to 5 GPM at 40 to 50 PSIG is ample supply of fresh water for lubricating lineshaft bearings, as long as bowl assembly bypass ports are open. If ports are plugged, lubricating water must be admitted to tubing under heads greater than that generated in the bowl assembly. Higher pressures will of course necessitate more frequent maintenance of packing.

Do not exceed 75 PSIG injection pressures with design pictured here. Over this amount, a different arrangement will be furnished.

(j) Fresh Water Flush System

When pumping fluids containing abrasive particles, it is often advisable to inject clean liquid directly into journal areas to provide lubrication and to prevent entrance of abrasive particles into bearing zones. One method by which this can be accomplished is to flush bearings continuously during operation with clean or filtered water.

In the case of the bowl assembly, refer to Fig. 39 & 40. The suction case is provided with a pipe tap in bottom of hub and lubricating fluid may be injected here. Bowls themselves may be cast with a port leading through a vane from outside into bearing area so that lubricating fluid may be admitted. At discharge case, if one is furnished, fluid is often injected into one of the bypass ports. Bowl assemblies must be ordered from factory in this condition so that porting will

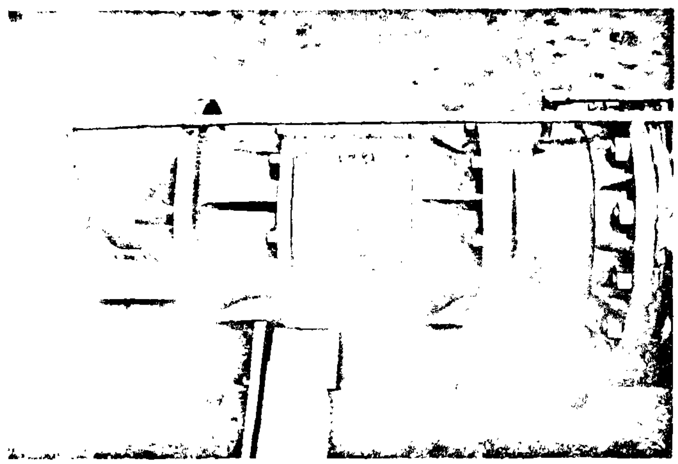


Fig. 39

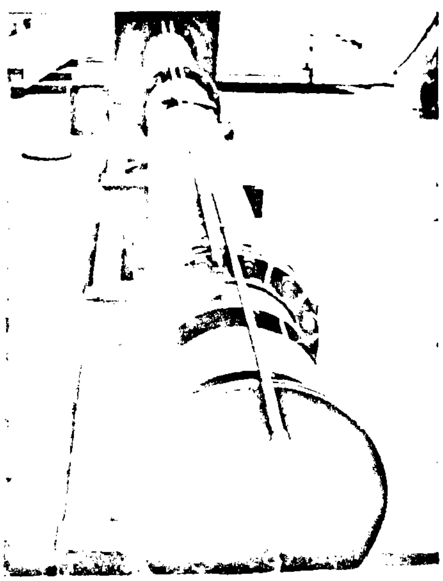


Fig. 40

be available. Piping is usually installed at jobsite, connecting each port either individually or from a common line to surface where user must furnish a source of proper fluid. However, short pumps are occasionally shipped with piping in place, ready for user's connections. In handling pumps with external piping, take care to avoid damage to pipe or tubing. Pinching or perforating a line could render the lubrication system inoperative.

The lubricating liquid must be free from abrasives and other foreign particles, must have sufficient lubricating properties to do the job, and should not be allowed to increase above 85° F in temperature. It must be injected at a pressure in excess of that

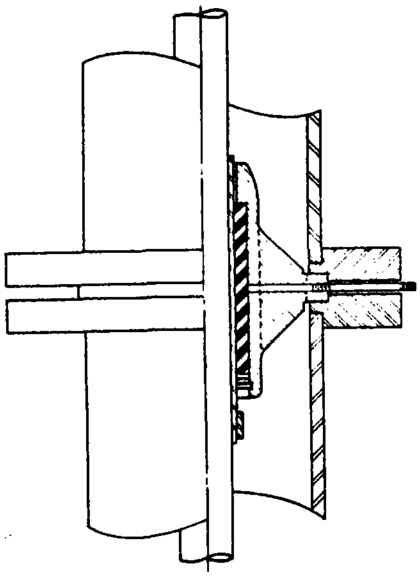


Fig. 41

existing across journal area in question, which usually means something greater than total discharge head on pump.

Open lineshaft bearings, if necessary, may be lubricated in much the same way as illustrated in Fig. 41. Again, piping is connected as shown and run from surface source of supply. It must be injected into bearing at a pressure in excess of that existing in column pipe at that point.

Flushing at packing box may be accomplished in a manner as depicted in Fig. 42. Similar arrangements are made in case of mechanical seals, as shown in Fig. 43.

Occasionally, a water flush arrangement is used in connection with tube enclosed construction and may be accomplished as described in Section 10h.

Although subject option is referred to as a fresh water flush system, any suitable

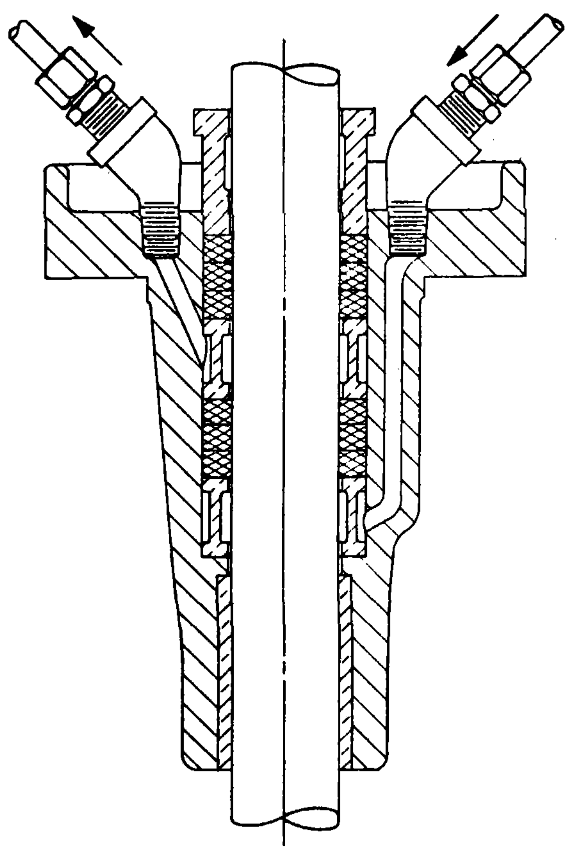


Fig. 42

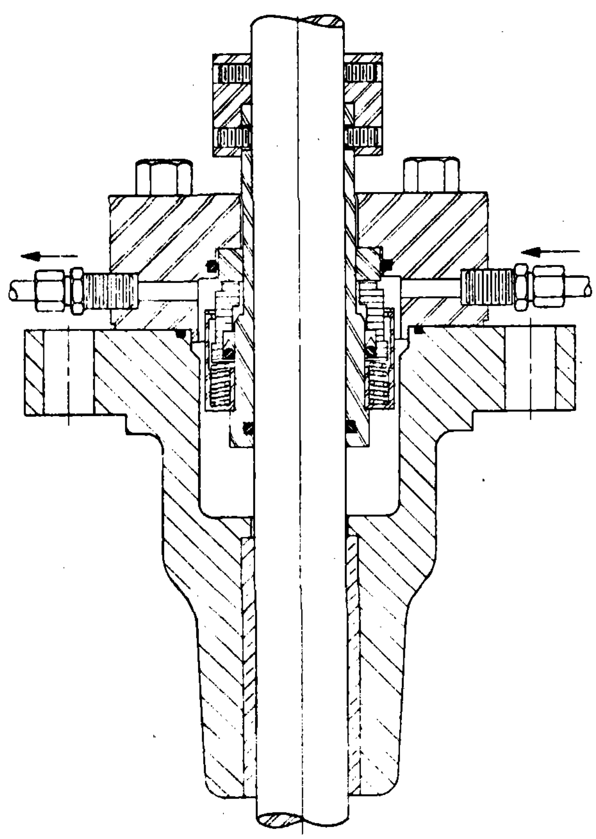


Fig. 43

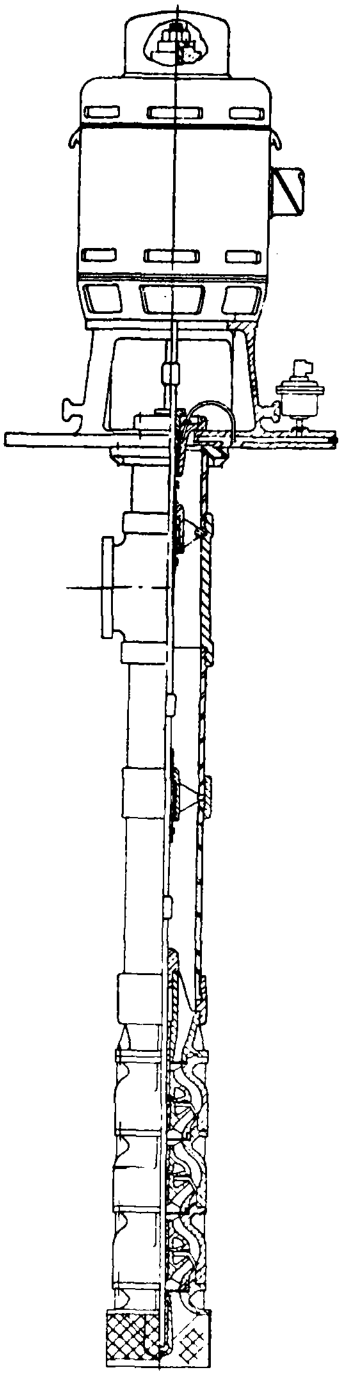


Fig. 44

lubricant that is compatible with the pumped liquid may be used so long as conditions of flow and pressure permit. In general, capacity of a water flush system must be approximately 1 GPM for each journal to be served, up to 1 inch shaft; 2 GPM for each journal, up to 2 inch shaft; 5 GPM each journal up to 3 inch. For diameters in excess of 3 inches, consult factory.

Available capacity could be reduced slightly when oil is used as a lubricant. If grease is used, it is only necessary to keep lines full under adequate pressure. Grease lines on completely assembled pumps will be filled with grease at factory.

(k) BELOW BASE DISCHARGE

Although most pump assemblies are so constructed that the discharge elbow is above the mounting surface and is usually an integral part of the driver pedestal, some pumps are designed for specific customer requirements to place the discharge outlet at a position below the mounting base. This type of construction is illustrated in Fig. 44.

The discharge elbow in this arrangement is actually a tee, in which the run portion is a part of the column and the side outlet becomes the discharge connection. Vertical location of centerline discharge may vary within reason according to user requirements. However, there are limitations as to how close the discharge may be located to bottom of base. This will depend on clearance with mounting structure and upon size and shape of discharge tee.

Because column pipe dead ends above discharge tee, it is possible to entrap air in this area. Therefore, all mounting pedestals are furnished with a port from which air may be released. It is recommended that, in each case, user shall make provisions for either manual or automatic release of air. Air release should preferably occur continuously during operation but at least at each startup. See suggested arrangement in Fig. 45.

As may be seen in Fig. 46, mounting base is part of driver pedestal. All connections at this point may be handled in same manner as that used for above base discharge construction. Provisions for shaft sealing, tube connection, column pipe attachment, pre-lubrication connections that may be necessary, and other details will feature components identical to those found in above base discharge pumps. Therefore, please refer to the proper sections of these instructions for assembly and operation procedures.

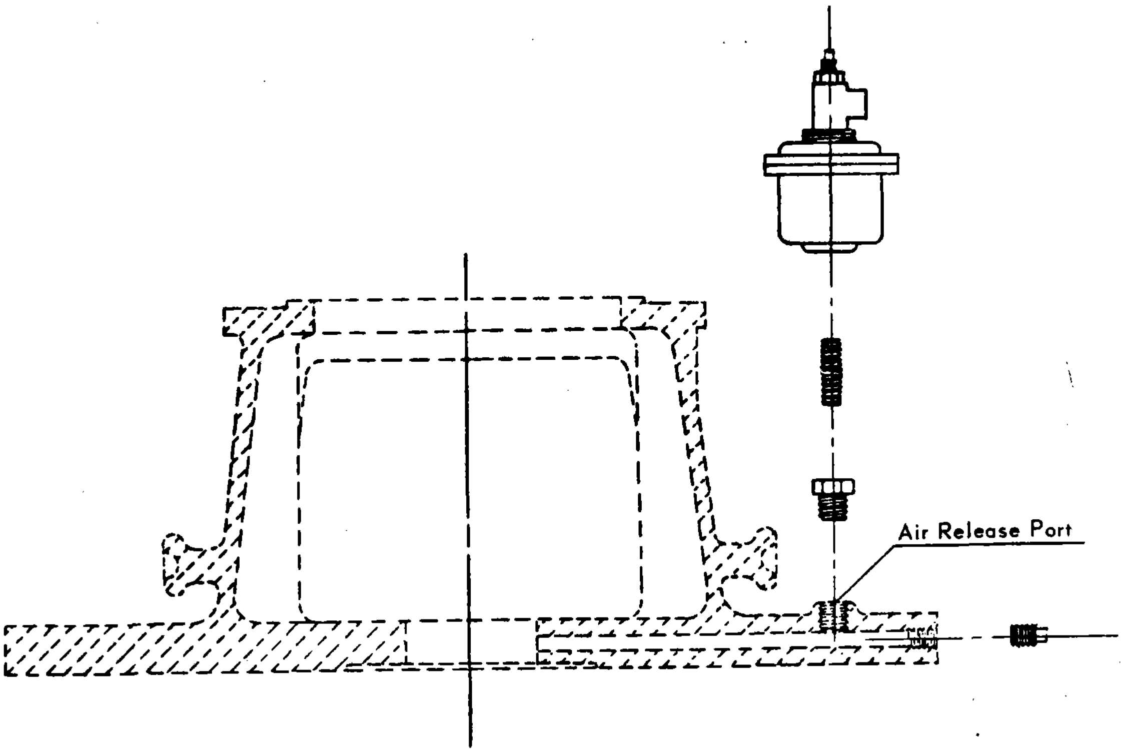

Air Release Port

Fig. 45

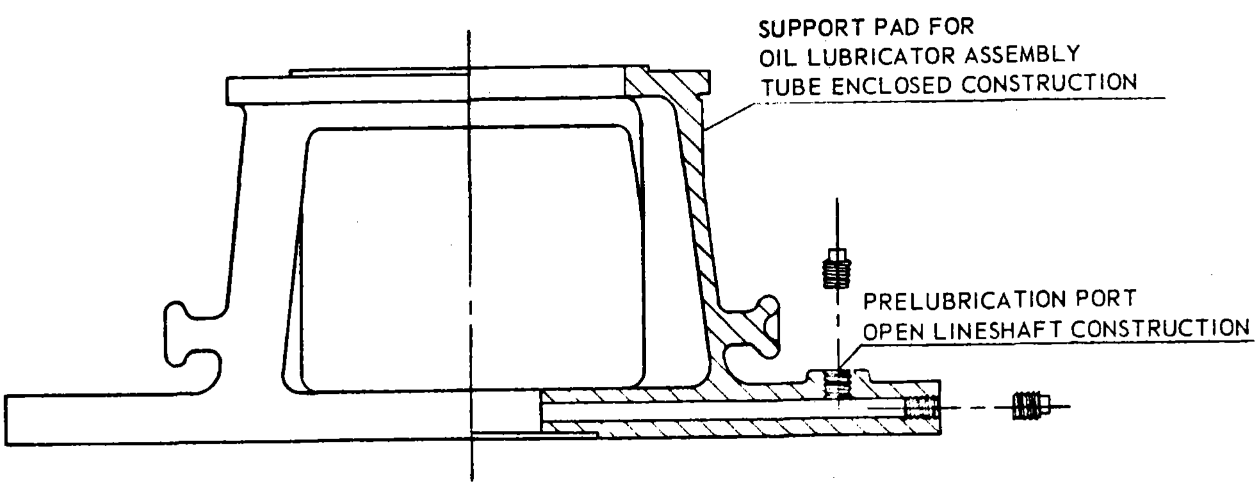

SUPPORT PAD FOR
OIL LUBRICATOR ASSEMBLY
TUBE ENCLOSED CONSTRUCTION
PRELUBRICATION PORT
OPEN LINESHAFT CONSTRUCTION

Fig. 46

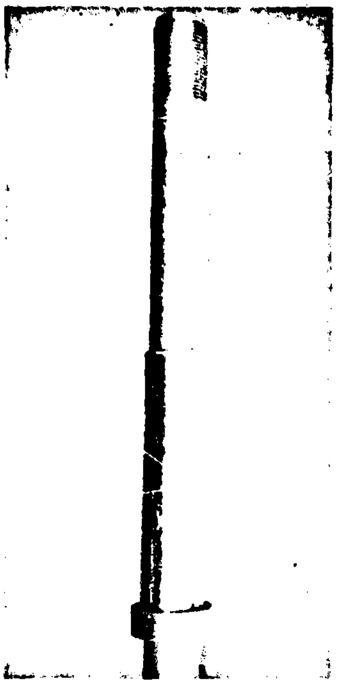


Fig. 47

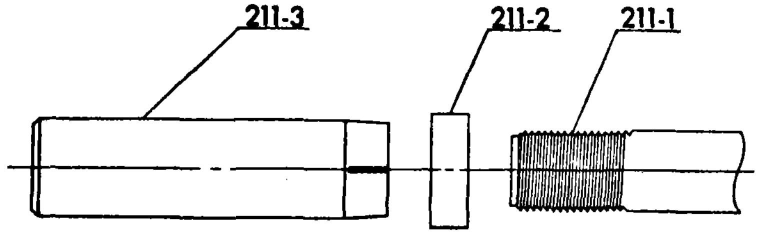


Fig. 48

(m) OPEN LINESHAFT REPLACEABLE SLEEVE

Lineshafting may be furnished with a sleeve at journal points, using several different designs. Fig. 47 depicts a collet attached field replaceable sleeve arrangement often used in open lineshaft construction. Individual parts are identified in Fig. 48.

If it is necessary to remove sleeve in field for repair or relocation, this may be accomplished by driving collet down off sleeve taper as shown in Fig. 49. Collet is driven in either direction by a two piece collet driver as illustrated in Fig. 50. Thus, the tool may be used both for assembly and removal of journal sleeve.

To replace sleeve at jobsite, coat shaft with an epoxy adhesive such as Loc-Tite or, failing that, a filler material based on shellac. Slip collet item 211-2 over shaft item 211-1 with open end of taper away from threads. It must be moved away from threads to a point beyond eventual sleeve location. Slide sleeve item 211-3 onto shaft with tapered end away from threads to a point at which it will run in bearing. It is imperative that journal point be properly located and this may be done by reference to position of bearing. Having established sleeve in proper

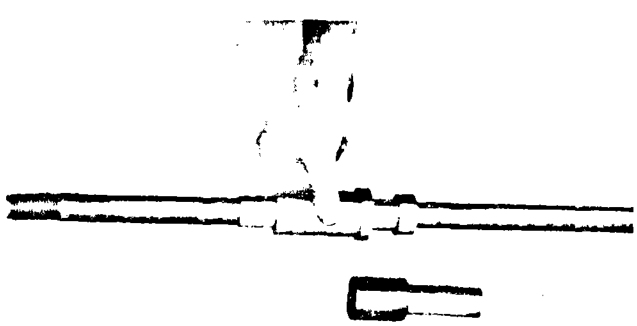


Fig. 49

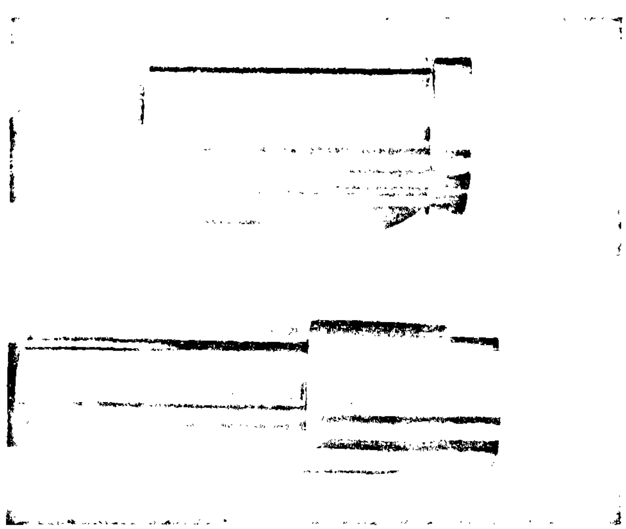


Fig. 50

location, it is advisable to construct a stop for end of shaft and also end of sleeve so that the latter will not move with respect to shaft. Collet may then be driven on sleeve taper <u>firmly</u> with collet driver, working as indicated in Fig. 51.

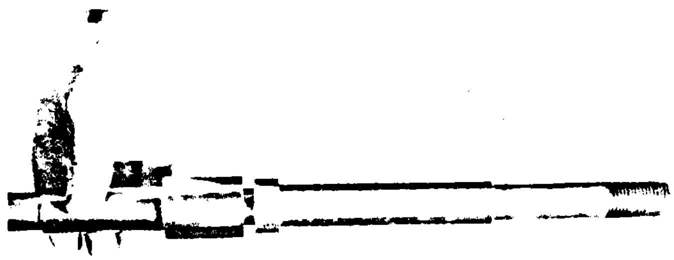


Fig. 51

SECTION 11

BOWL ASSEMBLY PROCEDURE

Gather together all parts required for the assembly, using applicable assembly drawing if necessary. Procure all tools necessary for various operations, including following:

Impeller collet driver.

Thin bladed screw driver or special wedge tool for spreading collet.

Bolt to fit tapped hole in bottom of shaft, washers as necessary.

Open end or box wrench for above bolt.

Open end or box wrench for nuts on bowl studs, if flanged bowls.

Strap wrench or pipe wrench for tube adapter.

Chain tongs for pipe coupling and for bowls if threaded.

Using information on Fig. 52, locate lower impeller on shaft. To attach impeller securely, slip collet over shaft down into impeller hub opening, small end down. Using screw driver blade or wedge tool in collet slot will facilitate sliding it on shaft. Slip collet driver on shaft from top or threaded end as shown in Fig. 53 and drive collet in place, holding impeller location as noted above. Collet may be firmly wedged into position by sliding driver rapidly along shaft and striking top of collet with a sharp blow several times. On a new unit, assembled collet will project above opening from 0 to 1/8". Subsequent re-assembly operations may find collet driven further into opening to effect a secure attachment.

Slide bearing cap, if any, onto shaft from bottom, small end up. Do not lock set screws.

Slide suction case onto shaft from bottom, seating impeller firmly in suction case. Locate bearing cap to cover bushing projection and lock in place with set screws. Insert bolt through grease filler hole in bottom of suction case hub, threading it into tapped hole in shaft; pull up tight, using washers or spacer so that impeller is firmly and securely seated against wear ring.

Slide an intermediate bowl onto shaft from top end into position against suction case. Attach firmly with two or three nuts on studs, if flanged bowls; screw in place if threaded.

Slip next impeller down over shaft and set firmly against bowl wear ring; slide collet in place and drive collet in as before. See Fig. 54.

Continue as above for required number of stages. Loosen tie down bolt in bottom of shaft after each impeller is set and check to see that shaft will rotate freely by hand without dragging or hanging up. Make this check with the shaft all the way in and again all the way out, while at the same time observing lateral movement of shaft to be sure of adequate end play.

Top bowl has no bushing, and therefore discharge case is assembled onto shaft so that its bushing projects into top bowl hub when flanges butt. Again, fasten in position with two or three nuts, if flanged. Some installations require no discharge case at all. If this is the case, ignore next three paragraphs.

Deflector collar may now be slipped over shaft by forcing a screw driver blade into slot of collar, thus spreading it open somewhat. Collar may be poked down into hub of discharge case with screw driver so that it is roughly opposite bypass ports. It should never be set so close to bottom of tube adapter that it restricts shaft end play.

Tube adapter or cap may now be screwed into hub of discharge case and seated firmly against shoulder. If assembly is for open lineshaft pump, screw pipe plugs into bypass ports, plugging ports securely. If pump is of enclosed lineshaft design, ports must be open except as noted in Section 10r. If cap is used in discharge case, assemble setscrew through tapped hole in case hub. Setscrew must not displace cap for enough to hang up on shaft.

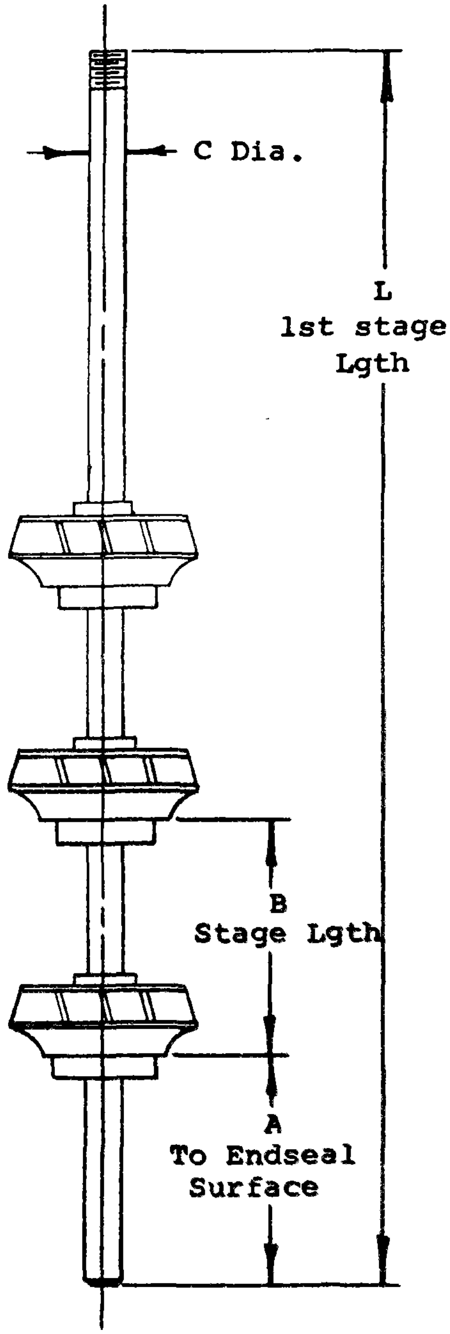
Column and/or suction pipe couplings (if any) may now be assembled by threading onto discharge case and suction case respectively. Column coupling or flange must butt solidly; suction coupling or flange may occasionally be taper thread, but must be made up tight.

At this point, check shaft for ease of rotation and proper amount of end play. Check also for projection above pipe butt. Assemble all nuts, each stage, leaving none loose.

Check shaft again as above and assemble shaft coupling so that end of shaft is in middle of coupling. Fill suction case hub with recommended grease. Screw in pipe plug. Bowls should now be ready to re-assemble on pump. Check all available instructions for complete installation according to specific pump in question.

BOWL	A	B	C	L	SHAFT PART NO.
4R	2.63	3.000	.625	15.16	HS3450
4RC	2.41	3.000	.625	15.16	HS6108
6LL	3.94	3.625	.750	17.75	HS3111
6T	5.19	3.500	1.000	24.13	HS4368
6EH	3.38	4.500	1.000	23.25	HS5191
6R	5.25	5.125	1.000	25.50	HS5132
6FH	5.25	4.750	1.000	25.75	HS5730
7R	8.50	7.250	1.500	36.25	HS4455
8EL	5.13	4.500	1.000	30.50	HS2434
8ED	5.50	5.000	1.188	30.44	HS6094
8EH	5.25	5.813	1.188	30.31	HS2046
8R	5.63	6.500	1.188	33.38	HS6780
8GH	6.00	6.750	1.188	33.13	HS5766
8FH	6.38	7.500	1.188	35.00	HS3564
10EXL	5.94	7.063	1.188	32.94	HS3017
10EH	8.63	7.063	1.500	36.56	HS2080
10R	8.56	8.375	1.688	38.38	HS3250
10JK	8.25	7.625	1.500	36.63	HS2997
10FH	9.00	8.750	1.688	39.00	HS4930
12EL	9.00	7.000	1.500	36.75	HS2203
12EH	8.75	9.125	1.500	40.75	HS2087
12R	8.53	10.000	1.938	41.00	HS6181
12KH	7.63	8.500	1.688	39.50	HS2107
12FH	8.00	11.000	1.938	41.25	HS3930
14TM	8.56	9.750	1.938	41.50	HS3097
14KH	9.88	11.000	1.938	42.75	HS1953
14R	12.63	13.375	2.188	50.38	HS3347
14MS	9.63	11.000	1.938	43.00	HS2418
14FH	11.88	12.312	2.188	47.63	HS5443
16EH	9.56	12.000	1.938	45.38	HS2679
16KH	9.69	12.000	2.188	45.06	HS2654
16FH	12.75	14.500	2.188	51.00	HS4623
18EH	11.25	14.000	2.188	49.00	HS2653
18FXH	10.13	14.000	2.188	47.00	HS2348
18CF	11.25	15.000	2.438	50.00	HS3523
20EH	12.25	15.000	2.438	52.13	HS2667
20K	10.16	18.250	2.438	54.00	HS7646
22MS	11.81	17.000	2.688	53.00	HS3681
24EH	11.88	18.000	2.688	54.00	HS2926
28SK	11.00	22.500	2.688	62.25	HS3141
30K	*	28.500	3.250	73.50	LS9007
36EH	*	29.313	3.250	75.38	LS8537
46FH	*	45.500	5.500	131.50	LS4430

Note: For semi-open impellers 4R and 6L, dimension A refers to lowest point of vane.



*Impeller located by keyway in bowl shaft

Fig. 52

BOWL PARTS RELATIONSHIP

DURING ASSEMBLY ONTO BOWL SHAFT

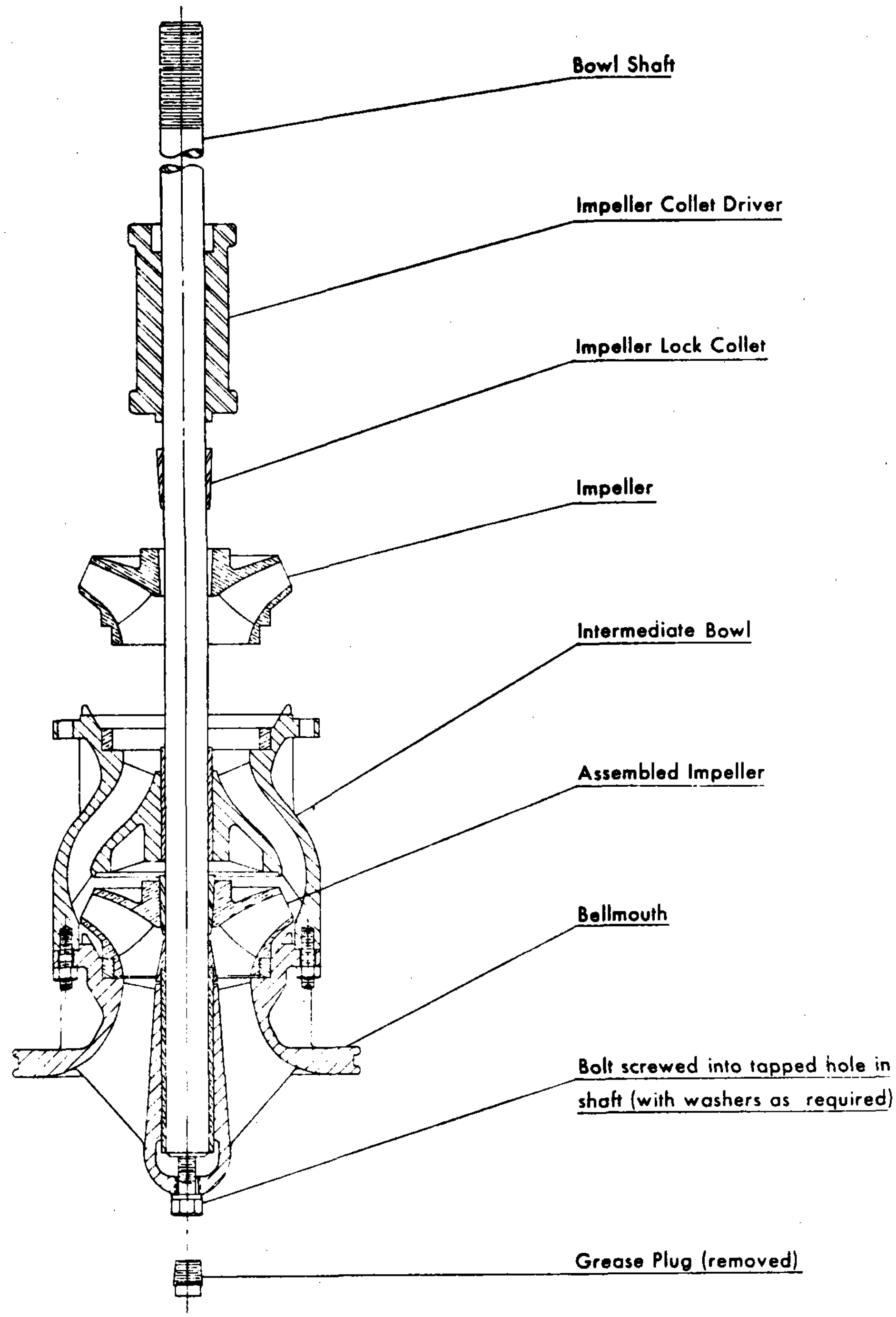


Fig. 53

IMPELLER ASSEMBLY

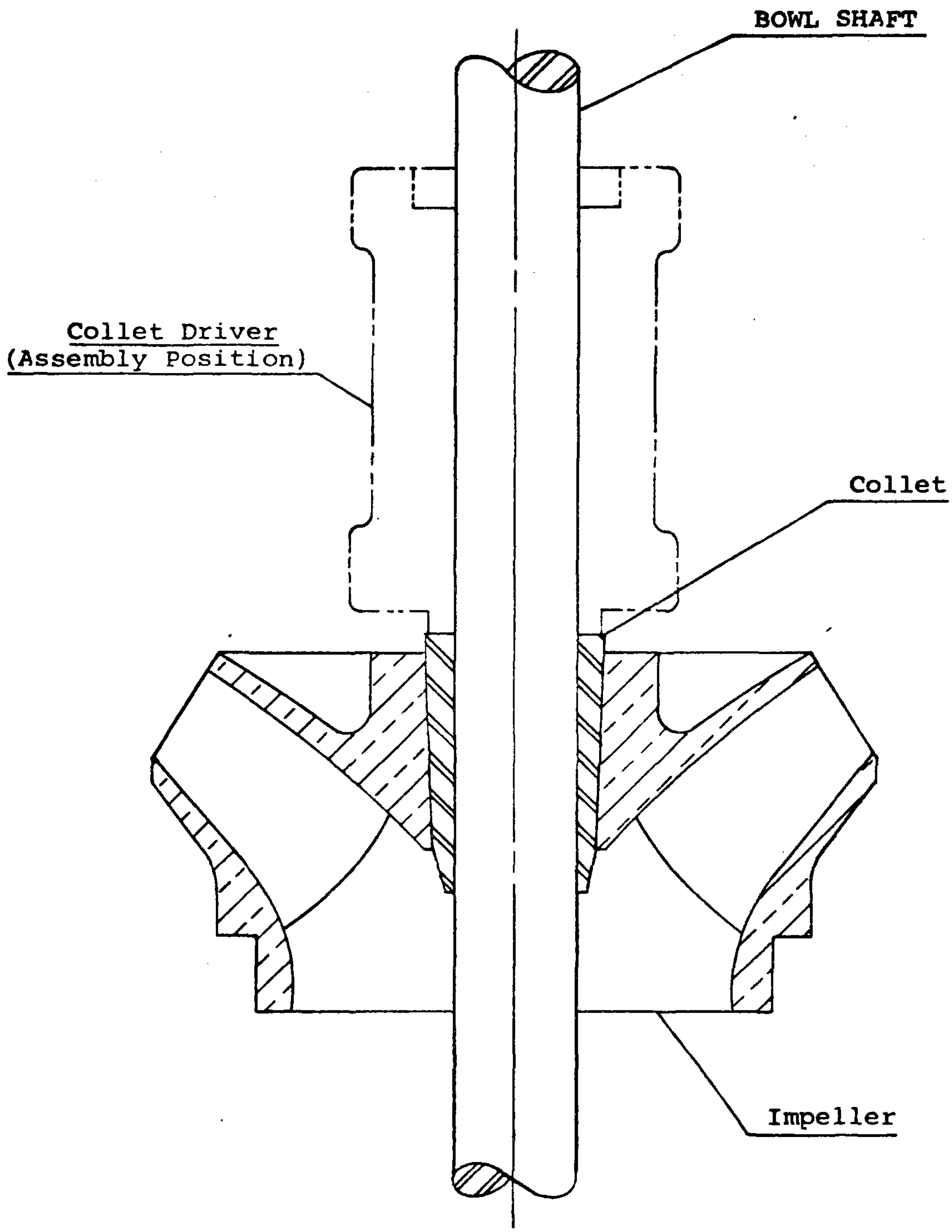


Fig. 54

SECTION 12

BOWL DISASSEMBLY PROCEDURE

Provide tools as listed in "Assembly Procedure," Section 11.

Remove shaft coupling and tube adapter. Remove deflector collar by reaching down into discharge case hub and insert screw driver blade into collar slot. Collar may then be withdrawn by pulling out with screw driver.

Remove nuts under top bowl flange and slide discharge case off shaft. In same manner, take top bowl off. If desired, discharge case and top bowl need not be separated, and may be handled as one part for disassembly operations.

Slip collet driver onto shaft from top into position as shown in Fig. 55 (reverse ends from assembly position.) Pull shaft out as far as possible so that impellers are well off seats and knock impeller off collet. Using screw driver to spread collet, remove collet from shaft by sliding along and off threaded end. Remove next bowl and continue operation as described.

GENERAL NOTE

In either assembly or disassembly operation, it is beneficial to oil shaft very lightly. This will facilitate sliding parts on and off shaft.

In making up pipe adapter coupling, tube adapter, threaded bowls, or other threaded joints, it would be advisable to use approved thread compound.

In taking apart an old unit in which shaft may be frozen in bushings or collet frozen to shaft, it may be necessary to apply heat with a torch in order to effect removal.

In all cases when assembling any threaded parts, threads must be perfectly clean.

For new units, impeller skirt and wear ring clearances should be as listed in Fig. 56.

For standard units, endplay characteristics will be as noted in Verti-Line Catalog Page 8.1 and 8.2, Section 2.1.

Before starting any disassembly work, shaft endplay should be checked so that, upon reassembly, same endplay may be maintained, un :ss more lateral is required.

Before starting any disassembly work, shaft and tube projections should be measured and recorded so that parts may be reassembled in same manner.

IMPELLER DISASSEMBLY

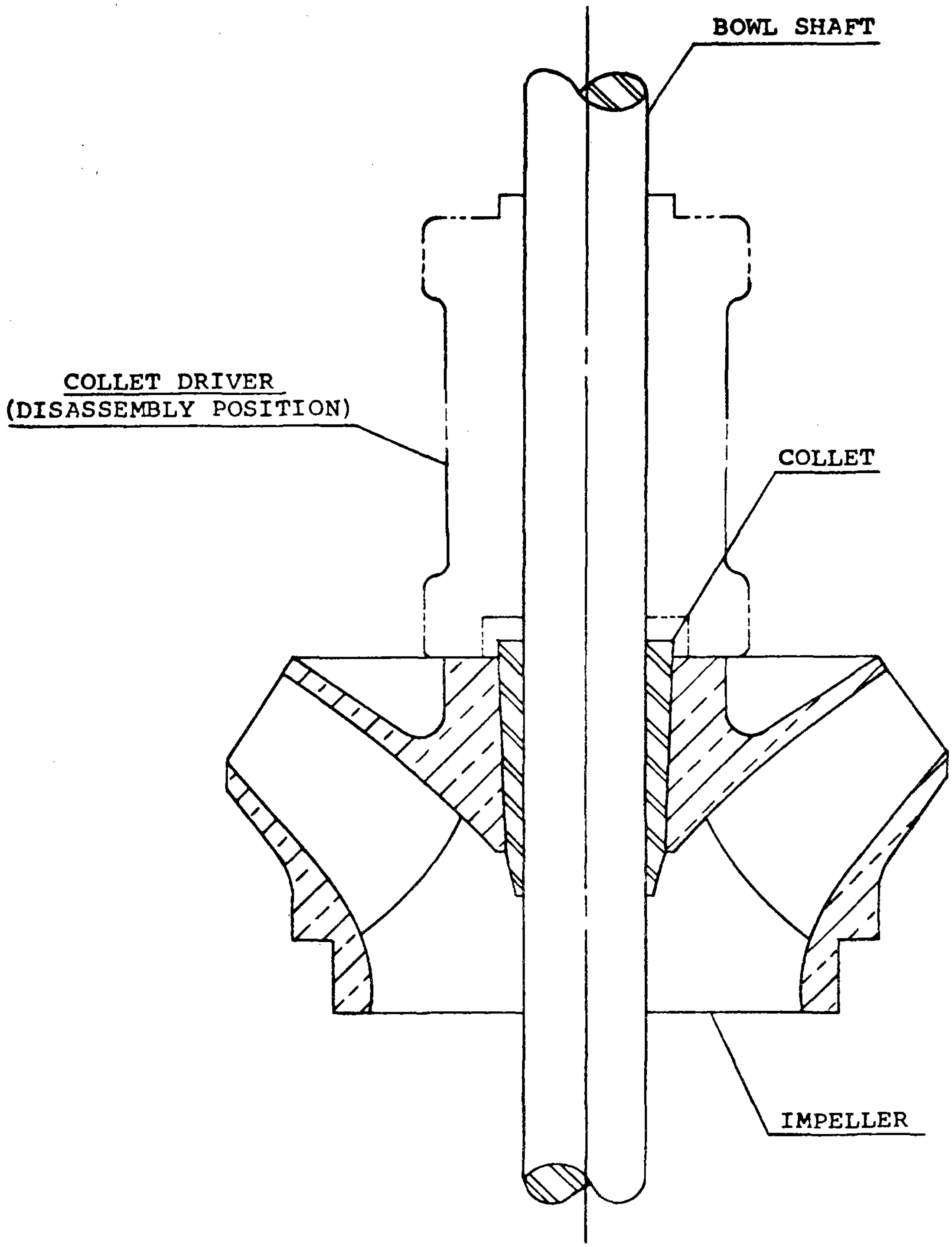


Fig. 55

BOWL	IMPELLER SKIRT O.D.		BOWL BORE I.D.		DIA. CLEARANCE	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
4RC	2.240	2.242	2.250	2.252	.008	.012
6T	3.237	3.238	3.250	3.252	.012	.015
6EH	2.615	2.616	2.625	2.627	.009	.012
6R	3.112	3.113	3.125	3.127	.012	.015
6FH	3.612	3.613	3.625	3.627	.012	.015
7R	4.235	4.237	4.250	4.252	.013	.017
8EL	3.237	3.238	3.250	3.252	.012	.015
8ED	3.612	3.613	3.625	3.627	.012	.015
8EH	4.110	4.112	4.125	4.127	.013	.017
8R	4.110	4.112	4.125	4.127	.013	.017
8GH	4.985	4.987	5.000	5.002	.013	.017
8FH	4.985	4.987	5.000	5.002	.013	.017
10EXL	4.110	4.112	4.125	4.127	.013	.017
10EH	4.860	4.862	4.875	4.877	.013	.017
10R	5.234	5.236	5.250	5.252	.014	.018
10JK	6.171	6.173	6.187	6.189	.014	.018
10FH	6.609	6.611	6.625	6.627	.014	.018
12EL	4.735	4.737	4.750	4.752	.013	.017
12EH	5.434	5.436	5.450	5.452	.014	.018
12R	6.171	6.173	6.187	6.189	.014	.018
12KH	6.798	6.800	6.814	6.816	.014	.018
12FH	7.233	7.235	7.250	7.252	.015	.019
14TM	6.484	6.486	6.500	6.502	.014	.018
14KH	7.733	7.735	7.750	7.752	.015	.019
14R	7.858	7.860	7.875	7.877	.015	.019
14MS	8.983	8.985	9.000	9.002	.015	.019
14FH	9.483	9.485	9.500	9.502	.015	.019
16EH	7.733	7.735	7.750	7.752	.015	.019
16KH	8.983	8.985	9.000	9.002	.015	.019
16FH	10.981	10.983	11.000	11.002	.017	.021
18EH	8.983	8.985	9.000	9.002	.015	.019
18FXH	9.483	9.485	9.500	9.502	.015	.019
18CF	10.233	10.235	10.250	10.252	.015	.019
20EH	10.233	10.235	10.250	10.252	.015	.019
20K	10.608	10.610	10.625	10.627	.015	.019
22MS	13.730	13.732	13.750	13.752	.018	.022
24EH	12.230	12.232	12.250	12.252	.018	.022
28SK	14.978	14.980	15.000	15.002	.020	.024
30K	15.998	16.000	16.020	16.022	.020	.024
36EH	18.748	18.750	18.770	18.772	.020	.024
46FH	29.965	29.970	30.000	30.005	.030	.040

Fig. 56

SECTION 13

DON'T

Don't pull discharge piping to pump discharge flange with bolts or capscrews. Install pipeline so that fasteners are used to prevent leakage only.

Don't hang weight of discharge line and fittings on discharge head alone. Support pipeline by blocking or concrete saddles according to best piping practice. Use dresser-type couplings wherever possible to eliminate piping strains imposed on pump.

Don't start pump while it is rotating in reverse direction after having shut down. It is advisable to install time delay relay on electric drives to prevent this. Non-reverse protection in driver could also be a solution.

Don't put heavier than recommended heaters in starter if pump load begins to trip those furnished originally. These are protective devices. Contact your Layne & Bowler Representative for assistance.

Don't add oil to driver while running. Don't add grease to grease lubricated driver without removing relief plug.

Don't drop parts into pump during installation or disassembly. Don't drop parts into motor when canopy has been removed and top is open. Parts must be removed before next operation.

Don't tighten shaft packing where provided except in increments, i.e., tighten gland nuts part of a turn and let pump run 5 to 10 minutes before tightening further. If leakage water is too hot to put on hand, back gland nuts off a little until water cools, then tighten again. Gland nuts must be adjusted evenly so as to prevent cocking gland, forcing it against shaft.

Don't start pump equipped with mechanical seal until air or vapor is vented from seal housing. Housing should be filled with liquid to avoid damage to seal faces.

Don't forget that this equipment contains rotating parts. Use CAUTION when working near such parts to avoid injury. Don't neglect to replace all guards, covers, and shields before start-up.

Don't run pump backward. Clockwise operation (looking down on pump). under power can unscrew threaded joints. Power requirements of impellers can increase when driven backward and can thus create undesirable overloads. These problems do not apply to pumps coasting backward due to return flow of water from system; overspeed is the circumstance to guard against then.

Don't throttle the suction of a pump in a closed system.

Don't change pump speed without checking effect on power, internal pressure, and other conditions.

Don't allow oil, grease, or thread lubricant to contact rubber bearings.

Don't work on pumps, wiring, or any pump or system components without opening energizing circuits such as at main breaker or pump disconnect switch. This will prevent "surprise" starts that may occur due to automatic control systems. It will also prevent other possibility of personal injury.

SECTION 14

MAINTENANCE HINTS

For pump lubrication, use light turbine oil equivalent to Standard Oil O.C. Turbine Oil #9 or good grade of mineral oil with proper additives having viscosity equal to SAE #10.

Remove old oil from driver once a year. Flush with kerosene and refill. Follow manufacturer's instructions carefully as to method and type of lubricant. Replace self-lubricated driver ball bearings in about 5 years. It is generally less expensive to replace these before they fail.

Replace all shaft packing on open lineshaft pumps after maintenance has required addition of two rings. Always let packing box leak slightly at top to add life to packing.

Be aware of changing conditions in system. Any change from original conditions or any variation in system can create an undesirable reaction in pump as the energizer of the system. Refer to Vertical Turbine Pump Association Environmental Data Brochure for some of the system variable conditions that might occur.

Don't attempt to remove or to repair your pump without consulting a company representative. If it becomes necessary to attempt any repair work on your equipment, be sure to review all instructions for operation and maintenance of unit.

SECTION 15

OPERATION AT SHUTOFF HEADS

In the usual application of Verti-Line vertical turbine pumps, no harm will result from operations under conditions of static flow heads. However, not all installations are "usual" and for this reason consideration should be given to any unit which may be subjected to this usage. The following points should therefore be checked and resolved before putting the equipment into operation at or near shutoff heads.

a. Thrust bearing capacity must be adequate

b. If prolonged operation at no flow is contemplated, the problem of heat dissipation may become acute since the entire shutoff horsepower is converted to heat in the available fluid.

c. For high pressure units, stresses at shutoff heads should be investigated. This information may be obtained from the factory upon request.

d. Certain impeller designs may have critical horsepower characteristics at low flows. Shutoff power requirements should be examined for driver overload.

e. It must be kept in mind that open lineshaft units depend upon pumped fluid for lubrication. Fluid temperatures, if raised excessively due to lack of flow, my impair lubrication efficiency.

To summarize, designs will easily accommodate most of the considerations listed above. However, to obtain the best possible application, the factory should be notified at the time of order if operation at static flow heads will be a possibility and this precaution must be observed to validate any warrantees.

NOTES

SERVICE RECORD

TERMS AND CONDITIONS OF SALE

NOT INTENDED FOR SALE OR USE FOR PERSONAL, FAMILY, OR HOUSEHOLD PURPOSES. 7-77 Printed in U.S.A.

All orders shall be made out to Aurora Pump at North Aurora, Illinois, and shall be subject to acceptance by us at North Aurora.

1. CONSTRUCTION AND LEGAL EFFECT. Our sale to you will be solely upon the terms and conditions set forth herein. They supersede and reject any conflicting terms and conditions of yours, any statement in yours to the contrary notwithstanding. Exceptions to any of our terms and conditions must be contained in a written or typed (not printed) statement received from you; we shall not be deemed to have waived any of our terms and conditions or to have assented to any modification or alteration of such terms and conditions unless such waiver or assent is in writing and signed by an authorized officer. No representation of any kind has been made by us except as set forth herein; this agreement conclusively supersedes all prior writings and negotiations with respect thereto and we will furnish only the quantities and items specifically listed on the face hereof; we assume no responsibility for furnishing other equipment or material shown in any plans and/or specifications for a project to which the goods ordered herein pertain. Any action for breach of contract must be commenced within one year after the cause of action has accrued. Our published or quoted prices, discounts, terms and conditions are subject to change without notice.

2. PRICES. Unless otherwise noted on the face hereof, prices are net F.O.B. our producing factory, and include standard catalogue literature only. Service time of a factory-trained service man is not included and may be charged extra. The amount of any applicable present or future tax or other government charge upon the production, sale, shipment or use of goods ordered or sold will be added to billing unless you provide us with an appropriate exemption certificate. We may adjust prices to our prices in effect at time of shipment. Purchased equipment such as motors, controls, gasoline engines, etc., will be invoiced at prices in effect at time of shipment in accordance with pricing policy of manufacturer.

3. DEFECTIVE EQUIPMENT. Providing Purchaser notifies us promptly, if within one year from date of shipment equipment or parts manufactured by us fail to function properly under normal, proper and rated use and service because of defects in material or workmanship demonstrated to our satisfaction to have existed at the time of delivery, the Company reserving the right to either inspect them in your hands or request their return to us will at our option repair or replace at our expense F.O.B. our producing factory, or give you proper credit for such equipment or parts determined by us to be defective, if returned transportation prepaid by Purchaser. The foregoing shall not apply to equipment that shall have been altered or repaired after shipment to you by anyone except our authorized employees, and the Company will not be liable in any event for alterations or repair except those made with its written consent. Purchaser shall be solely responsible for determining suitability for use and the Company shall in no event be liable in this respect. The equipment or parts manufactured by others but furnished by us will be repaired or replaced only to the extent of the original manufacturer's guarantee. Our obligations and liabilities hereunder shall not be enforceable until such equipment has been fully paid for. Purchaser agrees that if the products sold hereunder are resold by purchaser, he will include in the contract for resale, provisions which limit recoveries against us in accordance with this section. In case of our failure to fulfill any performance representation, it is agreed that we may at our option remove and reclaim the equipment covered by this agreement at our own expense and discharge all liability by repayment to the purchaser of all sums received on account of the purchase price. (THE FOREGOING OBLIGATIONS ARE IN LIEU OF ALL OTHER OBLIGATIONS AND LIABILITIES INCLUDING NEGLIGENCE AND ALL WARRANTIES, OF MERCHANTABILITY OR OTHERWISE, EXPRESS OR IMPLIED BY FACT OR BY LAW, AND STATE OUR ENTIRE AND EXCLUSIVE LIABILITY AND BUYER'S EXCLUSIVE REMEDY FOR ANY CLAIM OF DAMAGES IN CONNECTION WITH THE SALE OR FURNISHING OF GOODS OR PARTS, THEIR DESIGN, SUITABILITY FOR USE, INSTALLATION OR OPERATION.) WE WILL IN NO EVENT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES OR DELAY RESULTING FROM ANY DEFECT WHATSOEVER, AND OUR LIABILITY UNDER NO CIRCUMSTANCES WILL EXCEED THE CONTRACT PRICE FOR THE GOODS FOR WHICH LIABILITY IS CLAIMED.

4. DELIVERY. Delivery, shipment and installation dates are estimated dates only, and unless otherwise specified, are figured from date of receipt of complete technical data and approved drawings as such may be necessary. In estimating such dates, no allowance has been made, nor shall we be liable directly or indirectly for, delays of carriers or delays from labor difficulties, shortages, strikes or stoppages of any sort, fires, accidents, failure or delay in obtaining materials or manufacturing facilities, acts of government affecting us directly or indirectly, bad weather, or any causes beyond our control or causes designated Acts of God or force majeure by any court of law, and the estimated delivery date shall be extended accordingly. We will not be liable for any damages or penalties whatsoever, whether direct, indirect, special or consequential, resulting from our failure to perform or delay in performing unless otherwise agreed in writing by an authorized officer.

5. OPERATING CONDITIONS AND ACCEPTANCE. Recommendations and quotations are made upon the basis of operating conditions specified by the Purchaser. If actual conditions are different than those specified and performance of the equipment is adversely affected thereby, Purchaser will be responsible for the cost of all changes in the equipment required to accommodate such conditions, and we reserve the right to cancel this order and Purchaser shall reimburse us for all costs and expenses incurred in, and reasonable profit for, performance hereunder. We reserve the right to refuse any order based upon a quotation containing an error. The provisions in any specification or chart are descriptive only and are not warranties or representations; we will certify to a rated capacity in any particular product upon request. Capacity, head and efficiency certifications are based on shop tests and when handling clear, fresh water at a temperature of not over 85°F. Certifications are at this specified rating only and do not cover sustained performance over any period of time nor under conditions varying from these .

6. SHIPPING. Unless you specify otherwise in writing, (a) goods will be boxed or crated as we may deem proper for protection against normal handling, and extra charge will be made for preservation, waterproofing, export boxing and similar added protection of goods; (b) routing and manner of shipment will be at our discretion, and may be insured at your expense, value to be stated at order price. On all shipments F.O.B. our producing factory, delivery of goods to the initial carrier will constitute delivery to you and all goods will be shipped at your risk. A claim for loss or damage in transit must be entered with the carrier and prosecuted by you. Acceptance of material from a common carrier constitutes a waiver of any claims against us for delay or damage or loss.

7. PATENT INFRINGEMENT. We will not be liable for any claim of infringement unless due to infringement by goods manufactured by us in the form in which we supply such goods to you and without regard to their use by you. If you notify us promptly of any such claim of infringement and, if we so request, authorize us to defend or settle any suit or controversy involving such claim, we will indemnify you against the reasonable expenses of any such suit and will satisfy any judgment or settlement in which we acquiesce, but only to an amount not exceeding the price paid to us for the allegedly infringing goods. If an injunction is issued against the further use of allegedly infringing goods we shall have the option of procuring for you the right to use the goods, or replacing them with non-infringing goods, or modifying them so that they become non-infringing, or of removing them and refunding the purchase price. The foregoing expresses our entire and exclusive warranty and liability as to patents, and we will not be liable for any damages whatsoever, suffered by reason of any infringement claimed, except as provided herein. You will hold us harmless and indemnified against any and all claims, demands, liabilities, damages, costs and expenses resulting from or connected with any claim of patent infringement arising out of the manufacture by us of goods in accordance with a design or specifications which you furnish us.

8. CANCELLATION AND RETURNED EQUIPMENT. Orders may be cancelled only with our written consent and upon payment of reasonable and proper cancellation charges. Goods may be returned only when specifically authorized and you will be charged for placing returned goods in saleable condition, any sales expenses then incurred by us, plus a restocking charge and any outgoing and incoming transportation costs which we pay.

9. CREDIT AND PAYMENT. Payment for products shall be 30 days net. Pro-rata payments shall become due with partial shipments. A late charge of 1 percent per month or the maximum permitted by law, whichever is less, will be imposed on all pastdue invoices. We reserve the right at any time to alter, suspend, credit, or to change credit terms provided herein, when in its sole opinion your financial condition so warrants. In such a case, in addition to any other remedies herein or by law provided, cash payment or satisfactory security from you may be required by us before shipment; or, the due date of payment by you under this contract may be accelerated by us. Failure to pay invoices at maturity date at our election makes all subsequent invoices immediately due and payable irrespective of terms, and we may withhold all subsequent deliveries until the full account is settled, and we may terminate this agreement. Acceptance by us of less than full payment shall not be a waiver of any of our rights. You represent by sending each purchase order to us that you are not insolvent as that term is defined in applicable state or federal statutes. In the event you become insolvent before delivery of any products purchased hereunder, you will notify us in writing. A failure to notify us of insolvency at the time of delivery shall be construed as a reaffirmation of your solvency at that time. Irrespective of whether the products purchased hereunder are delivered directly to you, or to a customer of yours, and irrespective of the size of the shipment, we shall have the right to stop delivery of the goods by a bailee if you become insolvent, repudiate, or fail to make a payment due before delivery, or if for any other reason we have a right to withhold or reclaim goods under the applicable state and federal statutes. Where you are responsible for any delay in shipment the date of completion of goods may be treated by us as the date of shipment for purposes of payment. Completed goods shall be held at your cost and risk and we shall have the right to bill you for reasonable storage and insurance expenses.

10. SPECIAL JIGS, FIXTURES AND PATTERNS. Any jigs, fixtures, patterns and like items which may be included in an order will remain our property without credit to you. We will assume the maintenance and replacement expenses of such items, but shall have the right to discard and scrap them after they have been inactive for one year without credit to you.

11. INSPECTION. Inspection of goods in our plant by you or your representative will be permitted insofar as this does not unduly interfere with our production workflow, provided that complete details of the inspection you desire are submitted to us in writing in advance.

12. RECORDS, AUDITS AND PROPRIETARY DATA. Unless otherwise specifically agreed in writing signed by an authorized officer, neither you nor any representative of yours, nor any other person, shall have any right to examine or audit our cost accounts, books or records of any kind or on any matter, or be entitled to, or have control over, any engineering or production prints, drawings or technical data which we, in our sole discretion, may consider in whole or in part proprietary to ourselves.

AURORA PUMPS

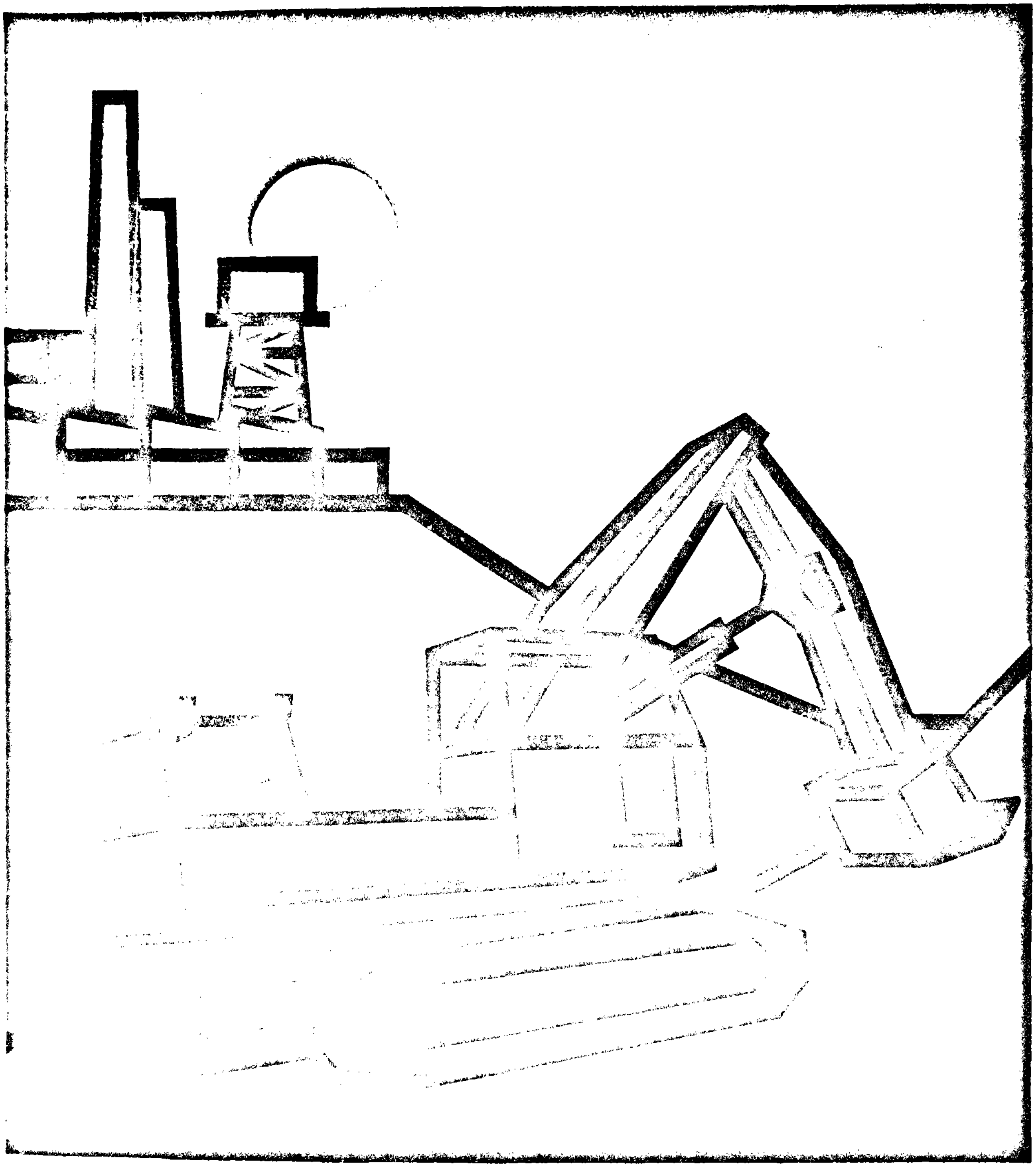
AURORA PUMP

A UNIT OF GENERAL SIGNAL

... ORT ROAD, NORTH AURORA ILLINOIS 60542

1.2.7.230

Construction/Industrial Diesel Engines Operation and Maintenance Manual



1.2.7.231

Operation and Maintenance Manual

Cummins Diesel Engines

Agricultural

Construction

Industrial

Industiral Fire Pump

Logging

Mining

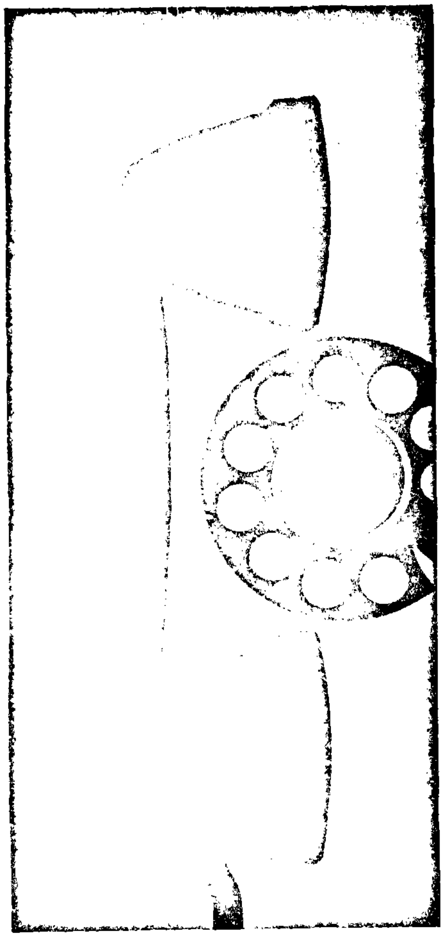
Railway

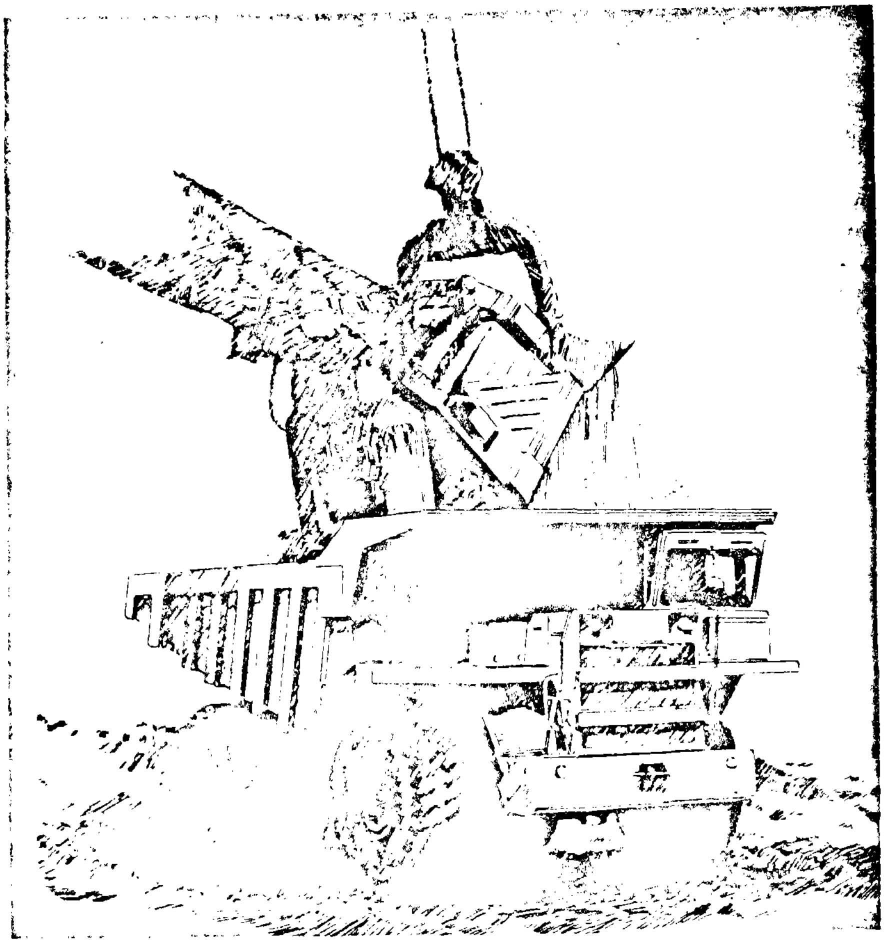
Generator

Bulletin 3379052-08, Printed 6/80

Emergency Service Assistance

If you should require emergency service assistance, check the yellow pages for the nearest Cummins distributor or authorized dealer.





Should you be unable to reach the local dealer or distributor in the above manner, Cummins Engine Company has established a 24 hours a day, toll free number for service assistance. In 47 states, you can call Cummins Customer Relations toll free by dialing 800-457-5300. In Alaska, Hawaii, Indiana and Canada, call collect 812-379-6115.

Cummins Owner Assistance

Cummins Engine Company backs its engines with expert service and complete parts support. We built a service network of more than 3,000 Cummins distributors and dealers, the largest in the world devoted exclusively to diesel engines. We trained our people to provide the Cummins owner with sound advice, expert service and professional treatment at all Cummins locations.

Any problem that you have in connection with the sale, operation or service of your engine can be handled at the nearest Cummins location. Occasionally, you may feel a problem has not been handled to your satisfaction. At those times, we urge you to pursue the problem until you are satisfied.

Many problems result from a breakdown in communications and can often be solved by bringing in a third party as a mediator. Bring your problem to the next higher authority to discuss.

We recommend:

1. If problem originates with a salesperson or service technician, talk to the sales or service manager.
2. If problem originates with a sales or service manager, talk to the owner of the service location.
3. If problem originates with a dealer, talk to the Cummins distributor with whom he has his service agreement.
4. If problem originates with a distributor, please call the nearest Cummins Divisional Office. Most problems are solved at or below the divisional office level. Their phone numbers and addresses are listed below. However, before you call, write down the following information and have it ready:
   A. Name and location of the Cummins distributor or dealer
   B. Type and make of equipment
   C. Engine model and serial number
   D. Total miles or hours of operation
   E. Nature of problem
   F. Summary of the current problem arranged in the order of occurrence.

If you still have problems please write:

Customer Relations
Cummins Engine Company, Inc.
1000 Fifth Street
Columbus, Indiana 47201

We do request that the above steps be followed in order. Most of the actual work on an engine can be performed at the original location, so please give them a chance to satisfy you first.

Cummins Divisional Offices

Canadian Division

Cummins Engine Company, Inc.
77 City Centre Drive
Suite 302
Mississauga, Ontario
Canada
Phone: 416-270-0240

Eastern Division

Cummins Engine Company, Inc.
Norwalk Towers
Suite 200
Bedlon Avenue & Cross Street
Norwalk, Connecticut 06850
Phone: 203-846-3241

Midwestern Division

Cummins Engine Company, Inc.
Oak Brook East Building
2000 Spring Road
Oak Brook, Illinois 60521
Phone: 312-654-0020

Plains Division

Cummins Engine Company, Inc.
Twin Towers, North
Suite 633
8585 North Stemmons Freeway
Dallas, Texas 75247
Phone: 214-638-5410

Rocky Mountain Division

Cummins Engine Company, Inc.
5660 S. Syracuse Circle
Englewood, Colorado 80110
Phone: 303-773-2866

Southern Division

Cummins Engine Company, Inc.
6425 Powers Ferry Road
Suite 120
Atlanta, Georgia 30339
Phone: 404-955-5025

Western Division

Cummins Engine Company, Inc.
Two Embarcadero Center
Suite 2050
San Francisco, California 94111
Phone: 415-981-2900

Cummins Distributors — United States

ALABAMA

Birmingham Distributor
Cummins Alabama, Inc.
2200 Pinson Highway
P.O. Box 1147
Birmingham, Alabama 35201
Telephone: (205) 841-0421

Mobile Branch
Cummins Alabama, Inc.
1924 Beltline Highway, I-65 North
P.O. Box 2566
Mobile, Alabama 36601
Telephone: (205) 456-2236

Montgomery Branch
Cummins Alabama, Inc.
2325 West Fairview Avenue
P.O. Box 9271
Montgomery, Alabama 36108
Telephone: (205) 263-2594

ALASKA

Anchorage Branch of Seattle
Cummins Northwest-Alaska, Inc.
2618 Commercial Drive
Anchorage, Alaska 99501
Telephone: (907) 279-7594

Fairbanks Branch of Seattle
Cummins Northwest-Alaska, Inc.
Corner of Peger & Davis Roads
P.O. Box 60282
Fairbanks, Alaska 99701
Telephone: (907) 452-7011

ARIZONA

Phoenix Distributor
Cummins Arizona Diesel, Inc.
2239 North Black Canyon Highway
P.O. Box 6697
Phoenix, Arizona 85005
Telephone: (602) 252-8021

Tucson Branch
Cummins Arizona Diesel, Inc.
1912 W. Prince Road
P.O. Box 5425
Tucson, Arizona 85703
Telephone: (602) 887-7440

ARKANSAS

Little Rock Branch of Memphis
Cummins Mid-South, Inc.
6700 Interstate Drive
P.O. Box 5240, Southside Station
Little Rock, Arkansas 72206
Telephone: (501) 565-0946

Ft. Smith Branch of Memphis
Cummins Mid-South, Inc.
6709 South 28th Street
Ft. Smith, Arkansas 72903
Telephone: (501) 646-6201

CALIFORNIA

Los Angeles Distributor
Cummins Service & Sales, Inc.
1800 E. 16th Street
Los Angeles, California 90021
Telephone: (213) 746-3850

Bakersfield Branch
Cummins Service & Sales, Inc.
301 East Fourth Street
Bakersfield, California 93304
Telephone: (805) 325-9404

Montebello Branch
Cummins Service & Sales, Inc.
1105 South Greenwood Avenue
Montebello, California 90640
Telephone: (213) 728-8111

Rialto Branch
Cummins Service & Sales, Inc.
161 East Valley Boulevard
Rialto, California 92376
Telephone: (714) 877-0433

San Francisco Distributor
Watson & Meehan
1960 Folsom Street
San Francisco, California 94103
Telephone: (415) 621-8930

Eureka Branch
Watson & Meehan
1048 Vigo Street
Eureka, California 95501
Telephone: (707) 433-7385

Fresno Branch
Watson & Meehan
2740 Church Avenue
Fresno, California 93706
Telephone: (209) 486-6050

Redding Branch
Watson & Meehan
2725 Favretto Avenue
Redding, California 96001
Telephone: (916) 241-2154

West Sacramento Branch
Watson & Meehan
2661 Evergreen Avenue
West Sacramento, California 95691
Telephone: (916) 371-0630

COLORADO

Denver Distributor
Cummins Power, Inc.
5100 East 58th Avenue
P.O. Box 628 (Zip 80037)
Commerce City, Colorado 80022
Telephone: (303) 287-0201

Grand Junction Branch
Cummins Power, Inc.
2380 U.S. Highway 6 & 50
P.O. Box 339
Grand Junction, Colorado 81501
Telephone: (303) 242-5776

CONNECTICUT

Hartford Distributor
Cummins Diesel Engines of Connecticut, Inc.
260 Murphy Road
Hartford, Connecticut 06114
Telephone: (203) 527-9156
Parts: (203) 525-5606

FLORIDA

Tampa Distributor
Cummins Florida, Inc.
5910 East Hillsborough Avenue
P.O. Box 11737
Tampa, Florida 33610
Telephone: (813) 626-1101

Hialeah Branch
Cummins Florida, Inc.
9900 N.W. 77th Avenue
P.O. Box 2367
Hialeah, Florida 33012
Telephone: (305) 821-4200

Jacksonville Branch
Cummins Florida, Inc.
2060 West 21st Street
P.O. Box 12036
Jacksonville, Florida 32209
Telephone: (904) 355-3437

Orlando Branch
Cummins Florida, Inc.
4820 N. Orange Blossom Trail
Orlando, Florida 32804
Telephone: (305) 298-2080

GEORGIA

Atlanta Distributor
Cummins Georgia, Inc.
100 University Avenue, S.W.
Atlanta, Georgia 30315
Telephone: (404) 524-7716

Augusta Branch
Cummins Georgia, Inc.
1255 New Savannah Road
Augusta, Georgia 30901
Telephone: (404) 722-8825
(404) 798-0973 after 5:00 p.m.

Dalton Branch
Cummins Georgia, Inc.
4031 South Dixie Road
Dalton, Georgia 30720
Telephone: (404) 277-1144
(404) 226-3555 after 6:00 p.m.

Savannah Branch
Cummins Georgia, Inc.
420 Telfair Road
Savannah, Georgia 31401
Telephone: (902) 232-5565

HAWAII

Honolulu Distributor
Cummins Engine Sales of Hawaii, Inc.
215 Puuhale Road
Honolulu, Hawaii 96819
Telephone: (808) 845-6606

Hilo Branch
Cummins Engine Sales of Hawaii, Inc.
845 Kanoelehua Avenue
P.O. Box 877
Hilo, Hawaii 96720
Telephone: (808) 935-5411

IDAHO

Boise Branch of Salt Lake City
Cummins Intermountain Idaho, Inc.
2851 Federal Way
P.O. Box 5215
Boise, Idaho 83705
Telephone: (208) 336-5000 (24 hours)

ILLINOIS

Chicago Distributor
Cummins Illinois Engine Sales Corp., Inc.
5555 South Kilpatrick Avenue
Chicago, Illinois 60629
Telephone: (312) 581-3100

Lake Zurich Branch
Cummins Illinois Engine Sales Corp., Inc.
532 West Main Street
Lake Zurich, Illinois 60047
Telephone: (312) 438-5151

Rock Island Branch
Cummins Illinois Engine Sales Corp., Inc.
730-31st Avenue
Rock Island, Illinois 61201
Telephone: (309) 794-9181

Rockford Branch
Cummins Power-Rockford
4117 11th Street
Rockford, Illinois 61109
Telephone: (815) 397-0600

Bloomington Normal Branch of Indianapolis
Cummins Bloomington
U. S. 51 N. and I-55
Bloomington-Normal, Illinois 61761
Telephone: (309) 452-4454

INDIANA

Indianapolis Distributor

Cummins Mid States, Inc.
3621 West Morris Street
Indianapolis, Indiana 46241
Telephone: (317) 244-7251

Ft. Wayne Branch
Cummins Diesel Ft. Wayne
3220 West California Road
Ft. Wayne, Indiana 46808
Telephone: (219) 483-6489

Evansville Branch of Louisville
Cummins Diesel Sales of Evansville
1650 North Fares Avenue
Evansville, Indiana 47727
Telephone: (812) 425-2464
Parts: (812) 422-7721 after 5:00 p.m.
Service: (812) 853-7286 after 5:00 p.m.

Gary Branch of Chicago
Cummins Power-Gary
1440 Texas Street
Gary, Indiana 46402
Telephone: (219) 885-5591

IOWA

Cedar Rapids Branch of Omaha
Cummins Great Plains Diesel, Inc.
215 - 50th Avenue, S.W.
Cedar Rapids, Iowa 52404
Telephone: (319) 366-7537
(319) 362-1042 after 5:30 p.m.

Des Moines Branch of Omaha
Cummins Great Plains Diesel, Inc.
1680 N. E. 51st Avenue
Des Moines, Iowa 50316
Telephone: (515) 262-9591
(515) 262-9591 after 5:30 p.m.

KANSAS

Wichita Branch of Arlington
Cummins Sales & Service, Inc.
5101 North Broadway
P.O. Box 2681
Wichita, Kansas 67201
Telephone: (316) 838-0875
(316) 838-5587 nights

Colby Branch of Arlington
Cummins Sales & Service, Inc.
1880 South Range
P.O. Drawer "P"
Colby, Kansas 67701
Telephone: (913) 462-3945
(913) 462-3143

Olathe Branch of Kansas City Missouri
Cummins Diesel Olathe
15580 South 169 Highway
Olathe, Kansas 66061
Telephone: (913) 782-9470

Chanute Industrial Branch
Mid-America Industrial Power, Inc.
502 E. Maine Street
Chanute, Kansas 66720
Telephone: (316) 431-4661

KENTUCKY

Louisville Distributor

Cummins Diesel Sales of Louisville, Inc.
9820 Bluegrass Parkway
Louisville, Kentucky 40299
Telephone: (502) 491-4263

Hazard Branch
Cummins Diesel Sales of Louisville, Inc.
Highway 15-North
Hazard, Kentucky 41701
Telephone: (606) 436-5718
(606) 436-4820 after 6:00 p.m.
Parts: (606) 436-5236 after 6:00 p.m.

LOUISIANA

Baton Rouge Branch of Arlington
Cummins Sales & Service, Inc.
10424 Airline Hwy.
P.O. Box 14028
Baton Rouge, Louisiana 70813
Telephone: (504) 293-7150 (day & night)

Morgan City Branch of Arlington
Cummins Sales & Service, Inc.
Highway 90 East
P.O. Box 2283
Morgan City, Louisiana 70380
Telephone: (504) 631-0576 (day & night)

New Orleans Branch of Arlington
Cummins Sales & Service, Inc.
4628 I-10 Service Road
P.O. Box 277, Metairie, La.
New Orleans, Louisiana 70004
Telephone: (504) 885-5675
(504) 887-6250 nights

Shreveport Branch of Arlington
Cummins Sales & Service, Inc.
1308 North Market
P.O. Box 7255
Shreveport, Louisiana 71107
Telephone: (318) 221-1636
(318) 949-2687 nights

MAINE

South Portland, Branch of Boston
Cummins North Atlantic, Inc.
205 Lincoln Street
South Portland, Maine 04106
Telephone: (207) 767-3356

MARYLAND

Baltimore Branch of Philadelphia
Cummins Diesel Engines, Inc.
3410 Washington Boulevard
Baltimore, Maryland 21230
Telephone: (301) 644-6500

Baltimore Industrial Branch
Branch of Philadelphia
Cummins Diesel Engines, Inc.
1400 Desoto Road
Baltimore, Maryland 21230
Telephone: (301) 644-6500

MASSACHUSETTS

Boston Distributor

Cummins North Atlantic, Inc.
100 Allied Drive
Dedham, Massachusetts 02026
Telephone: (617) 329-1750

West Springfield Branch
Cummins North Atlantic, Inc.
of Springfield
720 Union Street
West Springfield, Massachusetts 01089
Telephone: (413) 737-2659

MICHIGAN

Detroit Distributor

Cummins Michigan Inc.
41216 Vincenti Court
Novi, Michigan 48050
Telephone: (313) 478-9700

Detroit Industrial Branch
See Detroit Distributor

Dearborn Branch
Cummins Michigan Inc.
3760 Wyoming Avenue
Dearborn, Michigan 48120
Telephone: (313) 843-6200

Grand Rapids Branch
Cummins Michigan Inc.
3715 Clay Avenue, S. W.
Wyoming, Michigan 49509
Telephone: (616) 538-2250

Iron Mountain Branch of Milwaukee
Cummins Wisconsin, Inc.
Iron Mountain
1901 North Stephenson Avenue
Iron Mountain, Michigan 49801
Telephone: (906) 774-2424

MINNESOTA

St. Paul Distributor

Cummins Diesel Sales, Inc.
2690 Cleveland Avenue North
P.O. Box 43578
St. Paul, Minnesota 55164
Telephone: (612) 636-1000

Dickinson Branch
This branch is located in Dickinson, North Dakota. Its information is listed under NORTH DAKOTA.

Duluth Branch
Cummins Diesel Sales, Inc.
3115 Truck Center Drive
Duluth, Minnesota 55806
Telephone: (218) 628-3641

Fargo Branch
This branch is located in Fargo, North Dakota. Its information is listed under NORTH DAKOTA.

Grand Forks Branch
This branch is loacted in Grand Forks, North Dakota. Its information is listed under NORTH DAKOTA.

Hibbing Branch
Cummins Diesel Sales, Inc.
604 West 41st Street
P.O. Box 159
Hibbing, Minnesota 55746
Telephone: (218) 263-7558

Minot Branch
This branch is located in Minot, North Dakota. Its information is listed under NORTH DAKOTA.

Williston Branch
This branch is located in Williston, North Dakota. Its information is listed under NORTH DAKOTA.

MISSISSIPPI

Jackson Branch of Memphis
Cummins Mid-South, Inc.
New Highway 49 South
P.O. Box 8747
Jackson, Mississippi 39204
Telephone: (601) 939-1800

MISSOURI

Kansas City Distributor
Cummins Mid-America, Inc.
3527 Gardner Avenue
Kansas City, Missouri 64120
Telephone: (816) 483-6313

Kansas City Industrial Branch
Mid-America Industrial Power, Inc.
1203 Ozark
North Kansas City, Missouri 64116
Telephone: (816) 474-5080

Kansas City Parts Branch
Cummins Mid-America
Parts Warehouse
1052 North Monroe
Kansas City, Missouri 64120
Telephone: (816) 483-6423

Joplin Branch
Cummins Diesel Joplin, Inc.
3507 East 20th Street
Joplin, Missouri 64801
Telephone: (417) 623-1661

Springfield Branch
Cummins Diesel Springfield
3637 E. Kearney
Springfield, Missouri 65803
Telephone:(417) 862-0777

Springfield Industrial Branch
Mid-America Industrial Power, Inc.
3637 A East Kearney
Springfield, Missouri 65803
Telephone: (417) 862-0777

Nevada Branch
Cummins Diesel Nevada
Highway 71 at Vernon
P.O. Box 562
Nevada, Missouri 64772
Telephone: (417) 667-2046

St. Louis Distributor
Cummins Missouri, Inc.
7210 Hall Street
St. Louis, Missouri 63147
Telephone: (314) 389-5400

Columbia Branch of St. Louis
Cummins Missouri, Inc.
Highway 63 North
P.O. Box 1726
Columbia, Missouri 65201
Telephone: (314) 449-3711

Sikeston Branch of St. Louis
Cummins Missouri, Inc.
101 Keystone Drive
Highway 60 East
P.O. Box 786
Sikeston, Missouri 63801
Telephone: (314) 472-0303

MONTANA

Great Falls Branch of Casper
Cummins Diesel Sales Corporation
52nd Street & 10th Avenue North
P.O. Box 3021
Great Falls, Montana 59401
Telephone: (406) 452-8561

Billings Branch of Casper
Cummins Diesel Sales Corporation
5151 Midland Road
P.O. Box 30377 (Zip 59101)
Billings, Montana 59107
Telephone: (406) 245-4194

Missoula Branch of Seattle
Cummins Northwest Diesel, Inc.
4950 North Reserve Street
Missoula, Montana 59801
Telephone: (405) 728-1300

NEBRASKA

Omaha Distributor
Cummins Great Plains Diesel, Inc.
5515 Center Street
Omaha, Nebraska 68106
Telephone: (402) 551-7678
(402) 572-1484 after 1:00 a.m.

Omaha Industrial Branch
See Omaha Distributor

Lincoln Parts Branch
Cummins Great Plains Diesel, Inc.
4209 Progressive Drive
Lincoln, Nebraska 68504
Telephone: (402) 464-5909
(402) 467-3163 after 5:30 p.m.

Des Moines Branch
This branch is located in Des Moines, Iowa. Its information is listed under IOWA.

Sioux Falls Branch
This branch is located in Sioux Falls, South Dakota. Its information is listed under SOUTH DAKOTA.

Cedar Rapids Branch
This branch is located in Cedar Rapids, Iowa. Its information is listed under IOWA.

NEVADA

Las Vegas Branch of Los Angeles
Cummins Service & Sales, Inc.
3337 South Industrial Road
Las Vegas, Nevada 89102
Telephone: (702) 735-4058

Reno Branch of San Francisco
Watson & Meehan
2590 East 2nd Street
Reno, Nevada 89502
Telephone: (702) 786-3744

NEW JERSEY

Newark Branch of Bronx
Cummins Metropower Inc.
Routes U. S. 1 & 22
Newark, New Jersey 07114
Telephone: (201) 242-2255

NEW MEXICO

Albuquerque Distributor
Cummins Rio Grande Sales & Service, Inc.
1921 Broadway N.E.
P.O. Box 6186
Albuquerque, New Mexico 87107
Telephone: (505) 247-2441

Albuquerque Industrial Branch
See Albuquerque Distributor

Clayton Field Service Office
Clayton, New Mexcico Branch
100 E. Front Street
P.O. Box Drawer A
Telephone: (505) 374-8077

Clovis Branch
Cummins Rio Grande Sales & Service, Inc.
1101 East Brady
Clovis, New Mexico
Telephone: (505) 762-3878

Clovis Industrial Branch
See Clovis Branch

El Paso Branch
This branch is located in El Paso, Texas. Its information is listed under TEXAS.

Farmington Field Service Office
Cummins Rio Grande
5301 Juniper Place
Farmington, New Mexico
Telephone: (505) 327-2789

NEW YORK

Syracuse Distributor
Cummins Mohawk Diesel, Inc.
29 Eastern Avenue
Syracuse, New York 13211
Telephone: (315) 437-2751

Albany Branch
Cummins Mohawk Diesel, Inc.
101 Railroad Avenue
Albany, New York 12205
Telephone: (518) 459-1710

Albany Industrial Branch
See Albany Branch

Buffalo Branch
Cummins Mohawk Diesel, Inc.
55 Benbro Drive
Buffalo, New York 14225
Telephone: (716) 684-5222

Bronx Distributor
Cummins Metropower, Inc.
1930-1950 Eastchester Road
Bronx, New York 10461
Telephone: (212) 892-2400

Newark Branch
This branch is located in Newark, New Jersey. Its information is listed under NEW JERSEY.

Plainview Branch
Cummins Metropower, Inc.
105 South Service Road
Plainview, Long Island, New York 11803
Telephone: (516) 249-7500

NORTH CAROLINA

Charlotte Distributor
Cummins Carolinas Inc.
3700 North Interstate 85
P.O. Box 26603
Charlotte, North Carolina 28213
Telephone: (704) 596-7690

Charlotte Industrial Branch
Cummins Carolinas Inc.
Industrial Center
200 Olympic Street
Charlotte, North Carolina 28210
Telephone: (704) 588-1240

Columbia Branch
This branch is located in Columbia, South Carolina. Its information is listed under SOUTH CAROLINA.

Charleston Branch
This branch is located in Charleston, South Carolina. Its information is listed under SOUTH CAROLINA.

Greensboro Branch
Cummins Carolinas Inc.
513 Preddy Boulevard
P.O. Box 22066
Greensboro, North Carolina 27420
Telephone: (919) 275-4531

Wilson Branch
Cummins Carolinas Inc.
Highway 301 Bypass
P.O. Box 640
Wilson, North Carolina 27894
Telephone: (919) 237-1125

Wilmington Branch
Cummins Carolinas Inc.
Highway 421 North
P.O. Box 2150
Wilmington, North Carolina 28401
Telephone: (919) 763-8256

NORTH DAKOTA

Dickinson Branch of St. Paul
Cummins Diesel Sales, Inc.
Business I-94 East
P.O. Box 145
Dickinson, North Dakota 58601
Telephone: (701) 225-9194
(701) 677-4520 after 5:00 p.m.

Fargo Branch of St. Paul
Cummins Diesel Sales, Inc.
3950 West Main Avenue
Fargo, North Dakota 58102
Telephone: (701) 282-2466
24 Hour Service

Grand Forks Branch of St. Paul
Cummins Diesel Sales, Inc.
4728 Gateway Drive
P.O. Box 636
Grand Forks, North Dakota 58201
Telephone: (701) 775-8197
(701) 772-7689 after 5:00 p.m.

Minot Branch of St. Paul
Cummins Diesel Sales, Inc.
Highway 2 & 52 Bypass
P.O. Box 1179
Minot, North Dakota 58701
Telephone: (701) 852-3585
(701) 839-4786 after 12:30 a.m.

Williston Branch of St. Paul
Cummins Diesel Sales, Inc.
Highway 2 North
P.O. Box 1106
Williston, North Dakota 58801
Telephone: (701) 572-6348
(701) 572-2431 after 5:00 p.m.

OHIO

Cleveland Distributor
Cummins Diesel of Northern Ohio, Inc.
7585 Northfield Road
Cleveland, Ohio 44146
Telephone: (216) 439-6800
(216) 439-6801 after 5:00 p.m.

Cleveland Industrial Branch
Cummins Diesel of Northern Ohio, Inc.
Cleveland Industrial Center
7560 Independence Drive
Cleveland, Ohio 44146
Telephone: (216) 439-6800

Akron Branch
Cummins Diesel of Northern Ohio, Inc.
1033 Kelly Avenue
Akron, Ohio 44307
Telephone: (216) 773-7821

Youngstown Branch
Cummins Diesel of Northern Ohio, Inc.
7125 Hubbard-Sharon Road
P.O. Box 338
Hubbard, Ohio 44425
Telephone: (216) 534-1935
(216) 534-1938 after 5:30 p.m.

Toledo Branch
Cummins Diesel of Northern Ohio, Inc.
801 Illinois Avenue
Maumee, Ohio 43537
Telephone: (419) 893-8711

Strasburg Branch
Cummins Diesel of Northern Ohio, Inc.
South Wooster Avenue
P.O. Box 136
Strasburg, Ohio 44680
Telephone: (216) 878-5511
(216) 343-0969 after 4:30 p.m.

Columbus Distributor
Cummins Central Ohio, Inc.
101 Phillipi Road
P.O. Box 28009
Columbus, Ohio 43228
Telephone: (614) 276-0111

Lima Branch
Cummins Central Ohio, Inc.
960 Broadway
Lima, Ohio 45804
Telephone: (419) 227-2641

South Charleston Branch
Cummins Central Ohio, Inc.
9031 Columbus-Cincinnati Road
South Charleston, Ohio 45638
Telephone: (513) 462-8263

Cincinnati Branch of Charleston
Cummins Sales, Inc.
10470 Evendale Drive
Cincinnati, Ohio 45240
Telephone: (513) 563-6670

OKLAHOMA

Duncan Branch of Arlington
Cummins Sales & Service, Inc.
607 East Bois D'Arc
P.O. Box 790
Duncan, Oklahoma 73533
Telephone: (405) 255-1414
(405) 255-6709 nights

Oklahoma City Branch of Arlington
Cummins Sales & Service, Inc.
5800 West Reno
P.O. Box 1511
Oklahoma City, Oklahoma 73101
Telephone: (405) 946-4481
(405) 789-2098 nights

Tulsa Branch of Arlington
Cummins Sales & Service, Inc.
161st E. Avenue & I-44
P.O. Box 45569
Tulsa, Oklahoma 74145
Telephone: (918) 234-3240
(918) 341-7738 nights

OREGON

Portland Distributor
Cummins Oregon Diesel, Inc.
2257 N. W. Vaughn Street
P.O. Box 10446
Portland, Oregon 97210
Telephone: (503) 224-0800

Bend Branch
Cummins Oregon Diesel, Inc.
3500 N. Highway 97
P.O. Box 309
Bend, Oregon 97701
Telephone: (503) 389-1900

Eugene Branch
Cummins Oregon Diesel, Inc.
Coburg Industrial Parkway
P.O. Box 10887
Eugene, Oregon 97440
Telephone: (503) 687-0000

Longview Branch
This branch is located in Longview, Washington. Its information is listed under WASHINGTON.

Medford Branch
Cummins Oregon Diesel, Inc.
4045 Crater Lake Highway
Medford, Oregon 97501
Telephone: (503) 779-0151

North Bend Branch
Cummins Oregon Diesel, Inc.
612 California Avenue
P.O. Box 447
North Bend, Oregon 97459
Telephone: (503) 756-3111

Pendleton Branch
Cummins Oregon Diesel, Inc.
223 S.W. 23rd Street
Pendleton, Oregon 97801
Telephone: (503) 276-2561

PENNSYLVANIA

Philadelphia Distributor
Cummins Diesel Engines, Inc.
855 E. Hunting Park Avenue
Philadelphia, Pennsylvania 19124
Telephone: (215) 426-6005

Ashland Branch
Cummins Diesel Engines, Inc.
32 Lehigh Street
Ashland, Pennsylvania 17921
Telephone: (717) 875-2200

Baltimore Branch
This branch is located in Baltimore, Maryland. Its information is listed under MARYLAND.

Baltimore Industrial Branch
This branch is located in Baltimore, Maryland. Its information is listed under MARYLAND.

Clearfield Parts Branch
Cummins Diesel Engines, Inc.
Clearfield Parts Center
501 Williams Street
Clearfield, Pennsylvania 16830
Telephone: (814) 765-2421

Monroeville Branch
Cummins Diesel Engines, Inc.
2740 Mosside Boulevard
Monroeville, Pennsylvania 15146
Telephone: (412) 351-1650

Pittsburgh Branch
Cummins Diesel Engines, Inc.
Parkway West
4637 Campbells Run Road
Pittsburgh, Pennsylvania 15205
Telephone: (412) 787-5365

SOUTH CAROLINA

Columbia Branch of Charlotte
Cummins Carolinas Inc.
1500 Bluff Road
P.O. Box 13543
Columbia, South Carolina 29201
Telephone: (803) 799-2410

Charleston Branch of Charlotte
Cummins Carolinas Inc.
3010 Montague Avenue
P.O. Box 10341
Charleston, South Carolina 29411
Telephone: (803) 554-5112

SOUTH DAKOTA

Rapid City Branch of Casper
Cummins Diesel Sales Corporation
2310 Haines Avenue
P.O. Box 244
Rapid City, South Dakota 57701
Telephone: (605) 343-6130
Parts: (605) 343-7418 after 5:00 p.m.
Service: (605) 342-1986 after 5:00 p.m.

Sioux Falls Branch of Omaha
Cummins Great Plains Diesel, Inc.
701 East 54th North
Sioux Falls, South Dakota 57104
Telephone: (605) 336-1715
(605) 334-6492 after 5:30 p.m.

TENNESSEE

Memphis Distributor
Cummins Mid-South, Inc.
1784 East Brooks Road
P.O. Box 16942
Memphis, Tennessee 38116
Telephone: (901) 345-1784

Nashville Distributor
Cummins Engines of Tennessee, Inc.
706 Spence Lane
Nashville, Tennessee 37217
Telephone: (615) 242-4493

Bristol Branch
Cummins Engines of Tennessee, Inc.
Volunteer Parkway at Melrose
Bristol, Tennessee 37620
Telephone: (615) 968-3147

Chattanooga Branch
Cummins Engines of Tennessee, Inc.
2013 South Kelly Street
Chattanooga, Tennessee 37404
Telephone: (615) 629-1448

Knoxville Branch
Cummins Engines of Tennessee, Inc.
1211 Ault Road
Rutledge Pike Exit I-40 East
Knoxville, Tennessee 37917
Telephone: (615) 523-0446

TEXAS

Arlington Distributor
Cummins Sales & Service, Inc.
600 Watson Road
P.O. Box 1008
Arlington, Texas 76010
Telephone: (817) 640-6801

Arlington Industrial Branch
See Arlington Distributor

Amarillo Branch
Cummins Sales & Service, Inc.
5224 Interstate 40 — Expressway East
P.O. Box 32050
Amarillo, Texas 79120
Telephone: (806) 373-3793 day and night

Baton Rouge Branch
This branch is located in Baton Rouge, Louisiana. Its information is listed under LOUISIANA.

Brownsville Branch
Cummins Sales & Service, Inc.
Shrimp Basin
Star Route Box 2158
Brownsville, Texas 78521
Telephone: (512) 831-4231
(513) 831-9023 nights

Colby Branch
This branch is located in Colby, Kansas. Its information is listed under KANSAS.

Corpus Christi Branch
Cummins Sales & Service, Inc.
1302 Corn Products Road
P.O. Box 9033
Corpus Christi, Texas 78408
Telephone: (512) 882-5647
(512) 368-9091 nights

Dallas Branch
Cummins Sales & Service, Inc.
3707 Irving Boulevard
Dallas, Texas 75247
Telephone: (214) 631-6400
(214) 631-6400 nights

Duncan Branch
This branch is located in Duncan, Oklahoma. Its information is listed under OKLAHOMA.

Fort Worth Branch
Cummins Sales & Service, Inc.
2900 Deen Road
Fort Worth, Texas 76106
Telephone: (817) 624-2107
(817) 284-8298 nights

Houston Branch
Cummins Sales & Service, Inc.
4750 Homestead Road
P.O. Box 2523
Houston, Texas 77001
Telephone: (713) 675-7421
(713) 772-3894

Houston Marine Branch
Cummins Sales & Service, Inc.
6230-B Navigation Blvd.
P.O. Box 9483
Houston, Texas 77011
Telephone: (713) 928-2431
(713) 782-1227 nights

Lubbock Branch
Cummins Sales & Service, Inc.
120 Southeast Loop 289
P.O. Box 3910
Lubbock, Texas 79452
Telephone: (806) 745-4605
(806) 795-8391 nights

Morgan City Branch
This branch is located in Morgan City, Louisiana. Its information is listed under LOUISIANA.

New Orleans Branch
This branch is located in New Orleans, Louisiana. Its information is listed under LOUISIANA.

Odessa Branch
Cummins Sales & Service, Inc.
1210 South Grandview
P.O. Box 553
Odessa, Texas 79760
Telephone: (915) 332-9121
(915) 366-6764 nights

Oklahoma City Branch
This branch is located in Oklahoma City, Oklahoma. Its information is listed under OKLAHOMA.

Orange Branch
Cummins Sales & Service, Inc.
3514 Interstate 10, West
P.O. Box 1637
Orange, Texas 77630
Telephone: (Orange) (713) 883-6362
(Beaumont—Port Arthur—Nederland Line) 722-5296
(Lake Charles, Louisiana Line) 433-7366

San Antonio Branch
Cummins Sales & Service, Inc.
6226 Pan Am Expressway North
P.O. Box 18306 — Serna Station
San Antonio, Texas 78218
Telephone: (512) 655-5420
(512) 625-1648 nights

Shreveport Branch
This branch is located in Shreveport, Louisiana. Its information is listed under LOUISIANA.

Tulsa Branch
This branch is located in Tulsa, Oklahoma. Its information is listed under OKLAHOMA.

Wichita Branch
This branch is located in Wichita, Kansas. Its information is listed under KANSAS.

El Paso Branch of Albuquerque
Cummins Rio Grande Sales & Service, Inc.
7200 Alameda
P.O. Box 9096
El Paso, Texas 79982
Telephone: (915) 778-4216

UTAH

Salt Lake City Distributor
Cummins Intermountain
1030 South 300 West
P.O. Box 25428
Salt Lake City, Utah 84125
Telephone: (801) 355-6500
(801) 355-6501 nights

Boise Branch
This branch is located in Boise, Idaho. Its information is listed under IDAHO.

Rock Springs Branch
This branch is located in Rock Springs, Wyoming. Its information is listed under WYOMING.

VIRGINIA

Richmond Distributor
Cummins Virginia Inc.
3900 Deep Water Terminal Road
P.O. Box 34628
Richmond, Virginia 23234
Telephone: (804) 232-7891

Roanoke Branch
Cummins Virginia Inc.
5307 Peters Creek Road
P.O. Box 7237
Roanoke, Virginia 24019
Telephone: (703) 362-1673

WASHINGTON

Seattle Distributor
Cummins Northwest Diesel, Inc.
811 S.W. Grady Way
P.O. Box 9811
Renton, Washington 98055
Telephone: (206) 235-3400

Seattle Industrial Branch
Pacific Marine & Industrial, Inc.
5930 First Avenue South
Seattle, Washington 98108
Telephone: (206) 762-9252

Aberdeen Branch
Cummins Northwest Diesel, Inc.
601 West Heron Street
Aberdeen, Washington 98520
Telephone: (206) 533-2532

Anchorage Branch
This branch is located in Anchorage, Alaska. Its information is listed under ALASKA.

Fairbanks Branch
This branch is located in Fairbanks, Alaska. Its information is listed under ALASKA.

Missoula Branch
This branch is located in Missoula, Montana. Its information is listed under MONTANA.

Chehalis Branch
Cummins Northwest Diesel, Inc.
1200 N. W. Maryland
P.O. Box 1363
Chehalis, Washington 98532
Telephone: (206) 748-8841

Pasco Branch
Cummins Northwest Diesel, Inc.
210 S. Oregon
P.O. Box 2565
Pasco, Washington 98301
Telephone: (509) 547-3333

Spokane Branch
Cummins Northwest Diesel, Inc.
E. 3904 Trent Avenue
P.O. Box 2746 — Terminal Annex
Spokane, Washington 99220
Telephone: (509) 534-0411

Tacoma Branch
Cummins Northwest Diesel, Inc.
1662 Lincoln Avenue
Tacoma, Washington 98421
Telephone: (206) 572-9800

Yakima Branch
Cummins Northwest Diesel, Inc.
1905 East Central Avenue
Yakima, Washington 98902
Telephone: (509) 248-9033

Longview Branch of Portland
Cummins Longview
(Branch of Cummins Oregon Diesel, Inc.)
1153 Third Avenue
P.O. Box 1459
Longview, Washington 98632
Telephone: (206) 425-0100

WEST VIRGINIA

Charleston Distributor

Cummins Engines of West Virginia, Inc.
Charleston Ordnance Center
P.O. Box 8456
South Charleston, West Virginia 25303
Telephone: (304) 744-6373

Cincinnati Branch
This branch is located in Cincinnati, Ohio. Its information is listed under OHIO.

Fairmont Branch
Cummins Engines of West Virginia, Inc.
South Fairmont Exit, I-79
Route 73, South
P.O. Box 988
Fairmont, West Virginia 26554
Telephone: (304) 367-0196

WISCONSIN

Milwaukee Distributor

Cummins Wisconsin, Inc.
1921 South 108th Street
P.O. Box 2798
Milwaukee, Wisconsin 53227
Telephone: (414) 543-3160

Milwaukee Industrial Branch
Cummins Wisconsin, Inc.
2860 South 171st Street
New Berlin, Wisconsin 53151

Madison Branch
Cummins Wisconsin, Inc.
925 East Broadway
Madison, Wisconsin 53716
Telephone: (608) 222-0603

Green Bay Branch
Cummins Wisconsin, Inc.
P.O. Box W-219, Route #3
De Pere, Wisconsin 54115
Telephone: (414) 336-9631

Iron Mountain Branch
This branch is located in Iron Mountain, Michigan. Its information is listed under MICHIGAN.

WYOMING

Casper Distributor

Cummins Diesel Sales Corporation
2000 East "F" Street
P.O. Drawer 2560
Casper, Wyoming 82601
Telephone: (307) 265-6900

Gillette Branch
Cummins Diesel Sales Corporation
901 E. Lincoln Street
P.O. Box 1207
Gillette, Wyoming 82716
Telephone: (307) 682-9611

Billings Branch
This branch is located in Billings, Montana. Its information is listed under MONTANA.

Great Falls Branch
This branch is located in Great Falls, Montana. Its information is listed under MONTANA.

Rapid City Branch
This branch is located in Rapid City, South Dakota. Its information is listed under SOUTH DAKOTA.

Rock Springs Branch of Salt Lake City
Cummins Intermountain
Rock Springs Branch
2000 Foothill Boulevard
P.O. Box 1634
Rock Springs, Wyoming 82901
Telephone: (307) 362-5168

Cummins Distributors — Canada

ALBERTA

Calgary Branch of Vancouver
Cummins Diesel Power Ltd.
703-64 Avenue, S. E.
Calgary, Alberta
T2H 2C3
P.O. Box 880
Station "T"
Calgary, Alberta
T2H 2H3
Telephone: (403) 255-6691

Edmonton Branch of Vancouver
Cummins Diesel Power Ltd.
14755 — 121A Avenue
Edmonton, Alberta
T5L 2T2
Telephone: (403) 455-2151

BRITISH COLUMBIA

Vancouver Distributor

Cummins Diesel Sales of B.C. Ltd.
4270 Dawson Street
North Burnaby, B.C.
V5C 4B1
P.O. Box 2088
Vancouver, B.C.
V6B 3T3
Telephone: (604) 299-9111

Calgary Branch
This branch is located in Calgary, Alberta. Its information is listed under ALBERTA.

Cranbrook Parts Branch
Cummins Diesel Sales of B.C. Ltd.
520-C Slater Road
Cranbrook, B.C.
Telephone: (604) 489-4151/2/3

Edmonton Branch
This branch is located in Edmonton, Alberta. Its information is listed under ALBERTA.

Prince George Parts Branch
Cummins Diesel Sales of B.C. Ltd.
2316 Ospika Boulevard
Prince George, B.C.
V2N 3N5
Telephone: (604) 563-3693

MANITOBA

Winnipeg Distributor

Cummins Diesel Sales and Service Ltd
2010 Notre Dame Avenue
P.O Box 985
Winnipeg, Manitoba
Postal Code R3C2V8
Telephone: (204) 633-7986

Saskatoon Branch
This branch is located in Saskatoon, Saskatchewan. Its information is listed under SASKATCHEWAN.

NEW BRUNSWICK

Fredericton Branch of Montreal
Cummins Diesel (Division of Cummins Quebec Ltd.)
Vanier Highway
P.O. Box 1178, Station "A"
Fredericton, New Brunswick, E3B 5C8
Telephone: (506) 455-2021

NEWFOUNDLAND

St. John's Branch of Montreal
Cummins Diesel (Div. of Cummins Quebec Ltd.)
Box 8056, Kenmount Road
St. Johns, Newfoundland, A1C 5N8
Telephone: (709) 753-6972

NOVA SCOTIA

Halifax Branch of Montreal
Cummins Diesel (Division of Cummins Quebec Ltd.)
3204 Barrington Street
Halifax, Nova Scotia B3K 2X5
Telephone: (902) 429-1440

ONTARIO

Toronto Distributor

Cummins Ontario Limited
150 North Queen Street
P.O. Box 40, Station "U"
Toronto, Ontario
Telephone: (416) 621-9921

Oakville Industrial Branch
Cummins Ontario Limited
301 Wyecroft Road
Oakville, Ontario
Telephone: (416) 844-5851

Thunder Bay Branch
Cummins Ontario Limited
1400 West Walsh Street
Thunder Bay "F", Ontario
Telephone: (807) 577-7561

Ottawa Branch of Montreal
Cummins Diesel (Div. of Cummins Quebec Ltd.)
3189 Swansea Crescent
Hawthorne Industrial Park
Ottawa, Ontario, K1G 3W5
Telephone: (613) 521-1146

Whitby Branch of Toronto
Cummins Ontario Limited
1311 Hopkins Street
Whitby, Ontario

QUEBEC

Montreal Distributor

Cummins Quebec Ltd
7200 Trans Canada Highway
Pointe Claire, Quebec H9R 1C6
Telephone (514) 695 8410

Fredericton Branch
This branch is located in Fredericton, New Brunswick. Its information is listed under NEW BRUNSWICK

Halifax Branch
This branch is located in Halifax, Nova Scotia. Its information is listed under NOVA SCOTIA.

Montreal Parts Branch
Montreal Parts Distribution Center
2000 St. Regis Boulevard
Dorval, Quebec
Telephone: (514) 684-1810

Ottawa Branch
This branch is located in Ottawa, Ontario. Its information is listed under ONTARIO.

Quebec City Branch
Cummins Quebec Ltd.
2400 Watt Street
Ste. Foy, Quebec, G1P 3T3
Telephone: (418) 651-2911

St. John's Branch
This branch is located in St. John's, Newfoundland. Its information is listed under NEWFOUNDLAND.

Sept Iles Branch
Cummins Quebec Ltd.
349 Laure Avenue
Sept Iles, Quebec, G4R 1X2
Telephone: (418) 962-2588

SASKATCHEWAN

Saskatoon Branch of Winnipeg
Cummins Diesel Sales and Service Ltd.
825 45th Street, East
P.O. Box 209
Saskatoon, Saskatchewan S7K 3K4
Telephone: (306) 652-4047

Regina Training Centre
Cummins Diesel Sales and Service Ltd.
360 Park Street
P.O. Box 1575
Regina, Saskatchewan S4P 3C4
Telephone: (306) 545-5611

Foreword

This is an engine operation and maintenance manual, not a repair manual. The design of Cummins Engines makes it possible to replace worn or damaged parts with new or rebuilt parts with a minimum of down time. Contact the nearest Cummins Distributor for parts replacement as they are equipped and have well informed, trained personnel to perform this service. If your shop is properly equipped to perform either maintenance, unit replacement and/or complete engine rebuild, contact the nearest Cummins Distributors to obtain available repair manuals and arrange for training of personnel.

For model identification of an engine, check the dataplate. The letter and number code indicates breathing (naturally aspirated except when letter "T" for turbocharged is present), cubic inch displacement, application and maximum rated horsepower.

Examples:

NTA-855-370
N=4 valve head
T=Turbocharger
A=Aftercooled
370=Maximum rated horsepower

V-903-320
V=Type engine
903=Cubic Inch Displacement
320=Maximum Rated horsepower

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A.

Table of Contents

Operating Instructions

The engine operator must assume the responsibility of engine care while the engine is being operated. There are comparatively few rules which the operator must observe to get the best service from a Cummins Diesel.

General—All Applications

New and Rebuilt Engines Break-In

Cummins engines are run-in on dynamometers before being shipped from the factory and are ready to be put to work in applications such as emergency fire trucks, rail car applications and generator sets.

In other applications, the engine can be put to work, but the operator has an opportunity to establish conditions for optimum service life during initial 100 hours of service by:

1. Operating as much as possible at three-quarter throttle of load range.
2. Avoiding operation for long periods at engine idle speeds, or at the maximum horsepower levels in excess of five minutes.
3. Developing the habit of watching the engine instruments closely during operation and letting up on the throttle if the oil temperature reaches 200° F [121° C] or the coolant temperature exceeds 200° F [93° F].
4. Operating with a power requirement that allows acceleration to governed speed when conditions require more power.
5. Checking the oil level every 8 to 10 hours during the break-in period.

New or Rebuilt Engines Pre-Starting Instructions — First Time

Priming The Fuel System

1. Fill the fuel filter with clean No. 2 diesel fuel oil meeting the specifications outlined in Section 3.
2. Remove the fuel pump suction line and wet the gear pump gears with clean lubricating oil.
3. Check and fill the fuel tanks.
4. If the injector and valve or other adjustments have been disturbed by any maintenance work, check to be sure they have been properly adjusted before starting the engine.

Priming the Lubricating System

Note: On turbocharged engines, remove the oil inlet line from the turbocharger and prelubricate the bearing by adding 2 to 3 oz. [50 to 60 cc] of clean lubricating oil. Reconnect the oil supply line.

1. Fill the crankcase to the "L" (low) mark on the dipstick. See Lubricating Oil Specifications, Section 3.
2. Remove the plug from the lubricating oil crossover passage on NH/NT-855 Engines, Fig. 1-1. Remove the plug from the head of the lubricating oil filter housing on V Engines, Fig's. 1-2, 1-3, 1-4, 1-5 and 1-6. On KT/KTA-1150 Engines, remove the plug from the front of the oil cooler housing, Fig. 1-7.

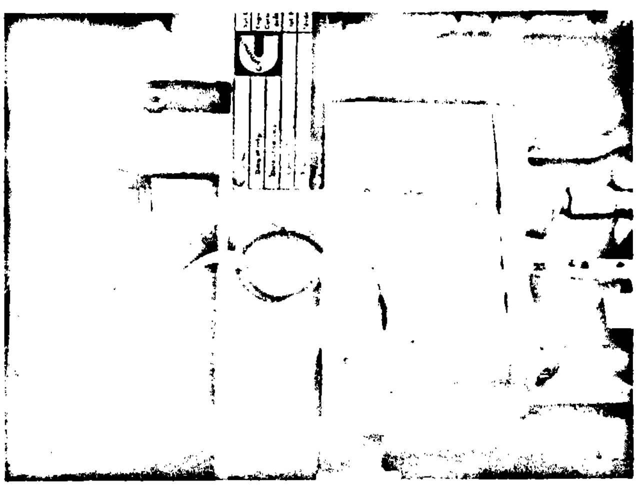


Fig. 1-1, (N11985). Lubricating system priming point — N/NT-855 Engine

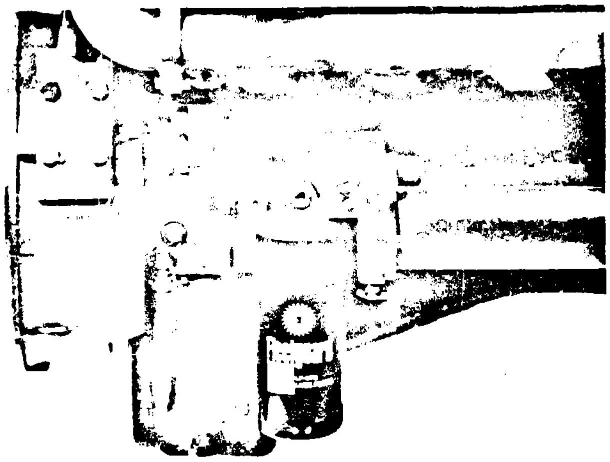


Fig. 1-2, (OM101). Lubricating system priming point — V/VT-903 Engine

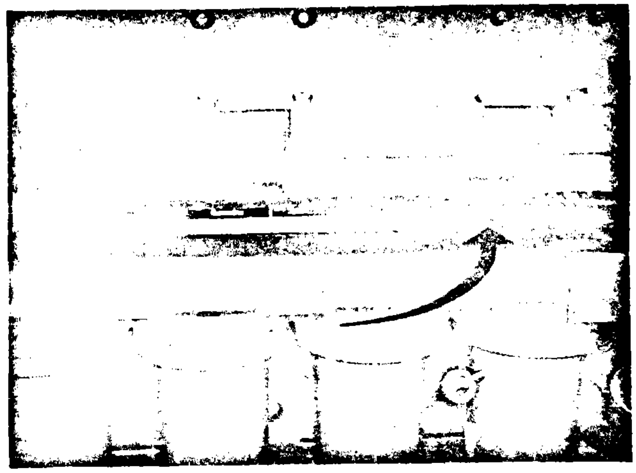


Fig. 1-4, (K21902). Lubricating system priming point — KT(A)-2300 Engine

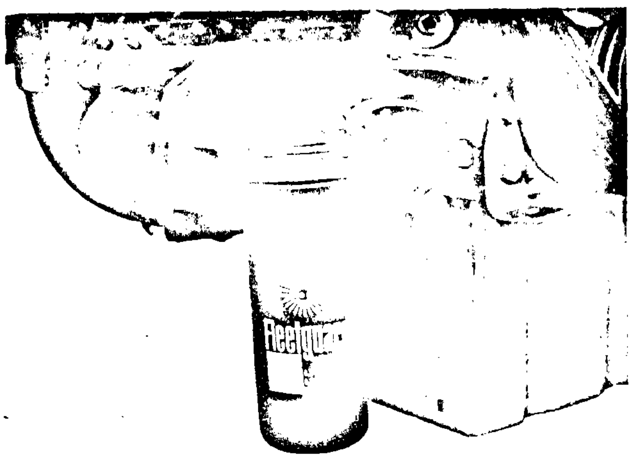


Fig. 1-3, (OM102). Lubricating system priming point — V-378, V-504, V/VT-555 Engines

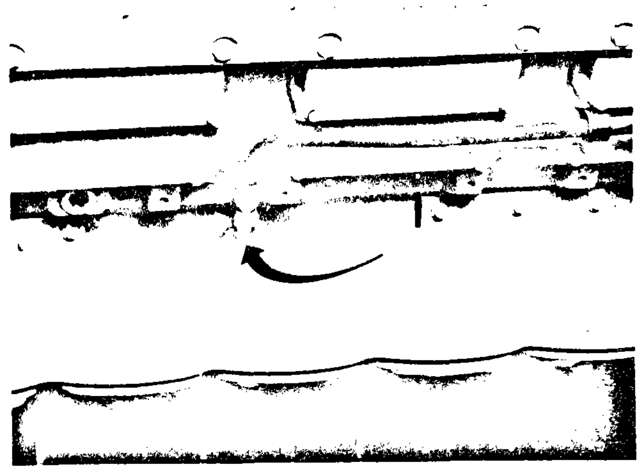


Fig. 1-5, (OM202). Lubricating system priming point — KTA-3067 Engine

Caution: Do not prime the engine lubricating system from the by-pass filter.

3. Connect a hand- or motor-driven priming pump line from a source of clean lubricating oil to the plug boss in the housing.
4. Prime until a 30 psi [207 kPa] minimum pressure is obtained.
5. Crank the engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining the external oil pressure at a minimum of 15 psi [103 kPa].
6. Remove the external oil supply and replace the plug.

Warning: Clean the area of any lubricating oil spilled while priming or filling the crankcase.

7. Fill the crankcase to the "H" (high) mark on the dipstick with oil meeting specifications, listed in Section 3. No change in oil viscosity or type is needed for new or newly rebuilt engines.

A dipstick oil gauge is located on the side of the engine, Fig. 1-8. The dipstick has an "H" (high) (1) and "L" (low) (2) level mark to indicate lubricating oil supply. The dipstick must be kept with the oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan part numbers. Check the dipstick calibration. If in doubt, your Cummins Distributor

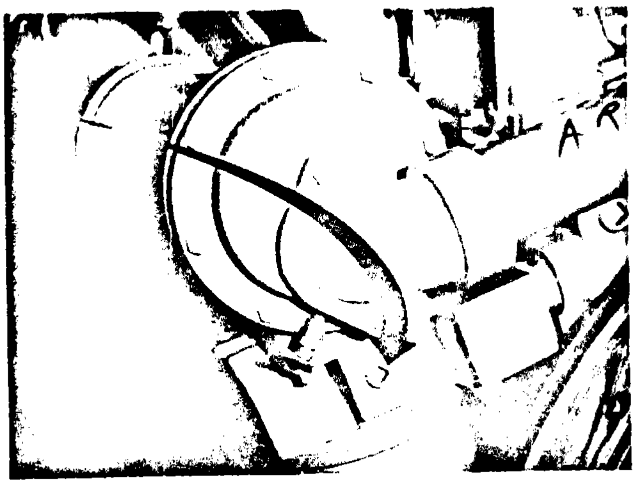


Fig. 1-6, (V41816). Lubricating system priming point — V-1710 Engine


Fig. 1-7, (K11949). Lubricating system priming point — KT(A)-1150 Engine

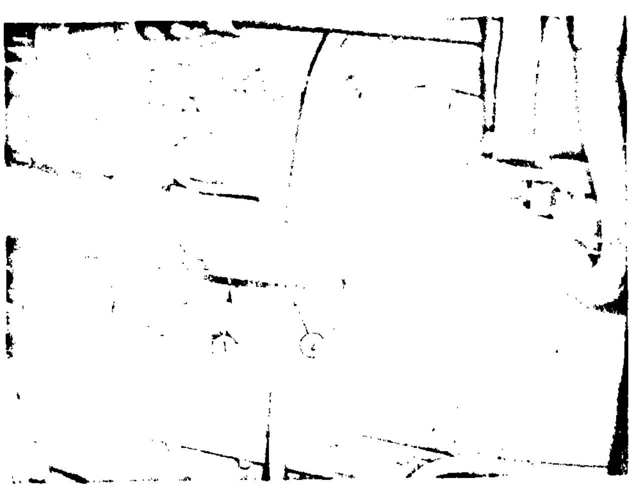


Fig. 1-8, (N12004). Checking engine oil level

can verify that you have the proper oil pan and dipstick calibration.

Check Hydraulic Governor

Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps which use lubricating oil as an energy medium, same weight as used in the engine. Oil level in the governor sump must be at the full mark on the dipstick.

Note: Engine applications in a cold environment should use a lighter weight oil in the governor sump.

Check Air Connections

Check the air connections to the compressor and the air equipment, as used, and to the air cleaners and air crossovers to assure that they all are secure and have no damage.

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check the engine coolant supply. Add coolant as needed.
2. Make a visual check for leaks and open the water filter shut-off valves.

Starting the Engine

Starting requires that clean air and fuel be supplied to the combustion chambers in the proper quantities at the correct time.

Normal Starting Procedure

Warning: Before starting be sure that everyone is clear of the engine and equipment.

If the fuel system is equipped with an overspeed stop, push the "Reset" button before attempting to start the engine.

1. On units equipped with an air activated prelube device, open the air valve to activate the piston in the prelube device which will lubricate all moving parts in the engine.

Note: On engines equipped with an oil pressure safety switch, hold the fuel by-pass switch in the "start" position until the engine oil pressure reaches 7 to 10 psi [48 to 69 kPa]; then, move it to the "run" position.

2. Set the throttle for idle speed and disengage the driven unit.

Caution: Protect the turbocharger during start-up by not opening the throttle or accelerating above 1000

rpm until the idle speed oil pressure registers on the gauge.

3. Open the manual fuel shut-down valve, if so equipped. Fig. 1-9. Electric shut-down valves operate as the switch is turned on. A manual override knob provided on the forward end of the electric shut-down valve allows the valve to be opened in case of an electric power failure. To use, turn fully clockwise; return it to the run position after an electric repair.

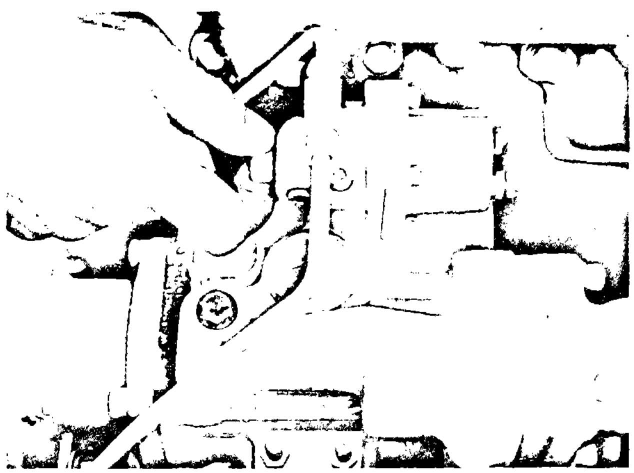


Fig. 1-9, (V21970). Using manual override knob

4. Pull the compression release (if so equipped) and press the starter button or turn the switch-key to the "start" position. After three or four seconds of cranking, close the compression release (if so equipped) and continue to crank until the engine fires.

Caution: To prevent permanent cranking motor damage, do not crank the engine for more than 30 seconds continuously. If the engine does not fire within the first 30 seconds, wait one to two minutes before recranking.

5. At the initial start or after oil or filter changes and after the engine has run for a few minutes, shut it down and wait 15 minutes for the oil to drain back into the pan. Check the engine oil level again; add oil as necessary to bring the oil level to the "H" mark on the dipstick. The drop in oil level is due to absorption by the oil filters. Never operate the engine with the oil level below the low level mark or above the high level mark.

Cold-Weather Starting

Note: A water jacket heater is recommended for stand-by generator set applications installed in a cold climate.

Preheater

The glow plug system supplies heat to the cylinders so that compression temperatures are sufficient to ignite the fuel.

To aid in starting the engine when the temperature is 50° F [10.0° C] or below, an intake air preheater is available.

Preheater equipment consists of a hand-priming pump to pump fuel into the intake manifold, and a switch to turn on the glow plug which is electrically heated by the battery. Fuel burns in the intake manifold and heats the intake air.

Warning: Do not use vapor in conjunction with the preheater. To do so could result in a fire.

To use the preheater for cold starting:

1. Set the throttle in idle position. Turn the glow plug toggle switch to the "ON" position. The red indicator light must be on.
2. After the red light has been on for 20 seconds, start cranking the engine. As soon as the engine begins rotating, operate the preheater priming pump to maintain 80 to 100 psi [552 to 689 kPa] fuel pressure. Use of the primer before the 20-second interval will wet the glow plug and prevent heating.
3. If the engine does not start within 30 seconds, stop cranking. Wait one or two minutes and repeat the cranking operation.
4. After the engine starts, pump the primer slowly to keep the engine idling smoothly. In cold weather this may require 4 to 5 minutes or longer. Do not accelerate the engine.
5. When the engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock the primer. Turn off the glow plug toggle switch. (The red indicator light will go out.)
6. If the engine gives no indication of starting during the first three full strokes of the preheater pump, touch-check the intake manifold for heat. If there is no heat, check the electrical wiring. If the wiring is all right, remove the 1/8 inch pipe plug (1, Fig. 1-10) from the manifold near the glow plug and

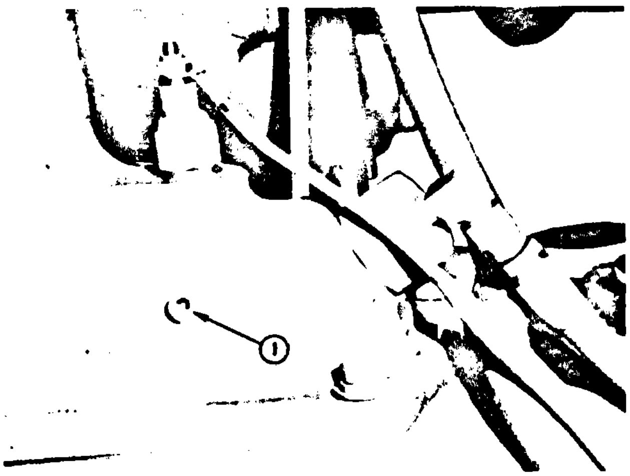


Fig. 1-10, (N11949). Glow plug inspection hole — N/NT-855 Engine

close the glow plug manual switch for 15 seconds and observe the glow plug through the 1/8 inch plug hole. The glow plug should be white hot; if not, connect the wiring to a 6- to 12-volt (as used) source and check the amperage; it should be 30 to 32 (minimum). If the glow plug is all right, check the manual switch and resistor (if used) and replace if necessary.

Note: The preheater priming pump, switches and resistor are located at the instrument panel and are to be checked during engine starting.

The cold starting aid, approved for use in Cummins Engines, has been based upon starting aid capabilities to —25° F [—32° C].

Caution: Do not attempt to use vapor compound type starting aids near heat, open flame or on engines equipped with a glow plug system.

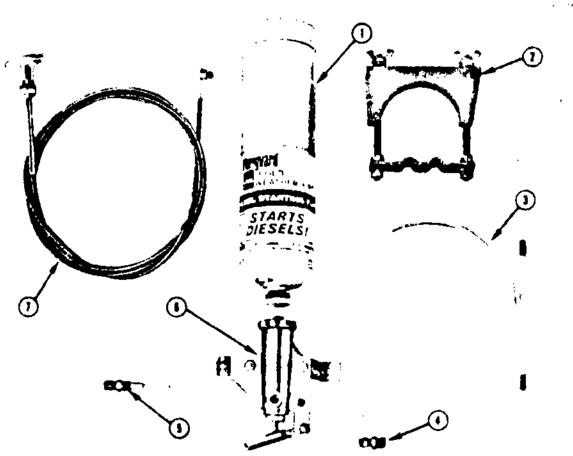


Fig. 1-11, (V11011). Manual operated valve

Manually Operated Valve

The manually operated valve, illustrated in Fig. 1-11 includes the valve body assembly (6), clamp (2) and nylon tube (3). The fuel cylinder (1), atomizer fitting (5) and pull control (7) must be ordered separately.

Standard pull or throttle control cables may be used, to actuate the manual valve, if desired.

Electrically Operated Valve

The electrically operated valve, Fig. 1-12, includes the valve body (7), 90 degree elbow (5), clamp (2), push button switch (6), and nylon tube (3). The thermostat is mounted on the engine exhaust manifold and cuts out the valve by sensing manifold heat when the engine is running. See parts catalog for fuel cylinder (1) and fuel atomizer fittings (4). These fittings must be ordered separately, as required.

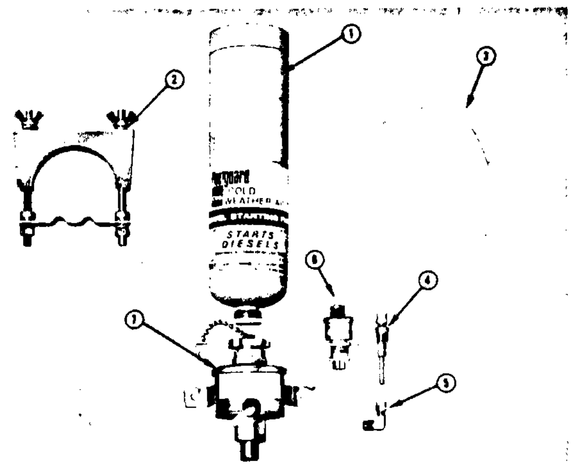


Fig. 1-12, (V11012). Electric operated valve

Installation Recommendations

The atomizer fittings must be mounted in the engine air intake manifold or inlet connection to provide an equal distribution of starting fuel to each cylinder. The atomizer holes are 180 degrees apart and must be mounted so the spray is injected the "long way" of the manifold. If incorrectly installed, the spray goes crosswise of the manifold.

Recommended Starting Technique Using Fleetguard Starting Aid

1. Set the throttle for idle.
2. Disengage the driven unit or make sure gears are in neutral.
3. Open the manual fuel shut-down valve, or electric

shut-down valve, whichever is used.

4. Engage the starter and while cranking, apply metered amounts of starting fluid until the engine idles smoothly.

Use of Starting Fluid Without Metering Equipment

1. Spray starting fluid into the air cleaner intake, while a second man cranks the engine.

Warning: Never handle starting fluid near an open flame. Never use it with a preheater or flame thrower equipment. Do not breathe the fumes. Use of too much will cause excessively high pressures and detonation, or over speed the engine.

2. Starting aid fumes will be drawn into the air intake manifold and the cold engine should start without difficulty.

Warning: Fuel oil or volatile fuel cold starting aids are not to be used in underground mine or tunnel operations. If the engine is so equipped check with the local U.S. Bureau of Mines Inspector for use of the starting aid.

Engine Warm-Up

When the engine is started, it takes a while to get the lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favorable clearances between moving parts are obtained only after all engine parts reach normal operating temperature. Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up.

On some emergency equipment (such as fire pump engines) warm-up may not be necessary due to the equipment being housed inside a heated building. For an engine starting with a parasitic load, such as a fire pump, the coolant temperatures must be a minimum of 120° F [49° C].

Engine Speeds

All Cummins engines are equipped with governors to prevent speeds in excess of the minimum or pre-determined lower speed rating.

The governor has two functions: First, it provides the fuel needed for idling when the throttle is in the idle position. Second, it overrides the throttle and shuts off the fuel if the engine rpm exceeds the maximum rated speed.

Speeds listed in Table 1-1 are for engines rated at maximum rpm and fuel rate.

Note: Engines in many applications are applied at a lower than maximum rated speed; check the serial dataplate.

Power generator units are pre-set to operate at a specific governed rpm.

Table 1-1: Engine Speeds (RPM)

Engine Model	Maximum Rated
All NH, NT, 855-R, 855-L	2100
All NH, NT	2300
V-903	2600
VT-903	2400
V-378, V-504, V-555	3000
V-378, V-504, V-555	3300
V-1710, V-1710-L	2100
KT-1150	2100
KTA-1150	2100
KT-2300	2100
KTA-2300	2100
KTA-3067	2100

Oil Temperature

The oil temperature gauge normally should read between 180° F [82° C] and 225° F [107° C]. Under full load conditions, an oil temperature of 240° F [116° C] for a short period is not cause for alarm.

Caution: Any sudden increase in oil temperature which is not caused by a load increase is a warning of possible mechanical failure and should be investigated at once.

During the warm-up period, apply the load gradually until the oil temperature reaches 140° F [60° C]. While the oil is cold it does not do a good job of lubricating. Continuous operation or long periods of idle with oil temperatures below 140° F [60° C] may cause crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

Water Temperature

A water temperature of 160° to 200° F [71° to 93° C] is the best assurance that the working parts of the engine have expanded evenly to the most favorable oil clearances. Maximum engine coolant temperatures should not exceed 200° F [93° C].

Keep the thermostats in the engine during summer and winter, avoid long periods of idling, and take the necessary steps to keep the water temperature up to a

Table 1-2: Oil Pressure PSI [kPa] @ 225°F [107°C]

Engine Series	Minimum @ Idle Speed	Rated Speed
NH/NT	8 [55]	40/70 [276/483]
Big Cam II	8 [55]	25/45 [172/310]
VT-350, V-903, VT-903	5 [34]	40/65 [276/448]
V/VT-378, V/VT-504, V/VT-555	10 [69]	50/90 [345/620]
V/VT/VTA-1710	15 [103]	50/90 [345/620]
KT/KTA-1150	15 [103]	45/70 [310/483]
KT/KTA-2300 @ 2100 RPM	15 [103]	45/70 [310/483]
KT/KTA-2300 @ 1500, 1800 or 1950 RPM	15 [103]	40/70 [276/483]
KT/KTA-3067 @ 2100 RPM	20 [138]	45/70 [310/483]
KT/KTA-3067 @ 1500 or 1800 RPM	15 [103]	40/70 [276/483]

minimum of 160°F [71°C]. If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

Oil Pressure

Normal engine oil pressures at 225°F [107°C] oil temperature are listed in Table 1-2.

Note: Individual engines may vary from the above normal pressures. Observe and record the pressure when the engine is new to serve as a guide for an indication of progressive engine condition. (High oil pressure during start-up is not cause for alarm.) For record purposes these readings are more accurate and reliable when taken immediately after an oil change.

High Altitude Operation

Some engines, particularly naturally aspirated, lose horsepower when they are operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft [304.8 m] of altitude above sea level for a naturally aspirated engine. Operate the engine using a lower power requirement at high altitude to prevent smoke and over-fueling.

Power Take-Off Application With PT (type G) VS Fuel Pump

The VS fuel pump governor lever is used to change the standard governed speed of the engine from rated speed to an intermediate power take-off speed.

When changing from the standard speed range to the power take-off speed with the engine idling on standard throttle, operate as follows:

1. Place the VS speed control lever in the operating position.
2. Lock the standard throttle in the full-open position.
3. Engage the power take-off.

To return to standard throttle:

1. Disengage the power take-off.
2. Return the standard throttle to the idle position.
3. Lock the VS speed control lever in the maximum speed position.

Engine Shut-Down

Idle Engine A Few Minutes Before Shut-Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow the lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, the turbocharger temperature may rise as much as 100°F [38°C]. The results of the extreme heat may be seized bearings or loose oil seals.

Do Not Idle Engine for Excessively Long Periods

Long periods of idling are not good for an engine because the combustion chamber temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings and may result in stuck valves.

If the engine coolant temperature becomes too low, raw fuel will wash the lubricating oil off the cylinder walls and dilute the crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If the engine is not being used, shut it down.

Turn Switch to "Off" Position to Shut Down the Engine

The engine can be shut down completely by turning off the switch on installations equipped with an electric shut-down valve, or by turning the manual shut-down valve knob. Turning off the switch which controls the electric shut-down valve stops the engine unless the override button on the shut-down valve has been locked in the open position. If the manual override on the electric shut-down valve is being used, turn the button fully counterclockwise to stop the engine. Refer to "Normal Starting Procedure". The valve cannot be reopened by the switch until after the engine comes to a complete stop, unless a rapid re-start valve is installed.

Caution: Never leave the switch key or the override button in the valve open or in the run position when the engine is not running. With overhead tanks this would allow fuel to drain into the cylinders, causing a hydraulic lock.

Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine.

Cold-Weather Protection

1. For cold-weather operation, use of permanent-type antifreeze with rust inhibitor additives is recommended. See Section 3.
2. Drain the cylinder block and heads on all engines by opening the petcocks and removing the drain plugs as shown in Fig's. 1-13 to 1-19. If an air compressor (Fig. 1-20), heat exchanger or other "water cooled" accessory is used, open the petcock and drain. Failure to properly drain the engine and accessories may cause serious damage during freezing weather.
3. Immersion-type water and oil heaters are available for engines used in cold-weather operations and to maintain temperatures to permit the engine to operate at full load at start-up.

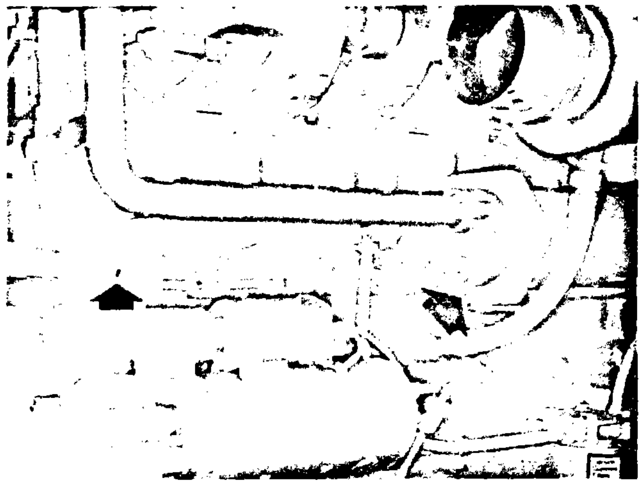


Fig. 1-13, (V100124). Coolant drain point — N/NT-855 Engine

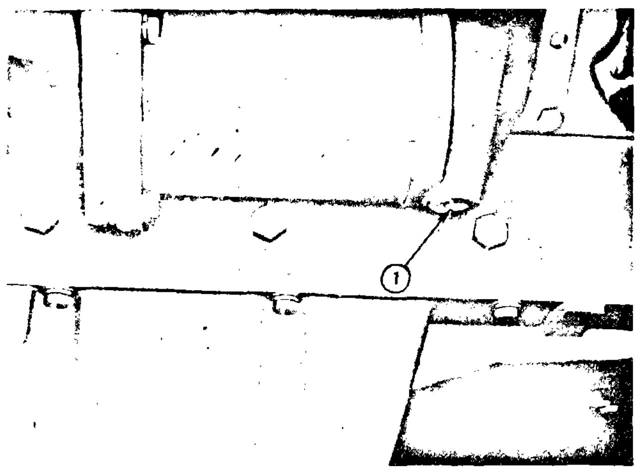


Fig. 1-14, (V50056). Coolant drain point — V/VT-903 Engine

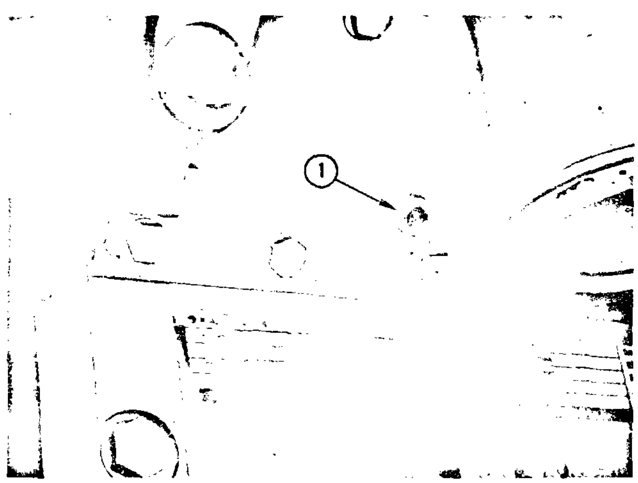


Fig. 1-15, (V10820). Coolant drain point — V-378, V-504, V/VT-555 Engines

Fig. 1-16, (V40033). Coolant drain point — V/VT-1710 Engine

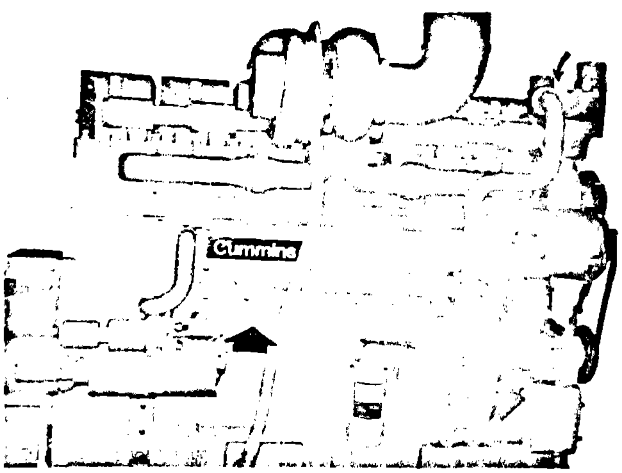


Fig. 1-17, (K11950). Coolant drain point — KT(A)-1150 Engine

Fig. 1-18, (K21903). Coolant drain point — KT(A)-2300 Engine

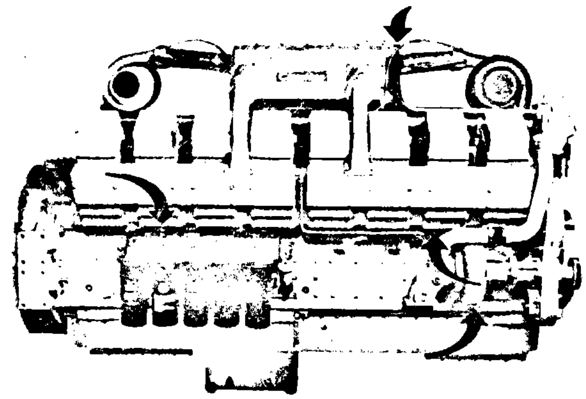


Fig. 1-19, (OM203.). Coolant drain point — KTA-3067 Engine

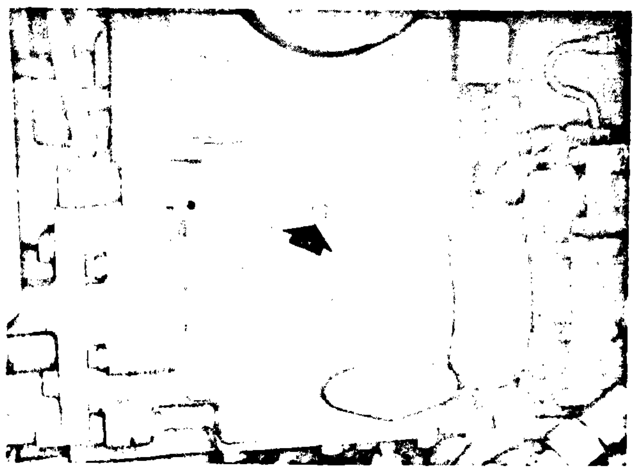


Fig. 1-20, (K21904). Two cylinder air compressor coolant drain

Engine Operation in Cold Weather

Satisfactory performance of a diesel engine operating in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures. The colder the temperatures encountered the greater the amount of modification required and yet with the modifications applied, the engines must still be capable of operation in warmer climates without extensive changes. The following information is provided to engine owners, operators and maintenance personnel on how the modifications can be applied to get satisfactory performance from their diesel engines.

There are three basic objectives to be accomplished:

1. Reasonable starting characteristics followed by

practical and dependable warm-up of the engine and equipment.

2. A unit or installation which is as independent as possible from external influences.
3. Modifications which maintain satisfactory operating temperatures with a minimum increase in maintenance of the equipment and accessories.

If satisfactory engine temperature is not maintained, higher maintenance cost will result due to the increased engine wear, poor performance and formation of excessive carbon, varnish and other deposits. Special provisions to overcome low temperatures are definitely necessary, whereas a change to warmer climate normally requires only a minimum of revision. Most of the accessories should be designed in such a way that they can be disconnected so there is little effect on the engine when they are not in use.

The two most commonly used terms associated with preparation of equipment for low temperature operation are "Winterization" and "Arctic Specifications"

Winterization of the engine and/or components so starting and operation are possible in the lowest temperature to be encountered requires:

1. Use of correct materials.
2. Proper lubrication, low temperature lubricating oils.
3. Protection from the low temperature air. The metal temperature does not change, but the rate of heat dissipation is affected.
4. Fuel of the proper grade for the lowest temperature.
5. Heating to be provided to increase the engine block and component temperature to a minimum of —25° F [—32° C] for starting in lower temperatures.
6. Proper external heating source available.
7. Electrical equipment capable of operating in the lowest expected temperature.

Arctic specifications refer to the design material and specifications of the components necessary for satisfactory engine operation in extreme low temperatures to —65° F [—54° C]. Contact Cummins Engine Company, Inc., or the equipment manufacturer to obtain the special items required.

Caution: "Anti-leak" antifreezes are not recommended for use in Cummins Engines. Although these antifreezes are chemically compatible with DCA water treatment, the "anti-leak" agents may clog the coolant filters and render them ineffective.

Industrial Fire Pump Engines

Fire pump engines are built and applied under conditions set down by agencies such as Underwriters Laboratory; therefore, parts originally supplied must not be deviated from without qualifying agency approval. The following instructions are those special items necessary to this application, and should be used in conjunction with those previously stated.

Initial Start-Up

Note: Contact operating personnel responsible for fire protection system before starting. Obtain approval to service or repair. After repair obtain authorized signature of acceptance.

1. Remove the heat exchanger cap, check or fill the engine coolant supply; open the water filter inlet and outlet valves.
2. Prelubricate the engine with oil meeting specifications MIL-L-46152 (API-CC/SC) viscosity 10W30. This includes removal of the turbocharger oil inlet line on turbocharged engines to prelubricate the housing by adding 2 to 3 oz [60 cc] of clean engine lubricating oil.
3. Check the crankcase oil level and fill to the high mark on the dipstick.
4. Remove the fuel pump solenoid lead and crank the engine through both cranking cycles.
5. If the engine is equipped with a "Vernier throttle", place it in the idle position; if not, place the MVS throttle in the idle position. On turbocharged models the delay cylinder line may be disconnected at the block and the block opening plugged.
6. Reconnect the fuel solenoid lead and start the engine; run it at idle speed.
7. Verify the lubricating oil pressure has been established, normally in 6 to 8 seconds.

Note: Some automatic controllers require lubricating oil pressure higher than the normal pessure at 600 rpm idle. Increase the idle to 800 to 900 rpm if this condition is encountered. All turbocharged engines should be set to 800 to 900 rpm idle.

8. Continue to operate the engine for 3 to 5 minutes and review all systems for leaks or unusual conditions; correct as required.
9. Stop the engine and install ST-1224 Adapter.
10. Check the crankcase oil level and fill it to the high mark.
11. Start the engine and adjust overspeed.
12. Remove ST-1224 and replace the original adapter.
13. Clean the raw water strainer.
14. Start the engine and adjust operating speed.
15. Adjust the raw water pressure regulator.
16. Engine is now ready for normal operation.

Normal Operation

1. Daily or normal operation would include the checking of fuel, lubricating oil, coolant and correcting any leaks or unusual conditions as required.
2. Check the coolant and oil heaters to assure at least 120° F [49° C] water temperature has been maintained.
3. Manually start the engine using the prescribed starting procedure.
4. Operate the engine the prescribed period of time or 5 minutes after stabilization of the coolant temperature.
5. Shut the engine down using the normal test shutdown procedures.

Fire Pump Engines — Overspeed Switch Adjustment (IF Engine Models)

The speed switches required for overspeed protection on fire pump engines require high speed for the overspeed adjustment. All engines are now being shipped adjusted at the maximum overspeed. The following overspeed adjustments are 20 percent above the rated engine speed.

An adapter, ST-1224 with 2:1 ratio, in speed switch drive only, (1, Fig. 1-21) is available to drive the speed switch at twice the engine speed. This tool when installed in place of the existing adapter permits adjustment to be made to the speed switch at slightly over 1/2 engine and pump speed. This maintains a pump speed well within its safe speed range while the adjustments are being made.

Table 1-3: Engine Overspeeds

Engine Model	Rated Speed	Overspeed
V-378-F1	1750-2200	2100-2640
V-378-F2	2400-3300	2880-3960
V-504-F1	1750-2200	2100-2640
V-504-F2	2400-3300	2880-3960
N-855	1460-2100	1750-2520
NT-855-F1	1750-2100	2100-2520
NT-855-F2	1750-2300	2100-2760
VT-1710-F	1750-2100	2100-2520

Adjustment Procedure

1. Remove the present tachometer drive adapter.
2. Install the service tool, ST-1224, in position of the standard drive adapter. Connect the tachometer and overspeed stop switch to the ST-1224 Tool.

Note: The overspeed stop switch cable must be connected to the short adapter connection. (1, Fig. 1-21).

3. Start the engine and warm to operating temperature.
4. Set the engine speed to one-half (1/2) the desired engine shut-down speed as indicated by the tachometer.

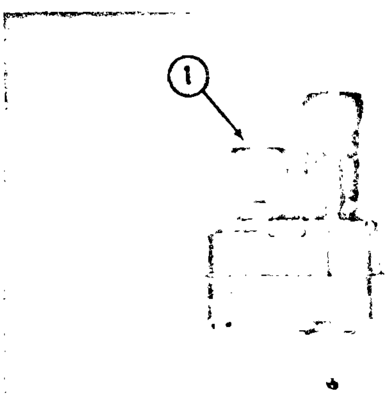


Fig. 1-21, (ST-1224). ST-1224 adapter

   a. On inline engine models, this can be accomplished by adjusting the Vernier throttle control.
   b. On Medium Duty V engines, the speed adjustment must be made by adjusting the governor idle and maximum speed screws. The idle screw is housed in the front of the MVS governor. The maximum speed screw is mounted to the MVS governor by a bracket and is on the left hand side of the fuel pump. Engine slow down is accomplished by turning the idle speed screw counterclockwise and turning the maximum speed screw in a clockwise direction. To increase the engine speed reverse the procedure.
5. Set the single element speed switch.
   a. Remove the lockwire from setscrews on the side of the switch. Loosen the three (3) setscrews.
   b. Rotate the cover clockwise (this decreases trip speed) until the switch actuates and stops the engine.
   c. Secure the setscrews and replace the locking wire.
   d. On manual reset models, re-activate the switch by pushing the reset button on top of the switch.
6. Set the dual element speed switches.

Caution: Do not break or remove the lockwire.

   a. Remove the round head dust cover screw marked 2 from the top of the switch. Fig. 1-22.
   b. Insert a 1/16 inch Hex Allen wrench into the adjusting screw located just below the surface of the cover.

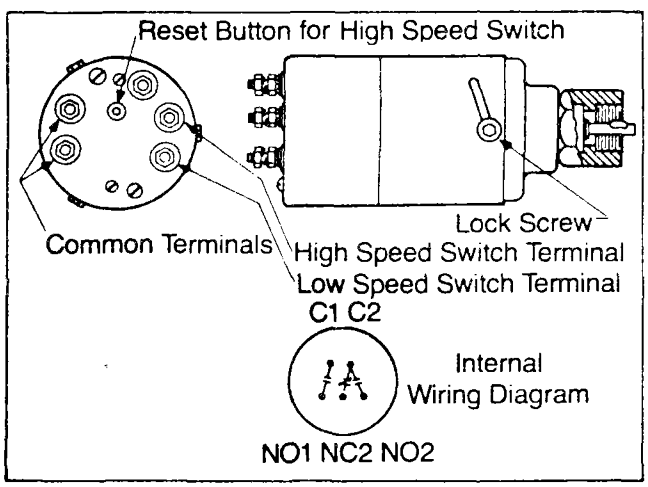


Fig. 1-22, (CGS27). Double speed switch

c. Turn counterclockwise to lower the engine shut-down speed. Turn clockwise to raise the engine shut-down speed.

Caution: Do not turn the adjusting screw more than three (3) revolutions in either direction from the factory setting. Do not attempt to set the duel element switch in the same manner as the single element switch.

d. Replace the dust cover screw removed in "Step a" above.

e. All overspeed switches must be manually reset, reactivate the switch by pushing the reset button on top of the switch.

7. Replace the service tool, ST-1224, with the original drive adapter and reconnect the cables.

Note: If the stop crank adjustment is required do not use the ST-1224 Adapter. Replace with a standard adapter to effect the adjustment.

Fire Pump Engine Operating Speed Adjustment

All Cummins fire pump engines will be shipped adjusted at the speeds in Table 1-4, unless prior approval has been established for a specific speed.

Final operating speed adjustment should be made at the time of the in-service inspection to obtain the required fire pump operating speed.

This speed adjustment must be made with the Vernier throttle in the full fuel position and the systems fire pump operating at its rated condition. All speed ranges of N-NT and V-12 models are available by adjusting the VS high speed adjusting screw. Fig's. 1-23 and 1-24.

Table 1-4: Fire Pump Engine Operating Speed

Engine Model	Fuel Pump Code	Factory Adjusted Speed	Maximum Operating Speed
V-378-F1	C-653	1750	2200
V-378-F2	C-651	2400	3300
V-504 F1	C-652	1750	2200
V-504 F2	C-650	2400	3300
N-855	8761	1750	2100
NT-855 F1	8770	1750	2100
NT-855 F2	8771	1750	2300
VT-1710 F	8784	1750	2100

This screw requires a 1/8 inch Allen wrench and adjustment is made by loosening the 7/16 inch locking nut and backing the screw out to increase the engine speed through the full speed range.

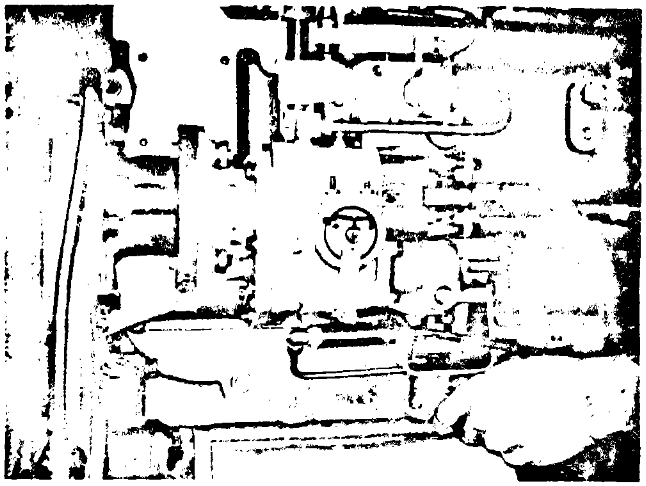


Fig. 1-23, (N11979). Adjusting engine speed

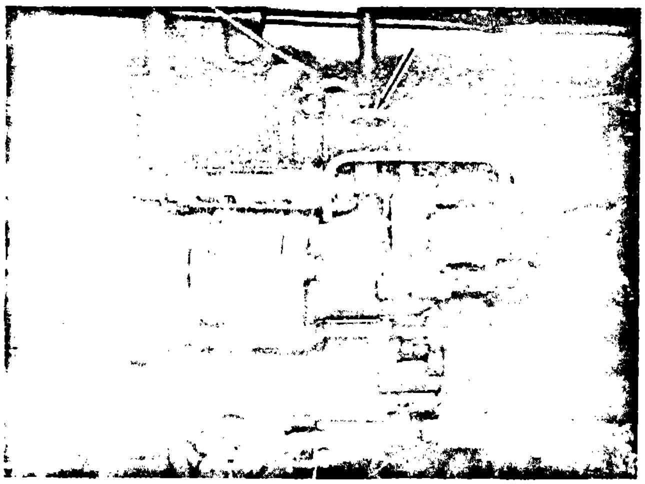


Fig. 1-24, (N11980). Governor adjusting screw

The V-378 and V-504 F1 and F2 models require two differently calibrated fuel pumps. One pump code provides speeds between 1750 and 2300 rpm. A different pump code is required for speeds between 2400 and 3300 rpm. The required speeds on these models are similarly obtained by MVS adjustment within the calibrated range as indicated above. It normally is prohibited by UL and FM to change engine ratings by changing fuel pumps on any models of fire pump engines. In the event of fuel pump rebuild, the pump must be calibrated to the original code and **any deviation would be a violation to the insurance agencies approval.**

Industrial Fire Pump Engine Maintenance Schedule

EQUIPMENT NO. ____________
MECHANIC ____________
TIME SPENT ____________
PARTS ORDER NO. ____________
ENGINE SERIAL NO. ____________
HOURS, CALENDAR ____________
CHECK PERFORMED ____________
DATE ____________

CUMMINS DIESEL FIRE PUMP ENGINES

Check each operation as performed.

1.2.7.257

A—CHECK

Daily

- ☐ Check engine operating log
- ☐ Check engine:
  - oil level
  - coolant level
- ☐ Check engine lubricating oil and coolant heaters
- * • oil bath cleaner oil level
- ☐ Visually inspect engine for damage, leaks, loose or frayed belts

Weekly

- ☐ Repeat Daily "A" Check
- ☐ Check air cleaner
  - clean precleaner dust pan
  - check restriction indicator
  - clean/change air cleaner element
  - * change oil bath cleaner oil
- ☐ Drain water/sediment from fuel tanks & fuel filters
- ☐ Check raw water strainer
- ☐ Check starter battery
- ☐ Start engine & check for unusual noise

B—CHECK

Repeat "A" (Daily/Weekly)

- ☐ *Change engine oil*
- ☐ Change filters
  - oil full flow
  - fuel filter
- ☐ Check coolant
  - check engine coolant DCA concentration level. Add make-up DCA and change element
- ☐ Clean/change
  - crankcase breather
- * Clean oil bath air cleaner tray/screen

C—CHECK

Repeat "A" & "B"

- ☐ Adjust valves & injectors
- * Clean oil bath air cleaner

D—CHECK

Repeat "A", "B" & "C"

- ☐ Clean & calibrate injectors, fuel pump
- ☐ Check and/or rebuild and/or replace the following assemblies:
  - turbocharger
  - vibration damper
- ☐ Rebuild or replace the following assemblies:
  - water pump

SEASONAL

Fall

- ☐ Clean & flush cooling system
- ☐ Replace hose as required
- ☐ Check cold start & thermal aids
- ☐ Clean electrical connections and check batteries
- ☐ Clean engine water heater

Spring

- ☐ Steam clean engine
- ☐ Tighten mounting bolts
- ☐ Check crankshaft end clearance
- ☐ Check heat exchanger zinc plugs annually or as required
- ☐ Check overspeed switch

OTHER

Electrical Components

- ☐ + Starter
- ☐ + Alternator
- ☐ + Batteries
- ☐ + Voltage regulator
- ☐ + Switches
- ☐ + Gauges
- ☐ + Tachometer
- ☐ + On these components follow the manufacturer's procedure

Engine Series	Interval	B	C	D		
All	Hours Calendar	250 6 mos.	1500 1 year	4500 2 years		

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time. In other words, use hours, or calendar time, whichever comes first.

*Cummins F[illegible]ne Company, Inc., recommends the use of dry type air cleane[illegible]

Maintenance

Maintenance is the key to lower operating costs. A diesel engine requires regularly scheduled maintenance to keep it running efficiently.

Maintenance Schedule

Preventive maintenance is the easiest and least expensive type of maintenance. It permits the Maintenance Department to do the work at a convenient time.

A Good Maintenance Schedule Depends On Engine Application

Actual operating environment of the engine governs the maintenance schedule. The suggested check sheet on the following page indicates some checks have to be performed more often under heavy dust or other special conditions.

Using the Suggested Schedule Check Sheet

The maintenance schedule check sheet is designed as a guide until adequate experience is obtained to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, or calendar of time.

A maintenance schedule should be established using the check sheet as a guide; the result will be a maintenance program to fit a specific operation.

The check sheet shown can be reproduced by any printer. The person making each check can then indicate directly on the sheet that the operation has been completed. When a complete column (Under A, B, C, etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

Storage for Engines Out of Service

If an engine remains out of service and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Contact the nearest Cummins Distributor or consult applicable Shop Manual for information concerning engine storage procedure.

Maintenance Schedule

CUMMINS DIESEL ENGINES

EQUIPMENT NO. ____________

MECHANIC ____________

TIME SPENT ____________

PARTS ORDER NO. ____________

ENGINE SERIAL NO. ____________

HOURS, CALENDAR ____________

CHECK PERFORMED ____________

DATE ____________

Check each operation as performed.

A—CHECK

Daily

- ☐ Check operator's report
- ☐ Check engine:
  - Oil level
  - Coolant level
  - * Oil bath cleaner oil level
- ☐ Visually inspect engine for damage, leaks, loose or frayed belts and listen for unusual noises

Weekly

- ☐ Repeat Daily "A" Check
- ☐ Check air cleaner
  - Clean precleaner dust pan
  - Check restriction indicator
  - Clean/change air cleaner element
  - * Change oil bath cleaner oil
- ☐ Drain air tanks
- ☐ Drain water/sediment from fuel tanks and fuel filters

B—CHECK

Repeat "A" (Daily/Weekly)

- ☐ Change engine oil
- ☐ Change filters
  - Oil full flow
  - Oil by-pass
  - Fuel filter
- ☐ Check coolant
  - Check engine coolant DCA concentration level. Add make-up DCA and change element
- ☐ Check oil levels
  - Aneroid
  - Hydraulic governor
- ☐ Clean/change
  - Crankcase breather—All except KT/KTA-2300 and 3067
  - Air compressor breather
- * ☐ Clean oil bath air cleaner tray/screen

C—CHECK

Repeat "A" & "B"

- ☐ Adjust valves & injectors
- ☐ Change oil
  - Aneroid
  - Hydraulic governor
- ☐ Replace aneroid breather
- ☐ Inspect back side idler
- * ☐ Clean oil bath air cleaner

D—CHECK

Repeat "A", "B" & "C"

- ☐ Clean & calibrate injectors, fuel pump and aneroid
- ☐ Check and/or rebuild and/or replace the following assemblies:
  - Turbocharger
  - Vibration damper
  - Air compressor
- ☐ Rebuild or replace the following assemblies:
  - Fan hub
  - Idler pulley assembly
  - Water pump
  - Back side idler
- ☐ Clean/change crankcase breather on KT/KTA-2300 and 3067

SEASONAL

Fall

- ☐ Clean and flush cooling system
- ☐ Replace hose as required
- ☐ Check cold start & thermal aids
- ☐ Clean electrical connections and check batteries

Spring

- ☐ Steam clean engine
- ☐ Tighten mounting bolts
- ☐ Check crankshaft end clearance
- ☐ Check heat exchanger zinc plugs annually or as required

OTHER

- ☐ + Alternator
- ☐ + Generator
- ☐ + Starter
- ☐ + Exhaust brake
- ☐ + Air compressor
- ☐ + Electrical connections
- ☐ + Batteries
- ☐ + Freon compressor

\+ On these components follow the manufacturer's recommended maintenance procedure

Engine Series	Interval	B	C	D		
All	Hours Calendar	Chart Method or 250 6 mos.	1500 1 year	4500 2 years		

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time. In other words, use hours, or calendar time, whichever comes first.

***Cummins Engine Company, Inc., recommends the use of dry type air cleaners.**

1.2.7.259

1.2.7.260

Maintenance Performance Record

Engine Serial No. ______________________ Engine Model ______________________

Owner Name ______________________ Equipment Name/Number ______________________

Interval Basis Mileage	[Kilometres]	Check	Mileage	[Kilometres]	Check	Other	Date	Actual Mileage	Distributor/Dealer Location/Shop	Authorized Signature
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B, C								
		A, B			A, B, C					
		A, B			A, B					
		A, B			A, B					
		A, B			A, B					
		A, B, C			A, B					
		A, B								
		A, B			A, B, C					
		A, B			A, B					
		A, B			A, B					
		A,B,C,D			A, B					
		A, B			A, B					
		A, B			A,B,C,D					

To prove that the Engine has been properly maintained retain records, such as work orders and receipts, showing that scheduled maintenance has been performed. The maintenance record form on this page is for that purpose.

Scheduled Maintenance

Schedule I, Schedule II

The following maintenance schedules should be used to establish maintenance practices for Cummins standby (GS) or continuous duty (GC) generator sets.

Schedule I is used with standby applications. Many of these installations are regulated by NFPA and/or local codes (reference NFPA No. 76A).

Standby rated generator sets are for supplying electric power in the event of normal utility power failure. No overload capability is available for this rating. This rating may be used for continuous service for as long as the emergency may last. This rating conforms with the BS 649:1958 overload rating and DIN "B" 6270.

Schedule II is used with continuous duty applications.

Continuous duty rated generator sets are for supplying electric power in lieu of commercially purchased power. Intermittent overloads up to the standby rating are allowable. This rating may be used for continuous service in commercial applications and it conforms with BS 649:1958 and DIN "A" 6270 for generator set applications.

Using The Suggested Schedule Check Sheet

Actual operating environment of the engine governs the maintenance schedule. The suggested check sheet on the following page indicates some checks have to be performed more often under heavy dust or other special conditions.

The maintenance schedule check sheet is designed as a guide until adequate experience is obtained to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, or calendar of time.

A maintenance schedule should be established using the check sheet as a guide; the result will be a maintenance program to fit a specific operation.

Cummins Standby Generator Sets

Cummins standby generator sets may be required to start and come on line in 10 seconds or less.

These engines must be equipped with engine coolant heaters capable of maintaining coolant temperature at a minimum of 100° F [38° C].

Engines subject to ambient temperatures less than 70° F [21° C] must also be equipped with a lubricating oil heater. When using a lubricating oil heater immersed in oil, the maximum surface of heater in contact with oil, should be less than 300° F [149° C] to minimize formation of hard carbon on the heating element.

Recommended wattage for the heaters when the unit is in a protected area or in an enclosure are shown in Bulletin No. 3379009, in Section 7 Miscellaneous.

Standby units should be operated once a week under a minimum of 25% of rated KW load for at least thirty minutes. During this test, the engine must reach normal operating temperature.

Cummins Continuous Duty Generator Sets

Continuous duty generator sets may be equipped with a cold starting aid. Maintenance procedures for these devices can be found in the seasonal maintenance section.

Stand-By Generator Set Maintenance

Engine Systems

		Checks	A			B	
			Daily	Weekly	Monthly	6 Mos / 250 Hrs.	Annual
Lubricating	Check:	– For Leaks	●	●	●	●	●
		– Operation of Oil Heater	●	●	●	●	●
		– Engine Oil Level		●	●	●	●
		– Hydraulic Governor Oil Level		●	●	●	●
	Change:	– Full Flow Filter				●	●
		– By-Pass Filter				●	●
		– Engine Oil				●	●
		– Hydraulic Governor Oil				●	●
Cooling	Check:	– For Leaks	●	●	●	●	●
		– For Radiator Air Restriction			●	●	●
		– Operation of Coolant Heater	●	●	●	●	●
		– Hose and Connections			●	●	●
		– Coolant Level		●	●	●	●
		– Anti-Freeze and DCA Concentration			●	●	●
		– Belt Condition and Tension			●	●	●
		– Fan Hub, Drive Pulley and Water Pump					●
		– Heat Exchanger Zinc Anode Plugs				●	●
		– Motor Operated Louvers			●	●	●
	Change:	– DCA Water Filter				●	●
	Clean:	– Cooling System					●
Air Intake	Check:	– For Leaks			●	●	●
		– Air Cleaner Restriction		●	●	●	●
		– Piping and Connections				●	●
	Clean:	– Crankcase Breather				●	●
		– Or Change Air Cleaner Element				●	●
Fuel	Check:	– For Leaks	●	●	●	●	●
		– Fuel Level			●	●	●
		– Governor Linkage				●	●
		– Fuel Lines and Connections				●	●
		– Fuel Transfer Pump			●	●	●
	Drain:	– Sediment from Tanks				●	●
	Change:	– Fuel Filters				●	●
		– Float Tank Breather					●
Exhaust	Check:	– For Leaks			●	●	●
		– For Exhasut Restriction			●	●	●
	Drain:	– Condensate Trap			●	●	●
	Tighten:	– Exhaust Manifold and Turbocharger Capscrews					●
Electrical	Check:	– Battery Charging System		●	●	●	●
		– Battery Electrolyte Level and Specific Gravity			●	●	●
		– Safety Controls and Alarms				●	●
Engine Related	Check:	– For Unusual Vibration		●	●	●	●
		Tighten Mounting Hardware					●
	Clean:	– Engine					●
Main Generator	Check:	– Air Inlet and Outlet for Restriction			●	●	●
		– Windings and Electrical Connections					●
		– Operation of Generator Heater Strips					●
	Grease:	– Bearing					●
		Measure and Record Generator Winding Resistance					●
	Check/Clean:	– Generator				●	●
Switchgear	Check:	– Start Switch in Automatic	●	●	●	●	●
		– Instrumentation					●
		– Power Distribution Wiring and Connections				●	●
		– Power Circuit Breaker				●	●
		– Transfer Switch				●	●
Operational Procedures	Perform:	– Operational Load Test		●	●	●	●
		– Generator Load Bank Test					●
	Check:	– Service Tool Availability			●	●	●

Continuous Duty Generator Set Maintenance

Engine Systems

			A	B	C	D	
Checks			Daily	6 Mos./ 250 Hrs.	1 Year/ 1500 Hrs.	2 Years/ 4500 Hrs.	Annual
Lubricating	Check:	— For Leaks	●	●	●	●	●
		— Operation of Oil Heater					●
		— Engine Oil Level	●	●	●	●	●
		— Hydraulic Governor Oil Level	●	●	●	●	●
	Change:	— Full Flow Filter		●	●	●	●
		— By-Pass Filter		●	●	●	●
		— Engine Oil		●	●	●	●
		— Hydraulic Governor Oil		●	●	●	●
Cooling	Check:	— For Leaks	●	●	●	●	●
		— For Radiator Air Restriction	●	●	●	●	●
		— Operation of Coolant Heater					●
		— Hose and Connections	●	●	●	●	●
		— Coolant Level	●	●	●	●	●
		— Anti-Freeze and DCA Concentration		●	●	●	●
		— Belt Condition and Tension	●	●	●	●	●
		— Fan Hub, Drive Pulley, and Water Pump		●	●	●	●
		— Heat Exchanger Zinc Anode Plugs					●
	Change:	— DCA Water Filter		●	●	●	●
	Clean:	— Cooling System					●
Air Intake	Check:	— For Leaks	●	●	●	●	●
		— Air Cleaner Restriction	●	●	●	●	●
		— Piping and Connections		●	●	●	●
	Clean:	— Crankcae Breather		●	●	●	●
		— Or Change Air Cleaner Element		●	●	●	●
Fuel	Check:	— For Leaks	●	●	●	●	●
		— Governor Linkage		●	●	●	●
		— Fuel Lines and Connections		●	●	●	●
	Drain:	— Sediment from Tanks	●	●	●	●	●
	Change:	— Fuel Filters		●	●	●	
	Clean:	— Float Tank Breather		●	●	●	●
		— and Calibrate Injectors				●	
		— and/or Calibrate Fuel Pump				●	
		Adjust Injectors and Valves			●	●	
Exhaust	Check:	— For Leaks	●	●	●	●	●
		— For Exhaust Restriction			●	●	
	Clean:	— Turbocharger Comp. Wheel and Diffuser				●	
	Check:	— Turbocharger Bearing Clearances				●	
		Tighten Exhasut Manifold and Turbocharger Capscrews			●	●	
Engine Related	Check:	— For Unusual Vibration	●	●	●	●	●
		— Vibration Damper				●	
		— Crankshaft End Play				●	
		Tighten Mounting Hardware				●	
	Clean:	— Engine					●
	Grease:	— Fan Pillow Block Bearings		●	●	●	●
Electrical	Check:	— Battery Charging System					●
		— Battery Electrolyte Level					
		Specific Gravity		●	●	●	●
		— Glow Plug					●
		— And Clean Magnetic Pickup Unit			●	●	
		— *Safety Control and Alarms*			●	●	
Main Generator	Check:	— Air Inlet and Outlet for Restriction	●	●	●	●	●
		— Windings and Electrical Connections	●	●	●	●	●
		— *Operation of Generator Heater Strips*					●
	Grease:	— Bearing			●	●	
	Clean:	— Generator					●
Switchgear	Check:	— Power Distribution Wiring and Connections	●	●	●	●	●
		— Power Circuit Breaker			●	●	
		— Transfer Switch			●	●	
Operational Procedures	Perform:	Generator Load Bank Test					●

"A" Maintenance Checks—Daily

Make a Daily Report of Engine Operation to the Maintenance Department

The engine must be maintained in top mechanical condition if the operator is to get optimum satisfaction from its use. The maintenance department needs daily running reports from the operator to make necessary adjustments in the time allotted and to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate most failures and emergency repairs.

Report to the Maintenance Department any of the following conditions:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noise.
5. Excessive smoke.
6. Excessive use of coolant, fuel or lubricating oil.
7. Any fuel, coolant or lubricating oil leaks.

Check Engine

Check Engine Oil Level

Note: Some dipsticks have dual markings, with high- and low-level marks: static oil marks on one side, engine running at low idle speed marks on opposite side. Be sure to use the proper scale.

1. Check the oil level with the dipstick oil gauge located on the engine. Fig. 2-1. For accurate readings, the oil level should not be checked for approximately 15 minutes after the engine is shut-down. Keep the dipstick with the oil pan with which it was originally shipped. Keep the oil level as near the "H" (high) mark as possible.

Caution: Never operate the engine with the oil level below the "L" (low) mark or above the "H" (high) mark.

2. If necessary, add oil of the same quality and brand as already in the engine. See Section 3.

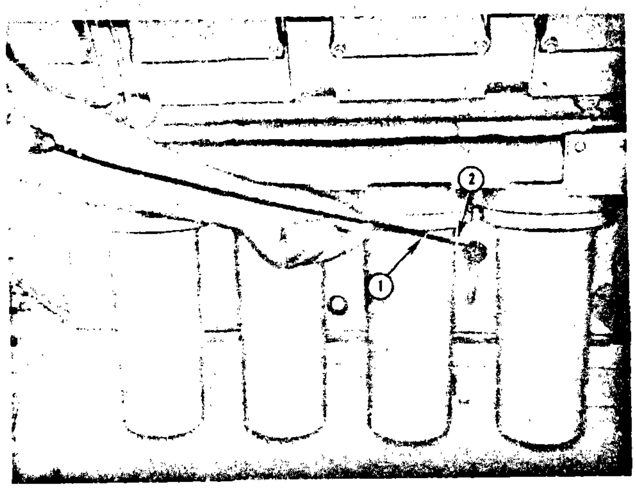


Fig. 2-1, (K21901). Checking engine oil level

Check Engine Coolant Level

Keep the cooling system filled to the operating level. Check the coolant level daily or at each fuel fill point. Investigate for causes of coolant loss. Check the coolant level only when the system is cool.

Check Belts

Visually check belts for looseness. If there is evidence of belt slippage adjust as follows:

Using the appropriate gauge, Fig's. 2-2 and 2-3, check


Fig. 2-2, (N11977). Checking belt tension with ST-1274

Table 2-1: Belt Tension (Lbs.)

Belt Width Inches	Belt Gauge	New Belt* Tension (lb.) ± 10	Minimum Tension (lb.)	• Used Belt Installation Tension • If Below Min. Tension, Retension to (lb.) ± 10
.380	ST-1274	140-150	60	100
.440	CAN-292	140-150	60	100
1/2		140-150	60	100
11/16		160-170	60	100
3/4	ST-1138	160-170	60	100
7/8		160-170	60	100
K-Sect. 5 Rib V-Ribbed	ST-1293	125-135	60	100
K-Sect. 6 Rib V-Ribbed	ST-1293	150-160	70	120
K-Sect. 10 Rib V-Ribbed	N/A	250-260	140	200

* Used belts should be retensioned to values listed in this column.

Note: A belt is considered as used if it has been in operation for a period of time of at least 5 minutes.

and/or adjust belts to the tension as indicated in Table 2-1.

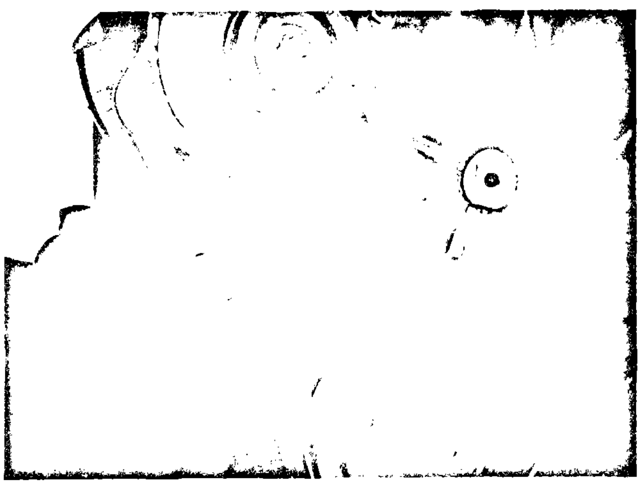


Fig. 2-3, (K114101). Checking belt tension with ST-1293

Note: When using the "Krikit" gauge the correct belt tension reading for the belt tested must be read at the point where the **top** of the black indicator arm crosses the bottom numbered scale. Position the gauge in the center of the belt between two pulleys. The flange at the side of the gauge should be flat against the edge of the belt.

Inline Engine Water Pump Belts (No Idler)

1. Eccentric water pump adjustment.
    a. Loosen the water pump clamp ring to allow the pump body to turn.
    b. Loosen the pump body by pulling up on the belts. A sharp jerk may be required.
    c. Insert a bar in the water pump body slots and rotate the pump body counterclockwise to tighten the belts.

Note: Do not adjust to final tension at this time.

    d. Snug the clamp ring capscrew farthest from the belts, on the exhaust side to 5 ft-lbs [7 N•m].
    e. Snug the two capscrews above and below the first one to 5 ft-lbs [7 N•m].
    f. Finish tightening by alternating from side to side in 5 ft-lbs [7 N•m] increments to a final torque of 12 to 15 ft-lbs [16 to 20 N•m].

g. Check the belt tension.

Final belt tension was not obtained by adjustment alone. The water pump body was pulled straight by snugging the capscrews in the order described, thus increasing the belt tension to the final value.

2. Adjustable (split) pulley water pumps, V-903 Engines only.
   a. Remove the capscrews joining the sheave(s) of the pulley.

Note: Clean the capscrew threads and holes in the sheaves thoroughly to avoid capscrew breakage during reassembly.

   b. The outer half of the pulley is screwed onto the hub extension of the inner half. Some pulleys are provided with flats, and some with lugs for barring.
   c. Bar the engine over to roll the belt outward on the pulley as the outer half is turned in.
   d. Adjust the belt(s) to the tension indicated in Table 2-1.
   e. Turn the outer sheave(s) in enough to align the capscrew holes.
   f. Start the capscrews and tighten alternately and evenly. Final tension is:

      5/16-18 capscrew, 10 to 12 ft-lbs [14 to 16 N•m]
      3/8-16 capscrew, 17 to 19 ft-lbs [23 to 26 N•m]

   g. Bar the engine over one or two revolutions to seat the belt.
   h. Recheck the belt tension.

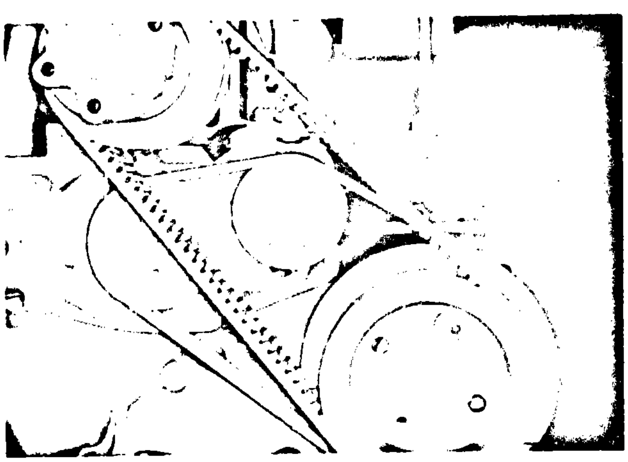


Fig. 2-4, (N11974). Water pump — with idler

Inline Engine Water Pump Belts (With Idler)

1. Loosen the capscrews and lockwashers or locknut securing the idler pulley to the bracket or water pump. Fig. 2-4.
2. Using a pry bar (NTA) or adjusting screw (FFC) adjust the idler pulley until the proper belt tension is indicated on the gauge. See Table 2-1.
3. Secure the idler pulley or bracket in position by tightening the locknut or capscrews and lockwashers to 45 to 55 ft-lbs [61 to 75 N•m] torque.

Note: The self tensioning idler on V-1710 belt driven water pumps requires no adjustment or belt tension check.

Fan Drive Belts

1. Loosen the large locking nut on the fan hub shaft or the capscrews securing the fan hub shaft to the mounting bracket. The fan hub will fall out of line when this is done.
2. Turn the adjusting screw to increase the belt tension.
3. Tighten the locknut or capscrews until the fan hub is straight. Snug the nut to maintain the hub in proper alignment with the fan hub bracket.

Caution: Do not adjust to full tension with the adjusting screw, as this would result in overtightening.

4. Belt tension should read as indicated in Table 2-1 on applicable gauge.
5. Tighten NH/NT Engines locknut to 400 to 450 ft-lbs [542 to 610 N•m]; then back off 1/2 turn. Tighten the four 1/2 inch capscrews, Fig. 2-5, on NTC-350 FFC Engines to 75 to 85 ft-lbs [101 to 115 N•m].

On V-903 Engines tighten capscrews to 75 ft-lbs [102 N•m] or single nut to 450 ft-lbs [610 N•m].

6. Recheck the belt tension.
7. Back out the adjusting screw one-half turn to prevent breakage.

Note: The self tensioning backside idler on KT/KTA-2300 and KTA-3067 belt driven fan requires no belt tension check.

Generator/Alternator Belts

Belt tension should be as indicated in Table 2-1 when measured with the applicable gauge.

Fig. 2-5, (N12018). Fan hub installation — NTC-350 FFC

Belt Installation

If the belts show wear or fraying, replace as follows:

1. Always shorten the distance between the pulley centers so the belt can be installed without force. Never roll a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage the belts and cause early failure.
2. Always replace the belts in complete sets. Belts riding depth should not vary over 1/16 in [1.6 mm] on matched belt sets.
3. Pulley misalignment must not exceed 1/16 in [1.6 mm] for each ft [0.3 m] of distance between the pulley centers.
4. Belts should not bottom on the pulley grooves nor should they protrude over 3/32 in [2.4 mm] above the top edge of the groove.
5. Do not allow belts to rub any adjacent parts.
6. Adjust belts to the proper tension.

Readjusting New Belts

All new belts will loosen after running for 5 minutes and must be readjusted to "belt tension after run-in". Ref. Table 2-1.

Check Oil Bath Cleaner Oil Level

Daily check oil level, Fig. 2-6, in the oil bath air cleaner to be sure the oil level in the cup is at the indicated mark. Refill as required.

***Cummins Engine Company, Inc. recommends the use of dry type air cleaners.**

Check for Damage

Visually check the fuel system, etc., for misadjustment or tampering; check all connections for leaks or damage. Check the engine for damage; correct as necessary.

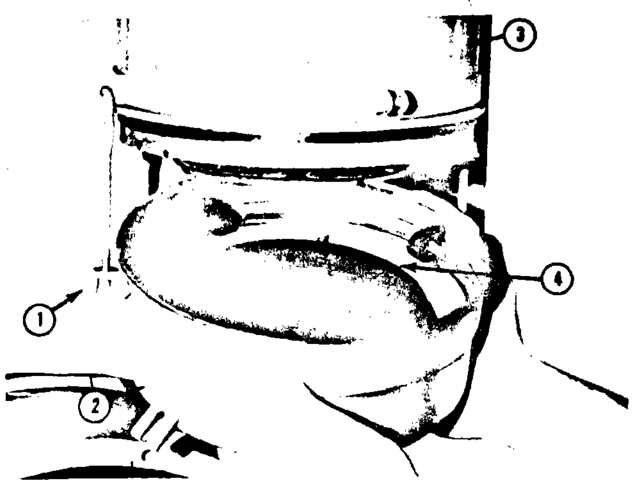


Fig. 2-6, (N11001). Checking oil level in air cleaner

"A" Maintenance Checks—Weekly

Repeat Daily Checks

Check Air Cleaner

Clean Pre-Cleaner and Dust Pan

Under extremely dirty conditions an air pre-cleaner may be used. Clean the pre-cleaner jar and dry-type air cleaner dust pans daily or more often, as necessary, depending on operating conditions.

Check Inlet Air Restriction

Mechanical Indicator

A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or on the vehicle instrument panel. The red flag (1, Fig. 2-7) in the window gradually rises as the cartridge loads with dirt. After changing or replacing the cartridge, reset the indicator by pushing the reset button (2).

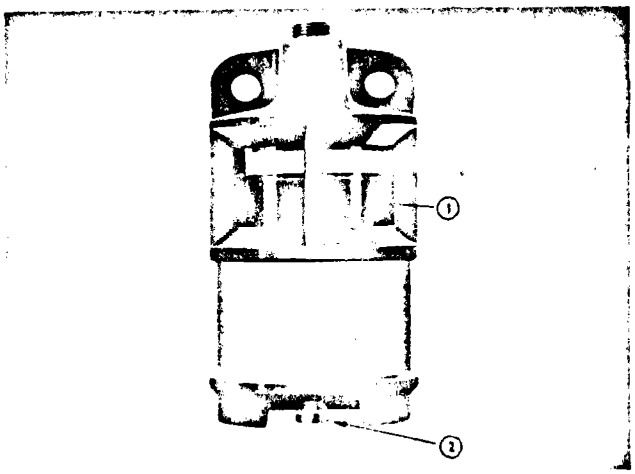
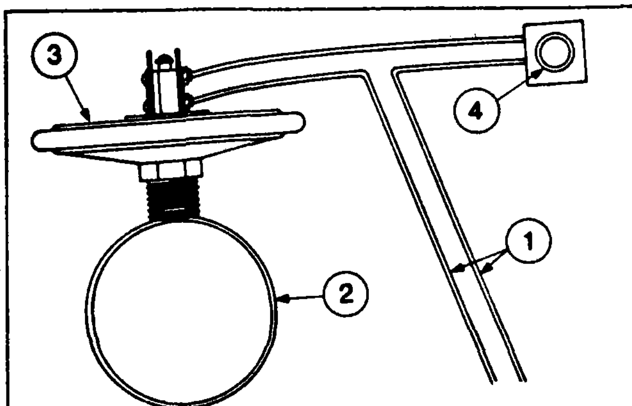


Fig. 2-7, (CGS-20). Air inlet restriction indicator

Note: Never remove the felt washer from the indicator. It is necessary to absorb moisture.

Vacuum Indicator

Vacuum switches, Fig. 2-8, are available which actuate a warning light on the instrument panel when the air restriction becomes excessive.



1. Wiring
2. Piping
3. Vacuum Switch
4. Warning Light

Fig. 2-8, (N21905). Vacuum switch to check air inlet

1. Air restriction on turbocharged engines must not exceed 25 inches [635 mm] of water or 1.8 inches [46 mm] of mercury under full power conditions.
2. Naturally aspirated engine air restriction must not exceed 20 inches [508 mm] of water or 1.5 inches [38 mm] of mercury at air intake manifold at rated speed.

Clean or Replace Air Cleaner Elements

The paper element in a dry-type air cleaner, Fig's. 2-9, 2-10, 2-11 and 2-12, may be cleaned several times by using air to blow off dirt or by washing with nonsudsing household detergent and water at 120 to 140° F [49 to 60° C], then drying with compressed air, approximately 30 psi [306 kPa]. Do not hold the air jet too close to the paper element.

Elements that have been cleaned several times will finally clog and air flow to the engine will be restricted. After cleaning, check the restriction as previously described and replace the element if necessary.

Caution: Holes, loose end seals, dented sealing surfaces and other forms of damage render the cleaner inoperative and require immediate element replacement.

To change the element:

1. Loosen the wing nut (1, Fig. 2-9) securing the

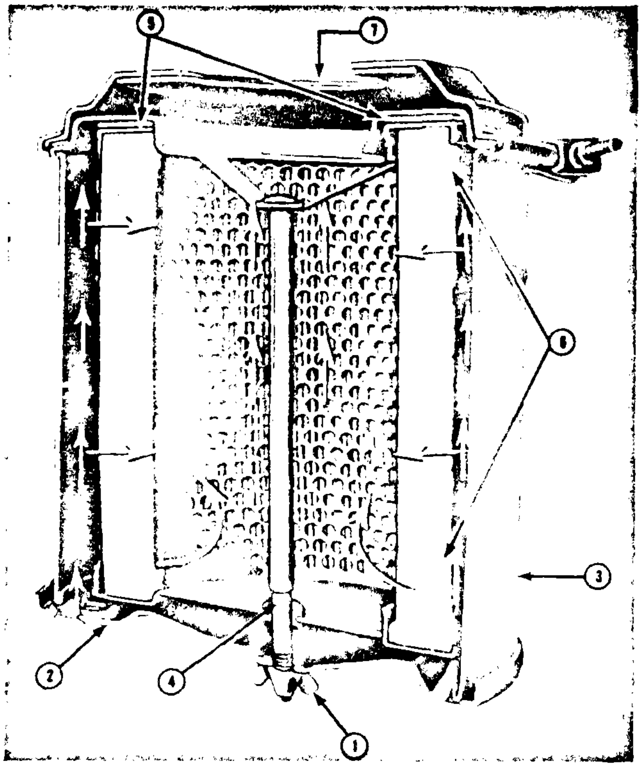


Fig. 2-9, (N11003). Air cleaner — dry type

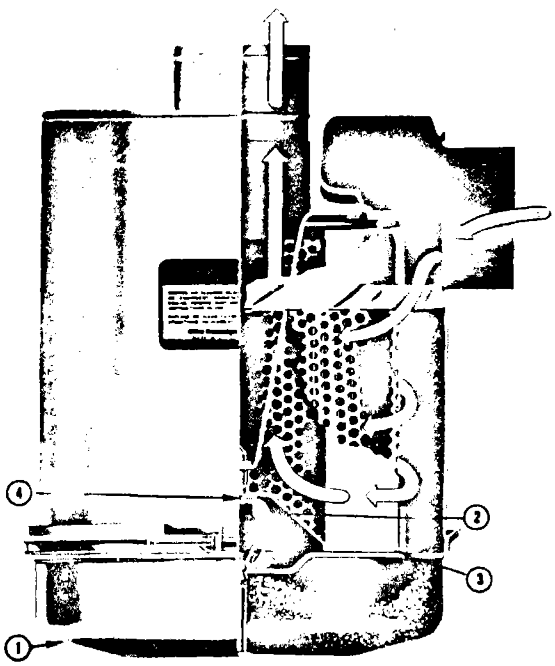


Fig. 2-11, (V10005). Air Cleaner — heavy duty

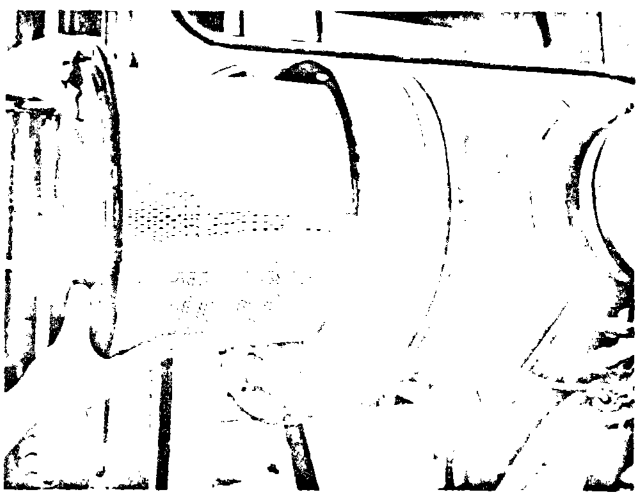


Fig. 2-10, (K11913). Changing air cleaner element

bottom cover (2) to the cleaner housing (3). Remove the cover.

2. Pull the element (6) down from the center bolt (4).

Caution: Pull the cover and the element straight out when removing them from the housing, Fig. 2-10, to avoid damage to the element.

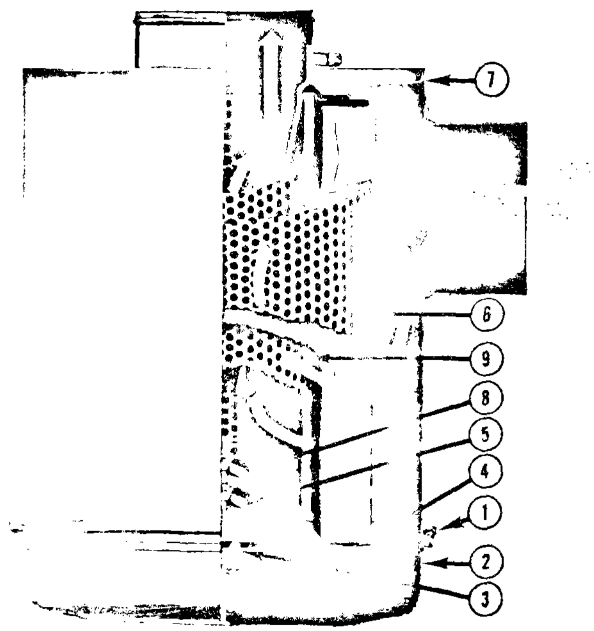


Fig. 2-12, (N11030). Air cleaner — heavy duty (dual element)

3. Remove the gasket (5) from the outlet end (7) of the housing.

When installing the element, make sure it seats on the gasket at the air cleaner outlet end.

Heavy Duty Dry-Type Air Cleaners

Heavy duty air cleaners (single and dual types) combine centrifugal cleaning with element filtering, Fig's. 2-11 and 2-12, before air enters the engines.

Before disassembly, wipe dirt from the cover and the upper portion of the air cleaner. To clean single or dual types:

1. Loosen the wing bolt, remove the band securing the dust pan (1, Fig. 2-11), (2, Fig. 2-12).
2. Loosen the wing nut (2, Fig. 2-11 and 3, Fig. 2-12), remove the dust shield (3, Fig. 2-11), (4, Fig. 2-12), from the dust pan (1, Fig. 2-11), (2, Fig. 2-12), clean the dust pan and shield.
3. Remove the wing nut (2, Fig. 2-11), (5, Fig. 2-12) securing the air cleaner primary element (6, Fig. 2-12) in the air cleaner housing, inspect the rubber sealing washer on the wing nut (4, Fig. 2-11), (5, Fig. 2-12).
4. Blow out the element from the clean air side with compessed air not exceeding 30 psi [207 kPa].
5. Wash the element with nonsudsing household detergent and water, 120 to 140° F [49 to 60° C]. Dry with compressed air, 30 psi [207 kPa].
6. Inspect the element after cleaning.
7. Install a new or the cleaned primary element.
8. Be sure the gasket washer is in place under the wing nut before tightening.
9. Reassemble the dust shield and dust pan, position them to the air cleaner housing and secure with the band.
10. On the dual element type Cyclopac cleaner:
    a. Check the air restriction indicator. If the air restriction is excessive, disassemble the air cleaner, remove the wing nut (8, Fig. 2-12), and replace the safety element (9).
    b. Reassemble the air cleaner as described in "Steps 8 and 9" above.

Cartridge Type Air Cleaner Element

1. Loosen the wing nuts (4, Fig. 2-13 or 2-14) on the air cleaner housing (5) to remove the pre-cleaner panel with the dust bin (1). To remove the pre-cleaner panel (2) equipped wth an exhaust aspirator loosen the "U" bolt clamp securing the pre-cleaner to the aspirator tubing.

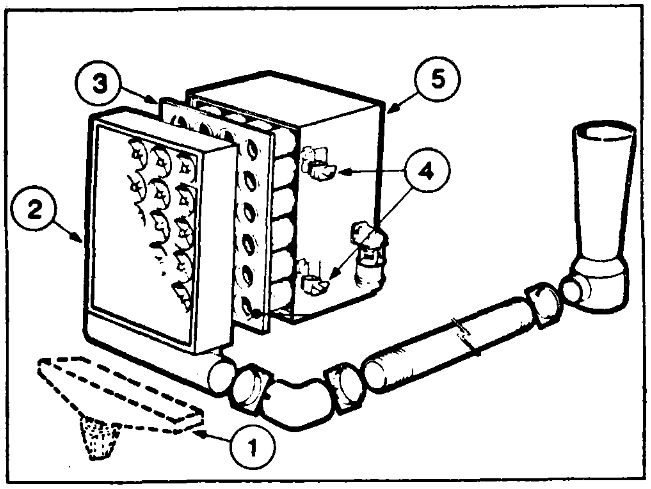


Fig. 2-13, (N21026). Air cleaner — cartridge type (two stage)

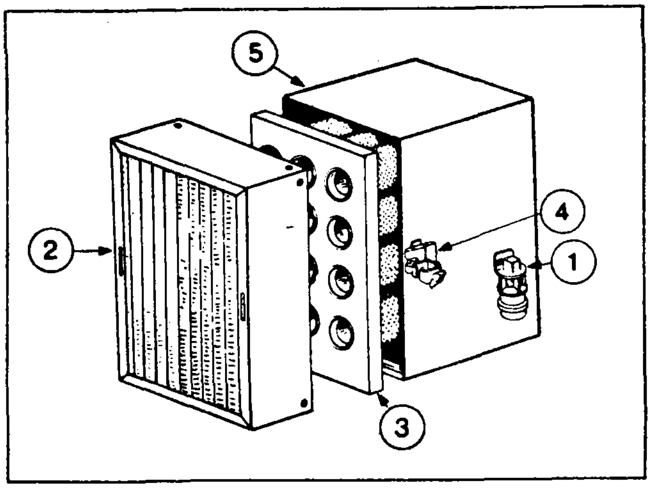


Fig. 2-14, (V11009). Air cleaner — cartridge type (single stage)

2. Remove the dirty Pamic cartridge (3), by inserting your fingers in the cartridge opening (loosen all four corners of the cartridge, one at a time) and pulling it straight out.

With the larger cartridge, it may be necessary to break the seal along the edges of the cartridge. After the seal has been broken, pull the cartridge straight out and slightly up so the cartridge will clear the sealing frame and edges of the air cleaner housing.

Cleaning and Inspection

1. Clean the pre-cleaner openings (2) of all soot, oil film and any other objects that may have become lodged in the openings. Remove any dust or dirt in

the lower portion of the pre-cleaner and aspirator tubing. Inspect the inside of the air cleaner housing for foreign material.

2. Inspect the dirty cartridge for soot or oil. If there is soot inside the Pamic tubes, check for leaks in the engine exhaust system, exhaust "blow-back" into the air intake and exhaust from other equipment. If the cartridge appears "oily", check for fumes escaping from the crankcase breather. Excessive oil mist shortens the life of any dry-type cartridge. Troubleshooting at this point can appreciably lengthen new cartridge life.
3. It is not recommended to clean and reuse the cartridge. When returned to service, life expectancy of a paper cartridge will be only a fraction of the original service life.
4. Inspect clamps and flexible hose or tubing to be sure all fittings are air tight on cleaners with exhaust aspirators.
5. The pre-cleaner dust bin is self-cleaning.

Assembly

1. Inspect the new filter cartridge for shipping damage before installing.
2. To install a new cartridge, hold the cartridge (3, Fig. 2-13 and 2-14) in the same manner as when removing it from the housing. Insert the clean cartridge into the housing; avoid hitting the cartridge tubes against the sealing flange on the edges of the air cleaner housing.
3. The cleaner requires no separate gaskets for seals; therefore, care must be taken inserting cartridge to insure a proper seat within the cleaner housing. Firmly press all edges and corners of the cartridge with your fingers to effect a positive air seal against the sealing flange of the housing. Under no circumstances should the cartridge be pounded or pressed in the center to effect a seal.
4. Replace the pre-cleaner panel (2) and tighten the wing nuts (4) by hand, for final tighteness turn 1-1/2 to 2 turns with a small adjustable wrench. Do not overtighten. On a pre-cleaner with an exhaust aspirator, assemble the aspirator tube to the pre-cleaner panel and tighten the "U" bolt.
5. Care should be taken to keep the cleaner face unobstructed.

Change Oil Bath Air Cleaner Oil

Before dirt build-up reaches 1/2 inch [12.7 mm], remove the oil cup from the cleaner. Discard the oil and wash the cup in cleaning solvent or fuel oil.

Note: During wet weather and in winter months, changing of the oil is equally as important as during dusty weather since the air cleaner inlet may be located in an air stream which carries moisture into the cleaner.

Fill the oil cup to the level indicated by the bead on the side with clean, fresh oil of the same grade as that in the crankcase and assemble it to the cleaner. In extremely cold weather a lighter grade may be necessary. A straight mineral, non-foaming detergent, or non-foaming additive oil may be used in oil bath air cleaners.

Caution: Never use dirty oil or used oil.

Drain Air Tanks

In cold weather, condensed moisture in the air tanks and lines may freeze and make controls useless.

Drain the air tanks to keep all water out of the compressed air system.

Drain Sediment from Fuel Tanks

Loosen the fuel tank drain cock or plug, if used, and drain approximately 1 cup of fuel to remove water and sediment. Close the drain cock or plug.

Fuel/Water Filter Separator

If more moisture than usual is present when checking the fuel tanks, it may be advisable to install a water separator.

Contact the nearest Cummins Dealer for a Fleetguard water separator that meets requirements.

Drain plugs are located in the bottom of some fuel filter cases and in the sump of some fuel supply tanks. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm returning fuel from the injectors heats the fuel in the supply tank. If the fuel level is low in cold weather, the fact that the upper portion of the tank is not being heated by returning fuel tends to increase condensation. In warm weather both the supply tank and the fuel are warm. In the night, however, cool air lowers the temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

Engine Front Trunnion

If used, the engine front trunnion mount should be lubricated with grease meeting specifications as outlined in Section 3.

"B" Maintenance Checks

B-Check

At each "B" Maintenance Check, perform all the "A" Checks in addition to the following.

Lubricating Oil Change Intervals

Note: If the lubricating oil is drained from the oil pan to make an engine repair, new oil must be used. Do not use oil after it has been drained from the oil pan.

Maintaining a proper "B" maintenance check interval is a very important factor in preserving the integrity of an engine. Lubricating oil contamination is the direct result of engine operation and the load factor involved. The amount of contamination generated depends on the amount of fuel the engine consumes. Laboratory and field tests have determined that, when using the recommended quality oils and filters, a turbocharged engine in good condition and equipped with a bypass oil filter can consume 255 gallons of fuel for each gallon of oil in the oil system before the maximum level of oil contamination is reached. Based on these findings, Cummins Engine Company, Inc., recommends that the "B" check interval be determined by the use of the "Chart Method". At each "B" check interval it is recommended to change the full-flow filter and the bypass filter.

The total lubricating system capacity in gallons can be determined by adding the high level of the lubricating oil in the oil pan and the capacities of the full-flow and bypass filters. All lubricating oil systems must be rounded to the nearest gallon when applied to the chart. Table 2-2 lists the capacities of the full-flow and bypass filter elements.

Chart Method

From laboratory and field tests we know that the maximum contamination level for a gallon of oil is reached when 255 gallons of fuel is consumed in a turbocharged engine or 280 gallons of fuel in a naturally aspirated engine. The 255 or 280 figure is the constant used in the equation for the oil change period.

The following illustration is how to use the chart method to determine the recommended oil change interval:

Table 2-2: Lubricating Oil Filter Elements

Description of Filter (Element P/N)	Capacity (Gals.)	Engine Family
Full-flow (LF516)	0.93	All Engines (except V-378 and V-504)
Full-flow (LF613)	0.83	V-378 & V-504 Only
Full-flow spin-on (LF670)	0.80	All Engines (Optional on V-555)
Full-flow (spin-on short) (LF670-SC)	0.65	Standard on All Small Vee
Bypass, 750 in³ (LF750-A)	2.91	All Engines (Except Small Vee)
Bypass, 750 in³ (LF750-C)	2.91	All Engines (Except Small Vee)
Bypass, 750 in³ (LF750)	2.91	All Engines (Except Small Vee)
Bypass, 500 in³ (LF500)	2.25	Small Vee Only
Bypass, spin-on (LF777)	0.70	C & I Engines and Small Vee
Full-flow spin-on (LF734)	0.50	Standard on All Small Vee (Will replace LF670-SC)

Assume a VT-1710 engine which has the following capacities:

Lubricating Oil Pan Capacity	=	18 gallons
Full-Flow Filter (3)	=	2.79 gallons
Bypass Filter 750 in³ (2)	=	5.82 gallons
Total Lubricating Oil System Capacity		= 26.61-27 gallons

Round this capacity to the nearest whole gallon and select the chart entitled "Off Highway Turbocharged with By-Pass Filter" "Lube System Capacity-27 gallons."

Also assume the average fuel consumption = 17.5 gallons per hour and the average oil consumption = 8 hours per quart.

To read the chart.

Change Period = Constant x fuel consumed x the oil available.

Oil Available = Oil system capacity + one-half the make-up oil added in a given period.

$$\text{Oil Added} = \frac{\text{Change Interval}}{\text{Oil Consumption Rate}}$$

$$\text{Change Period} = \text{The Constant x the fuel consumed x [the system capacity + one-half } \frac{\text{(the Change Period)}}{\text{(Oil Consump. Rate)}}$$

Solving this equation for the oil change period gives the equation which is used in developing the Chart Method.

$$\text{Change Period} = \frac{\text{Constant x fuel consumed x oil consumption x system capacity}}{\text{Oil consumption — one-half (constant x fuel consumed)}}$$

1. The numbers along the left side of the chart represent fuel consumption in gallons per hour. Divide the grid between "10" and "20" in 10 equal parts to find the point for fuel consumption.
2. Beginning at "17.5" (fuel consumption), draw a line from left to right to the curve "8". This curve represents oil consumption at the rate of 8 hours per quart.
3. From the point on the curve "8", draw a line perpendicular to the bottom of the chart. The numbers across the bottom of the chart represent the oil change interval in hours.
4. The perpendicular line from the curve "8" intersects the bottom line of the chart between "500" and "600". Divide the grid in 5 equal parts to find the point for the recommended oil change interval. In this example the recommended oil change interval is 505 hours.

Since it is not practical with a group of engines to use a different oil change interval for each engine based on the chart method, Cummins recommends that you use the chart method in the following manner:

1. Divide the engines into groups by engine model (engines with the same lube system capacity).

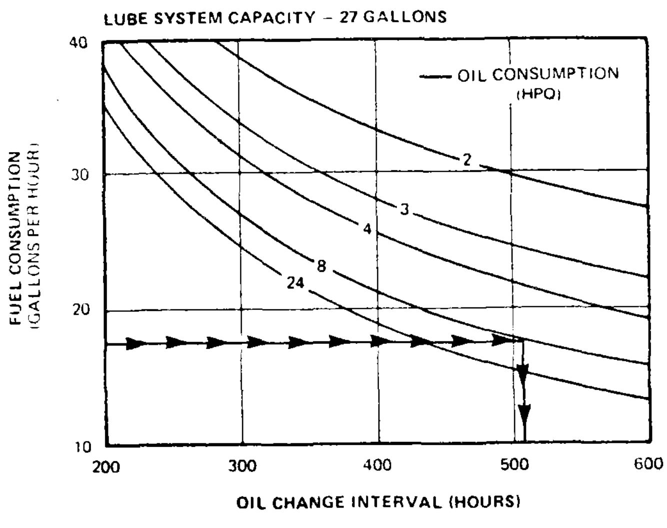
2a. Determine the average fuel consumption for all the engines in each group.

b. Select a group fuel consumption, for entering the chart, that is halfway between the average fuel consumption and the highest fuel consumption in the group.

3a. Determine the average lube oil consumption for all the engines in the group.

b. Select a group lube oil consumption for entering the chart that is halfway between the average lube oil consumption and the lowest oil consumption in the group.

4. Read the appropriate chart for each group using the fuel consumption determined in 2b and the lube oil consumption determined in 3b. The oil change interval determined in this manner should be applied to the entire group.
5. Since some will have more than one group of engine models, a change interval should be determined for each group. In some cases it may be wise to divide some groups into sub-groups (such as older NTC-290's and newer Formula 290's) for which a change interval is determined.
6. Practically, now, a manager must review the oil change intervals determined for each group or



subgroup; consider the other items in his preventative maintenance schedule; consider his own past practice; and select an oil change interval which he feels is the best compromise.

Note: Cummins Engine Co., Inc., does not recommend exceeding 25,000 miles and/or 600 hours on oil change intervals. Therefore, the charts or limited to 25,000 miles or 600 hours and must not be extended.

The charts for determining the recommended oil change intervals are included in the following pages.

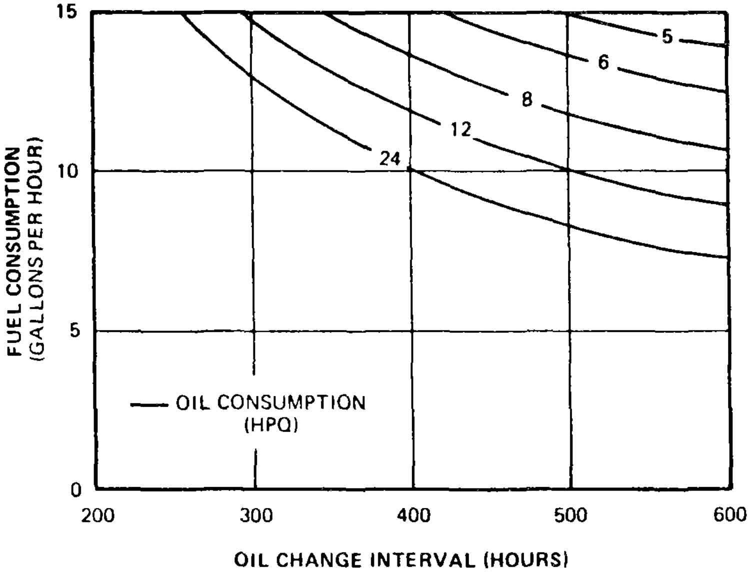
Chart Method Alternative

As an alternative to the Chart Method for determining the "B" maintenance check interval, Cummins Engine Co., Inc., recommends that the "B" check be performed every 10,000 miles, 250 hours or 6 months.

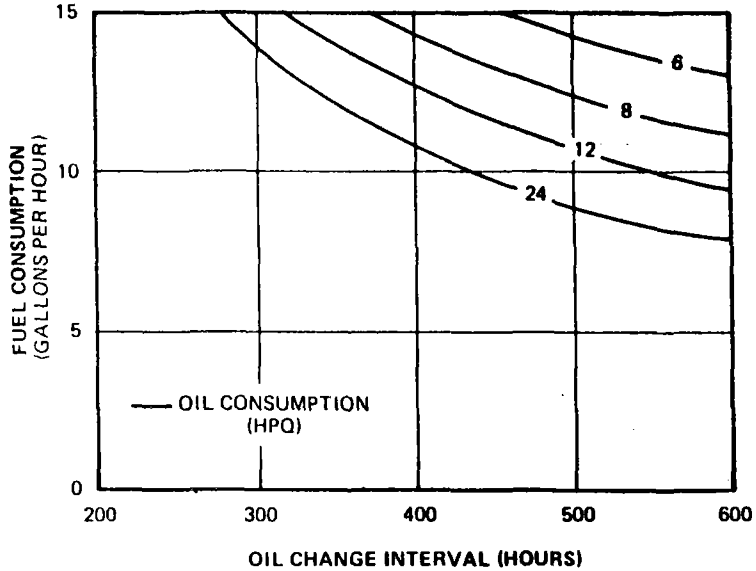
Note: Perform the "B" check in 6 month intervals for engiens in emergency or standby operations and any other operation where less than the recommended miles or hours have been accumulated in a 6 month interval.

OFF HIGHWAY – NATURALLY ASPIRATED WITH BY-PASS FILTER

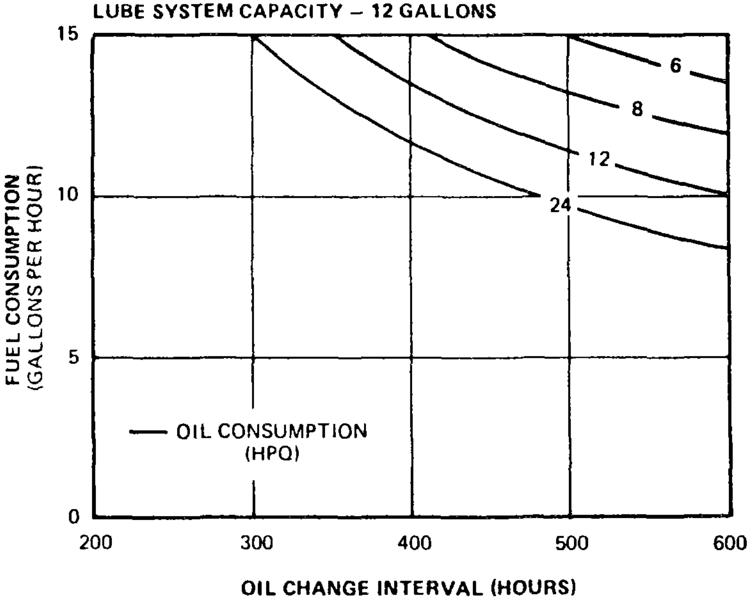
LUBE SYSTEM CAPACITY – 10 GALLONS



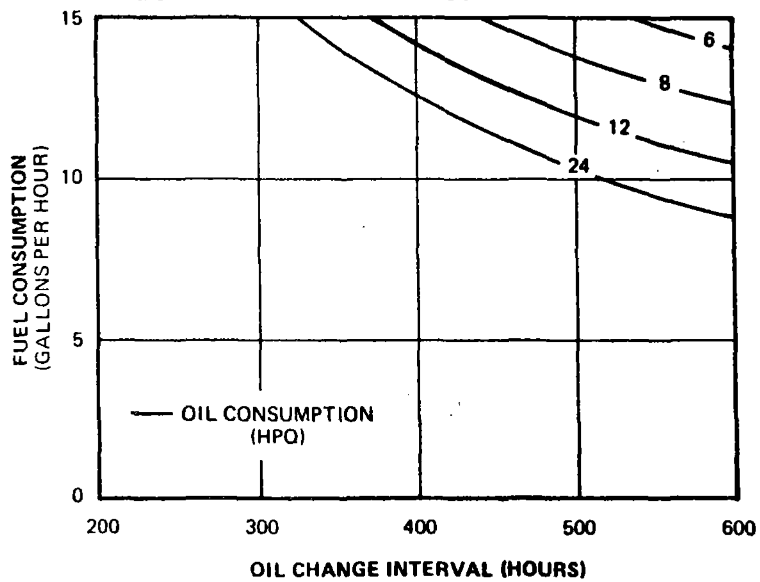
LUBE SYSTEM CAPACITY – 11 GALLONS



LUBE SYSTEM CAPACITY – 12 GALLONS

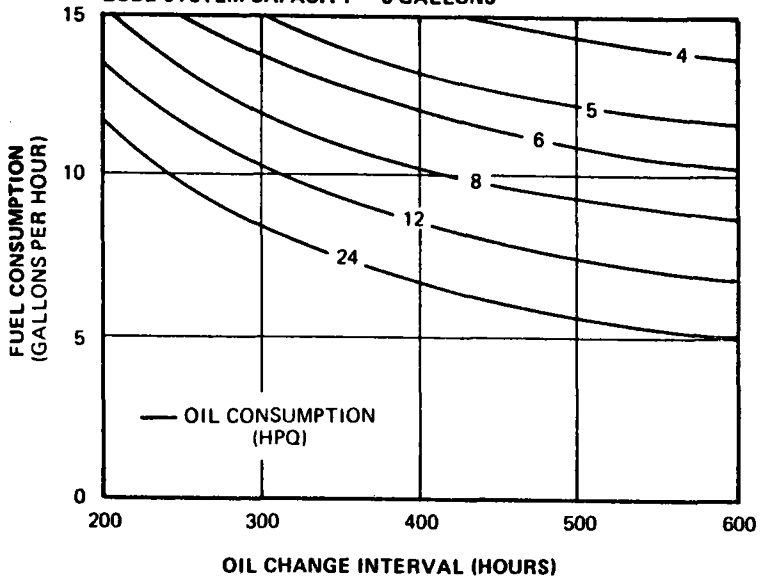


LUBE SYSTEM CAPACITY – 13 GALLONS

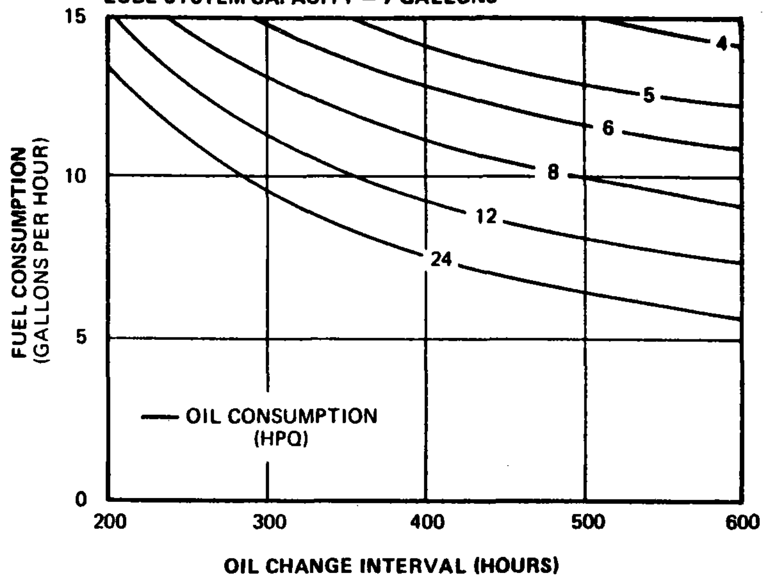


OFF HIGHWAY – NATURALLY ASPIRATED WITH BY-PASS FILTER

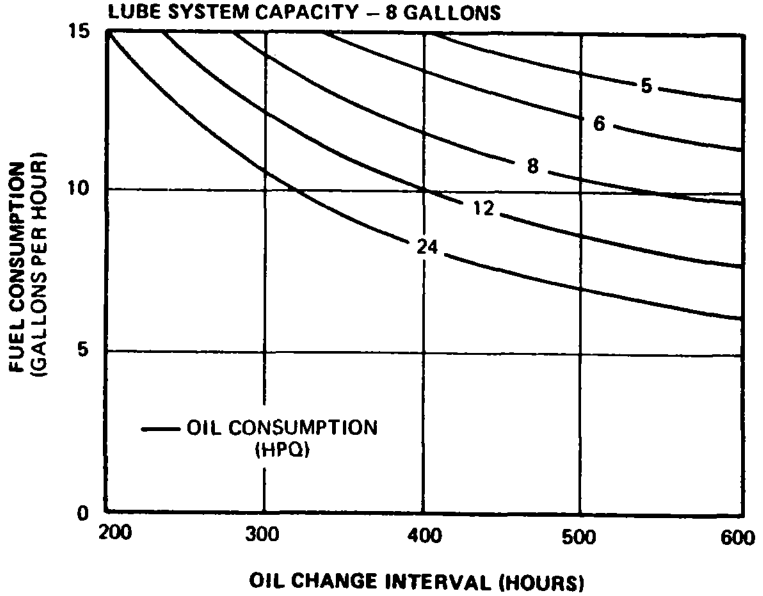
LUBE SYSTEM CAPACITY – 6 GALLONS



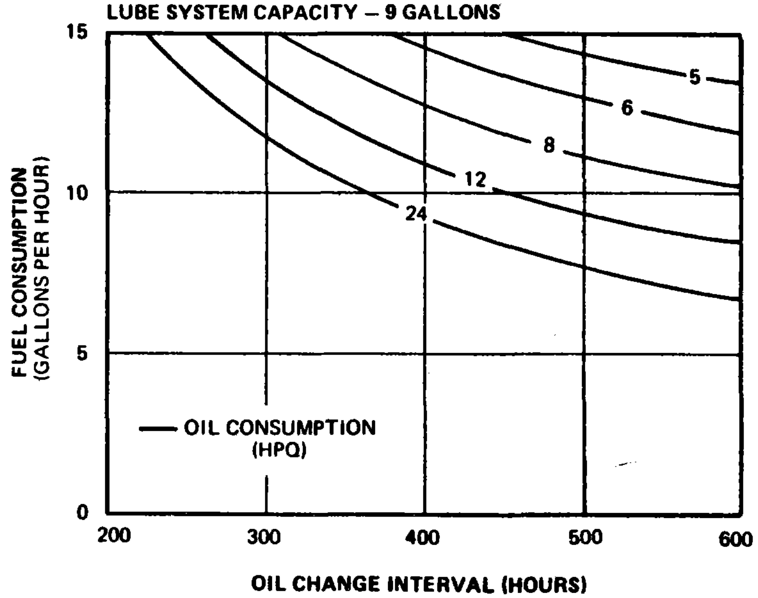
LUBE SYSTEM CAPACITY – 7 GALLONS



LUBE SYSTEM CAPACITY – 8 GALLONS



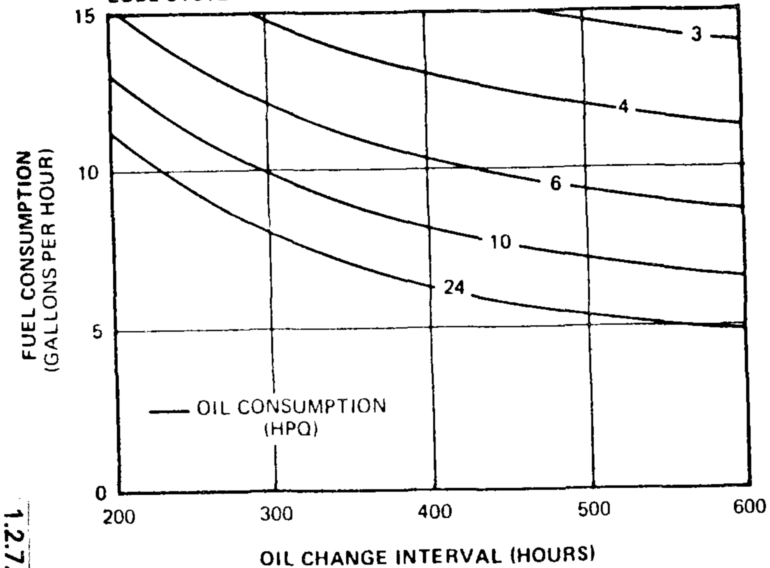
LUBE SYSTEM CAPACITY – 9 GALLONS



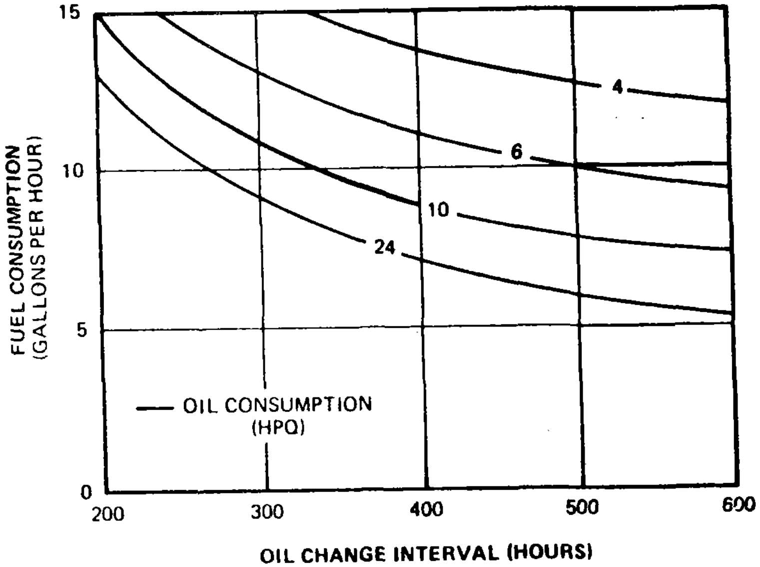
1.2.7.276

OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

LUBE SYSTEM CAPACITY – 8 GALLONS



LUBE SYSTEM CAPACITY – 9 GALLONS



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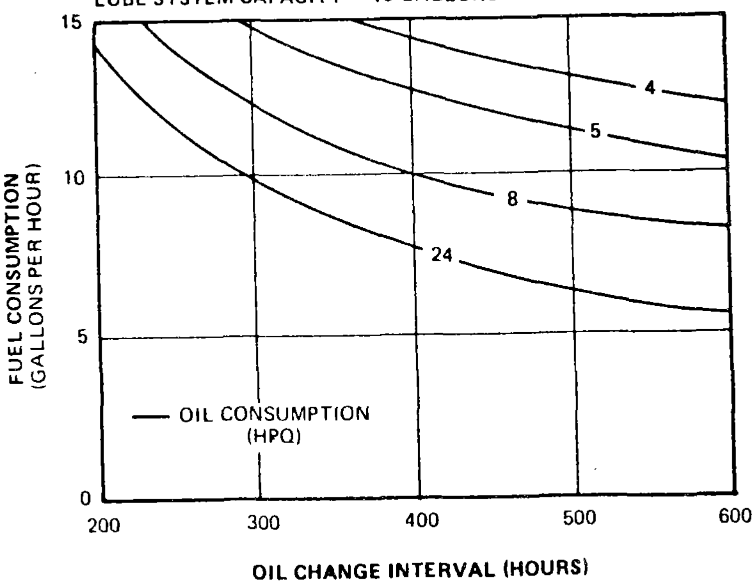
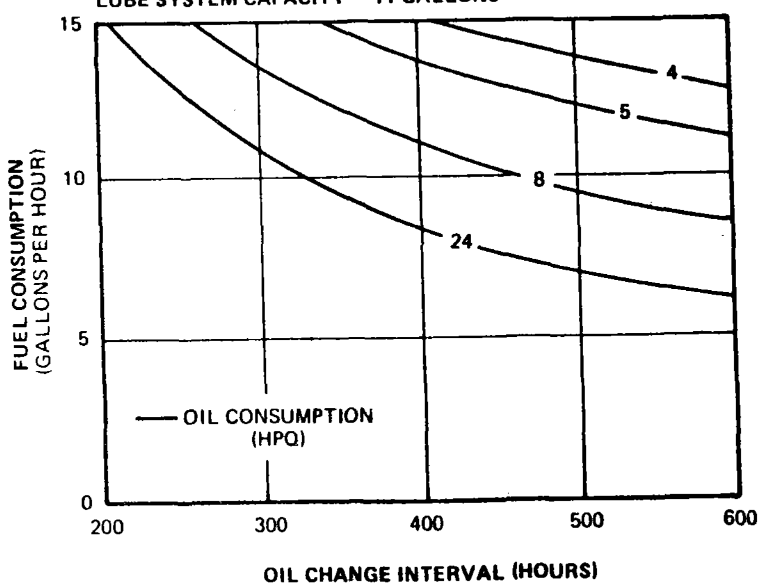
LUBE SYSTEM CAPACITY – 10 GALLONS

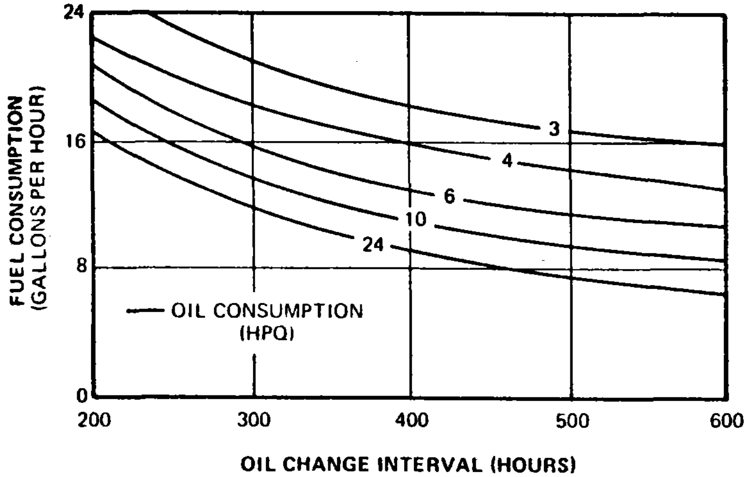


LUBE SYSTEM CAPACITY – 11 GALLONS

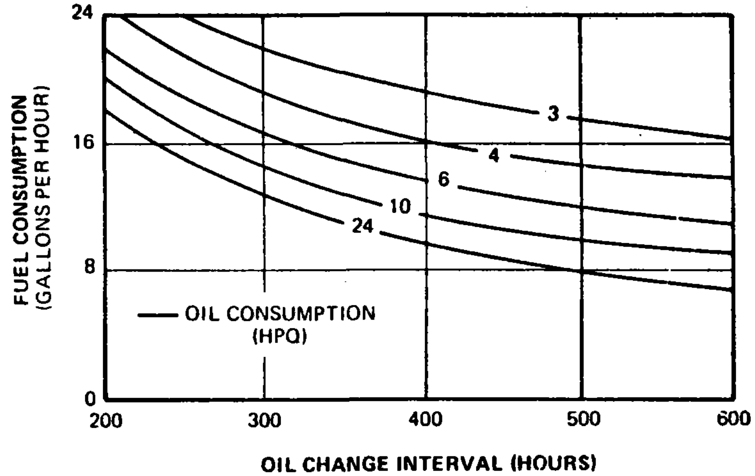


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

LUBE SYSTEM CAPACITY – 12 GALLONS



LUBE SYSTEM CAPACITY – 13 GALLONS



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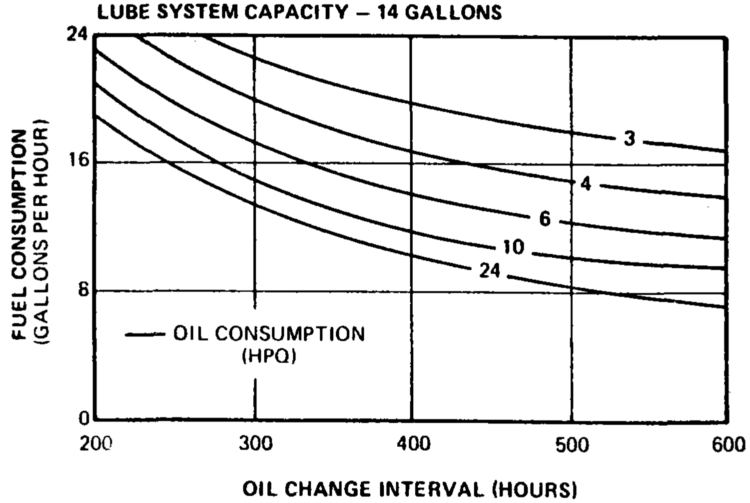
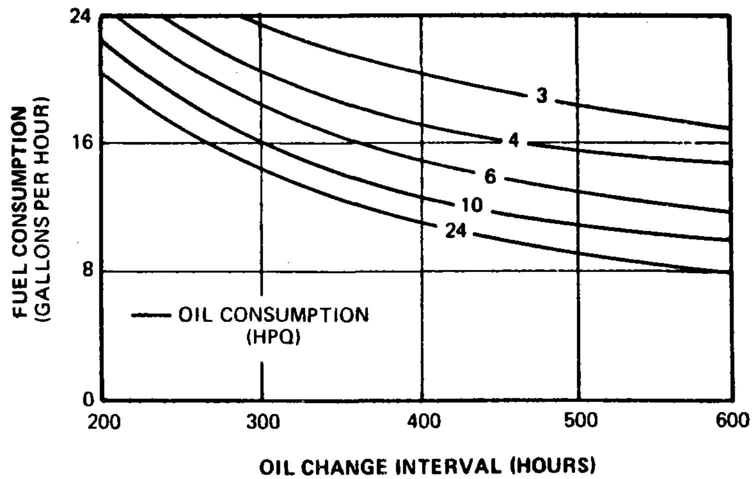
LUBE SYSTEM CAPACITY – 14 GALLONS

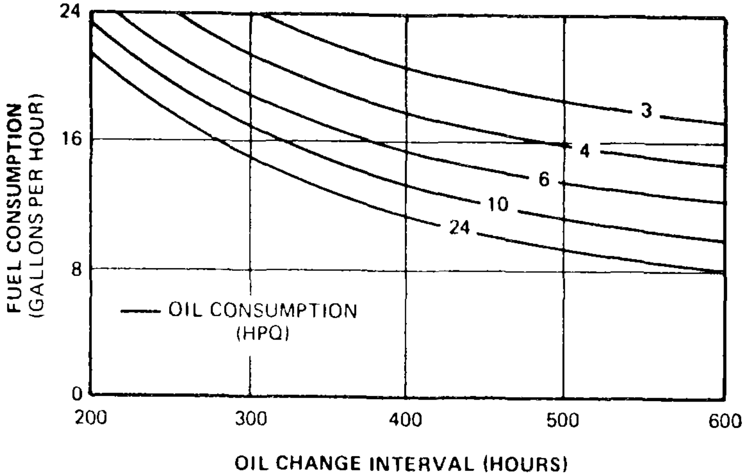


LUBE SYSTEM CAPACITY – 15 GALLONS

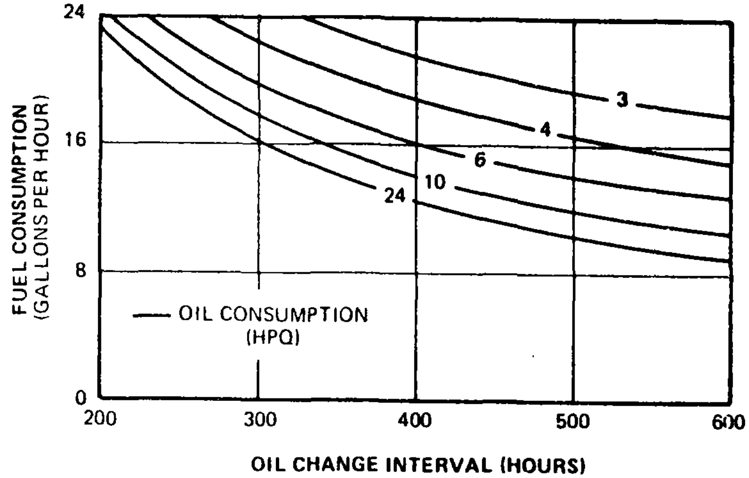


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

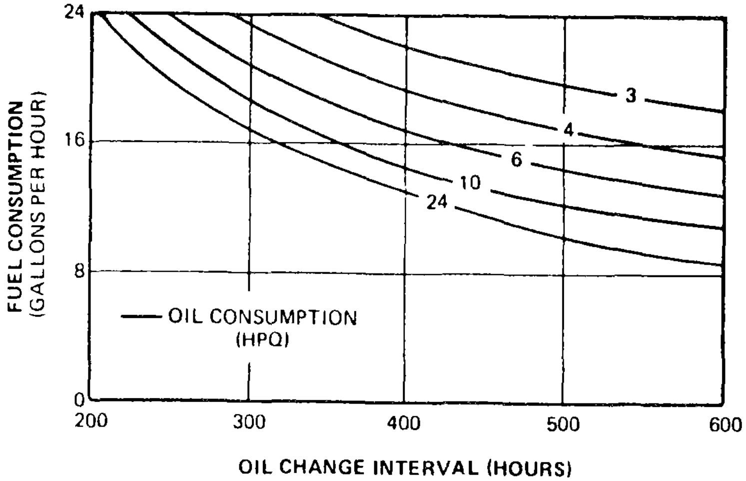
LUBE SYSTEM CAPACITY – 16 GALLONS



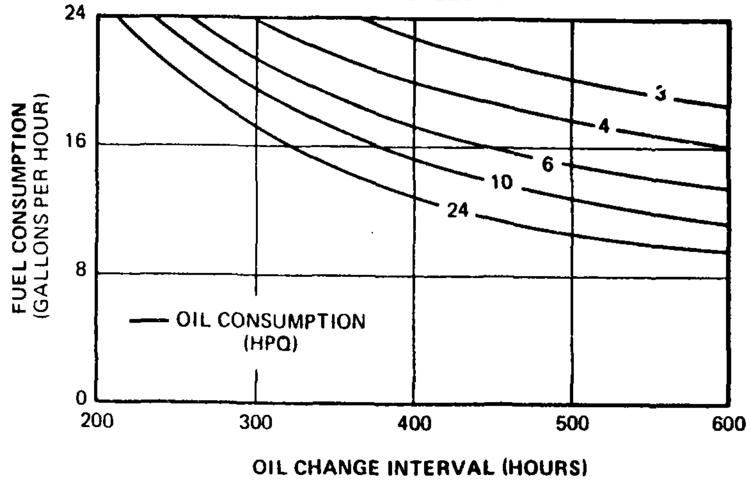
LUBE SYSTEM CAPACITY – 17 GALLONS



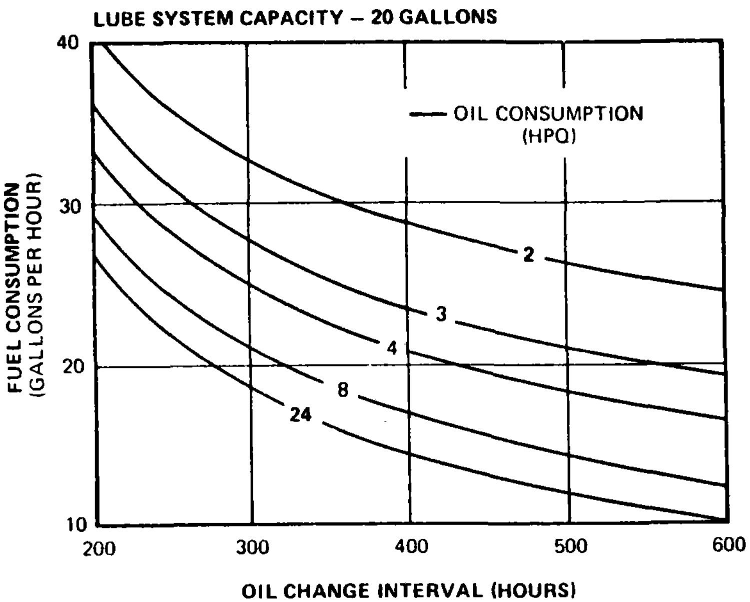
LUBE SYSTEM CAPACITY – 18 GALLONS

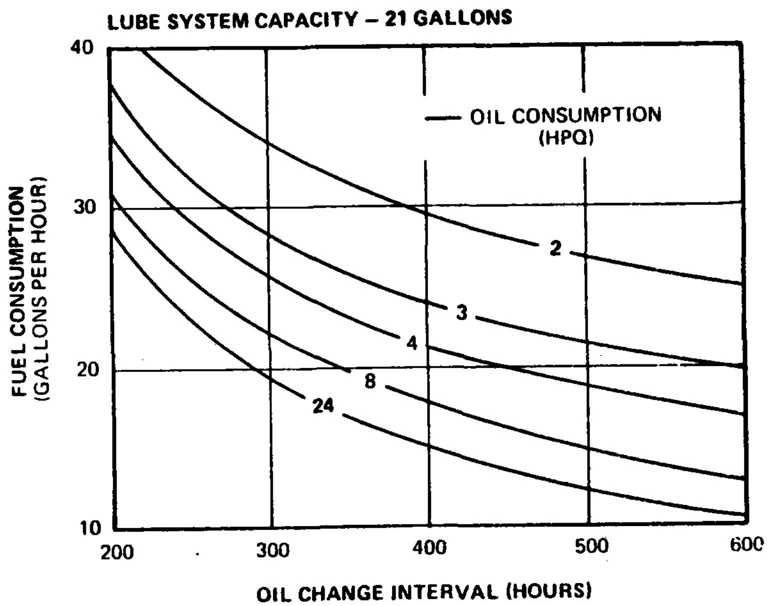


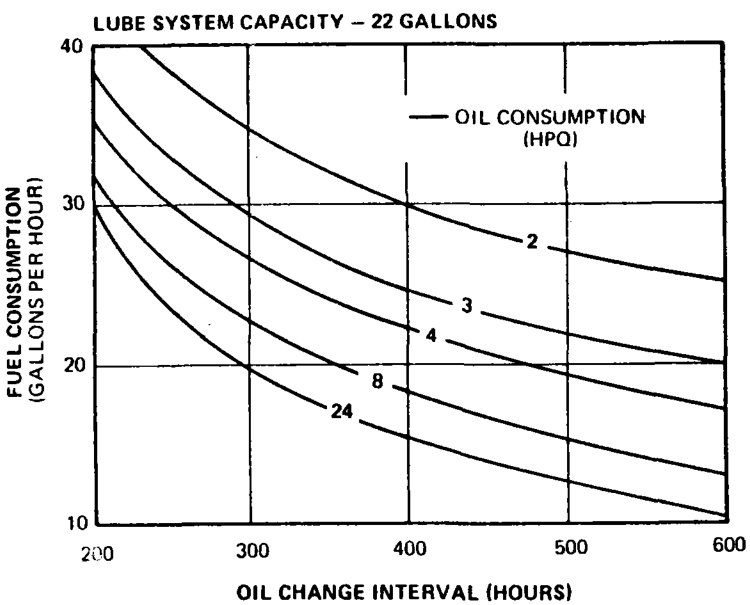
LUBE SYSTEM CAPACITY – 19 GALLONS

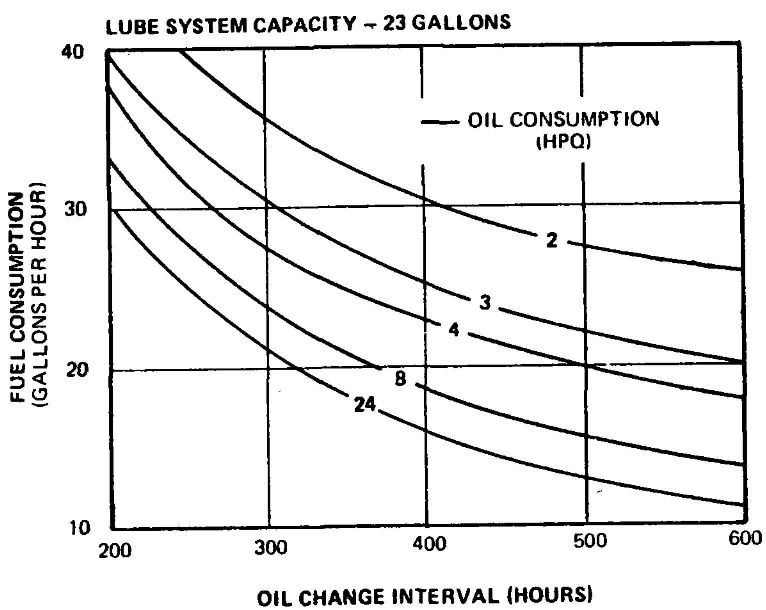


OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER





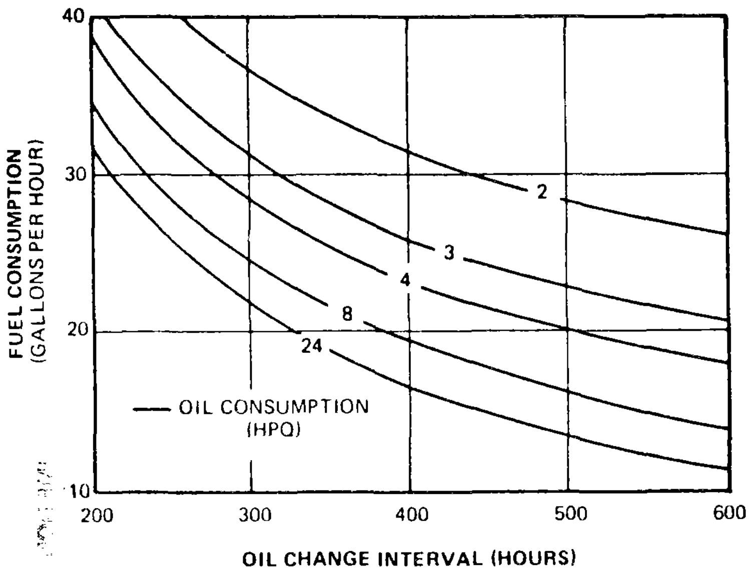




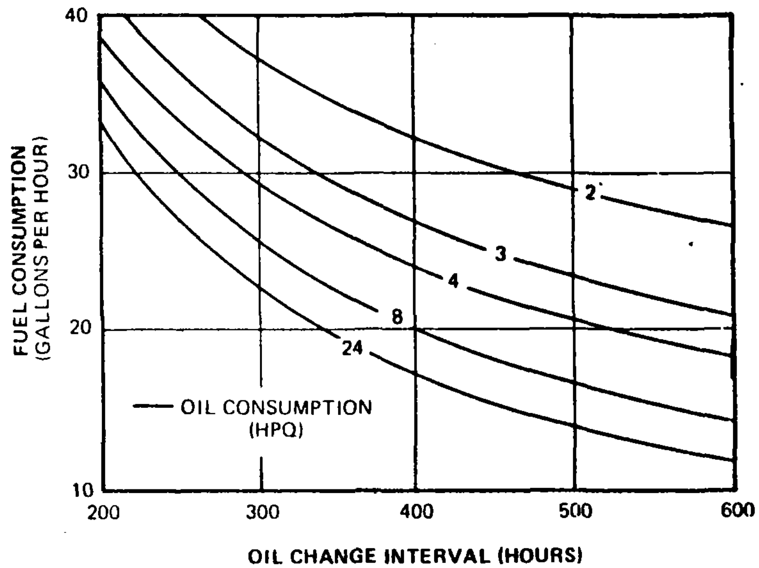
1.2.7.280

OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

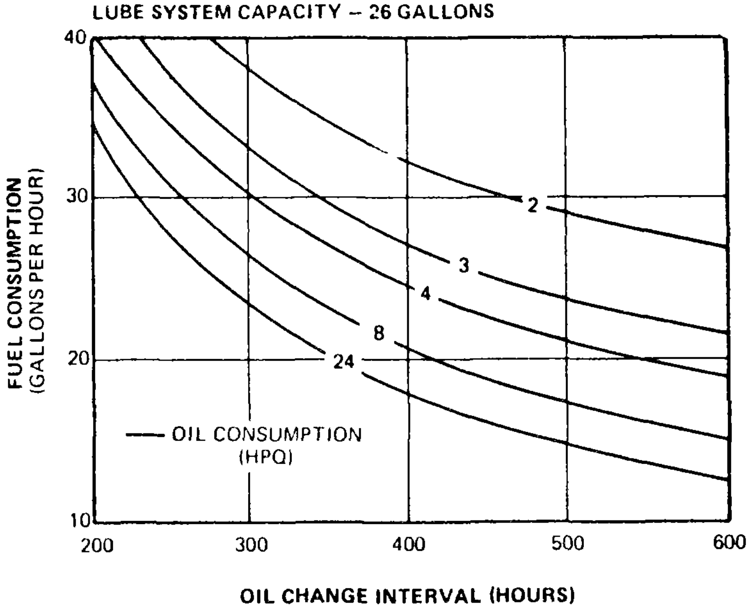
LUBE SYSTEM CAPACITY – 24 GALLONS



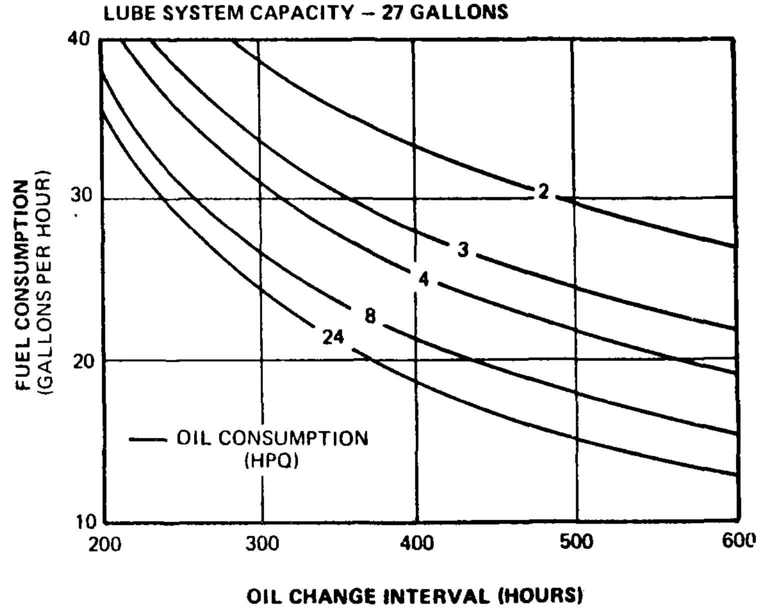
LUBE SYSTEM CAPACITY – 25 GALLONS



LUBE SYSTEM CAPACITY – 26 GALLONS



LUBE SYSTEM CAPACITY – 27 GALLONS



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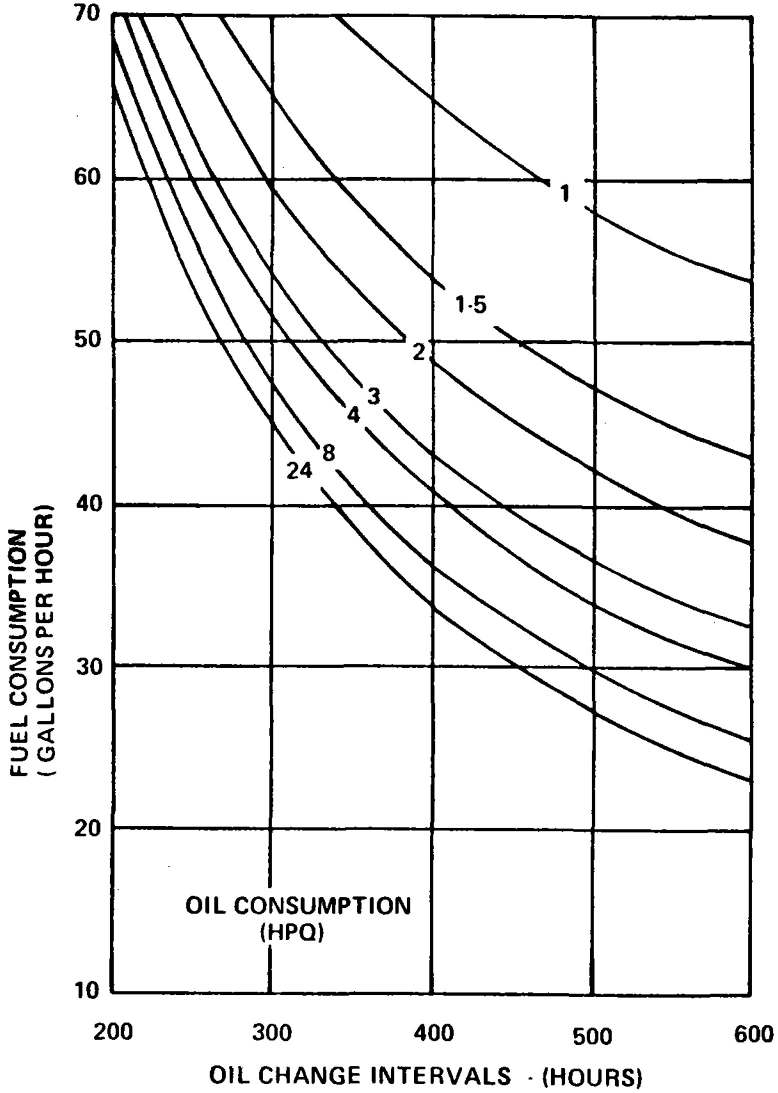
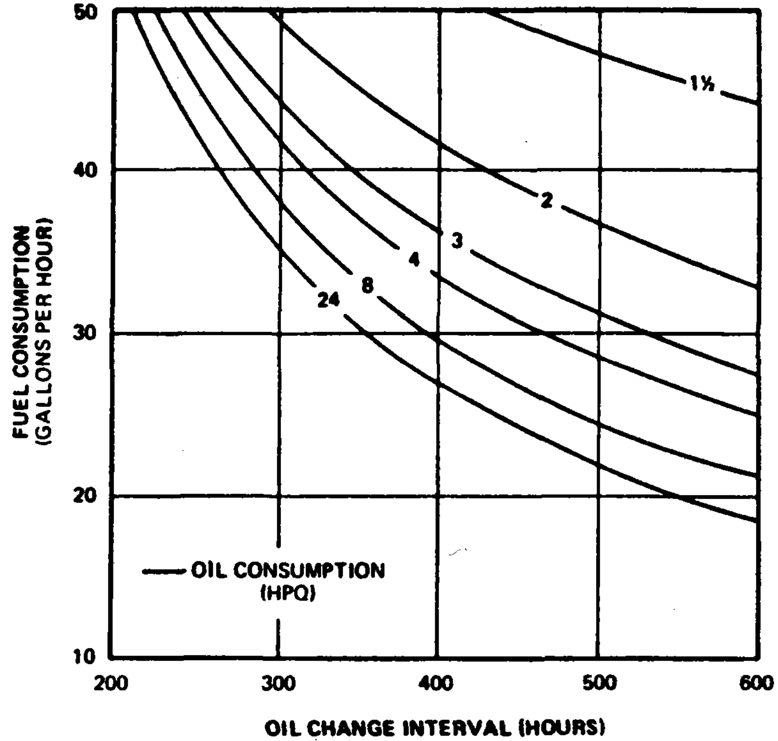
OFF HIGHWAY - TURBOCHARGED WITH BYPASS FILTER

LUBE SYSTEM CAPACITY - 51 GALLONS



OFF HIGHWAY – TURBOCHARGED WITH BY-PASS FILTER

LUBE SYSTEM CAPACITY – 40 GALLONS



Lubricating Oil Analysis

An alternate method for determining when to change lubricating oil and filters is by used oil analysis using laboratory tests. The analyses used are for the purpose of determining the amount of contamination in the oil; not for predicting potential engine failures. It is recommended that new engines be operated through at least one oil change interval determined by the chart method prior to initiating a used oil analysis program.

In order to initiate a used oil analysis program for a large number of engines they should be grouped by basic model, rated horsepower and type of service. The horsepower range of a group should not exceed 25; in other words NTC-270 and NTC-290 engines could be placed in the same group, however, NTC-290 and NTC-350 engines should be in separate groups. Small vee, medium vee, NH and K models should be in separate groups. After the engines have been grouped, a sub-group consisting of 10 percent of the total engines in each group should be selected for the used oil analysis program. If a group consists of less than 50 engines but more than 25 engines the sub-group size should be 5 engines. For groups of less than 25 engines the sub-group size should be 8 engines. The selecting of the engines for each sub-group should be completely random.

Each group of engines should be set up on oil change intervals as described under the "Chart Method". When the engines reach the end of the second chart method oil change interval, an oil change should be performed on all units in the group except those engines selected for the sub-group. The engines in the sub-groups should only have an oil sample taken. Additional oil samples should be taken from each of the engines in the sub-groups at every 48-operating-hour interval after the first sample. This sampling frequency may be varied somewhat as dictated by the operation. The sampling frequency should not be extended beyond 60 hours for equipment safety reason or reduced below 40 hours because of the added analytical costs.

This sampling process should continue until the results of the analyses of the samples indicate that any one of the condemnation limits listed in Table 2-3 has been reached or exceeded until the desired oil change interval extension is reached. This process should be continued cautiously since the engines in the sub-groups are subject to permanent damage because of the over-extended oil change interval. The analytical work on the samples and the examination of the analytical results should be done as quickly and carefully as possible to prevent serious engine damage.

Table 2-3: Lubricating Oil Condemnation Limits

Property (ASTM Method*)	Condemnation Limit
Viscosity @ 100° C (D-445)	± 1 SAE Viscosity grade** from the new oil
Insolubles, pentane, noncoagulated (D-893)	1.0% maximum
Insolubles, toluene, noncoagulated (D-893)	1.0% maximum
Total acid number (D-664)	3.5 number increase from the new oil value, maximum
Total base number (D-664)	2.0, minimum
Water content (D-95)	0.2% maximum
Additive metal content (AES or AAS**)	75% of new oil level, minimum

*ASTM (The American Society for Testing and Materials) publishes these methods in their Annual Book of Standards, Part 23. Other methods should not be used without consulting Cummins.

**SAE Viscosity grades are published by the Society of Automotive Engineers in their annual SAE Handbook as SAE Recommended Practice J300d, and are shown in Table 1 of thsi bulletin.

***AES (Atomic Emission Spectroscopy) and AAS (Atomic Absorption Spectroscopy) are not standard ASTM methods, however most used oil analysis laboratories are capable of determining additive metal concentration by one of these methods and sample results determined by the same laboratory using the same method can be safely compared.

To determine whether the maximum oil change interval has been reached the properties in Table 2-3 should be determined by the laboratory methods specified. This table also specifies condemnation limits to be used for determining the lubricating oils' useful life. This group of analyses and the methods are not generally part of the oil analyses offered by most commercial used oil analysis laboratories. These analyses are not low cost, generally costing between $50 and $135 per sample.

When any one of the condemnation limits is exceeded on any one sample an oil change should be performed on all engines in the sub-group. The hours at which the sample for which a condemnation limit was exceeded is the oil change interval at which 10% or more (depending on sub-group size) of the group are using lubricating oil which has exceeded its useful life. This sampling and analysis process should be repeated once to confirm the oil change interval. When this process is complete the entire group of engines can be placed on the new oil change interval.

This method of establishing an oil change interval will determine a different interval for each group of engines. It is not possible to provide maintenance on several different schedules or if one desires to schedule the oil change to coincide with other maintenance, the more conservative (or shorter) maintenance schedule should be used.

Please contact your Cummins Service Representative if you need assistance or have any questions about utilizing this method of determining an oil change interval.

Change Engine Oil

Factors to be checked and limits for oil analysis are listed below. Oil change at "B' Check, as shown in the maintenance chart on Page 2-2, is for average conditions.

1. Bring engine to operating temperature, shut down engine, remove drain plug from bottom of oil pan, and drain oil.
2. Install drain plug in oil pan. On 855, V-903, KT(A)-1150, KT(A)-2300 and KTA-3067 Engines torque to 60 to 70 ft-lbs [81 to 95 N•m]. On V-378, V-504 and V-555 Engines torque to 35 to 40 ft-lbs [47 to 54 N•m]. On V-1710 Engines torque to 45 to 55 ft-lbs [61 to 75 N•m].
3. Fill the crankcase to "H" (high level) mark on the dipstick.
4. Start engine and visually check for oil leaks.
5. Shut down the engine; allow 15 minutes for oil to drain back into the pan; recheck the oil level with the dipstick. Add oil, as required.

Note: Use lubricating oil meeting specifications listed in Section 3, and genuine Cummins filters on equipment.

Change Spin-On Lubricating Oil Filter Elements

1. Unscrew combination case and elements, Fig. 2-15, discard elements.

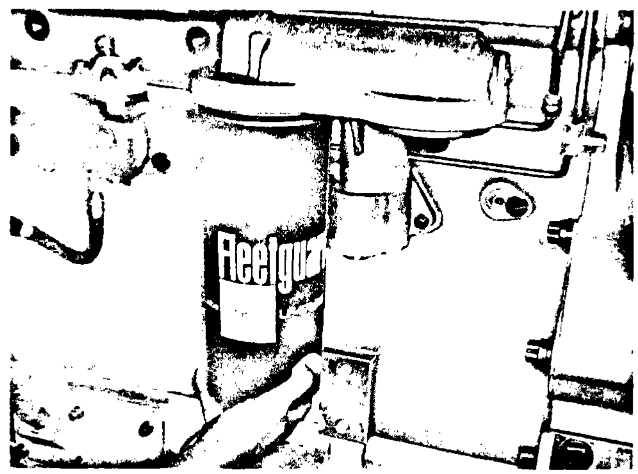


Fig. 2-15, (K11951). Removing "spin-on" lubricating oil filter — KT(A)-1150 Engine

Note: At each filter change check torque of adapter mounting capscrew; it should be 25 to 35 ft-lbs [34 to 47 N•m]. If the capscrew is not within torque range, the adapter may rotate when the spin-on filter is removed. Replace the adapter to the filter head gaskets at each "C" maintenance check.

2. Fill the filter with lubricating oil. Apply a light even coat of lubricating oil to the gasket sealing surface prior to installing the filter.

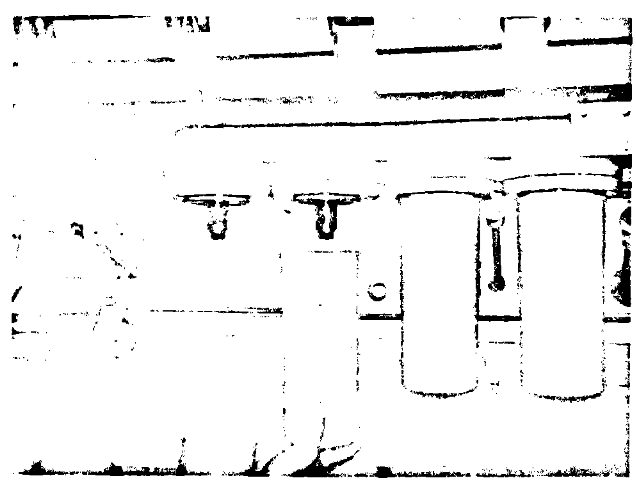


Fig. 2-16, (K21907). Installing "spin-on" lubricating oil filter — KT(A)-2300 Engine

3. Position element to the filter head, Fig. 2-16. Tighten by hand until the seal touches the filter head, tighten an additional one-half to three-fourths turn.

4. Run the engine, check for leaks, recheck engine oil level; add oil as necessary to bring the oil level to "H" mark on the dipstick.

Note: Always allow oil to drain back to the oil pan before checking the level. This may require 15 minutes.

Change the LF—777 Lubricating Oil Spin-On By-pass Filter.

1. Unscrew the spin-on filter from the filter head; discard the filter.
2. Apply a light even coat of lubricating oil to the gasket sealing surface, prior to installing the filter.
3. Position the filter to the filter head. Tighten by hand until the seal touches the filter head; tighten an additional one turn.
4. Run the engine, check for leaks, shut-down the engine. Add oil as necessary to bring the oil level to the "H" mark on the dipstick.

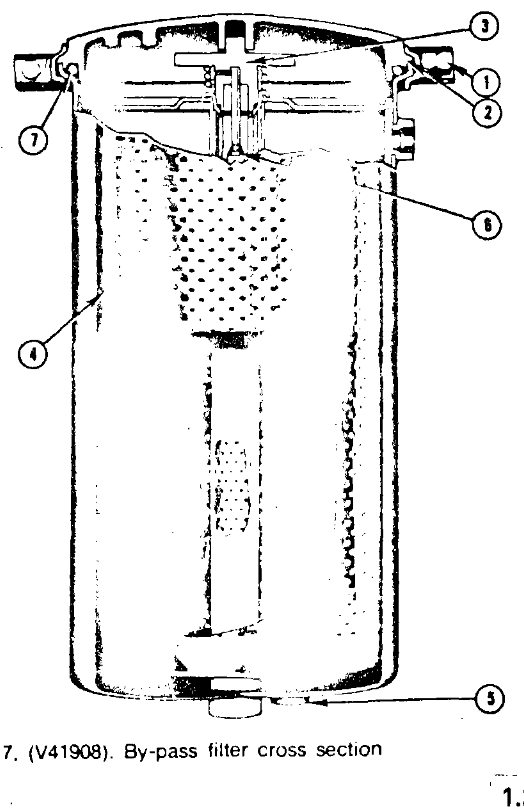


Fig. 2-17. (V41908). By-pass filter cross section

Change Lubricating Oil By-Pass Filter Element

Note: *By-pass filters may be mounted either vertically, horizontally or inverted; all are serviced in like manner.*

1. Remove the drain plug (5, Fig. 2-17) and drain oil.
2. Remove the clamping ring capscrew (1) and lift off the cover.
3. Unscrew the support hold-down assembly (3); lift out the element (4) and the hold-down assembly. Discard the element.
4. Clean the housing and hold-down assembly in solvent.
5. Inspect the hold-down assembly spring and seal. Replace if damaged.
6. Inspect the drain plug and connections. Replace if damaged.
7. Check the orifice plug (6) inside the oil outlet connection or standpipe; blow out with air to open and clean.
8. Check the filter cover O-ring (7). Replace if necessary.
9. Install the new element in the housing, Fig. 2-18.
10. Replace the support hold-down assembly in the filter and tighten down to stop.
11. Position the O-ring seal on the housing flange.
12. Install the cover and clamping ring; tighten the capscrews until the clamping lugs are indexed.
13. Run the engine, check for leaks; add enough extra oil to the crankcase to fill to the "H" (high) mark on the dipstick.

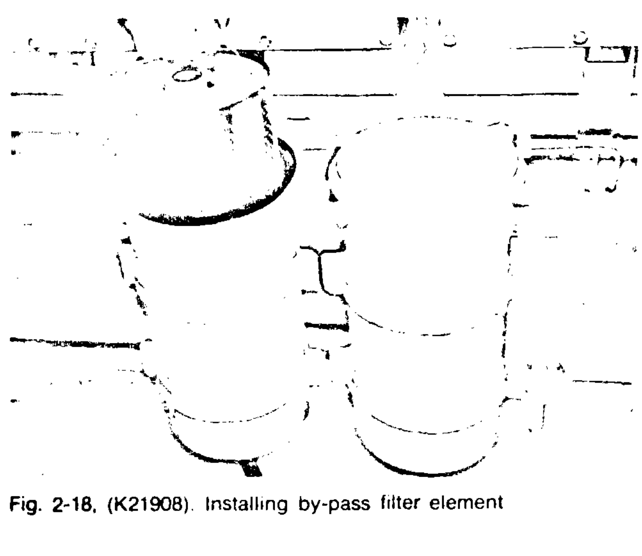


Fig. 2-18. (K21908). Installing by-pass filter element

Caution: Never use a by-pass filter in place of a full-flow filter.

Change Fuel Filter Element

Spin-On Type Filter

1. Unscrew the combination case and element, Fig. 2-19, discard the element.
2. Fill the new filter with clean fuel and apply a light even coat of lubricating oil to the gasket sealing surface prior to installing the filter.
3. Install the filter; tighten by hand until the seal touches the filter head. Tighten an additional one-half to three-fourths turn.

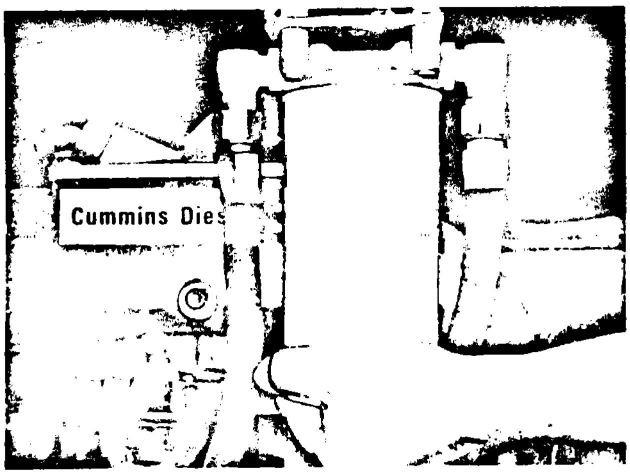


Fig. 2-19, (V11909). Changing "spin-on" type fuel filter

Caution: Mechanical tightening will distort or crack the filter head.

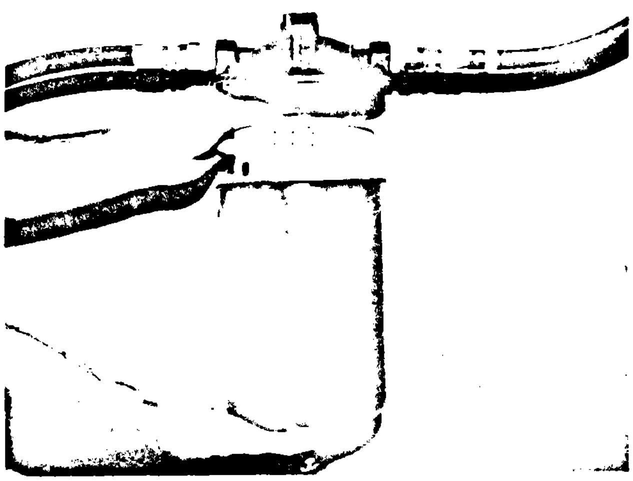


Fig. 2-20, (V11910). Installing replaceable fuel filter element

Replaceable Element

1. Open the drain cock(s) and drain the contents.
2. Loosen the nut(s) at the top of the fuel filter(s). Take out the dirty element, clean the filter case(s) and install new element(s). Fig. 2-20.
3. Install new gasket(s) in the filter(s) and assemble the case(s) and element(s). Tighten center bolt(s) to 20 to 25 ft-lbs [27 to 34 N•m] with a torque wrench. Fill the filter case(s) with clean fuel to aid in faster pick-up of fuel.
4. Check the fittings in the filter head(s) for leaks. Fittings should be tightened to 30 to 40 ft-lbs [41 to 54 N•m].

Check Engine Coolant

Periodic tests of the engine coolant should be made to ensure that the frequency of water filter servicing or concentration of DCA inhibitor is adequate to control corrosion for any specific condition of operation. In cases where "make-up" water must be added frequently, we suggest that a supply of water be treated and added as necessary.

The concentration of effective inhibitor dissolved in

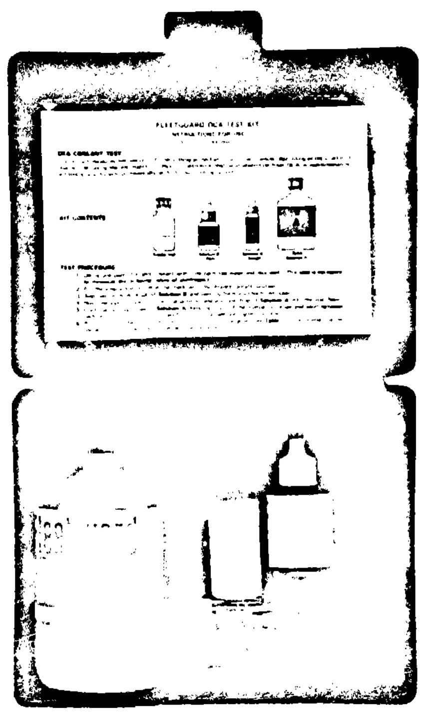


Fig. 2-21, (N12021). DCA coolant test kit the coolant can be measured by a Fleetguard DCA Coolant Checking Kit Part No. 3300846-S or Cummins 3375208 which is available from Cummins Distributors for this check. Fig. 2-21.

The test kit indicates DCA concentration by measuring the total nitrite of a coolant sample, which provides cylinder liner cavitation protection.

When antifreeze is present, it may contribute to the total nitrite, but most of the nitrite protection is obtained from the DCA inhibitor. In general, a good nitrite reading indicates that the combined inhibitor packages contained in the antifreeze (if used) and in DCA are sufficient to ensure complete cooling system protection.

Concentration Test Procedure

1. Rinse the plastic dropper pipet several times with the engine coolant. Fill the dropper exactly to the 1.0 ml. mark. Discharge into the empty vial.
2. Fill the vial to the 10 ml. scribe mark with tap water and mix well. (This dilution step is necessary to minimize the differing colors of antifreeze.)
3. Add two or three drops of Solution B and swirl to form a uniform red color.
4. Add one drop of Solution A to the vial, being careful to hold the dispenser provided in a vertical postion. Swirl.

Fig. 2-22, (V12022). Mixing bottle

5. Continue adding drops of solution A, keeping count of the number of drops and swirl between each drop until the color changes from red to a pale grey, green, or blue.
6. Record the number of drops required for the color change and consult Table 2-4 for coolant condition and recommended maintenance.

Adding Make-Up Coolant and DCA to Cooling System

1. Test the coolant for DCA according to the nitrite test procedure "With or Without Antifreeze"

Table 2-4: Number of Drops of Test Solution "A"

Coolant With Antifreeze	Coolant Without Antifreeze	Coolant Condition	Maintenance Required
0-12	0-6	Dangerous (0 to 0.6 oz. per gallon DCA)	Precharge system or add make-up DCA to top tank
12-17	7-12	Borderline (0.7 to 1.2 oz. per gallon DCA)	Replace service filter and/or add make-up DCA to top tank.
18-25	13-20	Acceptable (1.3 to 2.0 oz. per gallon DCA)	None.
25-30	20-30	Tolerable (2.0 to 3.0 oz. per gallon DCA)	None.
Over 30	Over 30	Overrated (over 3.0 per gallon DCA)	Drain part of coolant and make-up with plain antifreeze and water.

Note: Ethylene glycol/water solutions should not contain more than 3.0 oz. per gallon DCA or Dowtherm 209/water solutions should not contain more than 2.0 oz. per gallon DCA. Concentrations in excess of the above can cause sludge to form in the water filter.

depending on the presence or absence of antifreeze in the cooling system.

2. Estimate the make-up DCA. For example, if a fifteen gallon cooling system contains only 0.5 oz/gal. [4 ml per l] DCA, and 1.5 oz/gal. [12 ml per l] is required, 15 ounces [426 g] of DCA should be added to the make-up coolant.

Note: A one pint bottle of DCA-4L liquid (P/N 3300858) contains six dry ounces of DCA chemical in Step 2, concentrations are in dry ounces of chemical per gallon of coolant.

3. Estimate the total amount of make-up coolant required (gallons), and calculate the proportions of water and antifreeze, if used, required. For example, one gallon of 50-50 antifreeze/water solution will require two quarts of antifreeze and two quarts of water.
4. Add the required amount of water to a mixing container and dissolve the number of ounces of DCA obtained in Step 2 in the water. If negative or zero results were obtained in Step 2, do not add DCA. (For DCA to dissolve, water should be above 50°F [10°C].)
5. Add the required amount of antifreeze, if used, to the water solution and mix thoroughly.
6. Add the make-up coolant to the cooling system.

Note: If the DCA concentration is low, and the coolant level high, DCA may be added directly to the radiator in the amount indicated in Step 2. The engine should be running and warm enough to permit coolant circulation throughout the entire system.

Bulk Storage of Make-Up Coolant

If make-up coolant is stored in bulk, the following recommendations are provided for mixing and storing the coolant.

1. Drain and clean the bulk storage tank to remove any possible contaminants.
2. Knowing the total capacity of the holding tank, calculate the proportions of water and antifreeze, if used, required. For example, a 500 gallon [1892 l] tank will hold 250 gallons [946 l] of water and 250 gallons [946 l] of antifreeze for a 50-50 mixture.
3. Multiply the desired DCA concentration by the total capacity of the holding tank in gallons. In the example above, 1.5 oz. DCA per gallon [12 ml per l] of coolant can be used in the 50-50 mixture. Multiplying 1.5 oz. DCA per gallon [12 ml per l] times 500 gallons [1892 l] yields a total DCA requirement of 750 oz. [46 lb. 14 oz.) [21.3 kg].
4. Add the water to the holding tank. Agitating continuously, add the DCA to the water in small amounts until all of the chemical has dissolved. The water should be above 50°F [10°C].
5. Add the antifreeze last, if used, maintaining agitation to bring and keep the finished coolant in solution. Both antifreeze and DCA will settle to the bottom of the tank unless constant mixing or recirculation is provided. An example of recirculation is the use of a small pump operating continuously to draw DCA and antifreeze off the bottom of the tank and discharging the solution at the top. Samples of coolant can be drawn off the top, middle and bottom of the storage tank and tested for antifreeze and/or DCA concentration if inadequate mixing is suspected.

Change DCA Water Filter

Change the filter or element at each "B" Check; selection of element to be used should be based upon the size of the system. See "Coolant Specifications", Section 3.

Note: Whenever the coolant supply is changed the system must be drained, flushed, and precharged. See "Coolant Specifications", Section 3 for DCA compatibility with different brands of antifreeze.

Spin-On Element

1. Close the shut-off valves on the inlet and drain lines.
2. Unscrew the element and discard.
3. Apply a light even coat of lubricating oil to the

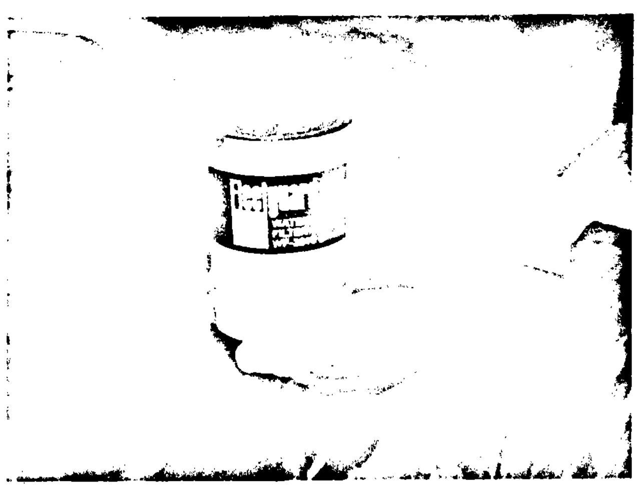


Fig. 2-23, (V514132). Installing DCA "spin-on" water filter gasket sealing surface prior to intalling the filter.

4. Install a new element, tighten until the seal touches the filter head. Tighten an additional one-half to three-fourths turn. Fig. 2-23. Open the shut-off valves.

Caution: Mechanical tightening will distort or crack the filter head.

Check Oil Levels

Check Aneroid Oil

1. Remove the pipe plug from the hole marked "Lub Oil".
2. Fill with engine lubricating oil to the level of the pipe plug hole. Reinstall the pipe plug.

Check Hydraulic Governor Oil Level

Keep the level half-way up on the inspection glass or to the high-level mark on the dipstick. Use the same grade oil as used in the engine.

Clean/Change Crankcase Breather

Mesh Element Breather

1. Remove the wing nut (6, Fig. 2-24), flatwasher and rubber washer securing the cover (1), to the breather body (5).
2. Lift off the cover and life out the breather element (2), vapor element (3), and gasket (4).
3. Clean all metal and rubber parts in an approved cleaning solvent. Dry thoroughly with compressed air.
4. Inspect the rubber gasket; replace it if necessary. Inspect the body and cover for cracks, dents or breaks; discard all unserviceable parts.
5. Install a cleaned or new breather element (2, Fig. 2-24) and cleaned vapor element (3) to the breather body (5).
6. Install the rubber gasket (4) in the cover (1); position the cover assembly to the body (5).
7. Install the rubber washer, flatwasher and wing nut (6); tighten securely.

Screen Element Breather — Cleaning and Inspection

1. Remove the vent tube if not previously removed.
2. Remove capscrews, washers, cover, screens and baffle if used, from the breather body. Fig. 2-25.

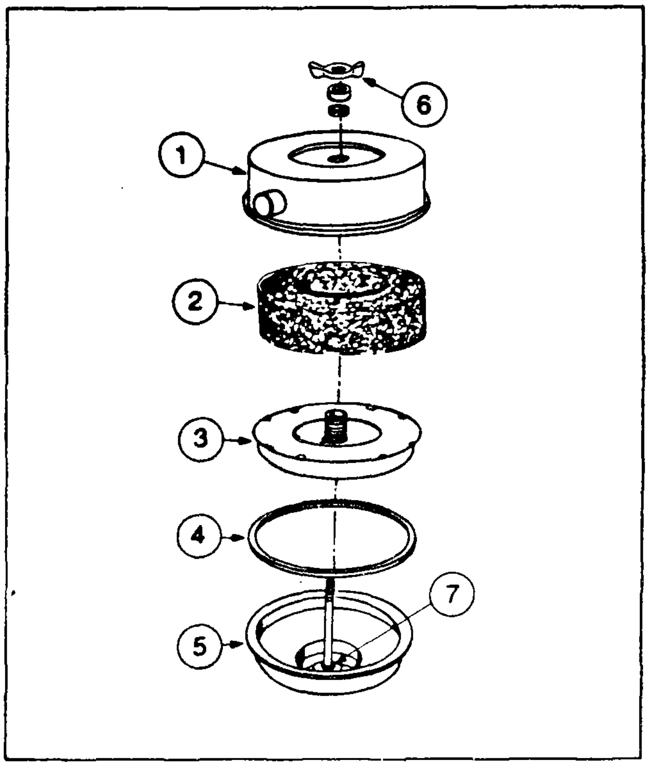


Fig. 2-24, (V51909). Crankcase breather — mesh element with vapor barrier


Fig. 2-25, (N11934). Crankcase breather — screen type

3. Clean the vent tube, screens and baffle in an approved cleaning solvent. Dry with compressed air. Wipe out the breather housing.
4. Assemble the baffle and screens, if used, and a new gasket in the body.
5. Replace the cover with the cover boss resting

securely on the point of the screen, if used; secure with washers and capscrews.

6. Replace the vent tube.

Clean Air Compressor Breather

When used, service breathers regularly as follows:

Bendix-Westinghouse Paper Element

Remove the breather cover and element. Fig. 2-26. Clean by reverse flushing with compressed air; reassemble on the compressor. Discard the element if it is damaged or unsuitable for cleaning.

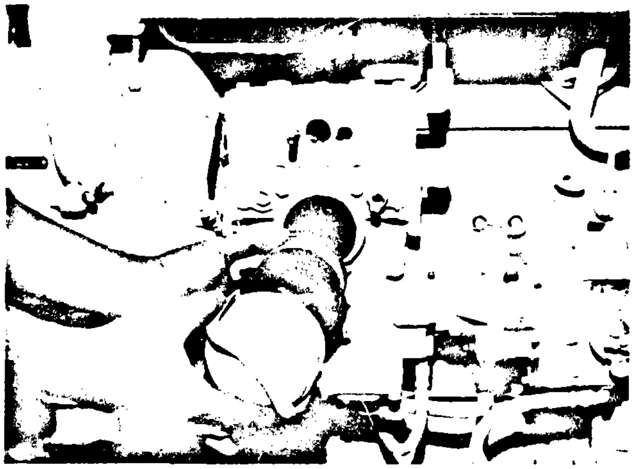


Fig. 2-26, (V41420). Bendix-Westinghouse air compressor breather

Bendix-Westinghouse Sponge

Remove the breather from the air compressor. Disassemble the breather, wash all metal parts in solvent and blow dry with compressed air. Wash the element in solvent; remove all solvent from the element; dip it in clean engine oil and squeeze excess oil from the element.

Cummins Paper

Clean the element at each "D" maintenance check. Remove the wing nut securing the front cover to the body. Lift off the front cover and element. Inspect the paper element before cleaning by reverse flow of compressed air; discard the element if it is damaged or unsuitable for cleaning. Fig. 2-27.

Caution: Do not rupture the filter element.

Clean the body and front cover with a clean cloth. With the rubber gasket on center bolt, place the element in the front cover and assemble over the center bolt; secure with the wing nut.

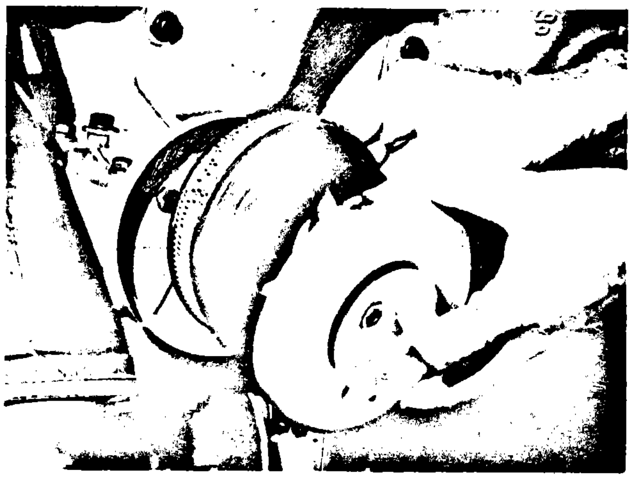


Fig. 2-27, (V414209). Cummins air compressor breather — paper element

Note: At any time the three-prong unloader hat is used, it will set up air pulsations across the compresor intake which can destroy the paper element. Pipe intake air for Cummins compressors from the engine air manifold when the three-prong unloader hat is applied; current factory-installed compressors are so equipped. This same procedure may be used for any Cummins Compressor in the Field.

Clean Tray Screen

Clean the tray screen in kerosene or cleaning solvent. Dry with compressed air, reassemble to the cleaner.

Note: If the tray screen is extremely dirty, it may be necessary to singe the screen with a flame. Do not melt the tin plate on the screen.

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all 'A", and "B" Checks in addition to those following:

Adjust Injectors and Valves

It is essential that the injectors and valves be in correct adjustment at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Final operating adjustments must be made using correct values as stated.

Caution: Be sure the injector and valve set markings, wherever located, are in proper alignment with the indicator mark.

Temperature Settings

The following temperature conditions provide the necessary stabilization of engine components to assure accurate settings.

Definition of "Cold Set"

The engine must have reached a stabilized temperature (4 hours minimum) without operation in ambient temperature where the adjustments are to be made.

Definition of "Hot Set"

1. Adjust the injectors and valves immediately after the engine has been operated at 210°F [99°C] oil sump temperature for a period of 10 minutes minimum, or until normal oil operating temperature has been obtained.
2. If an oil temperature gauge is unavailable, set the injectors and valves immediately after the engine has operated at rated speed and load or at high idle for a period of 40 minutes minimum.

Injector Plunger Adjustment Using Torque Method, V/VT-378, V/VT-504, V/VT-555 Engines

The injectors and valves must be in correct adjustment at all times for the engine to operate properly. This controls engine breathing and fuel delivery to the cylinders. Final adjustment must be made when the engine is at operating temperature. The injectors must always be adjusted before the valves. The procedure is as follows:

Valve Set Mark Alignment

1. Turn the crankshaft in direction of rotation until No. 1 "VS" mark appears on the vibration damper or crankshaft pulley. See Fig. 2-28 for the location of the valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1; if not, advance the crankshaft one revolution. See Fig. 2-29, Fig. 2-30 and Table 2-5 for firing order.

Fig. 2-28, (OM103). Valve set marks — V/VT-378, V/VT-504, V/VT-555 Engines

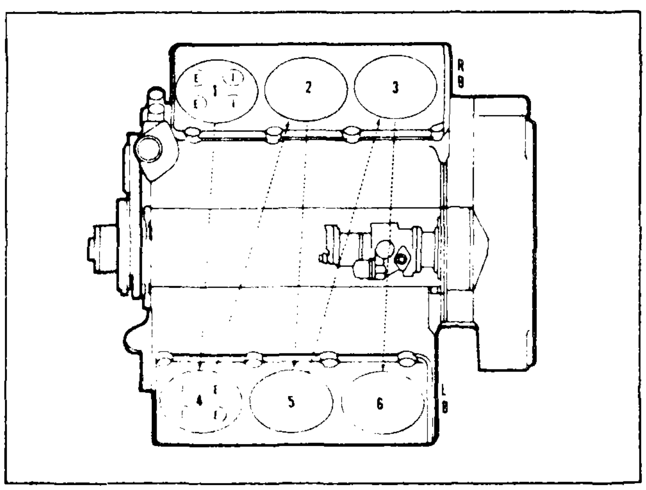


Fig. 2-29, (V11461). V6 firing order

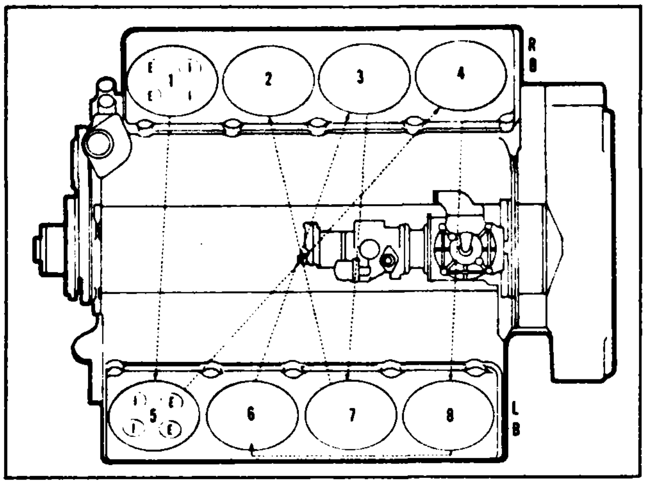


Fig. 2-30, (V11462). V8 firing order

Note: Do not use the fan to rotate the engine.

2. Adjust the injector plunger, then the crossheads and valves of the first cylinder as explained in succeeding paragraphs. Turn the crankshaft in the direction of rotation to the next "VS" mark corresponding to the firing order of the engine and the corresponding cylinder will be ready for adjustment. See Table 2-5.
3. Continue turning the crankshaft in the direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

Table 2-5: Engine Firing Order V Engines

Right Hand	V8	1-5-4-8-6-3-7-2
Right Hand	V6	1-4-2-5-3-6

Note: Two complete revolutions of the crankshaft are needed to set all injector plungers and valves. The injector and valves can be adjusted for only one cylinder at any one "VS" setting.

Injector Plunger Adjustment

Before adjusting the injector, tighten the injector hold-down capscrew to 30 to 35 ft-lbs [41 to 47 N•m].

The injector plungers of all engines must be adjusted with an in-lb torque wrench to a definite torque setting. Snap-On Model TQ12B or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. Fig. 2-31.

1. Turn the adjusting screw down until the plunger contacts the cup and advance an additional 15 degrees to squeeze the oil from the cup.

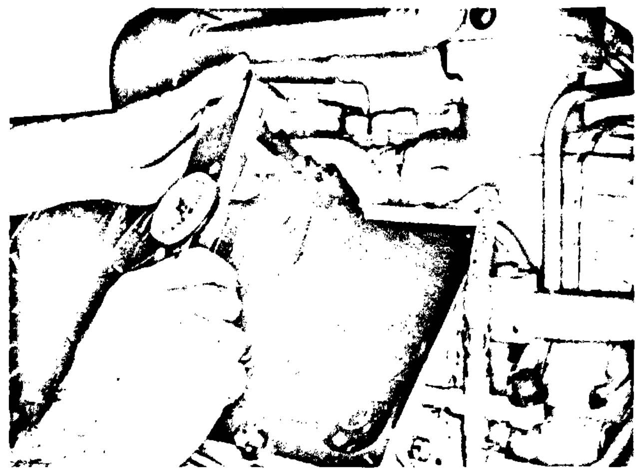


Fig. 2-31, (V11914). Adjusting injector plunger

2. Loosen the adjusting screw one turn. Using a torque wrench calibrated in in-lbs and a screwdriver adapter, tighten the adjusting screw to the values shown in Table 2-6 for cold setting and tighten the locknut.

Table 2-6: Injector Plunger Adjustment Torque V/VT-378, V/VT-504, V/VT-555 Engines

Oil Temperature Cold	Oil Temperature Hot
60 in-lbs [6.8 N•m]	60 in-lbs [6.8 N•m]

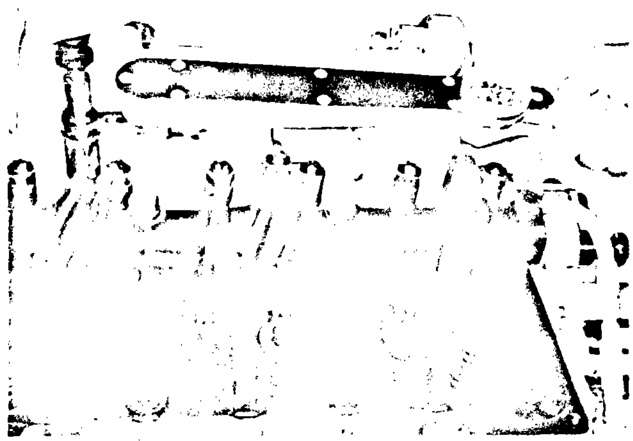


Fig. 2-32, (V114115). Tightening adjusting screws locknut

Note: After all the injectors and valves are adjusted and the engine has been started and warmed up to 140°F [69°C] oil temperature, reset the injectors to the warm setting. This is only necessary if the injectors, lever assemblies, or push rods have been changed.

3. Hold the injector adjusting screw and tighten the injector adjusting screw locknut to the values indicated in Table 2-7.

When an ST-669 Adapter is used, nut torque is reduced to compensate for additional torque arm length. Fig. 2-32.

Table 2-7: Injector and Valve Locknut Torque V/VT-378, V/VT-504, V/VT-555 Engines

Without ST-669	With ST-669
40 to 45 ft-lbs. [54 to 61 N•m]	30 to 35 ft-lbs. [41 to 47 N•m]

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead asjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw one turn.
2. Use light finger pressure at the rocker lever contact surface to hold the crosshead in contact with the valve stem (without the adjusting screw).

Fig. 2-33, (V11915). Adjusting crossheads

3. Turn down the crosshead adjusting screw until it touches the valve stem. Fig. 2-33.
4. Hold the adjusting screw in this position and torque the locknut to the values listed in Table 2-8.
5. Check the clearance between the crosshead and the valve spring retainer with a wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

The same crankshaft position used in adjusting the injectors is used for setting the intake and exhaust valves.

Table 2-8: Crosshead Locknut Torque

Without ST-669	With ST-669
25 to 30 ft-lbs. [34 to 41 N•m]	22 to 26 ft-lbs. [30 to 35 N•m]

1. Loosen the locknut and back off the adjusting screw. Insert a feeler gauge between the rocker lever and the top of the crosshead. Valve clearances are shown in Table 2-9. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Fig. 2-34. Torque the locknut to the values indicated in Table 2-7; note Step 2 under "Injector Plunger Adjustment".

Table 2-9: Valve Clearances — Inch [mm] V/VT-378, V/VT-504, V/VT-555 Engines

Intake Valve Oil Temperature		Exhaust Valve Oil Temperature	
Cold	Hot	Cold	Hot
0.012 [0.30]	0.010 [0.25]	0.022 [0.56]	0.020 [0.51]

2. Always make the final valve adjustment after the injectors are adjusted and with the engine at operating temperature.

V-903 Engines Injector Adjustment, Using Dial Indicator Method

This method involves adjusting the injector plunger

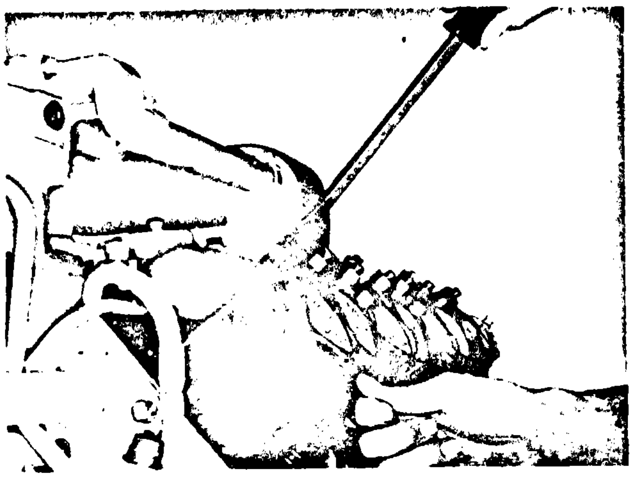


Fig. 2-34, (V11916). Adjusting valves

travel with an accurate dial indicator rather than tightening the adjusting screw to a specified torque.

The "indicator method" eliminates errors in adjustment caused by friction in the screw threads and distortion from overtightening the adjusting screw locknut. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-10 for specifications.

Table 2-10: Adjustment Limits Using Dial Indicator Method Inch [mm] V-903 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
1 to 1 Rocker Lever Ratio — Injector Lever P/N 211319		
0.187 ± 0.001 [4.75 ± 0.03]	0.012 [0.30]	0.025 [0.64]

Before adjustment, tighten the injector hold-down capscrew to 30 to 35 ft-lbs [41 to 47 N•m] torque.

Note: Remove the key, and using either a 3/8 inch hex drive for female type barring device or a 5/8 inch six-point socket for the male type barring device, press inward until the barring gear engages the drive gear; then advance. Fig. 2-35. After completion of adjustment, be sure the drive retracts and install the key into the safety lock groove.

Using the regular engine barring device, Fig. 2-35, rotate the engine in the direction of rotation with the "VS" mark for cylinder 2-8 is aligned with the pointer. In this position both the intake and exhaust valve rocker levers for No. 2 cylinder should be free and can be moved up and down. If not, bar the engine another 360 degrees in the direction of rotation and realign the 2-8 "VS" mark.

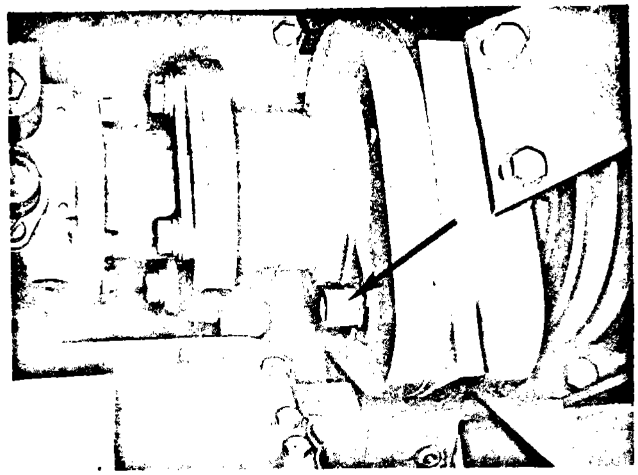


Fig. 2-35, (V51486). Engine barring arrangements — V-903

The timing mark locations (Fig's. 2-36 and 2-37) are used with the dial indicator method of setting the injectors and valves. Alignment, in either location, should be held to within one-half inch [12.7 mm] of the pointer.

Fig. 2-36, (V514115). Valve set marks on vibration damper — V-903

Note: No. 2 cylinder is selected for the purpose of illustration only. Any other cylinder could be used, if so desired.

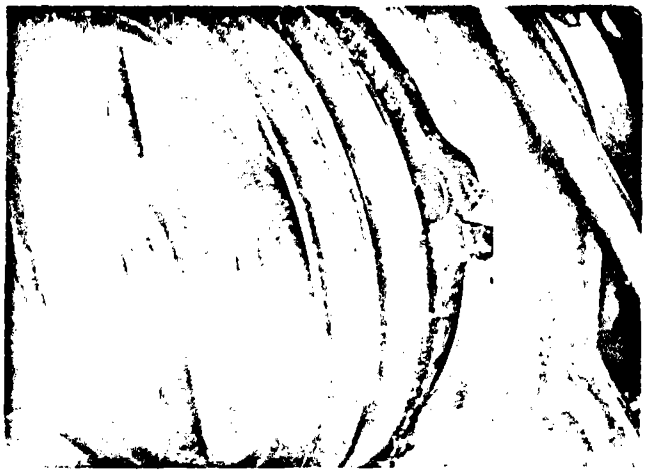


Fig. 2-37, (V514127). Valve set mark on accessory drive — V-903

1. Set up the ST-1270 Indicator Support with the indicator extension atop the injector plunger flange at No. 2 cylinder, Fig. 2-38.

Fig. 2-38, (V514114). Dial indicator in place — V-903

2. Screw the injector lever adjusting screw down until the plunger is bottomed in the cup, back off approximately 1/2 turn then bottom again, set the dial indicator at zero (0).

Note: Care must be taken to assure the injector plunger is correctly bottomed in the cup, without overtightening the adjusting screw, before setting the dial indicator.

3. Back the adjusting screw out until a reading of 0.187 inch [4.75 mm], reference Table 2-10, is obtained on the dial indicator. Snug tighten the locknut.

4. Using ST-1251 Rocker Lever Actuator, bottom the injector plunger, check the zero (0) setting. Fig. 2-39. Allow the plunger to rise slowly, the indicator must show the plunger travel to be within the range specified in Table 2-10.

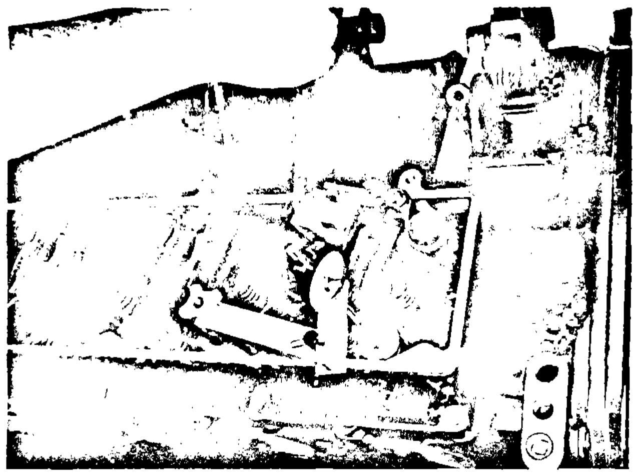


Fig. 2-39, (V514128). Bottoming injector plunger in cup — V-903

5. Using ST-669 Torque Wrench Adapter to hold the adjusting screw in position, torque the locknut 30 to 35 ft-lbs [41 to 47 N•m]. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver, torque the locknuts 40 to 45 ft-lbs [54 to 61 N•m].

6. Actuate the injector plunger several times as a check of the adjustment. Remove the dial indicator assembly.

7. Adjust the valves on the appropriate cylinder as determined in Step 1 and Table 2-10. Tighten the locknuts the same as the injector locknut.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw one turn.

2. Use light finger pressure at the rocker lever contact surfgace to hold the crosshead in contact with the valve stem (without adjusting screw). Fig. 2-40.

3. Turn down the crosshead adjusting screw until it touches the valve stem.

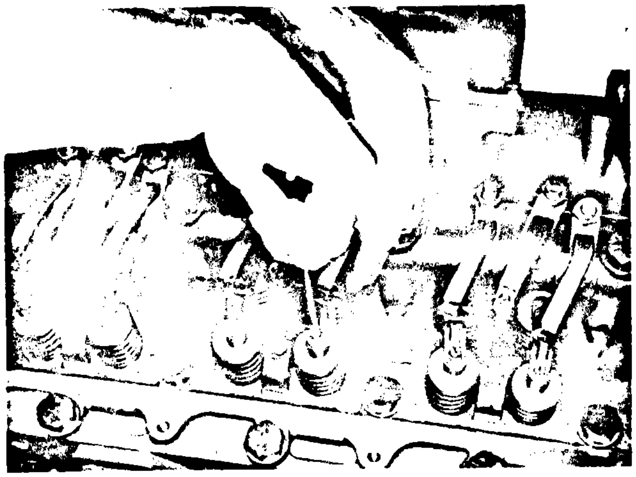


Fig. 2-40, (V51490). Adjusting crossheads — V-903

4. Hold the adjusting screw in position and torque the locknut to the values listed in Table 2-8.

Note: Be sure that the crosshead retainer on the exhaust valves, if used, are positioned equally on both sides of the spring over the crossheads and valve springs properly.

5. Check the clearance between the crosshead and the valve spring retainer with a wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

1. Loosen the locknut and back off the adjusting screw. Insert a feeler gauge between the rocker lever and the top of the crosshead. Fig. 2-41. Valve clearances are shown in Table 2-10. Turn the screw down until the lever just touches the gauge, and lock the adjusting screw in position with the locknut. Torque the adjusting screw locknuts to 40 to 45 ft-lb [54 to 61 N•m] or 30 to 35 ft-lb [41 to 47 N•m] when using an ST-669 Adapter.

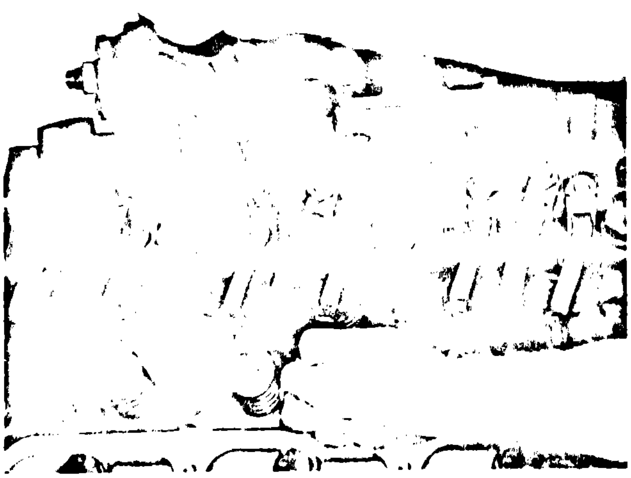


Fig. 2-41, (V51492). Adjusting valves — V-903

2. Always make the final valve adjustment after the injectors are adjusted.

NH-743, N-855, C.I.D. Engines, Injector and Valve Adjustment (Dial Indicator Method)

Note: Before adjusting the injectors and valves be sure to determine if the rocker housings are cast iron or aluminum and use the appropriate setting.

Before adjusting the injectors, torque the cylindrical injector, hold-down capscrews in alternate steps to 10 to 12 ft-lbs [14 to 16 N•m]. With flange injectors torque the hold-down capscrews in alternate steps to 12 to 14 ft-lbs [14.6 to 18 N•m]. Tighten the fuel inlet and drain connections to 20 to 25 ft-lbs [27 to 34 N•m] in the flange injectors.

Maintenance Adjustment

1. Bar the engine until "A" or 1-6 "VS" mark on the pulley, Fig. 2-42, is aligned with the pointer on the gear case cover. In this position, both valve rocker levers for cylinder No. 5 must be free (valves closed). The injector plunger for cylinder No. 3 must be at top of its travel; if not, bar the engine 360 degrees, realign the mark with the pointer.
2. Set up ST-1170 Indicator Support with the indicator extension on the injector plunger top at No. 3

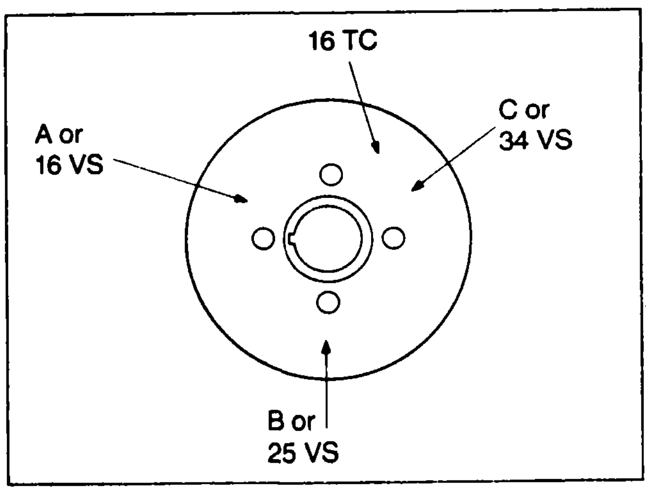


Fig. 2-42, (N114230). Accessory drive pulley marking — N-855

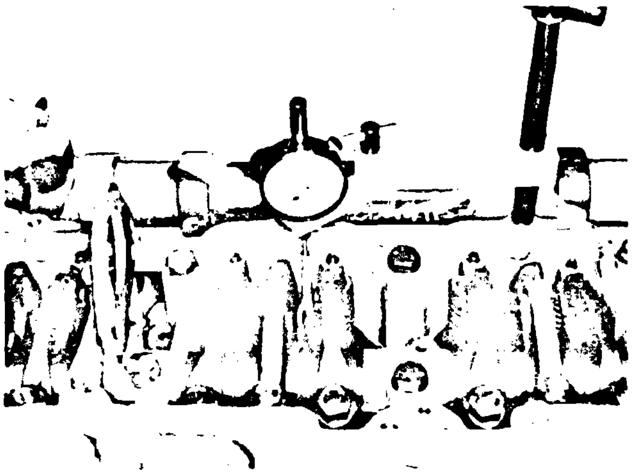


Fig. 2-43, (N114231). Dial indicator in place — extension in contact with plunger — N-855

cylinder, Fig. 2-43. Make sure the indicator extension is secure in the indicator stem and not against the rocker lever.

Note: Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only. Any cylinder combination may be used as a starting point. See Tabel 2-11.

Table 2-11: Injector and Valve Set Position N-855 Engines

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A or 1-6VS	3	5
Adv. To	B or 2-5VS	6	3
Adv. To	C or 3-4VS	2	6
Adv. To	A or 1-6VS	4	2
Adv. To	B or 2-5VS	1	4
Adv. To	C or 3-4VS	5	1

3. Using ST-1193 Rocker Lever Actuator, Fig. 2-44, or equivalent, bar the lever toward the injector until the plunger is bottomed to squeeze the oil film from the cup. Allow the injector plunger to rise, then bottom again. Set the indicator at zero (0). Check the extension contact with the plunger top.
4. Bottom the plunger again, release the lever; the indicator must show travel as indicated in Table 2-12. Adjust as necessary.
5. If loosened, tighten the locknut to 40 to 45 ft-lbs [54 to 61 N•m] and actuate the injector plunger several times as a check of the adjustment. Tighten to 30 to 35 ft-lbs [41 to 47 N•m] when using ST-669 Adapter.

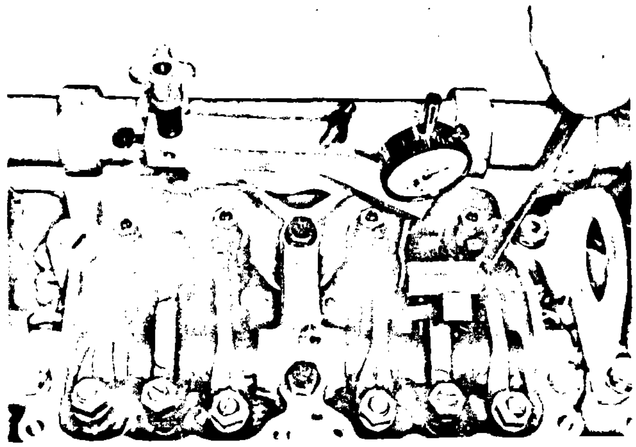


Fig. 2-44, (N114232). Bottoming injector plunger in cup — N-855

Table 2-12: Adjustment Limits Using Dial Indicator Method Inch [mm] N-855 Engines

Oil Temp.	Injector Plunger Travel Inch [mm]	Valve Clearance Inch [mm]	
	Adj. Value	Intake	Exhaust
Aluminum Rocker Housing			
Cold	0.170 [4.32]	0.011 [0.28]	0.023 [0.58]
Hot	0.170 [4.32]	0.011 [0.28]	0.023 [0.58]
Cast Iron Rocker Housing			
Cold	0.175 [4.45]	0.013 [0.32]	0.025 [0.63]
Hot	0.170 [4.32]	0.011 [0.28]	0.023 [0.58]
NT-855 (Big Cam only — Non Top-Stop)			
	0.228 [5.79]	0.011 [0.28]	0.023 [0.58]

Note: Check engine dataplate for injector and valve setting.

Adjust Injectors and Valves (Torque Method) V-1710, NH-743, N-855 C.I.D. Engines

Timing Mark Alignment

1. If used, pull the compression release lever back and

block in the open position only while barring the engine.

2. Loosen the injector rocker lever adjusting nut on all cylinders. This will aid in distinguishing between cylinders adjusted and not adjusted.

Note: Before adjusting the injectors and valves be sure to determine if the rocker housings are cast iron or aluminum and use the appropriate setting.

3. Bar the engine in the direction of rotation until a valve set mark (Fig's. 2-45, 2-46 and 2-47) aligns with the mark or pointer on the gear case cover. Example: A or 1-6 "VS" on Inline Engines or 1-6R "VS" on V-1710 Engines.
4. Check the valve rocker levers on the two cylinders aligned as indicated on the pulley. On one cylinder of the pair, both rocker levers will be free and the

Fig. 2-45, (V41484). Valve set mark — V-1710

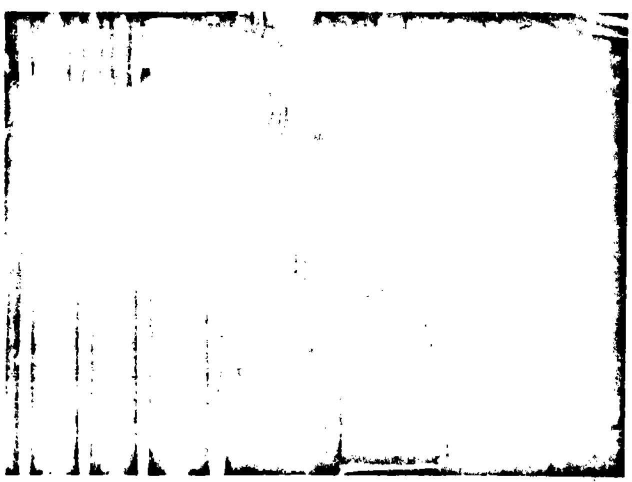


Fig. 2-46, (N114220-A). Valve set mark — N-855

valves closed; this is the cylinder to be adjusted.

5. Adjust the injector plunger first, then the cross-heads and valves to the clearances indicated in the following paragraphs.
6. For the firing order See Table 2-13 for Inline Engines and Tabel 2-14 and Fig. 2-47 for V-1710 Engines.

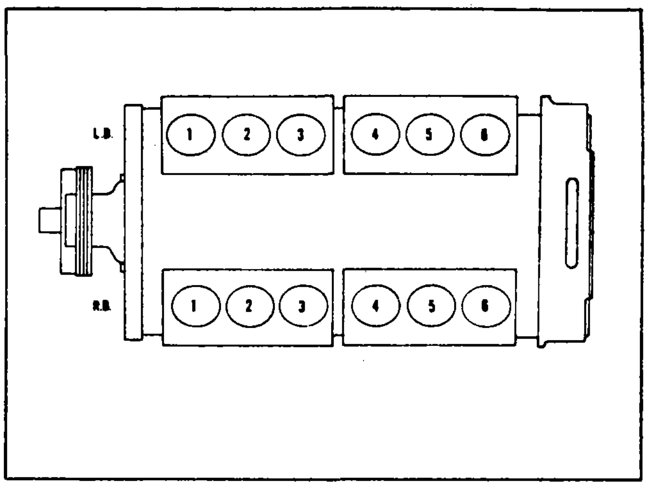


Fig. 2-47, (V414231). V-1710 piston position

Table 2-13: Engine Firing Order N-855 Engines

Right Hand Rotation	Left Hand Rotation
1-5-3-6-2-4	1-4-2-6-3-5

Table 2-14: Firing Order V-1710 Engines

Right Hand —

1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Left Hand —

1L-4R-3L-2R-5L-1R-6L-3R-4L-5R-2L-6R

7. Continue to bar the engine to the next "VS" mark and adjust each cylinder in the firing order.

Note: Only one cylinder is aligned at each mark. Two complete revolutions of the crankshaft are required to adjust all cylinders.

Injector Plunger Adjustment

The injector plungers must be adjusted with an inch-pound torque wrench to a definite torque setting.

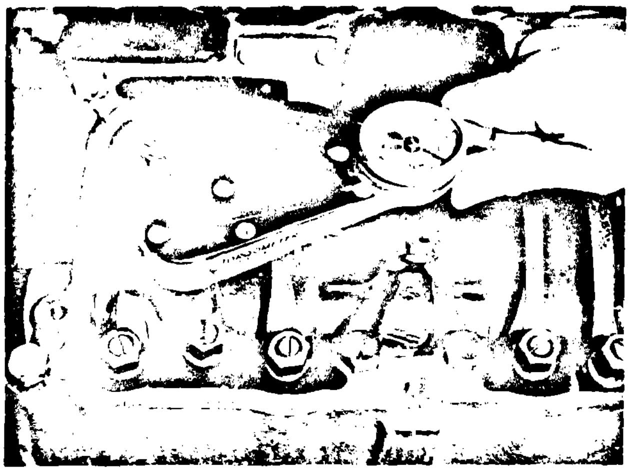


Fig. 2-48, (V414190). Adjusting injector plunger — V-1710

Fig. 2-49, (N11466). Adjusting injector plunger — N-855

Snap-On Model TE-12 or equivalent torque wrench and a screwdriver adapter can be used for this adjustment. See Fig's. 2-48 and 2-49.

1. Turn the adjusting screw down until the plunger contacts the cup and advance an additional 15 degrees to squeeze the oil from the cup.

Note: Number one L and one R cylinders on V-1710 Engines are at the gear case of the engine.

2. Loosen the adjusting screw one turn; then using a torque wrench calibrated in inch-pounds and a screwdriver adapter tighten the adjusting screw to the value shown in Tabel 2-15 and tighten the locknut to 40 to 45 ft-lbs [54 to 61 N•m] torque. If ST-669 Torque Wrench Adapter is used, torque to 30 to 35 ft-lbs [41 to 47 N•m].

Crosshead Adjustment

Crosseheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw (4, Fig. 2-50) one turn.

Table 2-15: Injector Plunger Adjustment — Inch-lbs [N•m]

Cold Set	Hot Set
V-1710 Engines	
50 [0.6]	
NH-NT-743 and 855 Engines Cast Iron Rocker Housing	
48 [5.4]	72 [8.1]
Aluminum Rocker Housing	
71 [8.1]	72 [8.1]

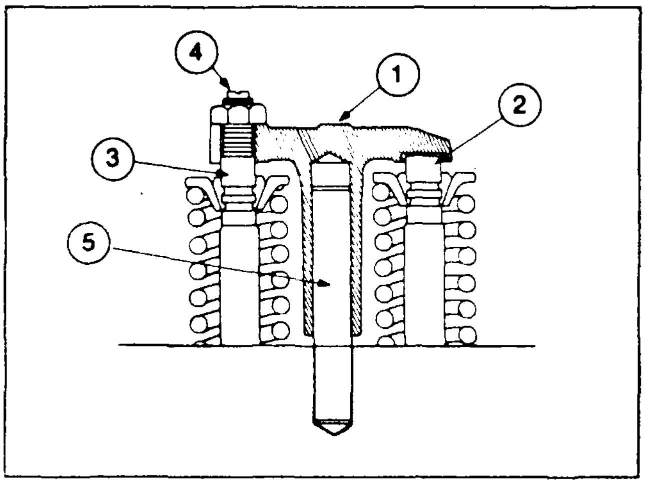


Fig. 2-50, (N21461). Valve crosshead

2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2).

3. Turn down the crosshead adjusting screw until it touches the valve stem (3).

4. Using ST-669 Torque Wrench Adapter, tighten the locknut to 22 to 26 ft-lbs [30 to 35 N•m]. If ST-669 is not available, hold the screws with a

screwdriver and tighten the locknuts to 25 to 30 ft-lbs [34 to 41 N•m].

5. Check the clearance between the crosshead and the valve spring retainer with a wire gauge. There must be a minimum of 0.020 inch [0.51 mm] clearance at this point.

Valve Adjustment

The same engine position used in adjusting the injectors is used for setting the intake and exhaust valves.

1. While adjusting the valves, make sure that the compression release, on those engines so equipped, is in the running position.
2. Loosen the locknut and back off the adjusting screw. Insert a feeler gauge between the rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Tighten the locknut to 40 to 45 ft-lbs [54 to 61 N•m] torque. When using ST-669 torque to 30 to 35 ft-lbs [41 to 47 N•m].
3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 2-16 for the appropriate valve clearances.

Table 2-16: Valve Clearances — Inch [mm]

Intake Valves		Exhaust Valves	
Cold Set	**Hot Set**	**Cold Set**	**Hot Set**
V-1710 Engines			
0.014 [0.36]		0.027 [0.69]	
NH-NT-743 and 855 Engines			
Cast Iron Rocker Housing			
0.016 [0.41]	0.014 [0.36]	0.029 [0.74]	0.027 [0.69]
Aluminum Rocker Housing			
0.014 [0.36]	0.014 [0.36]	0.027 [0.69]	0.027 [0.69]

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit KT(A)-1150 Engines

This method involves adjusting the injector plunger travel with an accurate dial indicator. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 2-17.

3375004 Injector Adjustment Kit is used to adjust the injectors with or without Jacobs Brake units installed.

It is essential that the injectors and valves be in correct adjustment at all times for the engine to operate properly.

Table 2-17: Injector and Valve Set Position KT(A)-1150

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Adv. To	B	6	3
Adv. To	C	2	6
Adv. To	A	4	2
Adv. To	B	1	4
Adv. To	C	5	1

Firing Order 1-5-3-6-2-4

One controls engine breathing; the other controls fuel delivery to the cylinders.

Operating adjustments must be made using the correct values as stated.

Injector and Valve Adjustment

Note: Do not use the fan to rotate the engine. Remove the shaft retainer key. Fig. 2-51, and press the shaft inward until the barring gear engages the drive gear; then advance. After the adjustments are complete retract the shaft and install the retainer key into the safety lock groove.

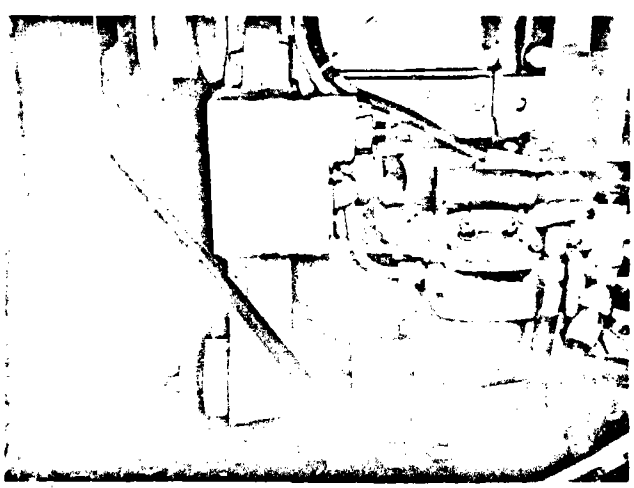


Fig. 2-51. (K11919). Engine barring arrangement — KT(A)-1150

Caution: The barring mechanism gear must be completely engaged when barring the engine to avoid damage to the teeth of the gear.

1. Bar the engine in the direction of rotation until "B" mark on the pulley, Fig. 2-52, is aligned with pointer on the gear case cover. In this position, both valve rocker levers for cylinder No. 3 must be free (valves closed). The injector plunger for cylinder No. 6 must be at top of travel; if not, bar the engine 360 degrees, realign the marks with the pointer.

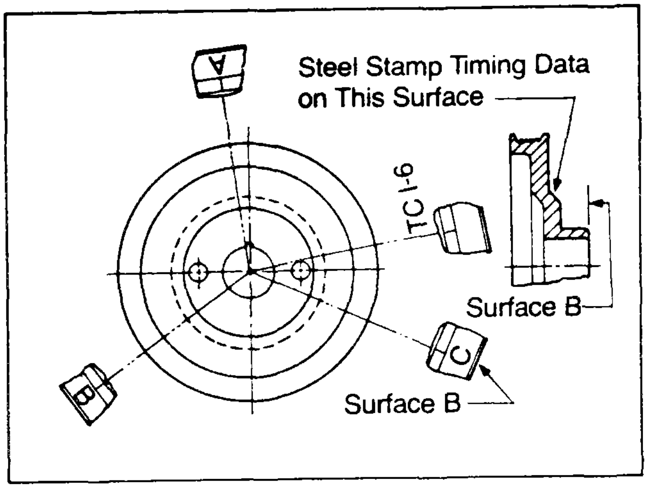


Fig. 2-52, (K11920). Accessory drive pulley marking — KT(A)-1150

Note: The injector and valves on any one (1) cylinder can not be set at the same valve set position. Example: If the rocker levers on No. 3 cylinder are free (valves closed) the injector plunger travel on No. 6 cylinder is to be adjusted. Any valve set position may be used as a starting point. See Table 2-17.

2. Install 3375004 Dial Indicator Assembly to the rocker housing, extension (3375005) must go through the opening in the Jacobs Brake housing and contact the injector plunger top, Fig. 2-53.

3. Screw the injector lever adjusting screw down until the plunger is bottomed in the cup, back off approximately 1/2 turn then bottom again, set the dial indicator at zero (0).

Note: Care must be taken to assure the injector plunger is correctly bottomed in the cup, without overtightening the adjusting screw, before setting the dial indicator.

4. Back the adjusting screw out until a reading of 0.304 inch [7.72 mm], reference Table 2-18, is obtained on the dial indicator. Snug tighten the locknut.

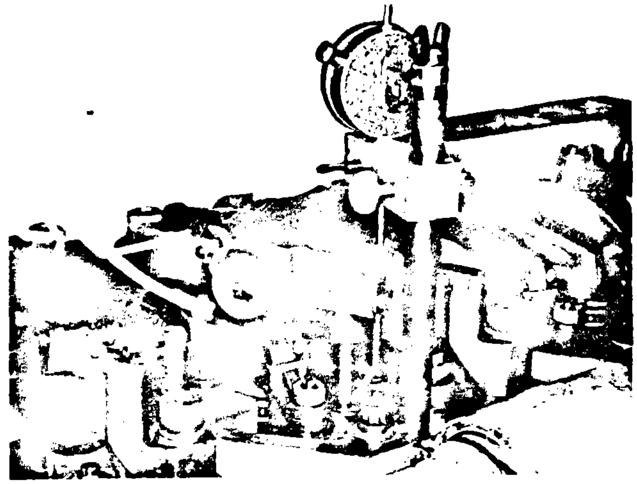


Fig. 2-53, (K114130). Dial indicator in place — extension in contact with plunger — KT(A)-1150

5. Using 3375009 Rocker Lever Actuator Assembly and Support Plate, bottom the injector plunger, check the zero (0) setting. Fig. 2-54. Allow the plunger to rise slowly; the indicator must show the plunger travel to be within the range specified in Table 2-18.

Table 2-18: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-1150 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.304 ± 0.001 [7.72 ± 0.03]	0.014 [0.36]	0.027 [0.69]

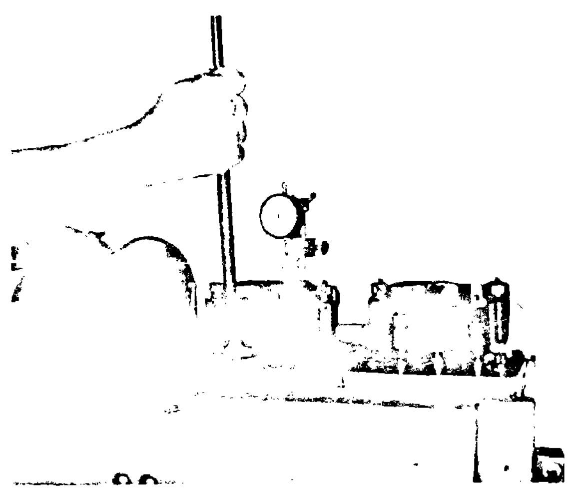


Fig. 2-54, (K114104). Actuating rocker lever

6. Using ST-669 Torque Wrench Adapter to hold the adjusting screw in position, torque the locknut to 30 to 35 ft-lbs [41 to 47 N•m]. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver, torque the locknuts to 40 to 45 ft-lbs [54 to 61 N•m].
7. Actuate the injector plunger several times as a check of the adjustment. Remove the dial indicator assembly.

Caution: If Jacobs Brake is not used, be sure the crossheads are adjusted before setting the valves. See Crosshead Adjustment following.

8. Adjust the valves on the appropriate cylinder as determined in Step 1 and Table 2-18. Tighten the locknuts the same as the injector locknut.
9. If Jacobs Brake is used, use 3375012 (0.018 inch [0.46 mm] thick) Feeler Gauge and 3375008 Torque Wrench Adapter, set the exhaust valve crosshead to Jacobs Brake slave piston clearance. Fig. 2-55.

Fig. 2-55, (K114105). Adjusting crosshead to slave piston clearance

Note: Turn both adjusting screws alternately and evenly until the crosshead and feeler gauge contact the slave piston and the adjusting screws are bottomed on the valve stem. Back the adjusting screws out one-fourth (1/4) to one-half (1/2) turn. Starting with the outer adjusting screw (next to water manifold), then moving to the screw under the rocker lever, retighten gradually until the crosshead and feeler gauge contact the slave piston. Snug tighten the locknuts.

10. Hold the crosshead adjusting screws with a screwdriver, torque the locknuts 22 to 26 ft-lbs [20 to 35 N•m] using 3375008 Adapter and torque wrench.
11. See Table 2-18 for valve clearance values.
12. Repeat the adjustment procedure for each cylinder. See Table 2-17 for firing order and injector and valve set positions.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw (4, Fig. 2-56) one turn.

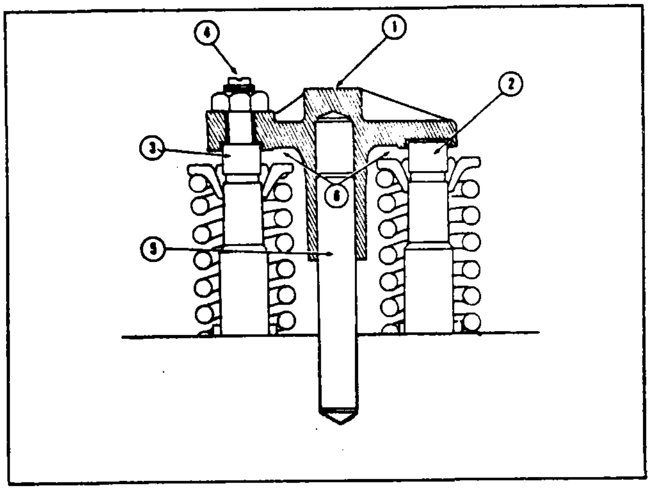


Fig. 2-56, (K21924). Valve crosshead

2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2) (without adjusting screw).
3. Turn down the crosshead adjusting screw until it touches the valve stem (3).
4. Using ST-669 Torque Wrench Adapter, tighten the locknuts to 22 to 26 ft-lbs [30 to 35 N•m]. If ST-669 is not available, hold the screws with a screwdriver and tighten the locknuts to 25 to 30 ft-lbs [34 to 41 N•m].
5. Check the clearance (6) between the crosshead and valve spring retainer with a wire gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Injector and Valve Adjustment Using 3375004 Dial Indicator Kit (KT(A)-2300 and KTA-3067 Engines

Valve Set Mark Alignment

Note: KT(A)-2300 and KTA-3067 injectors, crossheads and valves are adjusted to the same values. Refer to Fig's. 2-57 and 2-58 for specific cylinder arrangement and engine firing order.

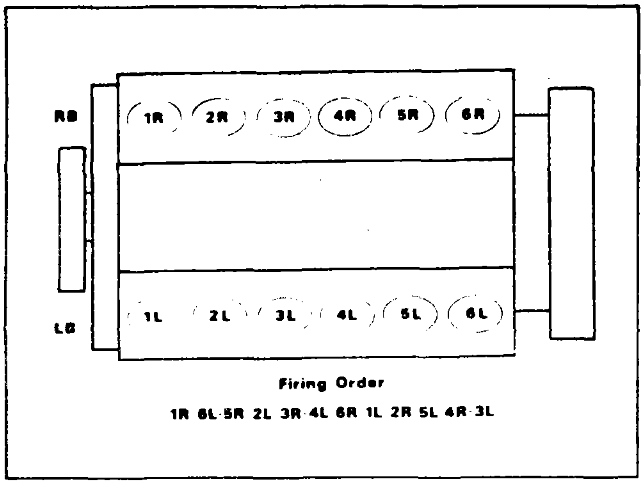


Fig. 2-57, (K21916). Cylinder arrangement and firing order — KT(A)-2300

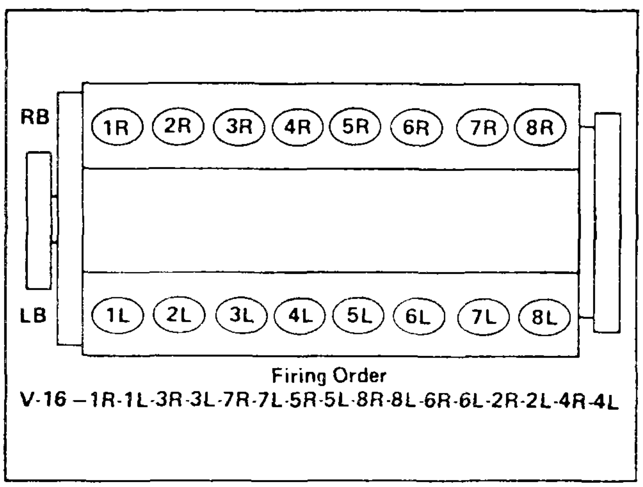


Fig. 2-58, (OM204). Cylinder arrangement and firing order — KTA-3067

Three locations are provided where valve and injector alignment marks may be viewed. Injector plunger travel and valves both may be set on one cylinder at the same valve set location. The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.

Note: The barring mechanism may be located on either the left bank or right bank at the flywheel housing. The cover plate on opening "A" or "C" directly above the barring mechanism must be removed when viewing the timing marks at the flywheel housing.

1. When viewing the engine at the vibration damper, Fig. 2-59, align the timing marks on the damper with the pointer on the gear case cover.

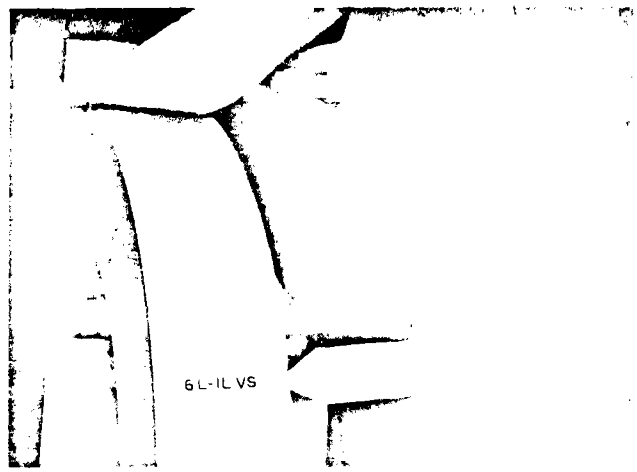


Fig. 2-59, (K21917). Valve set marks on vibration damper — KT(A)-2300

2. When barring the engine from the right bank at the flywheel housing "A" VS timing marks on the flywheel (1, Fig. 2-60) must align with the scribe mark (2) when viewed through the opening marked "A" on the flywheel housing.

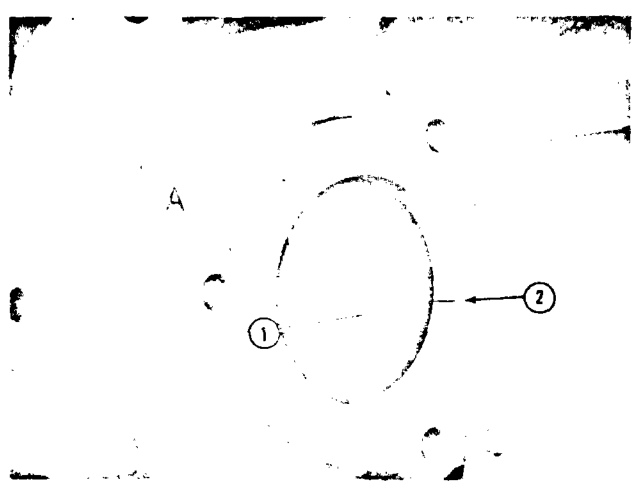


Fig. 2-60, (K21918) Valve set marks on right bank flywheel and housing — KT(A)-2300

3. When barring the engine from the left bank at the flywheel housing "C" VS timing marks on the flywheel (1, Fig. 2-16) must align with the scribe mark

(2) when viewed through the opening marked "C" on the flywheel housing.

Caution: When aligning valve set marks at either flywheel housing location, care must be taken to assure that "A" or "C" valve set marks on the flywheel match "A" or "C" marks on the flywheel housing opening.

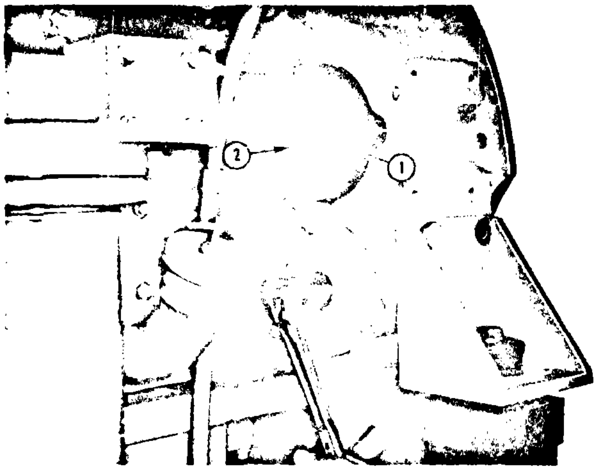


Fig. 2-61. (K21919). Engine barring device

Injector Plunger Adjustment

1. Bar the engine in the direction of rotation until the appropriate valve set mark is algined with the scribe mark on the flywheel housing or until a valve set mark on the vibration damper is aligned with the pointer on the gear case cover.

Note: Any valve set position may be used as a starting point when adjusting the injectors, crossheads and valves. Determine which of the two (2) cylinder indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

2. Set up 3375007 Indicator Support on the rocker lever housing, of the cylinder selected, with the indicator extension 3375005 on the injector plunger top. Fig. 2-62.

Note: Make sure the indicator extension is secure in the indicator stem and is not touching the rocker lever.

3. Using the rocker lever actuator, Fig. 2-63, depress the lever toward the injector until the plunger is bottomed in the cup to squeeze the oil film from the cup. Allow the injector plunger to rise, bottom again, hold in the bottom position and set the indicator at zero (0). Check the extension contact with the plunger top.

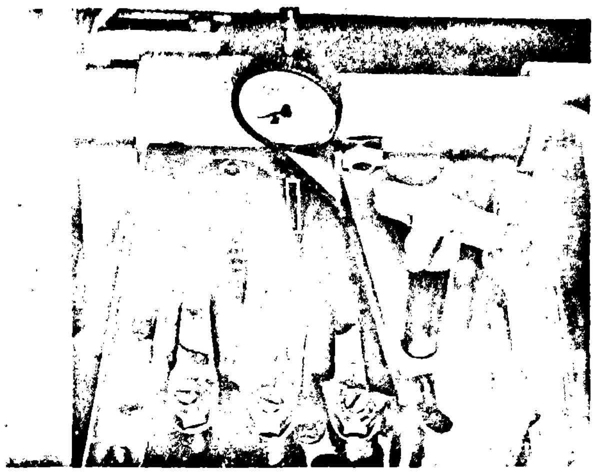


Fig. 2-62. (K21920). Dial indicator in place — extension in contact with plunger

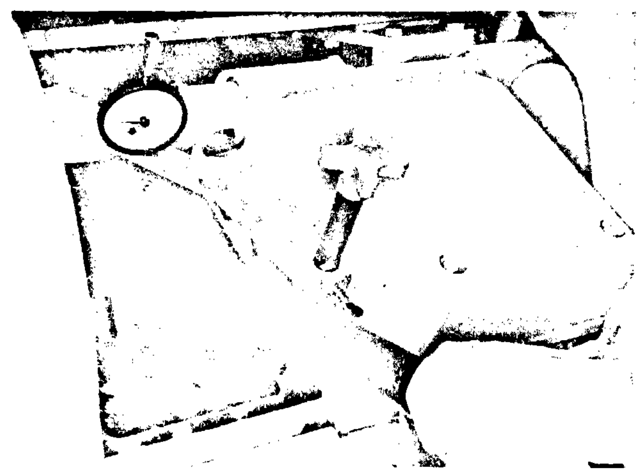


Fig. 2-63. (K21921). Bottoming injector plunger in cup

4. Allow the plunger to rise then bottom the plunger again, release the lever, the indicator must show travel as indicated in Table 2-19. Adjust as necessary.
5. If the adjusting screw locknuts were loosened for adjustment, tighten to 40 to 45 ft-lbs [54 to 61 N•m] torque and actuate the plunger several times as a

Table 2-19: Adjustment Limits Using Dial Indicator Method Inch [mm] KT(A)-2300 and KTA-3067 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.308 ± 0.001 [7.82 ± 0.03]	0.014 [0.36]	0.027 [0.69]

check of the adjustment. Tighten the locknuts to 30 to 35 ft-lbs [41 to 47 N•m] torque when using ST-669 Torque Wrench Adapter.

6. Remove 3375004 Kit.

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever, an adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.

1. Loosen the adjusting screw locknut, back off the screw (4, Fig. 2-56) one turn.
2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2). The adjusting screw should not touch the valve stem (3) at this point.
3. Turn down the adjusting screw until it touches the valve stem (3).
4. Using 3375008 Troque Wrench Adapter to hold the adjusting screw in position, tighten the locknut to 22 to 26 ft-lb [30 to 35 N•m] torque. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver, tighten the locknut to 25 to 30 ft-lb [34 to 41 N•m] torque.
5. Check the clearance (6) between the crosshead and the valve spring retainer with a gauge. There must be a minimum of 0.025 inch [0.64 mm] clearance at this point.

Valve Adjustment

1. Insert the correct thickness feeler gauge between the rocker lever and the crosshead for the valves being adjusted. See Table 2-19 for valve clearance.

Note: Exhaust valves are toward the front of the engine in each cylinder head on the LB side and are toward the rear of the engine in each cylinder head on the RB side.

2. If adjustment is required, loosen the locknut and turn the adjusting screw down until the rocker lever just touches the feeler gauge; lock the adjusting screw in this position with the locknut.
3. Tighten the locknut to 40 to 45 ft-lb [54 to 61 N•m] torque. When using ST-669 Torque Wrench Adapter tighten the locknuts to 30 to 35 ft-lb [41 to 47 N•m] torque.

After completing the injector plunger travel, crosshead and valve adjustment on this cylinder bar the engine in the direction of rotation until the next valve set mark is aligned with the scribe mark at the flywheel housing or the pointer on the gear case cover; repeat the procedure. See Fig's. 2-57 and 2-58 for cylinder arrangement and engine firing order.

Change Oil

Change Aneroid Oil

1. Remove fill plug (1, Fig. 2-64) from the hole marked "Lub oil".

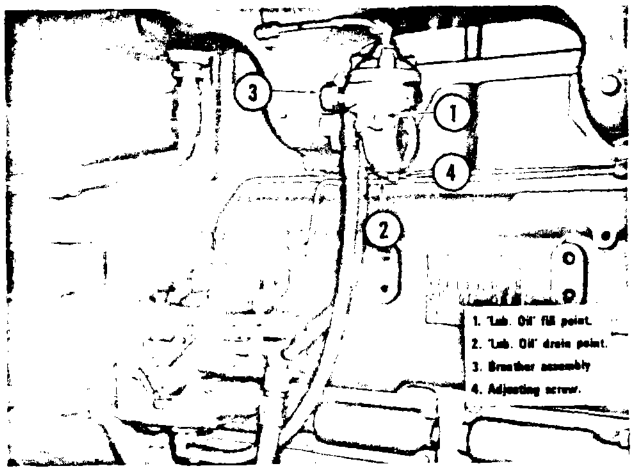


Fig. 2-64, (N10503). Aneroid

2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather (3, Fig. 2-64).

Change Hydraulic Governer Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note: When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Backside Idler Fan Drive

Inspect the idler assembly to be sure the pivot arm is not binding. Use the following procedure.

1. Check the idler arm for freedom of movement.
   a. Grasp the pulley and move the pulley and arm away from the fan belt until the arm is nearly vertical.
   b. Release the arm and pulley and allow them to move back to their original position against the belts.
   c. The motion of the arm and pulley assembly should be free with no binding.
2. If the arm appears to be binding or tight, release the spring tension by placing a box end wrench over the square knob on the end of the pivot arm cap and while holding up on the box end wrench, remove the capscrew which holds the cap in place and allow the spring to unwind by allowing the box end wrench to rotate counterclockwise.
   a. With the spring unloaded, rotate the cap until the slots inside the cap align with the roll pins in the pivot arm, and remove the cap by pulling away from the engine.
   b. With the torsion spring unloaded, the pivot arm should rotate freely. If it does not appear free, then the bushings require replacement or re-packing with lubricant.
3. To inspect the bushings, loosen and remove the large hex head capscrew in the center of the pivot arm and remove the pivot arm from the pivot arm support.
   a. Inspect the shaft for corrosion and clean it as necessary with fine grade emery cloth.
   b. Inspect the bushings and thrust washers, clean and repack them with a good grade of lubricant such as:
      — lubriplate
      — moly-disulfide grease
   c. Inspect the O-ring on the pivot arm and replace it as necessary. Lubricate the O-ring prior to installation.
   d. Reassemble the pivot arm assembly cap using a new spring.
   e. Retension the new spring and lock the cap in place. Install a new fan belt and test the unit.

Clean Complete Oil Bath Air Cleaner

Steam

Steam clean the oil bath cleaner main body screens. Direct the stream jet from the air outlet side of the cleaner to wash dirt out in the opposite direction of air flow.

Solvent-Air Cleaning

1. Steam clean the exterior of the cleaner.
2. Remove the air cleaner oil cup.
3. Clamp the hose with the air line adapter to the air cleaner outlet.
4. Submerge the air cleaner in solvent.
5. Introduce air into the unit at 3 to 5 psi [21 to 34 kpa] and leave it in the washer 10 to 20 minutes.
6. Remove the cleaner from solvent and steam clean thoroughly to remove all traces of solvent. Dry with compressed air.

Caution: Failure to remove solvent may cause engine to overspeed until all solvent is sucked from the cleaner.

7. If the air cleaner is to be stored, dip it in lubricating oil to prevent rusting of the screens.

Note: If screens cannot be thoroughly cleaned by either method, or if the body is pierced or otherwise damaged, replace with a new air cleaner.

"D" Maintenance Checks

At each "D" Maintenance Check, perform all "A", "B" and "C" checks in addition to those following. Most of these checks should be performed by a Cummins Distributor or Dealer and where Cummins Shop Manuals are available for complete instructions.

Clean and Calibrate Injectors

Clean and calibrate the injectors regularly to prevent restriction of fuel delivery to the combustion chambers. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

To clean and calibrate the injectors, refer to Bulletin No. 3379071 and revisions thereto.

After removing the injectors from KT(A)-1150, KT(A)-2300 or KTA-3067 Engines for cleaning the seal seat should be removed from the injector (1, Fig. 2-65) or injector "well" for cleaning, examination and/or replacement as necessary.

Fig. 2-65, (K11918) Injector seal seat — all KT Engines

Caution: There must be only one (1) seal seat used in each injector "well". Use of more than one seal seat per injector will change the injector protrusion and cause combustion inefficiency.

Clean and Calibrate Fuel Pump

Check the fuel pump calibration on the engine if required. See the nearest Cummins Distributor or Dealer for values.

Clean and Calibrate Aneroid

1. Remove the flexible hose or tube from the aneroid cover to the intake manifold.
2. Remove the lead seal (if used), screws and aneroid cover.
3. Remove the bellows, piston, upper portion of the two piece shaft and the spring from the aneroid body.

Note: *Count and record the amount of thread turns* required to remove the upper shaft, piston and bellows from the lower shaft.

4. Place the hex portion of the shaft in a vise, snug tighten the vise, remove the self-locking nut, retaining washer and bellows.
5. Clean the parts in an approved cleaning solvent.
6. Position the new bellows over the shaft to the piston, secure with retaining washer and self-locking nut. Tighten the self-locking nut to 20 to 25 ft-lb [2.3 to 2.8 N•m] torque.
7. Install the spring, shaft, piston and bellows assembly into the aneroid body. As the two piece shaft is re-assembled, turn the upper portion of the shaft the same amount of thread turns as recorded during disassembly.

Caution: The amount of thread turns during installation must correspond with turns during removal to avoid changing the aneroid setting.

8. Align the holes in the bellows with the corresponding capscrew holes in the aneroid body.
9. Position the cover to the body; secure with flatwashers, lockwashers and fillister head screws.
10. Install a new seal. Refer to Bulletin No. 3379084 for sealing instructions and calibration procedure. Calibration, if required, must be performed by a Cummins Distributor on a fuel pump test stand.

11. Reinstall the flexible hose or tube from the aneroid cover to the intake manifold.

Inspect/Install Rebuilt Unit as Necessary

The following assemblies should be inspected at this time. The options are: inspect and reuse, rebuild per shop manual instructions, replace with a new or Distributor/Dealer exchange unit or Cummins Diesel ReCon Inc. unit.

Inspect Water Pump and Fan Hub

Inspect the water pump and fan hub for wobble and evidence of grease leakage. Replace with rebuilt prelubricated units as necessary.

Idler Pulley

Inspect, rebuild and repack the idler pulley with correct grease. Refer to the Engine Shop Manual for the rebuild and lubricating procedure for the idler pulley.

Inspect Turbocharger

Check Turbocharger Bearing Clearance

Check bearing clearances. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate the end-play of the rotor shaft and a feeler gauge to indicate the radial clearance. Fig. 2-66.

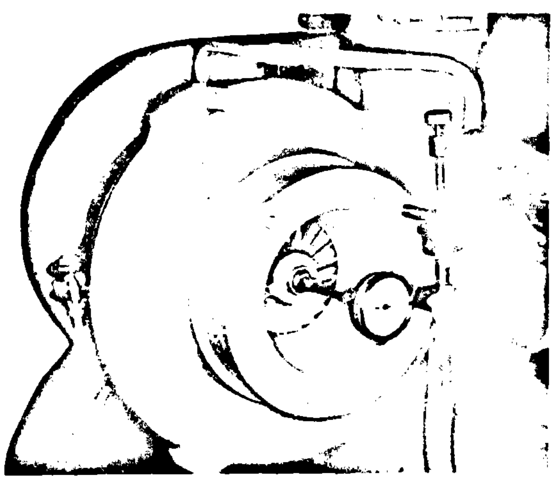


Fig. 2-66, (N11956). Checking turbocharger bearing and clearance

Checking Procedure

1. Remove the exhaust and intake piping from the turbocharger to expose the ends of the rotor assembly.
2. Remove one capscrew from the front plate (compressor wheel end) and replace it with a long capscrew. Attach an indicator to the long capscrew and register the indicator point on the end of the rotor shaft. Push the shaft from end-to-end making note of the total indicator reading. Fig. 2-66. On T-50, ST-50 and VT-50 the end clearance should be 0.006 to 0.018 inch [0.15 to 0.46 mm].
   a. Push the wheel toward the side of the bore.
   b. Using a feeler gauge, check the distance between the tip of the wheel vanes and the bore. On T-50, ST-50 and VT-50 the clearance should be 0.003 to 0.033 inch [0.08 to 0.84 mm].
3. Check the radial clearance on the compressor wheel only.
4. If end clearances exceed the limits, remove the turbocharger from the engine and replace it with a new or rebuilt unit.
5. Check T-18A turbochargers as follows:
   a. For checking procedures refer to Service Manual Bulletin No. 3379055.
   b. End clearance should be 0.004 to 0.009 inch [0.10 to 0.23 mm], radial clearance should be 0.003 to 0.007 inch [0.08 to 0.18 mm]. If the clearances exceed these limits, remove the turbocharger(s) from the engine and replace them with new or rebuilt units.
6. Intall the exhaust and intake piping to the turbocharger(s).

Inspect Vibration Damper

Rubber Damper

The damper hub (1, Fig. 2-67) and the inertia member (2) are stamped with an index mark (3) to permit the detection of movement between the two components.

There should be no relative rotation between the hub and the inertia member resulting from engine operation.

Check for extrusion or rubber particles between the hub and the inertia member.

If there is evidence of inertia member movement and rubber extrusion, replace the damper.

Viscous Dampers

Check the damper for evidence of fluid loss, dents and wobble. Visually inspect the vibration damper's thick-

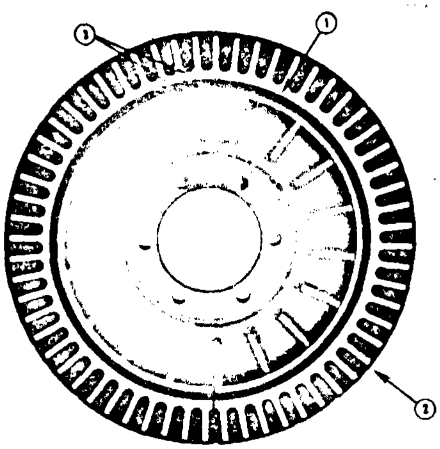


Fig. 2-67. (N10146). Vibration damper alignment marks

ness for any deformation or raising of the damper's front cover plate.

1. If a lack of space around the damper will not permit a visual inspection, run a finger around the inside and the outside of the front cover plate. If any variations or deformations are detected, remove the vibration damper and check as follows.
2. Remove paint, dirt and grime from the front and rear surface of the damper in four (4) equal spaced areas. Clean the surface with paint solvent and fine emery cloth.
3. Using a micrometer measure and record the thickness of the dampers at the four (4) areas cleaned in Step 3. Take the reading approximately 0.125 inch [3.18 mm] from the outside edge of the front cover plate.
4. Replace the damper if the variation of the four (4) readings exceed 0.010 inch [0.25 mm].

Viscous vibration dampers should be checked under the following conditions:

1. At any time the damper is removed from the engine.
2. At any time the engine experiences the following problems:
   a. Gear train failure
   b. Accessory drive shaft failure
   c. Crankshaft failure
   d. Damper mounting capscrew failure
   e. Flywheel mounting capscrew failure

Viscous vibration dampers should be replaced at our recommended change interval** regardless of condition. Gellation of the damper's silicon fluid occurs after extended service because of the high shear rates and resulting high temperatures imposed on the fluid during normal damper operation and, if the damper has not failed at this time, its failure is imminent.

Table 2-20: Viscous Vibration Damper Thickness Sepcifications — Inch [mm]

Damper Part Number	Maximum Allowable Thickness		**Recommended Change Interval
20633-1	1.981	[50.32]	9000
20634-1	1.644	[41.76]	9000
20835-1	1.142	[29.01]	9000
145789	1.663	[42.24]	6000
190213	1.663	[42.24]	6000
207531	2.574	[65.38]	18000
210758	1.550	[39.37]	6000
211268	1.663	[42.24]	6000
211914	1.981	[50.32]	9000
211915*			
211916	1.663	[42.24]	6000
217321	1.663	[42.24]	15000
217322	1.663	[42.24]	15000
217323	1.663	[42.24]	15000
218755	1.663	[42.24]	15000
3005973	2.574	[65.38]	18000
3015464	2.574	[65.38]	18000

*Due to vendor manufacturing differences 211915 Vibration Damper maximum allowable thickness depends upon the style of damper installed on the engine. Fabricated type 211915 Vibration Dampers, identified by a weld bead on the inside of the damper where the mounting flange joins the housing and vendor Part Number 709555, have a maximum allowable thickness of 1.570 inch [39.88 mm]. The recommended change interval for this damper is 12,000 hours. Cast and machined type 211915 Vibration Dampers (vendor Part Number 707843) have a maximum allowable thickness of 1.550 inch [39.37 mm]. The recommended change interval for this damper is 6,000 hours.

Air Compressor

Inspect the air compressor, check for evidence of oil or coolant leakage. Drain the air tank and check for air compressor lubricating oil carry over. Replace with a rebuilt unit as necessary.

Backside Idler Fan Drive

Remove the pivot arm assembly, disassemble and clean. Replace the Teflon bushings. Inspect the thrust washers and replace as necessary. Pack Teflon bushings with Aeroshell No. 5 Lubriplate (type 130AA) or Moly-disulfide grease, reassemble and install the idler assembly.

Clean Crankcase Breathers (KT(A)-2300 and KTA-3067 Engines

Remove the crankcase breathers from the right bank front and left bank rear of the cylinder block. Clean in an approved cleaning solvent, dry with compressed air, install the breather.

Seasonal Maintenance Checks

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to miles or hours operation but are performed once or twice each year.

Clean Cooling System (Fall)

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection from the radiator. Use clean water that will not clog any of the hundreds of small passages in the radiator or water passages in the block. Clean the radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

If rust and scale have collected, the system must be chemically cleaned. Use a good cooling system cleaner such as sodium bisulphate or oxalic acid followed by neutralizer and flushing.

Pressure Flushing

Flush the radiator and the block before filling with antifreeze, or installing a water filter on a used or rebuilt engine.

When pressure flushing the radiator, open the upper and lower hose connections and screw the radiator cap on tight. Use the hose connection on both the upper and lower connections to make the operation easier. Attach a flushing gun nozzle to the lower hose connection and let water run until the radiator is full. When full, apply air pressure gradually to avoid damage to the core. Shut off the air and allow the radiator to refill; then apply air pressure. Repat until the water coming from the radiator is clean.

Caution: Do not use excessive air pressure while starting the water flow. This could split or damage the radiator core.

Sediment and dirt settle into pockets in the block as well as the radiator core. Remove the thermostats from the housing and flush the block with water. Partially restrict the lower opening until the block fills. Apply air pressure and force water from the lower opening. Repeat the process until the stream of water coming from the block is clean.

Replace Hose (As Required)

Inspect the oil filter and cooling system hose and hose connections for leaks and/or deterioration. Particles of deteriorated hose can be carried through the cooling system or lubricating system and restrict or clog small passages, especially radiator core, and lubricating oil cooler, and partially stop circulation. Replace as necessary.

Check Preheater Cold-Starting Aid (Fall)

Remove the 1/8 inch pipe plug from the manifold, near the glow plug, and check the operation of the preheater as described in Section 1.

Check Shutterstats and Thermatic Fans (Fall)

Shutterstats and thermatic fans must be set to operate in the same range as the thermostat with which they are used. Table 2-21 gives the settings for shutterstats and thermatic fans as normally used. The 180 to 195° F [82 to 91° C] thermostats are used only with shutterstats that are set to close at 187° F [86° C] and open at 195° F [91° C].

Check Thermostats and Seals (Fall)

Remove the thermostats from the thermostat housings and check for proper opening and closing temperature.

Most Cummins Engines are equipped with either medium 170 to 185° F [77 to 85° C] or low 160 to 175° F [71 to 79° C] and in a few cases high-range 180 to 195° F [82 to 91° C] thermostats, depending on engine application.

Steam Clean Engine (Spring)

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use an approved solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the cleaner spray nozzle.

Table 2-21: Thermal Control Settings

Control	Setting With 160 to 175°F [71 to 79°C]		Setting With 170 to 185°F [77 to 85°C]		Setting With 180 to 195°F [82 to 91°C]	
	Open	Close	Open	Close	Open	Close
Thermatic Fan	185° F [85° C]	170° F [77° C]	190° F [88° C]	182° F [82° C]		
Shutterstat	180° F [82° C]	172° F [78° C]	185° F [85° C]	177° F [81° C]	195° F [91° C]	187° F [86° C]
Modulating Shutters Open	175° F [79° C]		185° F [85° C]		[91° C]	

Checking Mountings (Spring)

Tighten Mounting Bolts and Nuts (As Required)

Engine mounting bolts will occasionally work loose and cause the engine supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Tighten Turbocharger Mounting Nuts (As Required)

Tighten all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Tighten the mounting bolts and supports so that vibration will be at a minimum. Fig. 2-68.

Check Fan and Drive Pulley Mounting (Spring)

Check the fan to be sure it is securely mounted; tighten the capscrews as necessary. Check the fan for wobble or bent blades.

Check the fan hub and crankshaft drive pulley to be sure they are securely mounted. Check the fan hub pulley for looseness or wobble; if necessary, remove the fan pilot hub and tighten the shaft nut. Tighten the fan bracket capscrews.

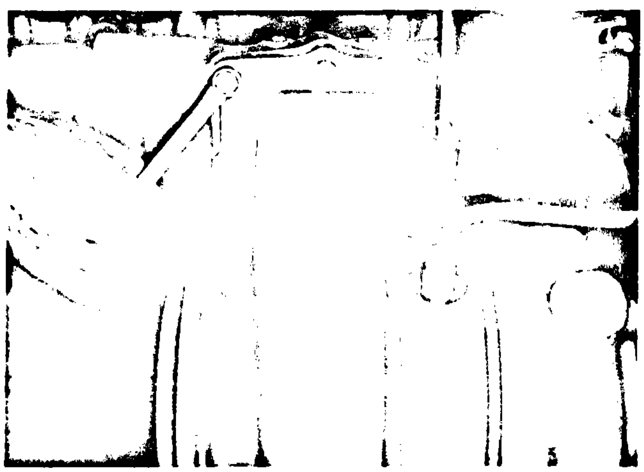


Fig. 2-68, (N11953). Tightening turbocharger mounting marks

Check Crankshaft End Clearance (Spring)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 2-22. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If the engine is disassembled for repair, install new thrust rings.

Table 2-22: Crankshaft End Clearance — Inch [mm]

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH, NT	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
V-903, VT-903	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]
V-378, V-504 V-555	0.004 [0.10]	0.014 [0.36]	0.022 [0.56]
V-1710	0.006 [0.15]	0.013 [0.33]	0.018 [0.46]
KT(A)-1150	0.007 [0.18]	0.017 [0.43]	0.022 [0.56]
KT(A)-2300 KTA-3067	0.005 [0.13]	0.015 [0.38]	0.022 [0.56]

Caution: Do not pry against the outer damper ring.

The check can be made by attaching an indicator to rest against the damper or pulley, while prying against the front cover and inner part of the pulley or damper. End clearance must be present with the engine mounted in the unit and assembled to the transmission or converter.

Check Heat Exchanger Zinc Plugs (Spring)

Check the zinc plugs in the heat exchanger and change if they are badly eroded. Frequency of change depends upon the chemical reaction of raw water circulated through the heat exchanger.

Specifications and Torque

Providing and maintaining an adequate supply of clean, high-quality fuel, lubricating oil, grease and coolant in an engine is one way of ensuring long life and satisfactory performance.

Lubricant, Fuel and Coolant

The Functions of Lubricating Oil

The lubricating oil used in a Cummins engine must be multifunctional. It must perform the primary functions of:

Lubrication by providing a film between the moving parts to reduce wear and friction.

Cooling by serving as a heat transfer media to carry heat away from critical areas.

Sealing by filling in the uneven surfaces in the cylinder wall, valve stems and turbocharger oil seals.

Cleaning by holding contaminants in suspension to prevent a build up of deposits on the engine surfaces.

In addition, it must also provide:

Dampening and cushioning of components that operate under high stress, such as gears and push tubes.

Protection from oxidation and corrosion.

Hydraulic Action for components such as Jacobs Brake and hydraulic controls.

Engine lubricating oil must be changed when it can no longer perform its functions within an engine. Oil does not wear out, but it becomes contaminated to the point that it can no longer satisfactorily protect the engine. Contamination of the oil is a normal result of engine operation. During engine operation a wide variety of contaminants are introduced into the oil. Some of these are:

Byproducts of Engine Combustion — asphaltenes, soot and acids from partially burned fuel.

Acids, varnish and sludge which are formed as a result of the oxidation of the oil as it breaks down or decomposes.

Dirt entering the engine through the combustion air, fuel, while adding or changing lubricating oil.

The oil must have an additive package to combat these contaminates. The package generally consists of:

Detergents/Dispersants which keep insoluble matter in suspension until they are filtered from the oil or are removed with the oil change. This prevents sludge and carbon deposits from forming in the engine.

Inhibitors to maintain the stability of the oil, prevent acids from attacking metal surfaces and prevent rust during the periods the engine is not operating.

Other Additives that enable the oil to lubricate highly loaded areas, prevent scuffing and seizing, control foaming and prevent air retention in the oil.

Oil Performance Classification System

The American Petroleum Institute (API), The American Society for Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE) have jointly developed and maintained a system for classifying lubricating oil by performance categories. The following are brief descriptions of the API categories used in the Cummins oil performance recommendations.

CC (Equivalent to MIL-L-2104B.) This category describes oils meeting the requirements of the military specification MIL-L-2104B. These oils provide low temperature protection from sludge and rust and are designed to perform moderately well at high temperature. For moderate-duty service.

CD (Equivalent to Series 3 and MIL-L-45199B.) This category described oils meeting the requirements of the Series 3 specification and MIL-L-45199B. These oils provide protection from deposits and oxidation at high temperature. For severe-duty service.

SC (Equivalent to 1964 MS Oils). This category describes oils meeting the 1964-1967 requirements of automobile manufacturers. Primarily for use in automobiles, it provides low temperature anti-sludge and anti-rust protection required in a light-duty diesel service such as a stop-and-go operation.

SD (Equivalent to 1968-1971 MS Oils.) This category describes oils meeting the 1964-1967 requirements of automobile manufacturers. Primarily for use in automobiles, it provides low temperature anti-sludge and anti-rust protection required in a light-duty diesel service such as a stop-and-go operation. It may be substituted for SC category.

SE (Equivalent to 1972 MS Oils.) This category describes oils meeting the 1972 requirements of automobile manufacturers. Primarily for use in automobiles, it provides protection from high temperature oxidation and low temperature anti-sludge and anti-rust as required in a light-duty diesel service such as a stop-and-go operation. It may be substituted for SC category.

CB (No equivalent Specification.) These oils were usually referred to as Supplement 1 oils. This category describes oils which met the requirements of the military specification MIL-L-2104A where the diesel engine test was run using fuel with a high sulphur content. For moderate duty service. Oils in this performance category should not be used in Cummins Engines.

The Engine Manufacturers Association (EMA) publishes a book entitled "Lubricating Oils Data Book". Copies may be purchased from the Engine Manufacturers Association, 111 E. Wacker Drive, Chicago, Ill. 60601. This book lists commercially available oils by oil company and brand name with the API performance categories met by each brand.

Oil Performance Recommendations

Cummins Engine Co., Inc. does not recommend the use of any specific brand of engine lubricating oil. Cummins recommends the use of oil designed to meet the following API categories:

CC for use in naturally aspirated engines.

CC/CD for use in turbocharged engines.

CC/SC for use only in engines that operate in a light-duty service including standby and emergency operation.

Dual Categories are used where more protection is required than is provided by a single category. CC/CD and CC/SC categories indicate that the oil is blended to meet the performance level required by each single category.

A **sulfated ash limit** has been placed on lubricating oil for use in Cummins engines. Past experience has shown that oils with a high ash content may produce deposits on valves that can progress to guttering and valve burning. A maximum sulfated ash content of 1.85 mass % is recommended for all oil used in Cummins engines except engines fueled with natural gas. For natural gas engines a sulfated ash range of 0.03 to 0.85 mass % is recommended. Cummins Engine Co., Inc., does not recommend the use of ashless oils for natural gas engines. When the ash content is below .15 mass %, the ash should represent organo-metallic anti-wear additives.

Break-In Oils

Special "break-in" lubricating oils are not recommended for new or rebuilt Cummins engines. Use the same lubricating oils used in normal engine operation.

Viscosity Recommendations

The viscosity of an oil is a measure of its resistance to flow. The Society of Automotive Engineers has classified engine oils in viscosity grades; Table 3-1 shows the viscosity range for these grades. Oils that meet the low temperature (0° F [—18° C]) requirement carry a grade designation with a "W" suffix. Oils that meet both the low and high temperature requirements are referred to as multigrade or multiviscosity grade oils.

Multigraded oils are generally produced by adding viscosity index improver additives to retard the thinning effects a low viscosity base oil will experience at engine operating temperatures. Multigraded oils that meet the requirements of the API classifications, are recommended for use in Cummins engines.

Cummins recommends the use of multigraded lubricating oil with the viscosity grades shown in Table 3-2. Table 3-2 shows Cummins viscosity grade recommendations at various ambient temperatures. The only viscosity grades recommended are those shown in this table.

Cummins has found that the use of multigraded lubricating oil improves oil consumption control, improved engine cranking in cold conditions while maintaining lubrication at high operating temperatures and may contribute to improved fuel consumption. Cummins does not recommend the use of single grade lubricating oils. In the event that the recommended multigrade oil is not available, single grade oils may be substituted.

Caution: When single grade oil is used, be sure that the oil will be operating within the temperature ranges shown in Table 3-3.

The primary criterion for selecting an oil viscosity grade is the lowest temperature the oil will experience while in the engine oil sump. Bearing problems can be caused by the lack of lubrication during the cranking and start up of a cold engine when the oil being used is too viscous to flow properly. Change to a lower viscosity grade of oil as the temperature of the oil in the engine oil sump reaches the lower end of the ranges shown in Table 3-2.

Table 3-1: SAE Viscosity Numbers for Lubricating Oils

SAE Viscosity Grade	Viscosity Range: millipascal-second, mPa•s (centipoise, cP) @ 0° F [-18° C] maximum	millimetre²/second, mm²/s (centistoke, cSt) @ 212° F [100° C] minimum	maximum
5W	1250	3.8	—
10W	2500	4.1	—
15W	5000	5.6	—
20W	10000	5.6	—
20	—	5.6	less than 9.3
30	—	9.3	less than 12.5
40	—	12.5	less than 16.3
50	—	16.3	less than 21.9

1. SAE Recommended Practice J300d
2. 1 mPa•s = 1 cP
3. 1 mm²/s = 1 cSt

Table 3-2: Cummins Recommendations for Viscosity Grade vs. Ambient Temperature

SAE Viscosity Grade*	Ambient Temperature**
Recommended	
10W - 30	-13° F to 95° F [-25° C to 35° C]
15W - 40	14° F and above [-10° C and above)
20W - 40	32° F and above [0° C and above]

*SAE-5W mineral oils should not be used.
**For temperatures consistently below -13° F [-25° C] See Table 4.

Table 3-3: Alternate Oil Grades

10W	-13° F to 32° F [-25° C to 0° C]
20W	23° F to 68° F [-5° C to 20° C]
20W-20*	23° F to 68° F [-5° C to 20° C]
20	23° F to 68° F [-5° C to 20° C]
30	39° F and above [4° C and above]
40	50° F and above [10° C and above]

*20W-20 is not considered a multigrade even though it meets two grades.

Synthetic Lubricating Oil

Synthetic oils for use in diesel engines are primarily blended from synthesized hydrocarbons and esters. These base oils are manufactured by chemically reacting lower molecular weight materials to produce a lubricant that has planned predictable properties.

Synthetic oil was developed for use in an extreme environment where the ambient temperature may be as low as —50° F [—45° C] and extremely high engine temperatures at up to 400° F [205° C]. Under these extreme conditions petroleum base stock lubricants (mineral oil) do not perform satisfactorily.

Cummins Engine Co., Inc. recommends synthetic lubricating oil for use in Cummins engines operating in areas where the ambient temperature is consistently lower than —13° F [—25° C]. Synthetic lubricating oils may be used at higher ambient temperatures provided they meet the appropriate API Service categories and viscosity grades.

Cummins Engine Co., Inc. recommends the same oil change interval be followed for synthetic lubricating oil as that for petroleum based lubricating oil.

Arctic Operations

For engine operation in areas where the ambient temperature is consistently below —13° F [—25° C] and where there is no provision to keep the engine warm when it is not operating, the lubricating oil should meet the requirements in the following table. Oil meeting these requirements usually have synthetic base stocks. SAE 5W viscosity grade synthetic oils may be used provided they meet the minimum viscosity requirement at 212° F [100° C].

Table 3-4: Arctic Oil Recommendations

Parameter (Test Method)	Specifications
Performance Quality Level	API Classification CC/SC API Classification CC/CD
Viscosity	10,000 mPa•s Max. at —31° F [—35° C] 4.1 mm^2/s Min. at 212° F [100° C]
Pour Point (ASTM D-97)	Min. of 9° F [5° C] Below the Lowest Expected Ambient Temperature
Sulfated Ash Content (ASTM D-874)	1.85% by Weight Maximum

Grease

Cummins Engine Company, Inc., recommends use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact the lubricant supplier for grease meeting these specifications.

TEST	TEST PROCEDURE
High-Temperature Performance	
Dropping point, ° F.	ASTM D 2265 350 min.
Bearing life, hours at 300° F 10,000 rpm	*FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM	ASTM D 1478
Start at 0° F	15,000 max.
Run at 0° F	5,000 max.
Rust Protection and Water Resistance	
Rust Test	ASTM D 1743 Pass
Water resistance, %	ASTM D 1264 20 max.
Stability	
Oil separation, % 30 hours @ 212° F	*FTM 321 5 max.
Penetration	
Worked	ASTM D 217 250-300
Bomb Test, PSI Drop	ASTM D 942
100 Hours	10 max.
500 Hours	25 max.
Copper, Corrosion	*FTM 5309 Pass
Dirt Count, Particles/cc	*FTM 3005
25 Micron +	5,000 max.
75 Micron +	1,000 max.
125 Micron +	None
Rubber Swell	*FTM 3603 10 max.

* Federal Test Method Standard No. 791a.

Caution: Do not mix brands of grease. Damage to the bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating the fan hub, replace both pipe plugs. Use of fittings will allow the lubricant to be thrown out, due to rotative speed.

Fuel Oil

Cummins diesel engines have been developed to take advantage of the high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins diesel engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

Recommended Fuel Oil Properties:

Viscosity (ASTM D-445)	1.3 to 5.8 CentiStoke [1.3 to 5.8 mm^2 Per Second] at 104° F [40° C].
Cetane Number (ASTM D-613)	40 minimum except in cold weather or in service with prolonged low loads, a higher cetane number is desirable.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 1% by weight.
Water and Sediment (ASTM D-1796)	Not to exceed 0.1% by weight.
Carbon Residue (Ransbottom ASTM D-524 or D-189)	Not to exceed 0.25% by weight on 10% residue.
Flash Point (ASTM D-93)	125° F [52° C] minimum. Certain marine registries require higher flash points.
Density (ASTM D-287)	30 to 42° F [—1 to 6° C] A.P.I. at 60° F [16° C] (0.816 to 0.876 Sp. Gr.)
Cloud Point (ASTM D-97)	10° F [—12° C] below lowest temperature expected to operate at.
Active Sulfur-Copper Strip-Corrosion (ASTM D-130)	Not to exceed No. 2 rating after 3 hours at 122° F [50° C].
Ash (ASTM D-482)	Not to exceed 0.02% by weight.
Distillation (ASTM D-86)	The distillation curve should be smooth and continuous. At least 90% of the fuel should evaporate at less than 680° F [360° C]. All of the fuel should evaporate at less than 725° F [385° C].

Coolant

Water should be clean and free of any corrosive chemicals such as chloride, sulphates and acids. It should be kept slightly alkaline with a pH value range of 8.5 to 10.5. Any water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleetguard DCA Water Filter on the engine. The filter bypasses a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

1. In summer, with no antifreeze, fill the system with water.
2. In winter, select an antifreeze and use with water as required by temperature.

Note: Some antifreeze also contains anti-leak additives such as inert inorganic fibers, polymer particles or ginger root. These types of antifreeze should not be used in conjunction with the water filter. The filter element will filter out the additives and/or become clogged and ineffective.

3. Install or replace the DCA Water Filter as follows and as recommended in Section 2.

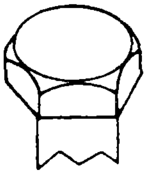
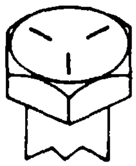
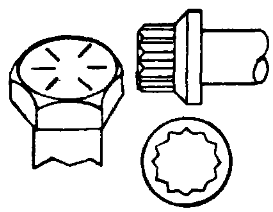
New Engines Going Into Service Equipped With DCA Water Filters

1. New engines shipped from Cummins Engine Company are equipped with water filters containing a DCA precharge element. This element is compatible with plain water or all permanent-type antifreeze except Methoxy Propanol. See Table 3-5 for Methoxy Propanol precharge instructions.
2. At the first "B" Check (oil change period) the DCA precharge element should be changed to DCA Service Element. See Table 3-5.
3. Replace the DCA Service Element at each succeeding "B" Check.
   a. If make-up coolant must be added between element changes, use coolant from a pre-treated supply, see "Make-Up Coolant Specifications", Section 2.
   b. Each time the system is drained, precharge per coolant specifications, Table 3-5.
4. The service element may be changed at the "C" Check if 3300858 (DCA-4L) direct chemical additive is added to the cooling system at each "B" Check between service element changes. One bottle of direct additive should be used for every 10 gallons of cooling system capacity. Add one bottle for every 15-gallon capacity if methoxy propanol antifreeze is used in the cooling system.
5. To ensure adequate corrosion protection, have the coolant checked at each third element change or more often. See "Check Engine Coolant", Section 2.

Table 3-5: Spin-on Type DCA Water Filter

Cooling System Capacity (U.S. Gallons)	Ethylene Glycol Base Antifreeze: DCA-4L Precharge (P/N 3300858)	Ethylene Glycol Base Antifreeze: Service Element(s)	Methoxy Propanol Base Antifreeze: DCA-4L Precharge (P/N 3300858)	Methoxy Propanol Base Antifreeze: Service Element(s)
0-8	1	WF-2010 (P/N 299080)	1	WF-2011 (P/N 3300721)
9-15	2	WF-2010	2	WF-2011
16-30	5	WF-2010	4	WF-2011
31-60	10	(2) WF-2010	8	(2) WF-2011
35-90 (V-1710)	12	(2) WF-2016 (P/N 299086)	8	(2) WF-2017 (P/N 3300724)
70-90 (KT-2300	16	(2) WF-2010	16	(2) WF-2011

Capscrew Markings and Torque Values

Current Usage	Much Used	Much Used	Used at Times	Used at Times
Minimum Tensile Strength PSI MPa	To 1/2–69,000 [476] To 3/4–64,000 [421] To 1–55,000 [379]	To 3/4–120,000 [827] To 1–115,000 [793]	To 5/8–140,000 [965] To 3/4–133,000 [917]	150,000 [1 034]
Quality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
SAE Grade Number	1 or 2	5	6 or 7	8
Capscrew Head Markings Manufacturer's marks may vary These are all SAE Grade 5 (3 line) 			 6  7	

Capscrew Body Size (Inches) – (Thread)	Torque Ft-Lbs [N•m]	Torque Ft-Lbs [N•m]	Torque Ft-Lbs [N•m]	Torque Ft-Lbs [N•m]
1/4 – 20	5 [7]	8 [11]	10 [14]	12 [16]
– 28	6 [8]	10 [14]		14 [19]
5/16 – 18	11 [15]	17 [23]	19 [26]	24 [33]
– 24	13 [18]	19 [26]		27 [37]
3/8 – 16	18 [24]	31 [42]	34 [46]	44 [60]
– 24	20 [27]	35 [47]		49 [66]
7/16 – 14	28 [38]	49 [66]	55 [75]	70 [95]
– 20	30 [41]	55 [75]		78 [106]
1/2 – 13	39 [53]	75 [102]	85 [115]	105 [142]
– 20	41 [56]	85 [115]		120 [163]
9/16 – 12	51 [69]	110 [149]	120 [163]	155 [210]
– 18	55 [75]	120 [163]		170 [231]
5/8 – 11	83 [113]	150 [203]	167 [226]	210 [285]
– 18	95 [129]	170 [231]		240 [325]
3/4 – 10	105 [142]	270 [366]	280 [380]	375 [508]
– 16	115 [156]	295 [400]		420 [569]
7/8 – 9	160 [217]	395 [536]	440 [597]	605 [820]
– 14	175 [237]	435 [590]		675 [915]
1 – 8	235 [319]	590 [800]	660 [895]	910 [1234]
– 14	250 [339]	660 [895]		990 [1342]

Notes:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6, 7 and 8 capscrews.
3. The above is based on use of clean, dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Reduce torque by 20% if new plated capscrews are used.
6. Capscrews threaded into aluminum may require reductions in torque of 30% or more of Grade 5 capscrews torque and must attain two capscrew diameters of thread engagement.

Caution: If replacement capscrews are of a higher grade than originally supplied, adhere to torque specifications for that placement.

Troubleshooting

Troubleshooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins diesel engine.

Cummins Diesel Engines

The chart does not give all the answers for correction of the problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the troubleshooting chart, find the complaint at the top of the chart; then follow down that column until you come to a black dot. Refer to the left of the dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done?
3. Has similar trouble occurred before?
4. If the engine still runs, is it safe to continue running it to make further checks?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first. Following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during disassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment, or more often, water in the fuel.

Tools And Procedures To Correct A Complaint

Tools and procedures to correct the complaints found in this Troubleshooting section are available from Cummins distributors and dealers. A list of publications, by bulletin numbers, is included in the back of this manual in the form of a purchase order. This list includes all engine model shop and and engine repair and rebuild manuals.

AFC Fuel Pump Adjustments

All AFC fuel pump adjustments are specified for calibration on a fuel pump test stand and not to be made on the engine. Contact your nearest authorized Cummins distributor to perform maintenance, if required.

Trouble Shooting
Cummins Engines

	CAUSES	Hard Starting or Failure to Start	Engine Misses	Excessive Black Smoke at Idle	Excessive White Smoke at Idle	Excessive Smoke Under Load	Excessive Acceleration Smoke	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Sluggish Engine Acceleration	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speed	Engine Dies	Surging at Governed RPM	Excessive Oil Consumption	Crankcase Sludge	Dilution	Low Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Oil Temperature Too High	Piston, Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks (Combustion Noise)	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration	Excessive Noise	Excessive Crankcase Pressure
Air System	Restricted Air Intake					●	●	●		●		●																				
	High Exhaust Back Pressure					●	●	●				●																				
	Thin Air in Hot Weather or High Altitude					●	●	●		●																						
	Air Leaks Between Cleaner and Engine						●	●		●														●	●	●						
	Dirty Turbocharger Compressor					●	●	●		●		●																				
	Improper Use of Starter Aid Air Temp.	●			●																			●	●		●					
Fuel System	Stuck Drain Valve			●		●	●					●	●																		●	
	Out of Fuel or Fuel Shut Off Closed	●													●																	
	Poor Quality Fuel Grade Fuel	●	●		●	●		●				●		●	●			●									●					
	Air Leaks in Suction Lines	●	●					●			●		●	●	●	●											●					
	Restricted Fuel Lines	●	●	●		●	●	●			●	●	●																			
	External or Internal Fuel Leaks							●				●			●				●													
	Plugged Injector Spray Holes		●	●		●	●	●				●																				
	Broken Fuel Pump Drive Shaft	●													●																	
	Scored Gear Pump or Worn Gears	●						●																								
	Wrong Injector Cups			●	●	●	●	●				●																				
	Cracked Injector Body or Cup	●	●	●	●	●	●	●				●							●								●					
	Damaged Injector O-Ring		●					●				●	●						●													
	Excessive Injector Check Ball Leakage												●																			
	Throttle Linkage or Adjustment							●	●				●	●	●	●																
	Incorrectly Assembled Idle Springs												●	●	●																	
	Incorrectly Assembled Governor Weights													●	●	●																
	High-Speed Governor Set Too Low							●	●																							
	Water in Fuel and/or Waxing	●	●						●		●			●	●																	
	AFC Calibration Incorrect	●					●	●			●																				●	
	Damaged/Worn AFC Plunger Seal/Barrel										●																					
	Fuel Pump Calibration Incorrect					●	●	●	●		●	●	●	●	●																●	
	Injector Flow Incorrect		●			●	●	●	●		●	●																				
	Plugged ASA							●			●																					
	ASA/AFC Air Leak, Bellows							●			●																					
	ASA Reverse Flow Valve Stuck Open						●																								●	
Lubricating System	External and Internal Oil Leaks																●			●												
	Dirty Oil Filter																	●		●					●	●						
	Faulty Cylinder Oil Control			●													●		●					●								
	Clogged Oil Drillings																			●				●	●	●						
	Oil Suction Line Restriction																			●				●	●	●						
	Faulty Oil Pressure Regulator																			●												
	Crankcase Low or Out of Oil																			●		●	●	●	●	●						
	Wrong Grade Oil for Weather Conditions																●			●				●	●							
	Oil Level Too High							●				●					●						●									
Cooling System	Insufficient Coolant Worn Pump																			●		●	●									
	Faulty Thermostats																	●		●	●	●	●									
	Damaged Hose Loose Belts																			●		●	●									
	Radiator Shutters Stuck Open				●													●			●											
	Internal Water Leaks																	●	●													
	Clogged Oil Cooler or Water Passages																			●			●									
	Exterior Leaks Air in System																			●		●	●									
	Low Coolant Capacity Dirty Radiator																			●		●	●									
	Coolant Temperature Low				●													●	●		●						●					
Operation and Maintenance Practices	Dirty Filters Screens Breather							●	●										●					●	●	●						
	Long Idle Periods	●	●	●	●	●		●										●	●		●											
	Engine Overloaded							●	●			●												●	●		●					
	Oil Needs Changing																	●						●	●	●						
	Engine Exterior Dirty																					●	●									
Mechanical Adjustments or Repair	Gasket Blow-By or Leakage	●	●	●		●	●	●	●		●	●	●	●	●	●	●		●	●												
	Faulty Damper Flywheel Balance																											●		●	●	
	Valve Leakage Adjustment Bad	●	●			●	●	●																		●					●	
	Broken or Worn Piston Rings	●	●	●		●		●									●							●				●				●
	Incorrect Bearing Clearances							●				●								●					●			●	●			
	Excessive Crankshaft End Clearance																								●			●	●			
	Broken Cam Lobes						●																									
	Main Bearing Bore Out of Alignment																								●			●		●		
	Engine Due for Overhaul	●		●		●		●				●					●			●				●	●	●		●	●	●		●
	Damaged Main or Rod Bearings																			●					●			●				
	Geartrain Backlash Broken Tooth																											●	●		●	
	Misalignment Engine to Driven Unit											●													●				●	●		
	Loose Mounting Bolts Head Capscrew																											●		●		
	Incorrect Valve and Injection Timing	●			●	●	●	●				●															●				●	
	Worn or Scored Liners or Pistons			●			●	●									●							●				●			●	●
	Injectors Need Adjustment		●	●	●	●	●	●	●		●	●															●					
	Broken Bent Push Rod or Cam Box						●																					●			●	
Mechanical Variable Timing System	Faulty Rail Pressure Switch (Open)			●	●		●																									
	Faulty Rail Pressure Switch (Closed)							●																							●	
	Faulty Solenoid			●	●		●																									
	Damaged Piston and Rack Seals			●	●		●																									●
	Insufficient Torque on Actuator Capscrew			●	●		●																									
	Solenoid Orifice Plugged							●																								
	System Stick in Retard			●	●		●																									
	Broken or Disconnected MVT Wire				●																											
	Loose Cam Follower Shaft Eccentric		●		●																											
	System Stuck in Advance							●																			●				●	
Maintenance	Plugged Airline to MVT Activator			●	●		●																									
	[illegible] Exhaust From MVT Activator							●																								

1.2.7.323

Operating Principles

Dependable service can be expected from a Cummins diesel engine when the operating procedures are based upon a clear understanding of the engine's working principles. Each part of the engine affects the operation of every other working part and of the engine as a whole. Cummins diesel engines treated in this manual are four-stroke-cycle, high-speed, full-diesel engines.

The Cummins Diesel Engine

Cummins Diesel Cycle

Cummins diesel engines have a high compression ratio; the charge taken into the combustion chamber during the intake stroke consists of air only — with no fuel mixture. Cummins injectors receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the proper time, in equal quantity and atomized condition for burning. Ignition of the fuel is caused by the heat of the compressed air in the combustion chamber.

It is easier to understand the function of the engine parts if it is known what happens in the combustion chamber during each of the four piston's strokes of the cycle. The four strokes and order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

In order for the four strokes to function properly, the valves and injectors must act in direct relation to each of the four strokes of the piston. The intake valves, exhaust valves and injectors are camshaft actuated, linked by tappets or cam followers, push rods, rocker levers and valve crossheads. The camshaft is gear driven by the crankshaft gear, thus the rotation of the crankshaft directs the action of the camshaft which in turn controls the opening and closing sequence of the valves and the injection timing (fuel delivery).

Intake Stroke

During the intake stroke, the piston travels downward; the intake valves are open, and the exhaust valves are closed. The downward travel of the piston allows air from the atmosphere to enter the cylinder. On turbocharged engines the intake manifold is pressurized as the turbocharger forces more air into the cylinder through the intake manifold. The intake charge consists of only air with no fuel mixture.

Compression Stroke

At the end of the intake stroke, the intake valves close and the piston starts upward on the compression stroke. The exhaust valves remain closed.

At the end of the compression stroke, the air in the combustion chamber has been forced by the piston to occupy a smaller space (depending upon the engine model, and is one-fourteenth to one-sixteenth as great in volume) than it occupied at the beginning of the stroke. Thus, the compression ratio is the direct proportion in the amount of space the air occupies in the combustion chamber before and after being compressed.

Compressing the air into a small space causes the temperature of that air to rise to a point high enough for ignition of the fuel.

During the last part of the compression stroke and the early part of the power stroke, a small metered charge of fuel is injected into the combustion chamber.

Almost immediately after the fuel charge is injected into the combustion chamber the fuel is ignited by the existing hot compressed air.

Power Stroke

During the beginning of the power stroke, the piston is pushed downward by the burning and expanding gases. Both the intake and exhaust valves are closed. As more fuel is added and burned, the gases get hotter and expand more to further force the piston downward and thus adds driving force to the crankshaft rotation.

Exhaust Stroke

During the exhaust stroke, the intake valves are closed, the exhaust valves are open, and the piston on the upstroke.

The upward travel of the piston forces the burned gases out of the combustion chamber through the open exhaust valve ports and into the exhaust manifold.

Proper engine operation depends upon two things — first, compression for ignition; and second, that the fuel be measured and injected into the cylinders in the proper quantity at the proper time.

Fuel System

The PT fuel system is used exclusively on Cummins Diesels. The identifying letters, "PT", are an abbreviation for "pressure-time".

The operation of the Cummins PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the passage size through which the liquid flows. To apply this simple principle to the Cummins PT Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors of each cylinder.
2. A means of controlling pressure of the fuel being delivered by the fuel pump to injectors so individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Fuel passages of the proper size and type so fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantities and proper condition to burn.

The PT fuel system consists of fuel suction line, fuel filters, fuel pump, aneroid, supply lines, fuel passages, fuel manifolds, injectors, drain passages and drain lines. See Fig's. 5-1 through 5-5 for fuel flow.

There are four types of fuel pumps currently used on Cummins Engines. The PT (type G), PT (type G) VS, PT (type g) AFC and the PT (type G) AFC (without Air/Fuel control).

Fuel Pump

The fuel pump is coupled to the air compressor, vacuum pump or fuel pump drive which is driven from the engine gear train. The fuel pump main shaft in turn drives the gear pump, governor and tachometer shaft assemblies.

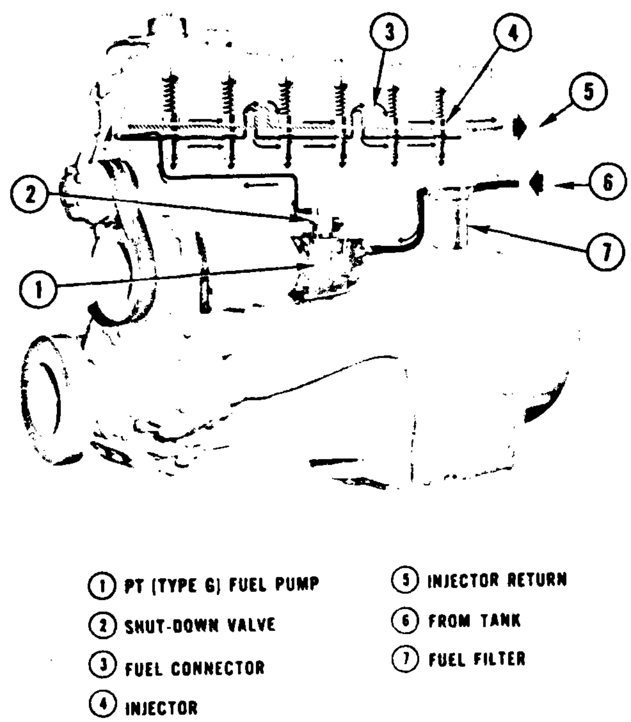


Fig. 5-1. (FWC-13). Fuel flow schematic — N/NT-855 Engine

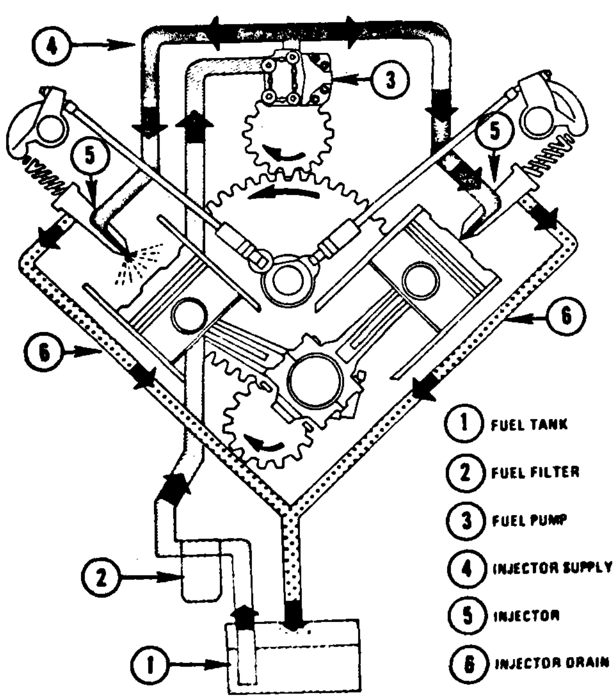


Fig. 5-2. (FWC-30). Fuel flow schematic — V Engine

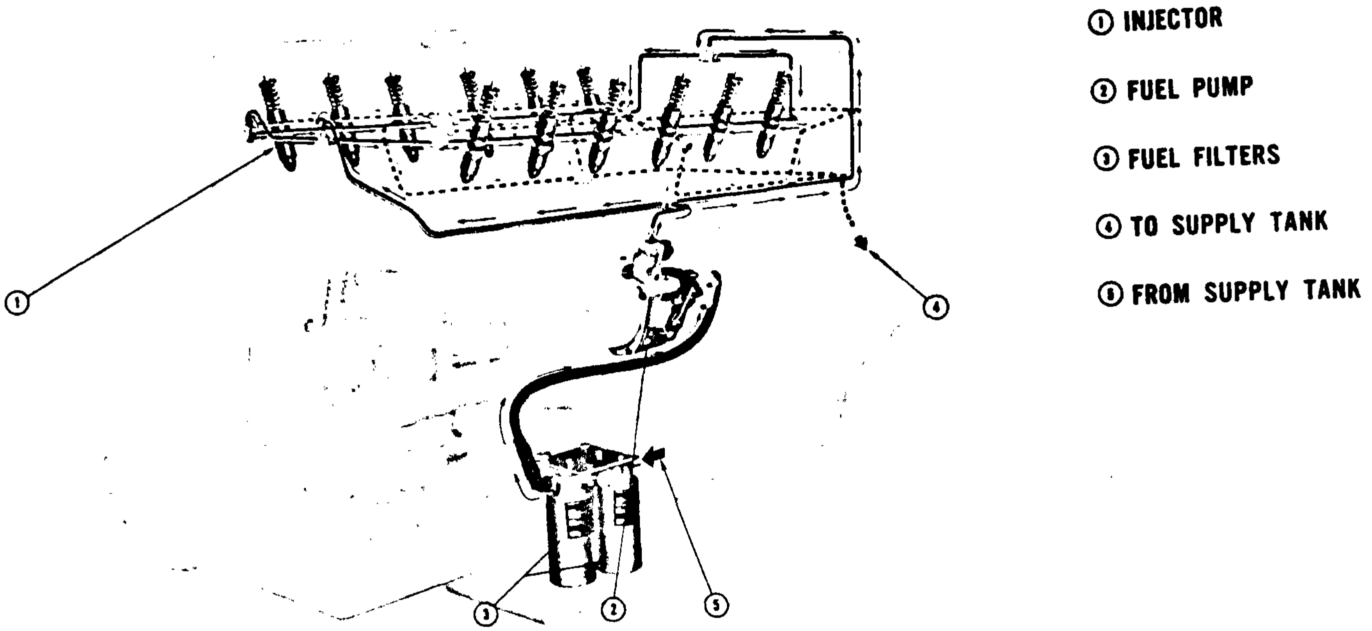


Fig. 5-3, (FWC-15A). Fuel flow schematic — V-1710 Engine

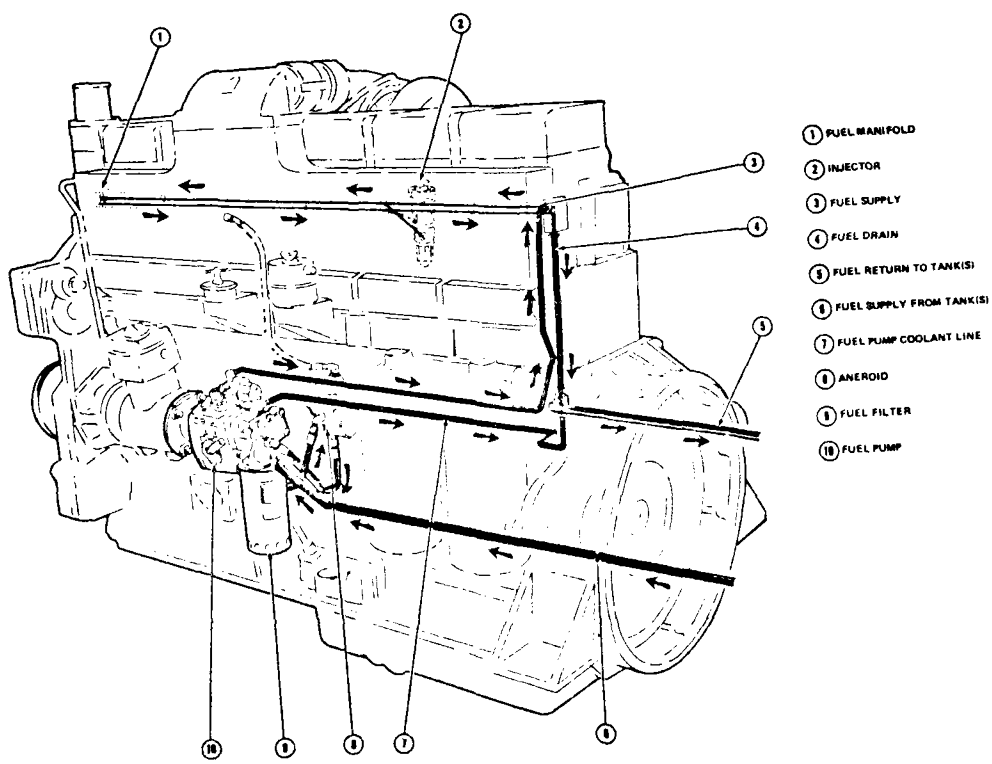


Fig. 5-4, (K11941). Fuel flow schematic — KT(A)-1150 Engine

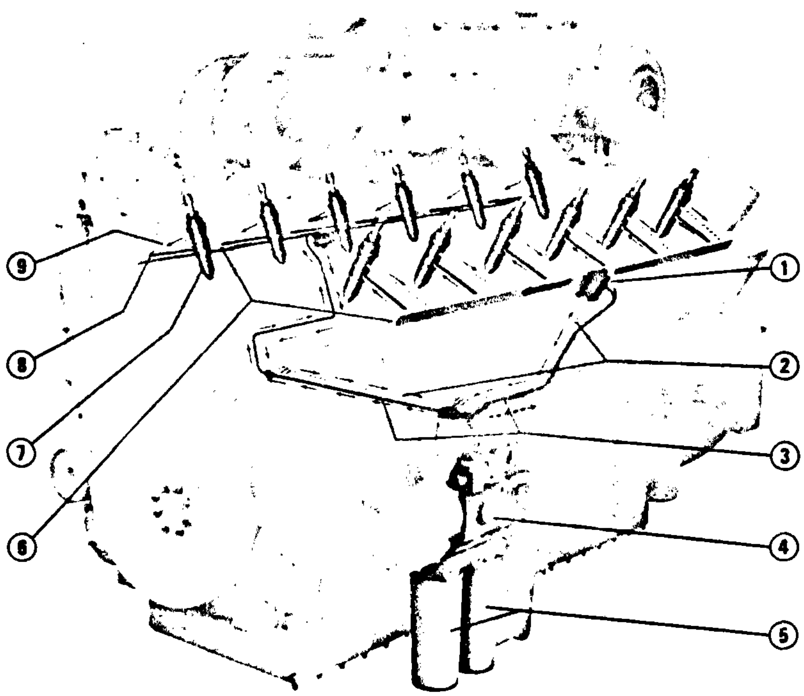


Fig. 5-5, (FWC-40). Fuel flow schematic — KT(A)-2300 Engine

PT (type G) Fuel Pump

The PT (type G) fuel pump assembly, Fig. 5-6, is made up of three main units: the gear pump, standard governor and throttle.

PT (type G) VS Fuel Pump

The PT (type G) VS fuel pump, Fig. 5-7, is made up of four main units: the gear pump, standard governor, throttle as in PT (type G) Fuel Pump and a VS (Variable Speed) governor.

Gear Pump and Pulsation Damper

The gear pump is driven by the pump main shaft and contains a single set of gears to pick up and deliver fuel throughout the fuel system. Inlet to the gear pump on small V-type engines may be through the fuel pump main housing. On other engines it's at the rear of the gear pump.

A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow through the fuel system. From the gear pump, fuel flows through the filter screen and:

In the PT (type G) and PT (type G) VS fuel pumps to the governor assembly as shown in Fig's. 5-6, 5-7 and 5-8.

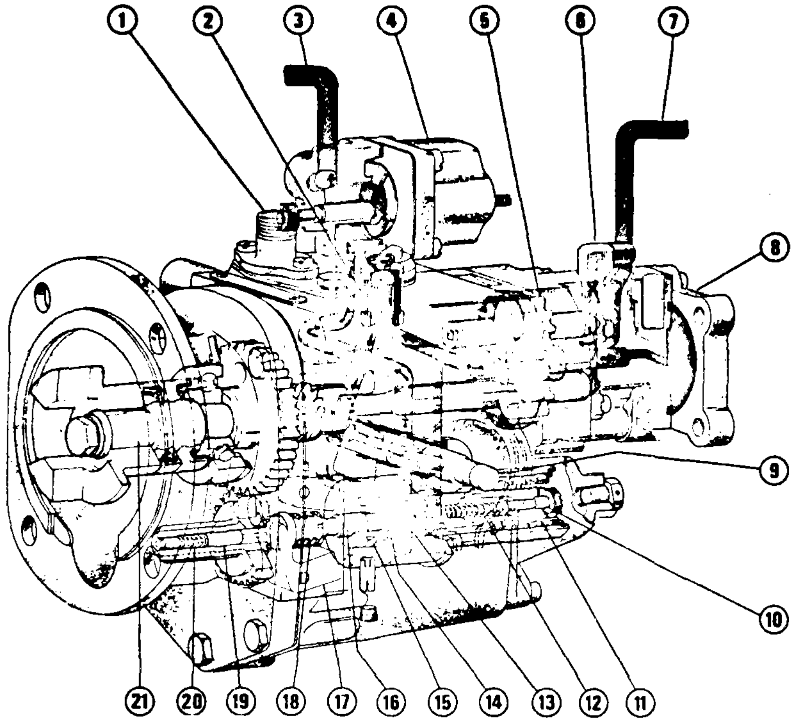
Throttle

The throttle provides a means for the operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In PT (type G) and PT (type G) VS fuel pumps, fuel flows through the governor to throttle shaft. At idle speed, fuel flows through idle port in governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to throttling hole in the shaft.

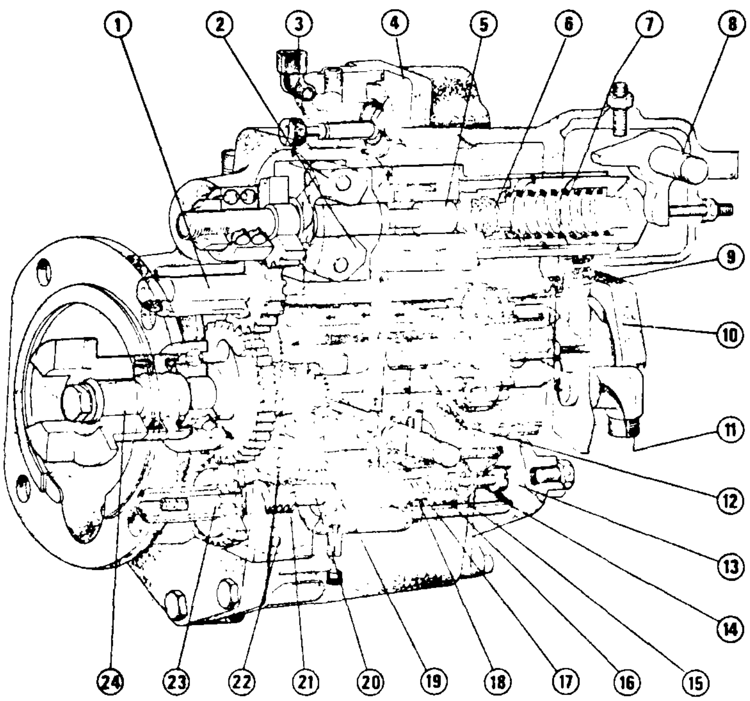
Governors

Idling and High-Speed Mechanical Governor: The mechanical governor, is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle springs in the governor spring pack, position the governor plunger so the idle fuel port is opened



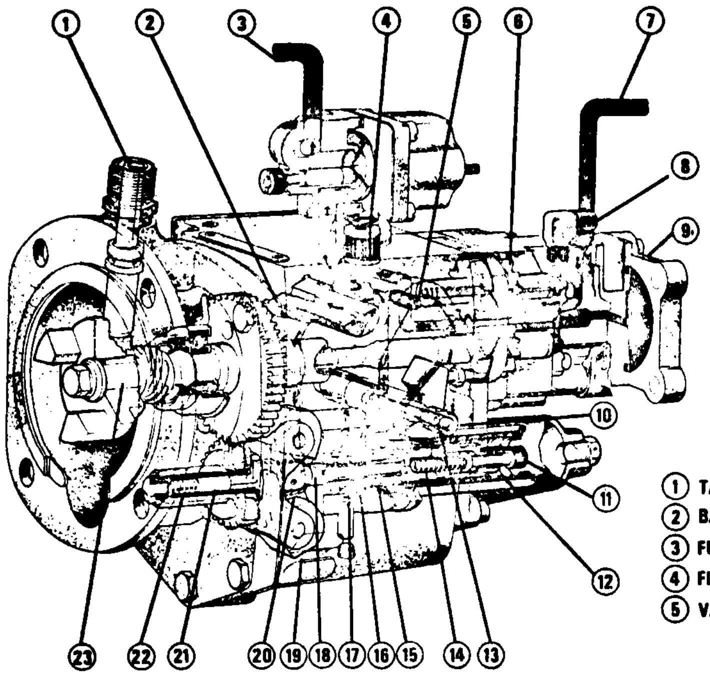
1. TACHOMETER SHAFT
2. FILTER SCREEN
3. FUEL TO INJECTORS
4. SHUT-DOWN VALVE
5. GEAR PUMP
6. CHECK VALVE ELBOW
7. FUEL FROM TANK
8. PULSATION DAMPER
9. THROTTLE SHAFT
10. IDLE ADJUSTING SCREW
11. HIGH SPEED SPRING
12. IDLE SPRING
13. GEAR PUMP PRESSURE
14. FUEL MANIFOLD PRESSURE
15. IDLE PRESSURE
16. GOVERNOR PLUNGER
17. GOVERNOR WEIGHTS
18. TORQUE SPRING
19. GOVERNOR ASSIST PLUNGER
20. GOVERNOR ASSIST SPRING
21. MAIN SHAFT

Fig. 5-6, (FWC-31). PT (type G) fuel pump and fuel flow



1. IDLER GEAR AND SHAFT
2. VS GOVERNOR WEIGHTS
3. FUEL TO INJECTORS
4. SHUTDOWN VALVE
5. VS GOVERNOR PLUNGER
6. VS IDLE SPRING
7. VS HIGH SPEED SPRING
8. VS THROTTLE SHAFT
9. GEAR PUMP
10. PULSATION DAMPER
11. FUEL FROM FILTER
12. PRESSURE REGULATOR VALVE
13. IDLE ADJUSTING SCREW
14. SPRING SPACER
15. HIGH SPEED SPRING
16. IDLE SPRING
17. IDLE SPRING PLUNGER
18. THROTTLE SHAFT
19. FILTER SCREEN
20. GOVERNOR PLUNGER
21. TORQUE SPRING
22. GOVERNOR WEIGHTS
23. GOVERNOR ASSIST PLUNGER
24. MAIN SHAFT

Fig. 5-7, (FWC-35). PT (type G) VS (Variable Speed) fuel pump and fuel flow



1. TACHOMETER DRIVE
2. BARREL PLUG
3. FUEL TO INJECTORS
4. FILTER SCREEN
5. VALVE PLUG
6. GEAR PUMP
7. FUEL FROM FILTER
8. CHECK VALVE ELBOW
9. PULSATION DAMPER
10. THROTTLE SHAFT
11. IDLE ADJUSTING SCREW
12. HIGH SPEED SPRING
13. FUEL ADJUSTING SCREW
14. IDLE SPRING
15. GEAR PUMP PRESSURE
16. FUEL MANIFOLD PRESSURE
17. IDLE PRESSURE
18. GOVERNOR PLUNGER
19. GOVERNOR WEIGHTS
20. TORQUE SPRING
21. GOVERNOR ASSIST PLUNGER
22. GOVERNOR ASSIST SPRING
23. MAIN SHAFT

Fig. 5-8. (FWC-52). PT (type G) fuel pump (Non-air fuel control)

enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors. This fuel is controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT (type G) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner, engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shut-down valve, inlet supply lines and on into the injectors.

PT (type G) Variable-Speed Governors

The VS governor, Fig. 5-7, in the upper portion of the fuel pump housing, operates in series with the standard governor to permit operation at any desired (near constant) speed setting within the range of the standard governor. Speed can be varied with the VS speed control lever, located at top of the pump. This pump gives surge-free governing throughout the engine speed range with a speed droop smaller than the standard governor and is suited to the varying speed requirements of power take-off etc., in which the same engine is used for propelling the unit and also driving a pump or other fixed-speed machine.

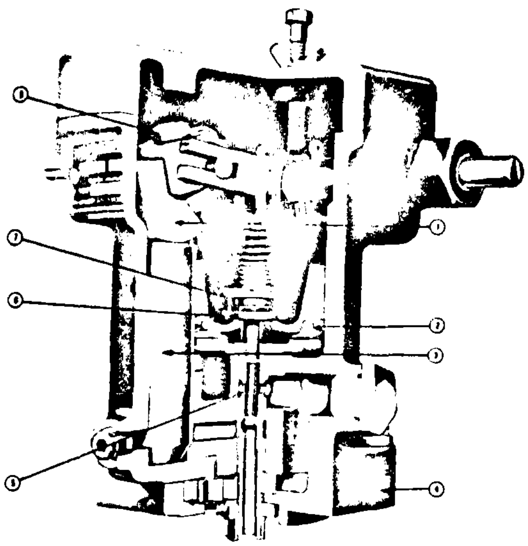
When operating the PT (type G) VS fuel pump at any desired constant speed, the VS governor lever should be placed in operating position and the throttle locked in full open position to allow a full flow of fuel through the standard governor.

Hydraulic Governor

Hydraulic governors are used on stationary power applications where it is desirable to maintain a constant speed with varying loads.

The Woodward Hydraulic Governor uses lubricating oil, under pressure, as an energy medium. It is supplied from a sump on the governor drive housing. For oil viscosity, see Page 3-2.

The governor acts through oil pressure to increase fuel delivery. An opposing spring in the governor control linkage acts to decrease fuel delivery.



1. TERMINAL LEVER
2. BALLARM PIN
3. SERVO MOTOR PISTON
4. GOVERNOR BASE
5. PILOT VALVE PLUNGER
6. THRUST BEARING
7. SPRING SEAT
8. SPEED DROP ADJUSTING SCREW

Fig. 5-9, (FWC-1). Woodward hydraulic governor

In order that its operation may be stable, speed droop is introduced into the governing system. Speed droop means the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop varies with engine applications and may easily be adjusted to cover a range of 0 to 5 percent on the PSG to 7 percent on SG.

Assume a certain amount of load is applied to the engine. The speed will drop, flyballs will be forced inward and will lower the pilot valve plunger. This will admit oil pressure underneath the servo piston, which will rise (as shown in Fig. 5-9). The movement of the servo piston is transmitted to the terminal shaft by the terminal lever. Rotation of the terminal shaft causes the fuel setting of the engine to be increased.

Aneroid

The *aneroid control*, Fig. 5-10, provides a fuel by-pass system that responds to air manifold pressure and is used on turbocharged engines for close control of exhaust smoke.

The aneroid limits fuel pressure to the injectors when accelerating the engine from speeds below normal operating range, and while air intake manifold air pressure is not sufficient for complete combustion. Air intake manifold pressure rises with the turbocharger speed which is powered by exhaust gas energy and is therefore low at low engine speed and exhaust gas output.

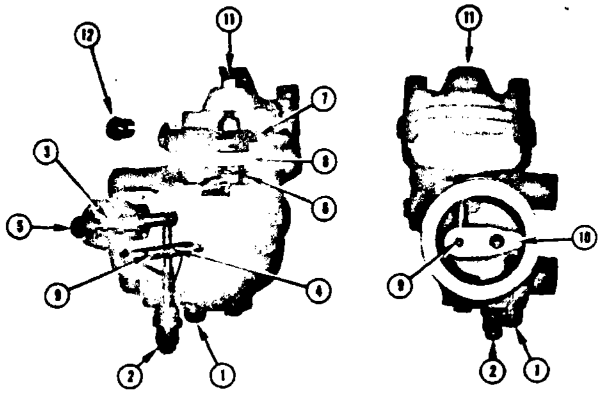


Fig. 5-10, (F-5244). Aneroid cutaway

During acceleration or rapid engine load changes, turbocharger speed (intake manifold pressure) change inherently lags behind the power or fuel demand exercised by opening of the throttle. This lag does not exist in the fuel system; therefore, an overrich or high fuel to air ratio, usually accompanied by smoke, occurs until the turbocharger "catches up".

The function of the aneroid is to create a lag in the fuel system so response is equivalent to the turbocharger, thus controlling engine smoke level.

Caution: Aneroids must not be removed, disconnected or otherwise rendered ineffective, nor should settings be altered to exceed specifications as set at the factory. See "Maintenance Schedule".

Fuel Flow

1. Fuel from the fuel pump enters the aneroid and is directed to the starting check valve area (5, Fig. 5-10).
2. The starting check valve (3) prevents the aneroid from by-passing fuel at engine cranking speeds. For speeds above cranking, fuel pressure forces the check valve open, allowing fuel to flow to the valve port (4) of the shaft (9).
3. The shaft (9) and its bore form a fuel by-pass valve. This shaft and bore allows passage or restricts the fuel flow.

4. The shaft and sleeve are by-passing fuel when the arm (10) of the lever is resting against the adjusting screw (1). The amount of fuel by-passed is adjusted by this screw, which protrudes from the bottom of the aneroid.
5. The lever arm connected to the piston (8) by the actuating shaft (6), rotates the shaft, closing the valve port. The lever is rotated by the action of the air intake manifold pressure (11) against the piston and diaphragm (7), moving the actuating shaft downward against the resisting spring force.
6. Anytime the engine intake manifold air pressure is above preset "air actuation pressure", the aneroid is "out of the system".
7. The aneroid begins dumping when the intake manifold pressure drops below a preset value.
8. The aneroid does not by-pass fuel under full throttle lug down conditions until speed is low enough to reduce the intake manifold air pressure to the aneroid operating range (usually below engine stall-out speed).
9. Fuel allowed to pass through the by-pass valve is returned (2) to the suction side (inlet fitting) of the PT gear pump. The by-passed fuel reduces the fuel pump output to the engine and reduces the fuel manifold pressure in proportion to the by-pass rate.

PT (type D) Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing and injection. Principles of operation are the same for inline and V-engines but injector size and internal design differs slightly. Fig. 5-11 and 5-12.

Fuel supply and drain flow are accomplished through internal drillings in the cylinder heads. Fig's. 5-1 through 5-5. A radial groove around each injector mates with the drilled passages in the cylinder head and admits fuel through an adjustable (adjustable by burnishing to size at test stand) orifice plug in the injector body. A fine mesh screen at each inlet provides final fuel filtration.

The fuel grooves around the injectors are separated by "O" rings which seal against the cylinder head injector bore. This forms a leak-proof passage between the injectors and the cylinder head injector bore surface.

Fuel flows from a connection atop the fuel pump shut-down valve through a supply line into the lower drilled passage in the cylinder head. A second drilling in the head is aligned with the upper injector radial groove to drain away excess fuel. A fuel drain allows return of the unused fuel to the fuel tank.

The injector contains a ball check valve. As the injector plunger moves downward to cover the feed opening, an impulse pressure wave seats the ball and at the same time traps a positive amount of fuel in the injector cup for injection. As the continuing downward plunger movement injects fuel into the combustion chamber, it also uncovers the drain opening and the ball rises from its seat. This allows free flow through the injector and out the drain for cooling purposes and purging gases from the cup.

Fuel Lines, Connections and Valves

Supply and Drain Lines

Fuel is supplied through lines to the cylinder heads. A common drain line returns fuel not injected, to the supply tank.

Connections

Fuel connectors are used between the inline engine cylinder heads to bridge the gap between each supply and drain passage (3, Fig. 5-1).

Flanged injectors are connected to the supply and drain manifolds through connections. The inlet connection contains a fine mesh screen which acts as the final filter before fuel enters the combustion chamber.

Shut-Down Valve

Either a manual or an electric shut-down valve is used on Cummins fuel pumps.

With a manual valve, the control lever must be fully clockwise or open to permit fuel flow through the valve.

With the electric valve, the manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn the manual knob clockwise to permit fuel to flow through the valve.

1. CUP
2. CUP RETAINER
3. BARREL
4. PLUNGER
5. CHECK BALL
6. GASKET
7. CLIP
8. SCREEN
9. FUEL IN
10. ORIFICE
11. ORIFICE GASKET
12. COUPLING
13. ADAPTER
14. SPRING
15. LINK
16. FUEL OUT
17. 'O' RING
18. NUT
19. ROCKER LEVER
20. ADJUSTING SCREW
21. PUSH ROD
22. TAPPET
23. CAMSHAFT LOBE

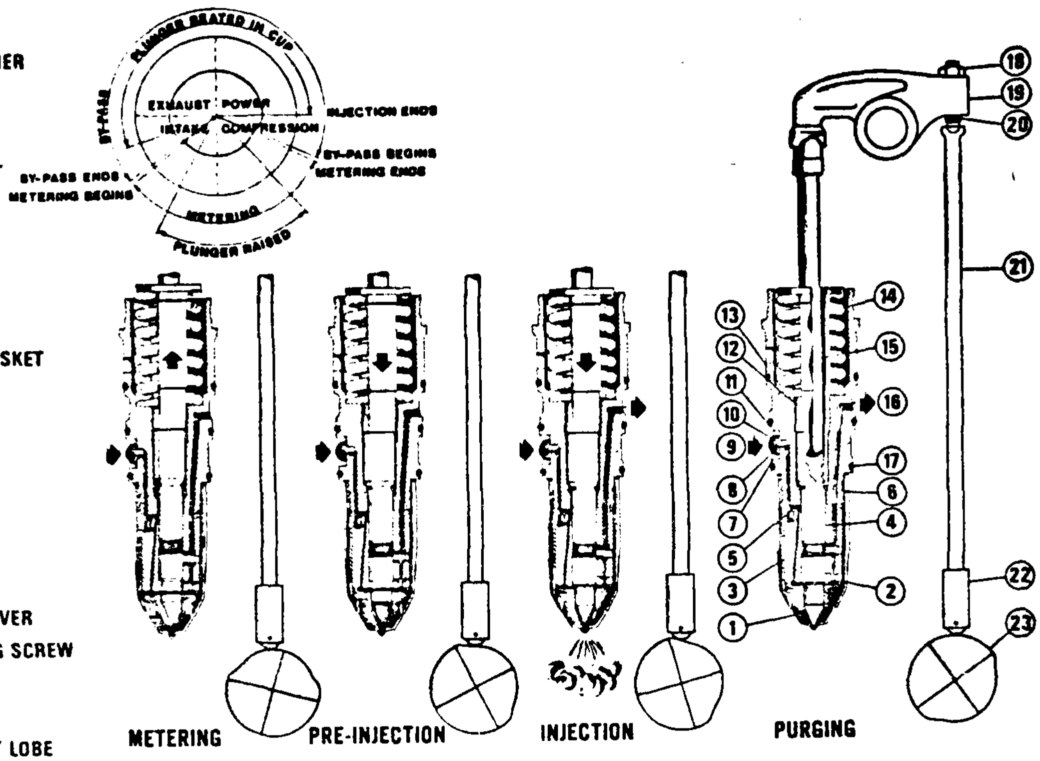


Fig. 5-11, (FWC-24). Fuel injection cycle PT (type D) injector 3/8 inch diameter plunger

1. CUP
2. CUP RETAINER
3. BARREL
4. PLUNGER
5. CHECK BALL
6. GASKET
7. CLIP
8. SCREEN
9. FUEL IN
10. ORIFICE
11. ORIFICE GASKET
12. COUPLING
13. ADAPTER
14. SPRING
15. LINK
16. FUEL OUT
17. 'O' RING
18. NUT
19. ROCKER LEVER
20. ADJUSTING SCREW
21. PUSH ROD
22. TAPPET
23. CAMSHAFT LOBE

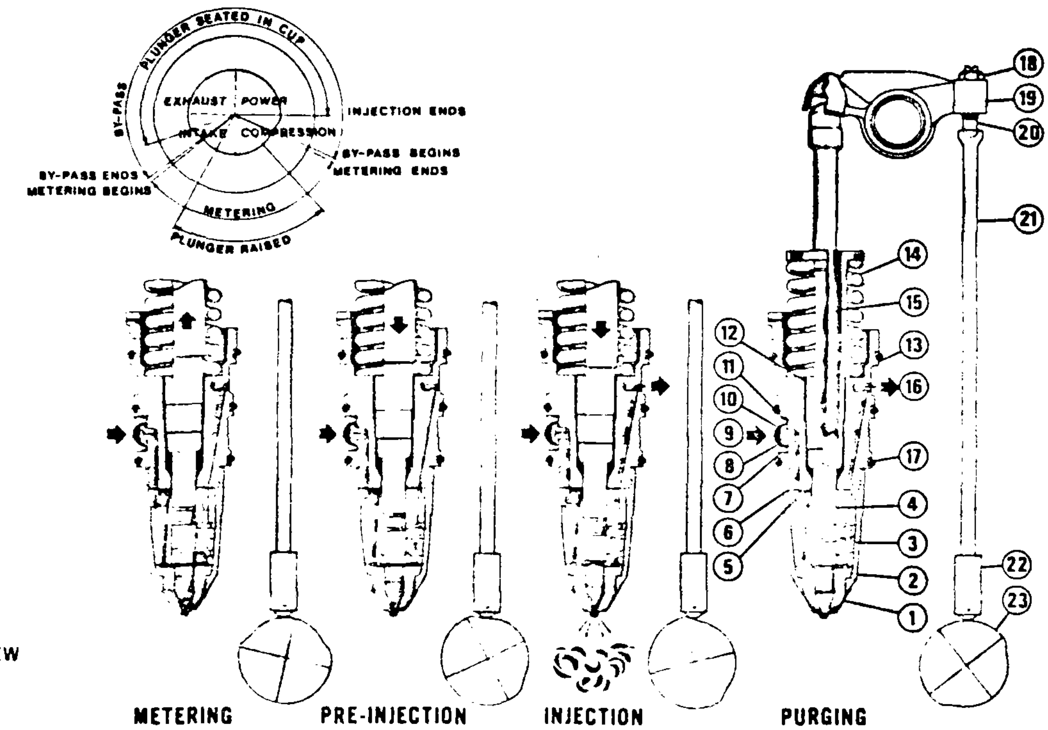


Fig. 5-12, (FWC-29). Fuel injection cycle PT (type D) injector 5/16 inch diameter plunger

Lubricating System

Cummins engines are pressure lubricated; pressure is supplied by a gear-type lubricating oil pump located in the oil pan or on the side of the engine.

A pressure regulator is mounted in the lubricating oil pump to control lubricating oil pressure.

Filters and screens are provided in the lubricating oil system to remove foreign material from circulation and prevent damage to bearings or mating surfaces. A by-pass valve is provided in the full-flow oil filter head as insurance against interruption of oil flow by a dirty or clogged element.

Maximum cleansing and filtration is achieved through use of both by-pass and full-flow lubricating oil filters. Full-flow filters are standard on all engines; by-pass filters are used on all turbocharged models and optionally on all other engines.

Some engines are equipped with special oil pans and filters for specific applications, and others with auxiliary oil coolers to maintain closer oil temperature regulation.

Air compressors and turbochargers are lubricated from the engine oil system. The turbocharger is also cooled by the same lubricating oil used for lubrication.

Fuel pumps and injectors are lubricated by fuel oil.

Inline Engines

NH and NT Series

Oil is drawn into the pump through an external oil line connected to the oil pan sump. A screen in the sump filters the oil. On NH and NT Engines (Fig. 5-13) oil is drawn from the pan by the pump out through a full-flow filter and circulates back into the block. The filter may be mounted directly to the rear of the pump, vertically mounted on the exhaust side of the engine or remote mounted. External lines are used for remote mounting arrangements.

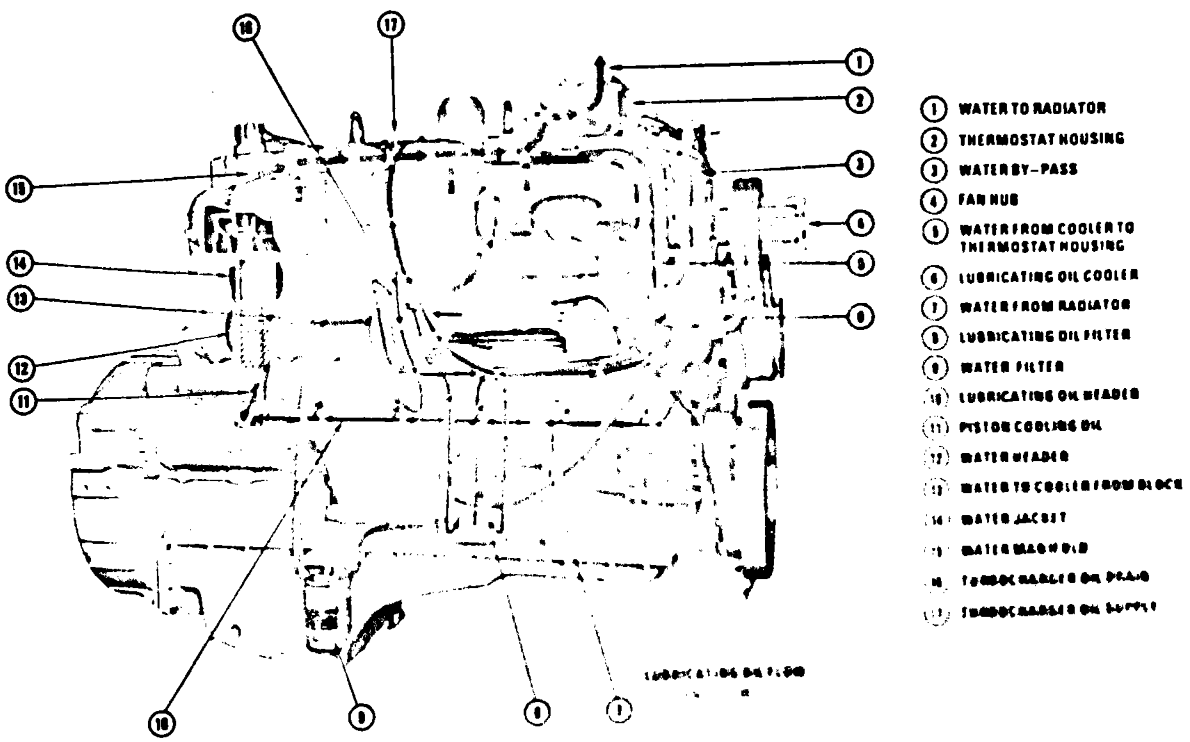


Fig. 5-13, (LWC-18). Lubricating oil and coolant flow — N NT-855 Engine

On remote and pump mounted filters oil flows from the pump to the oil cooler then flows to oil headers through internal drillings in the gear case. On NTA Engines oil flow is from the pan to the pump, to the filter, to the oil cooler, to the block.

An oil header drilled the full length of the block, fuel pump side, delivers oil to moving parts within the engine. Internal oil passages carry oil from the camshaft to the upper rocker housings and drillings through the block, crankshaft, connecting rods, and rocker levers complete the oil circulation.

On engines equipped with oil cooled pistons, an oil header drilled the length of the block, exhaust manifold side, supplies oil to six spray nozzles used for piston cooling.

A piston cooling oil pump, as a second section of the engine lubricating oil pump or a larger capacity oil pump, pumps this oil to the oil header.

FFC OIL FLOW CIRCUIT

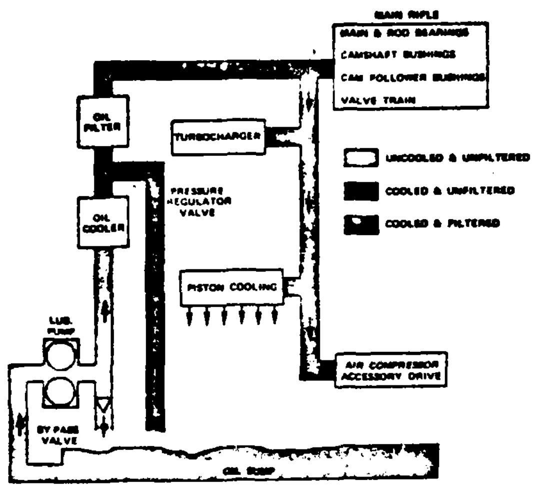


Fig. 5-14, (N10740). Full flow oil cooling schematic — NTC-855 Engine

NTA-855 Engines (Full Flow Oil Cooling)

The NTA (FFC) Engine is pressure lubricated by a gear-type lubricating oil pump located on the intake manifold side of the engine. Oil pressure to the main rifle is controlled by a regulator located in the cooler support on the exhaust side of the engine.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump. Fig's. 5-14 and 5-15, then transferred from the suction cavity by the pump gears into the pressure cavity.

Lubricating oil passes from the pump into the block, then across the front of the block by means of an internal oil passage and enters the cooler support. Oil is routed out of the cooler support and into the cooler housing, passing through the cooler housing. (The oil cooler is a counterflow tube-and-shell type heat exchanger, with oil passing from front to rear through the shell and coolant passing from rear to front through the tubes.) Oil exits the cooler housing and passes into the cooler cover, then enters the "rifle drilling" at the bottom rear of the cooler housing and flows forward into the filter head.

Lubricating oil flowing into the filter shell from the filter head enters outside the filter element and passes thorugh the element from outside to inside. Filtered lubricating oil then re-enters the filter head and flows through rifle drilling in the bottom of the cooler housing, then flows forward out of the cooler housing and into the cooler support where the flow divides.

Filtered and cooled lubricating oil from the cooler support is routed to the turbocharger through the supply hose. Turbocharger return oil is then routed by the drain hose back to the crankcase.

Filtered and cooled lubricating oil re-enters the block from the cooler support and is transferred internally back across the front of the block through a drilled oil transfer passage to the head of the main rifle drilling. Accessory drive lubrication is supplied from the transfer passage leading to the head of the main rifle drilling. An intersection drilling routes lubricating oil from the transfer passage out the front of the block and into the gear cover on the exhaust side of the engine, then across the front of the engine through a tube in the gear cover. The flow path then splits, part being routed to the accessory drive bushing in the gear cover and the rest being routed to the air compressor.

Piston-cooling is supplied from the transfer passage leading to the head of the main rifle drilling. An intersecting drilling allows flow to the piston-cooling rifle from the oil transfer passage. The piston-cooling rifle extends from the front to the rear of the block on the exhaust side of the engine. Six piston-cooling nozzles inserted from the outside of the block direct a spray of lubricating oil from the piston-cooling rifle to the bottom of each piston.

Lubricating oil entering the main rifle is routed by means of drilled passages to the main bearings, rod bearings, piston pin bushings, camshaft bushings, cam followers shafts and levers, rocker box shafts and rocker arms, etc., then returns to the oil pan.

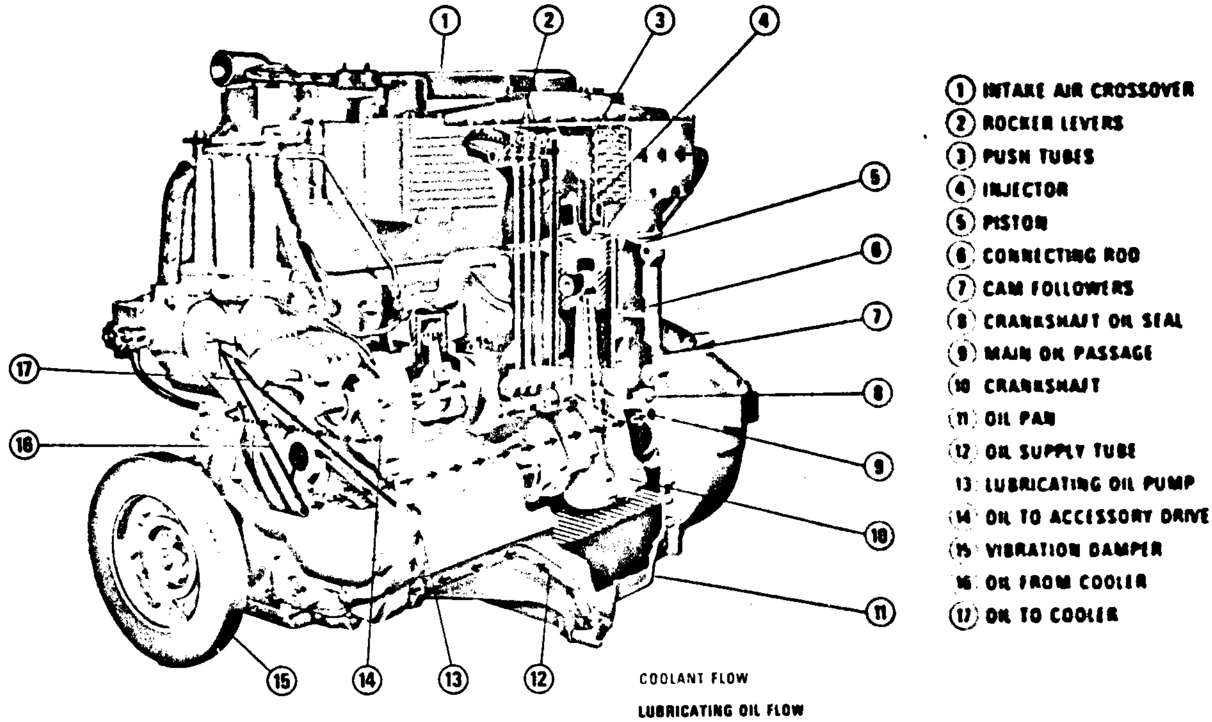


Fig. 5-15, (LWC-25). Lubricating oil and coolant flow — FFC (NTA Engine)

V Engines

V6 and V8 Engines are pressure lubricated by a gear type lubricating oil pump mounted on the bottom of the block, enclosed in the oil pan, and gear driven from the crankshaft gear.

Oil drawn from the pan sump through a screen is delivered to the engine working components through oil lines and oil headers which are drilled the length of the block. Drillings in the block, cylinder head, crankshaft and rocker lever shafts complete the oil circulation passages. Fig's. 5-16 and 5-17.

Oil flows through a suction tube to the lubricating oil pump up a passage in the rear of the block to the cooler (if used) and filter.

V-903 Engines

1. Oil flows from the cooler and filter to the right bank of the oil drilling at the front of the engine to the front center of the block. Oil flows through the crossover at the front of the block to the left bank and right bank main oil drillings (drilled the length of the block). Fig. 5-16.
2. Oil flows through the left bank drilling toward the rear of the engine to the left bank tappets, accessory drive, to the numbers 2, 3, 4 and 5 cam bushings, main bearings and connecting rods.
3. At the same time oil flows to a right bank drilling toward the rear of the engine to oil the right bank tappets.
4. The right bank rocker levers are oiled intermittently from the rear cam bushing location. The left bank rocker levers are oiled intermittently from the front cam bushing.

V-378, V-504 and V-555 Engines

1. Oil flows from the [illegible] drilling at the rear of the [illegible] gear, rear cam bushing and [illegible] which in turn supplies the two rear [illegible] Fig. 5-17.
2. The right bank rocker levers are oiled intermittently from the rear cam [illegible]
3. Oil flows through [illegible] the front of the engine to the [illegible] tappets.

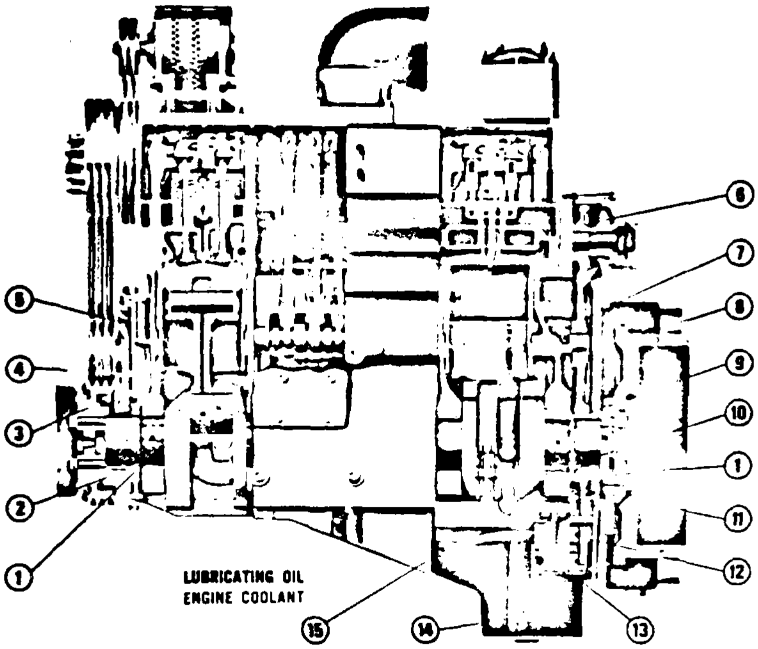


Fig. 5-16, (LWC-16). Lubricating oil and coolant flow — V-903 Engine

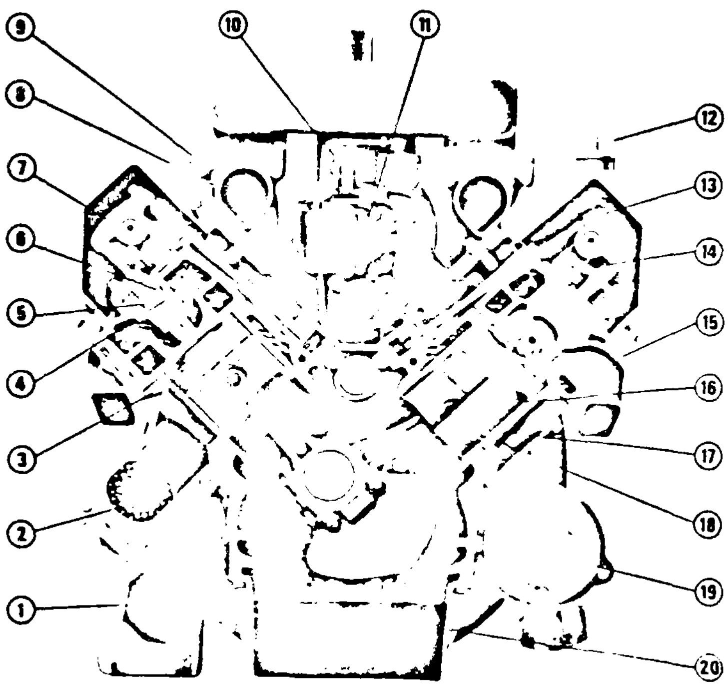


Fig. 5-17, (LWC-4). Lubricating oil and coolant flow — V-378, V-504, V-555 Engines

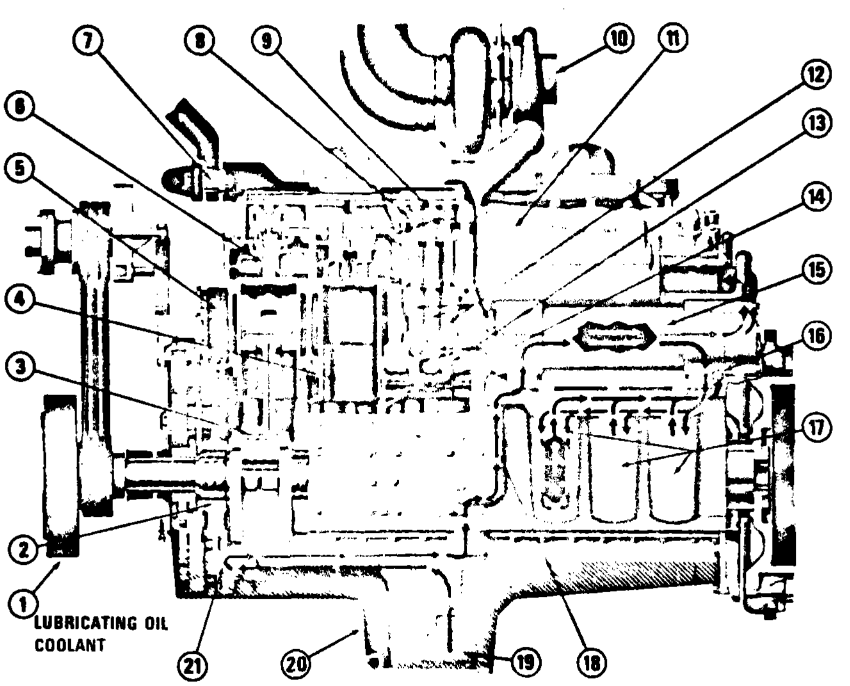


Fig. 5-18, (CWC-13). Lubricating oil and coolant flow — V-1710 Engine

to the center cam bushings, main bearings and connecting rods.

4. Oil flows through a crossover at the front of the block to the left bank.

5. The left bank rocker levers are oiled intermittently through the front cam bushing.

6. Oil then flows to a left bank drilling toward the rear of the engine to oil the left bank injector tappets.

V-1710 Engines

Cummins V-1710 Engines, Fig. 5-18, are pressure lubricated, pressure being supplied by a gear-type lubricating oil pump, located in the oil pan and gear driven from the crankshaft gear.

1. Oil is drawn into the pump through an oil line to the oil pan sump. A screen in the pump strains the oil.

2. Internal lubricating oil flows from the pump to the cooler to the full-flow filters mounted on the side of the engine, then to oil headers in the block.

3. The main oil header, drilled the full length in the center of the block delivers oil to moving parts within the engine.

4. Oil pipes — or a combination of pipes and passages — carry oil from the camshaft to the upper rocker housings; various drillings through the block, crankshaft, connecting rods and rocker levers complete the oil circulating system.

5. On engines equipped with oil-cooled pistons, oil is supplied from the front of the block to oil headers which are drilled the length of the block on each side; headers supply oil to the spray nozzles, which direct the oil to the piston skirts.

6. Lubricating oil pressure is controlled by a regulator located in the lubricating oil pump.

KT(A)-1150 Engines

The KT(A)-1150 Engines are pressure lubricated by a gear-type lubricating oil pump located on the exhaust manifold side of the engine directly below the water pump inside the gear cover.

Lubricating oil is drawn from the pan, through a suction tube, by the lubricating oil pump, Fig. 5-19, then trans-

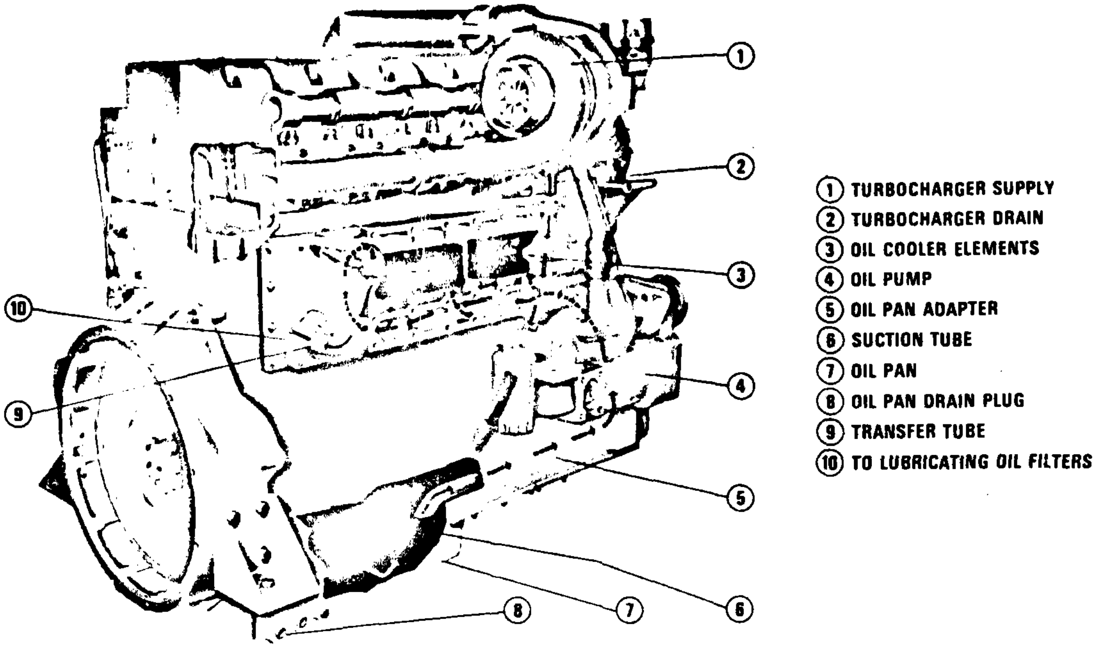


Fig. 5-19, (LWC-29). Lubricating oil flow — KT(A)-1150 Engine

ferred from the suction cavity by the pump gears into the pressure cavity. A pressure regulator valve dumps excess oil directly into the pump intake rather than back into the oil pan.

From the lubricating oil pump, oil flows to the lubricating oil cooler, through the cooler, then across the block. On the air intake side of the block it flows to the filter head. A by-pass valve is provided in the oil inlet cavity to assure against interruption of oil flow if the filter elements become clogged. From the filter head oil enters the shells and passes through the elements, then up, splitting into two passages. One flows to the main engine oil passage and the other to the piston-cooling passage. A second pressure control valve, located in the base of the filter head, limits the flow of lubricating oil to the nozzles depending on pump supplied pressure.

Main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from the main passage into the camshaft bushings; from there, by constant flow, it goes to the cam follower shafts and up through the cylinder heads. The cam followers are lubricated from their shaft; the cam followers are individually drilled to supply lubricating oil to the rollers and the push tube seats. The rocker lever bushings are also shaft lubricated. Adjusting screws are lubricated through drillings in the levers and bushings. See Fig. 5-20.

The connecting rod bearings get lubrication from cross drillings in the crankshaft; oil then flows through angle drillings in the connecting rods to lubricate the piston pins and bushings. It is then routed from the main passage through drillings in the gear housing and cover to the camshaft and water pump idler gears. It then moves across to the gear cover and is routed by drillings to the rest of the gears and bushings.

Filtered and cooled lubricating oil is routed to the turbocharger through an external drilling in the gear housing. The turbocharger drain oil is dumped directly into the crankcase. Fig. 5-19.

KT(A)-2300 and KTA-3067 Engines

The KT(A)-2300 and KTA-3067 Engines are pressure lubricated by a gear-type lubricating oil pump located in the oil pan at the rear of the engine. The pump is mounted to the block directly below the crankshaft and is driven from the rear crankshaft gear.

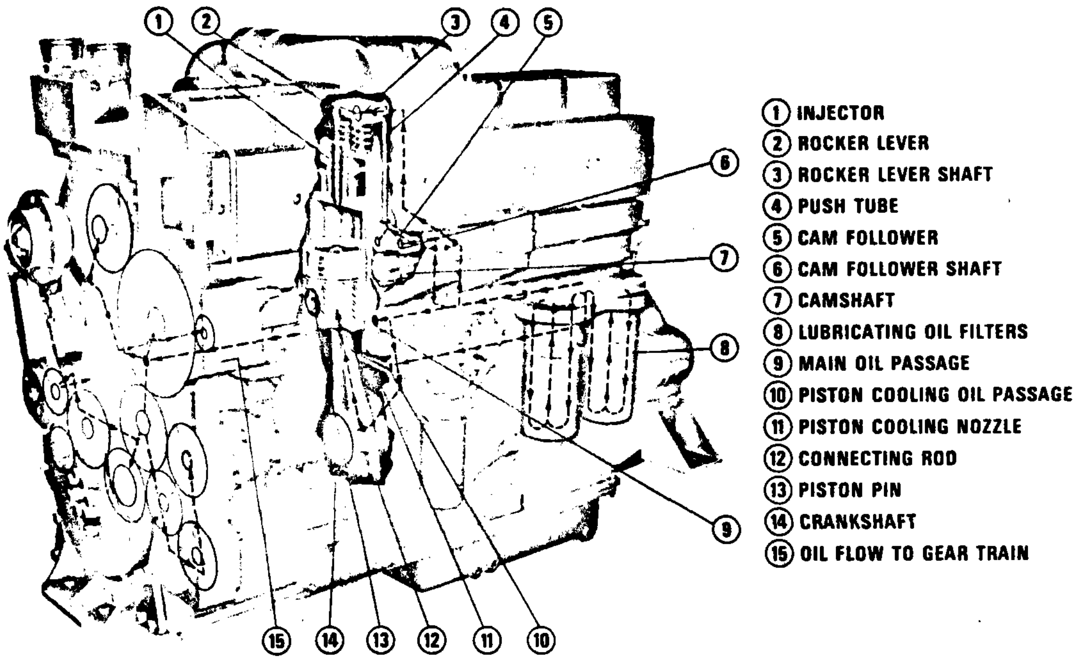


Fig. 5-20, (LWC-28). Lubricating oil flow — KT(A)-1150 Engine

Lubricating oil is drawn from the pan, through a suction tube, by the pump then transferred from the suction cavity by pump gears into the pressure cavity. A pressure regulator valve dumps excess oil back into the oil pan.

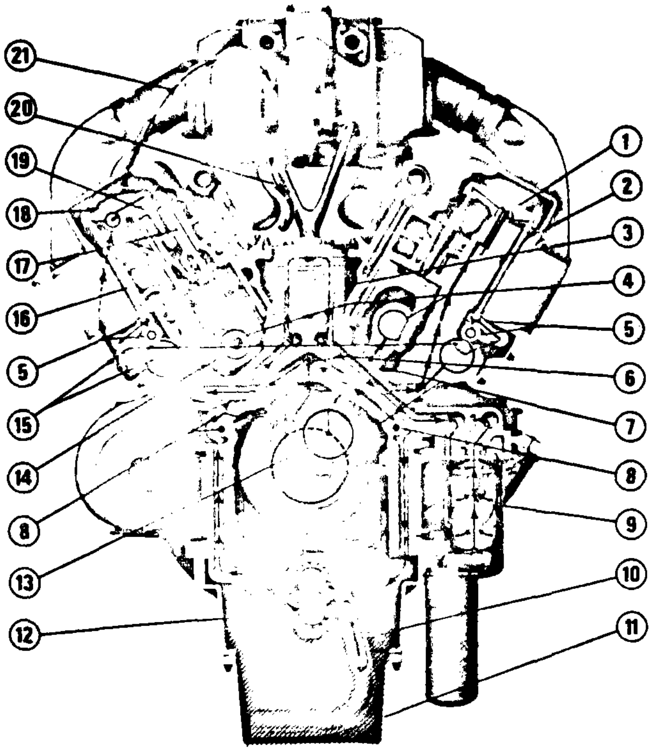
From the lubricating oil pump, oil flows through the block drillings to the lubricating oil cooler located in the block "V", through the cooler, then to filters which may be mounted on either side of the block. Fig's. 5-21, 5-22, 5-23 and 5-24. A by-pass valve is provided in the filter head oil inlet cavity to assure against interruption of oil flow if the filter elements become clogged.

From the filter head, oil enters and passes through the filter elements; it then flows to the main oil passage located in the block "V". This passage feeds two (2) camshaft and two (2) piston cooling drillings in the block. Pressure control valves limit the flow of lubricating oil to the piston cooling nozzles, depending on lubricating oil pump pressure.

The main bearings are lubricated through intersecting drillings, directly from the main oil passage. Oil flows from cam passages into camshaft bushings; from there by constant flow, it goes to the cam follower shafts and up through the cylinder heads. The cam followers are lubricated from their shaft; cam followers are individually drilled to supply lubricating oil to the rollers and push tube seats. The rocker lever bushings are also shaft lubricated. Adjusting screws and valve guides are lubricated through drillings in the rocker levers and bushings.

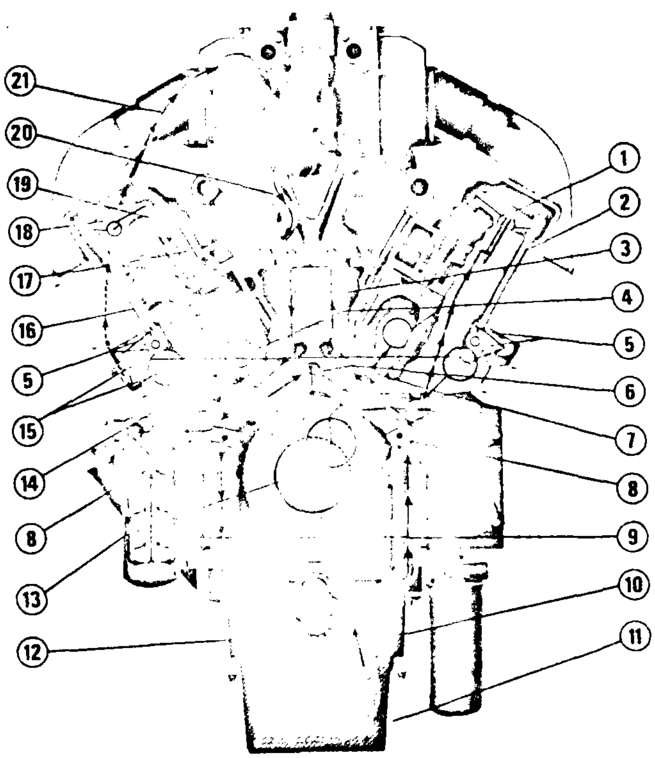
The connecting rod bearings are lubricated from cross drillings in the crankshaft; oil then flows through angle drillings in the connecting rods to lubricate the piston pins and bushings. Lubricating oil is routed from the main oil passage through passages in the gear housing and cover to lubricate the front gear train gears, bushings and idler shafts. The rear gear train receives lubrication through an intersecting drilling from the right bank camshaft passage.

Filtered and cooled lubricating oil is routed from camshaft passages to each turbocharger through external lines from drillings in the cylinder block. The turbocharger drain oil is dumped back into the oil pan through a drilling in the cylinder block.



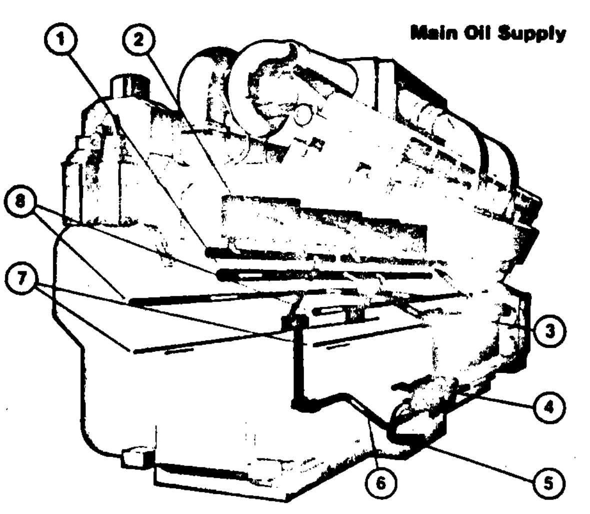
1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

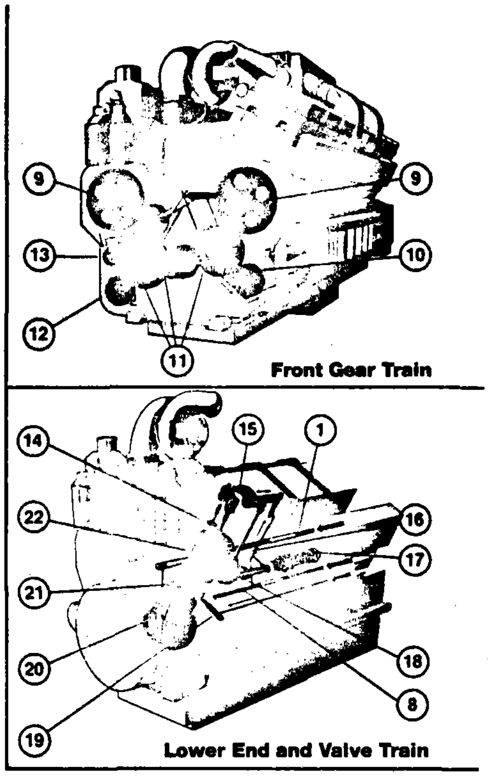
Fig. 5-21, (LWC-35). Front view standard lubricating oil flow — KT(A)-2300 Engine



1. INJECTOR ROCKER LEVER
2. INJECTOR PUSH TUBE
3. OIL COOLER ELEMENT
4. PISTON PIN
5. CAM FOLLOWER
6. MAIN OIL RIFLE
7. CONNECTING ROD
8. PISTON COOLING RIFLE
9. FULL FLOW OIL FILTER
10. OIL SUCTION TUBE
11. OIL PAN
12. OIL PUMP
13. CRANKSHAFT
14. CYLINDER LINER
15. CAMSHAFT
16. VALVE PUSHROD
17. VALVE GUIDE
18. VALVE ROCKER ARM
19. VALVE CROSS HEAD
20. TURBO DRAIN LINE
21. TURBO SUPPLY HOSE

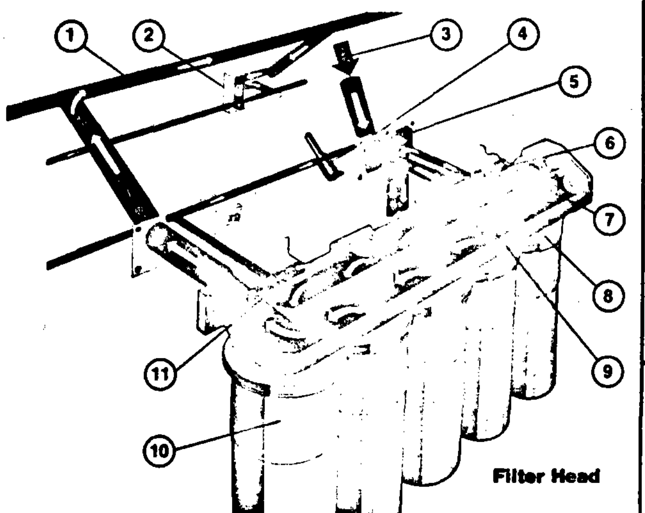
Fig. 5-22, (LWC-34). Front view optional lubricating oil flow — KT(A)-2300 Engine

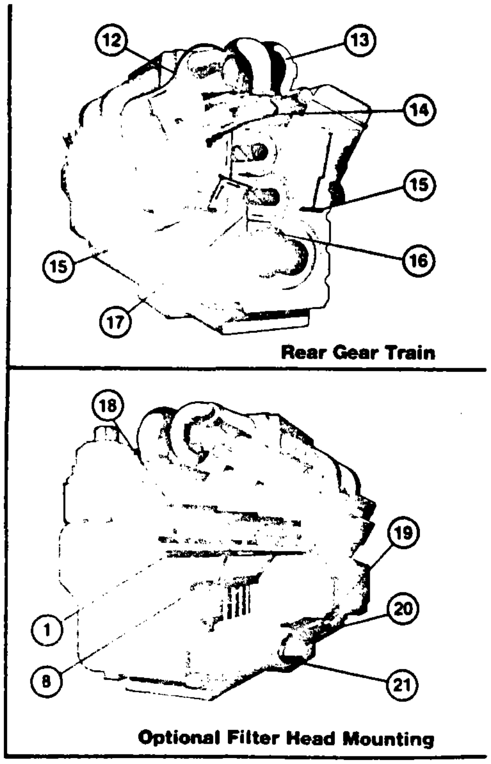




1 MAIN OIL RIFLE
2 OIL COOLER
3 FILTER HEAD
4 LUBRICATING OIL PUMP
5 SUCTION TUBE
6 DISCHARGE TUBE
7 PISTON COOLING OIL RIFLES
8 CAMSHAFT OIL RIFLES
9 CAMSHAFT DRIVE GEAR
10 ACCESSORY DRIVE GEAR
11 IDLER GEARS
12 HYDRAULIC PUMP DRIVE GEAR
13 WATER PUMP DRIVE GEAR
14 EXHAUST VALVES
15 ROCKER LEVER
16 OIL CONTROL ORIFICE
17 CAMSHAFT
18 CAM FOLLOWER
19 PISTON COOLING NOZZLE
20 CRANKSHAFT
21 CONNECTING ROD
22 PISTON

Fig. 5-23, (LWC-35). Lubricating oil flow schematic — KTA-3067 Engine





1 MAIN OIL RIFLE
2 PISTON COOLING REGULATOR R. B.
3 FLOW FROM OIL COOLERS
4 PISTON COOLING NOZZLE
5 BYPASS TO OIL PAN
6 PRESSURE REGULATOR
7 BYPASS VALVE
8 FILTER HEAD
9 REGULATOR CONTROL RIFLE
10 FILTERS
11 PISTON COOLING REGULATOR L. B.
12 TURBOCHARGER OIL SUPPLY LINE
13 TURBOCHARGER
14 TURBOCHARGER OIL DRAIN LINE
15 CAMSHAFT OIL RIFLE
16 THRUST BEARINGS
17 FROM MAIN OIL RIFLE
18 OIL COOLERS
19 DISCHARGE TUBE
20 LUBRICATING OIL PUMP
21 SUCTION TUBE

Fig. 5-24, (LWC-36). Optional lubricating oil flow schematic — KTA-3067 Engine

COOLING SYSTEM

Water is circulated by a centrifugal water pump mounted either in or on the front of the engine belt driven from the accessory drive or crankshaft.

Water circulates around wet-type cylinder liners, through the cylinder heads and around the injector sleeves. Fig. 5-13 through Fig. 5-18. The injector sleeves, in which the injectors are mounted, are designed for fast dissipation of heat. The engine has a thermostat or thermostats to control the engine operating temperature. Engine coolant is cooled by a radiator and fan or a heat exchanger.

The Fleetguard Water Filter is standard on Cummins Engines. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically. Refer to "Coolant Specifications" for water filter capacity and treatment of make-up water.

NTA Aftercooled Engine

Water flows from the radiator into the cavity of the water pump, where the water flow splits. One portion circulates to the cylinder block water header around wet type cylinder liners, through the cylinder head and around the injector sleeves, upwards to the water manifold, to the thermostat housing. At the rear of the block water header, the water is directed to the aftercooler, Fig. 5-25. Water flows forward through the aftercooler to the water crossover to the thermostat housing. The second portion of water flows from the cavity of the water pump housing through the oil cooler and tubing to the rear of the water manifold forward to the thermostat housing, to control engine temperature.

KT(A)-1150 Engines

Water is circulated by a centrifugal water pump, Fig.

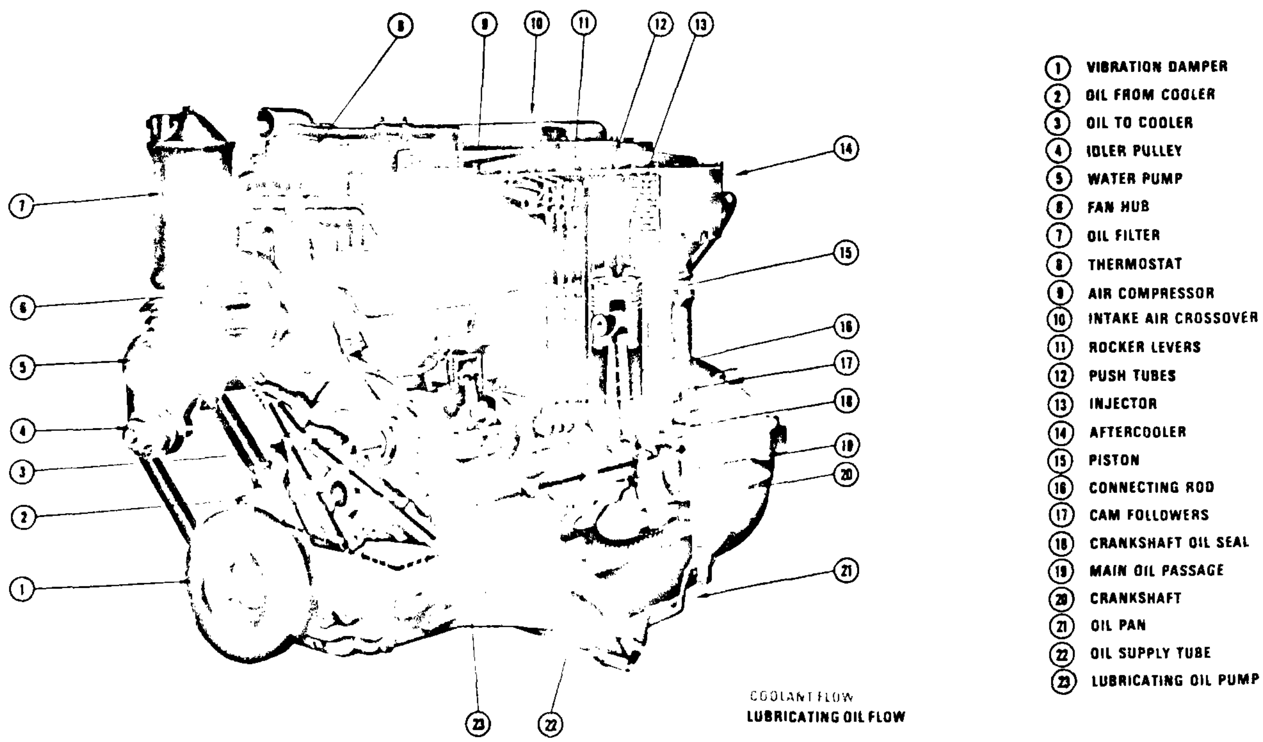


Fig. 5-25, (LWC-22). Coolant and lubricating oil flow — NTA Engine

5-26, mounted on the exhaust side of the block. The pump is driven by an idler gear from the crankshaft.

Coolant flows from the water pump volute into the oil cooler housing, through the cooler housing (serving as a water distribution manifold) into the block, maintaining an equal flow around all cylinder liners. From the liner area coolant flows into individual cylinder heads through holes drilled between the valves and around the injector "wells". From the cylinder heads water flows to the rocker housing (water outlet manifold) then to the thermostat housing. At the thermostat housing water is returned to the water pump via a by-pass tube until the engine coolant temperature activates dual thermostats. Coolant flow is then directed through a radiator or heat exchanger.

KT(A)-2300 and KTA-3067 Engines

Water is circulated by a centrifugal water pump mounted on the right bank side of the block. The pump is driven by an idler gear from the crankshaft. Fig's. 5-27 and 5-28.

Coolant flows from the water pump volute into the center of the "V" of the cylinder block, around the lubricating oil cooler elements. The center of the "V" serves as a water distribution manifold to supply a flow of coolant through the aftercooler elements and around the cylinder liners.

From the liner area coolant flows into individual cylinder heads through passages between the valves and around the injector "wells". From the cylinder heads coolant flows to the rocker housing (water outlet manifold) then to the thermostat housings. At the thermostat housings coolant is returned to the water pump via a by-pass tube until the engine coolant temperature activates the thermostats. Coolant flow is then directed through a radiator or heat exchanger. Coolant circulated through the aftercooler is also returned into the thermostat housings.

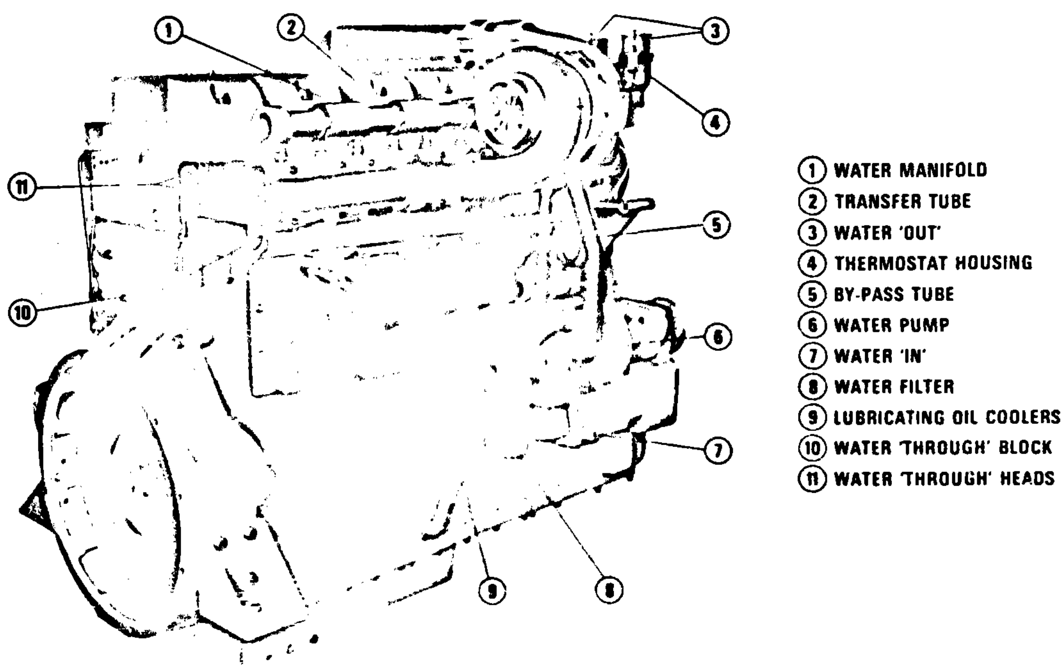


Fig. 5-26, (CWC-14). Coolant flow — KT(A)-1150 Engine

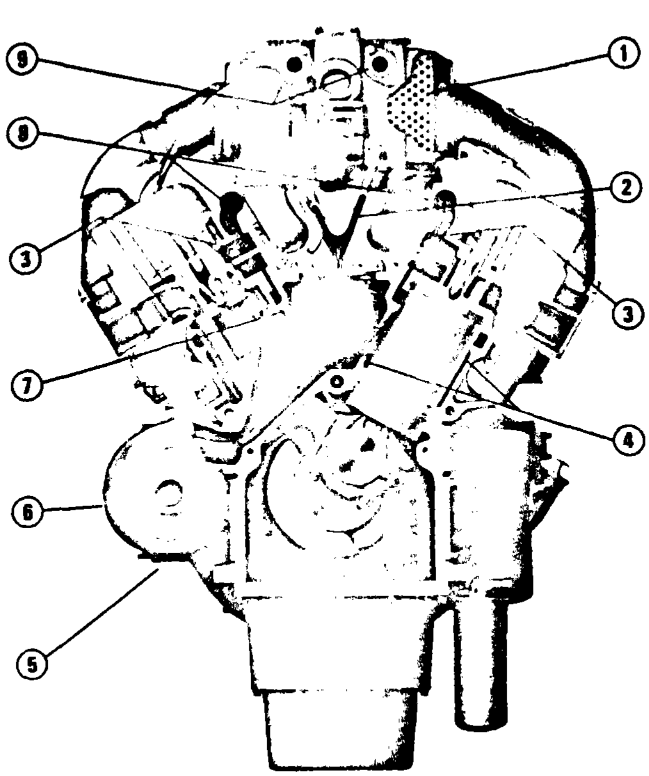


Fig. 5-27, (CWC-27). Coolant flow — KT(A)-2300 Engine

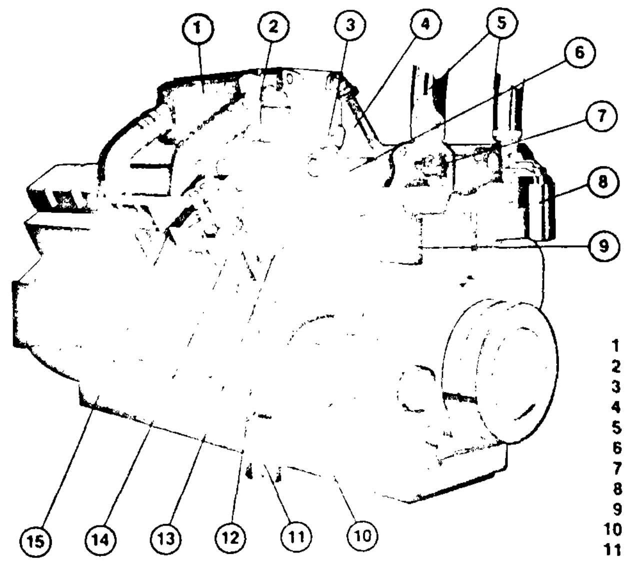


Fig. 5-28, (CWC-29). Coolant flow schematic — KTA-3067 Engine

Air System

The diesel engine requires hundreds of gallons of air for every gallon of fuel that it burns. For the engine to operate efficiently, it must breathe freely; intake and exhaust systems must not be restricted.

The intake air should always be routed through an air cleaner. The cleaner may be mounted on the engine or equipment and may be either oil bath, paper element or composite type depending upon engine application. Air is routed from the air cleaner directly to the intake air manifold, or turbocharger.

NTA and KT(A)-1150 Aftercooler

An aftercooler (or intercooler as it is sometimes called) is a device in the engine intake system designed to reduce intake air temperature and/or preheat intake air temperature.

The aftercooler consists of a housing, used as a portion of the engine intake air manifold, with an internal core. The core is made of tubes through which engine coolant circulates. Air is cooled or heated by passing over the core prior to going into the engine combustion chambers. Fig. 5-29. Therefore, improved combustion results from better control of the intake air temperature cooling or warming as applied by the aftercooler.

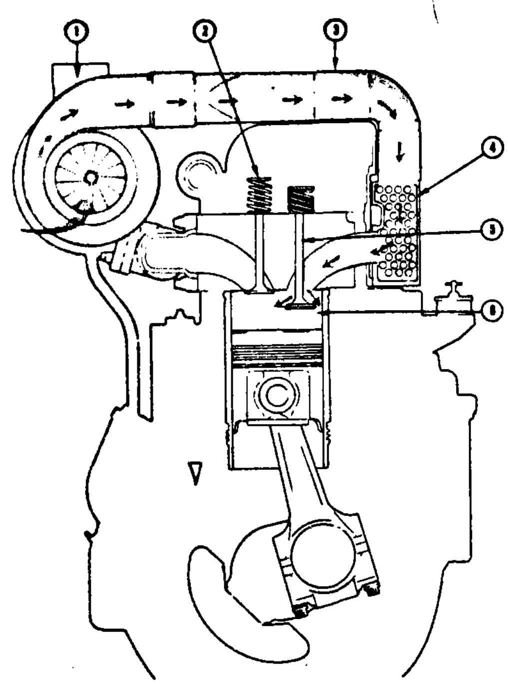


Fig 5-29. (K11947) Intake air flow schematic — KT(A)-1150 Engine

KT(A)-2300 and KTA-3067 Aftercooler

The aftercooler consists of a housing, mounted above the cylinder block, with two (2) internal cores. The cores through which engine coolant circulates, cools or heats the air passing over the core prior to going into the engine combustion chambers. Therefore, improved combustion results.

Turbocharger

The turbocharger forces additional air into the combustion chambers so the engine can burn more fuel and develop more horsepower than if it were naturally aspirated. In some cases the turbocharger is used for the engine to retain efficiency (balanced fuel to air ratio) at altitudes above sea level.

The turbocharger consists of a turbine wheel and a centrifugal blower, or compressor wheel, separately encased but mounted on and rotating with a common shaft

The power to drive the turbine wheel — which in turn drives the compressor — is obtained from the energy of the engine exhaust gases. The rotating speed of the turbine changes as the energy level of gas changes; therefore, the engine is supplied with enough air to burn fuel for its load requirements. Fig's. 5-32, 5-33, 5-34 and 5-35 The turbocharger is lubricated and cooled by engine lubricating oil.

Air Compressor

The Cummins air compressor may be either a single or two cylinder unit coupling or gear driven from the engine gear train accessory drive. Lubrication is received from the engine lubricating system, with oil carried by internal drillings; on 80 degree tilt engines the air compressor crankcase is drained by a scaven-

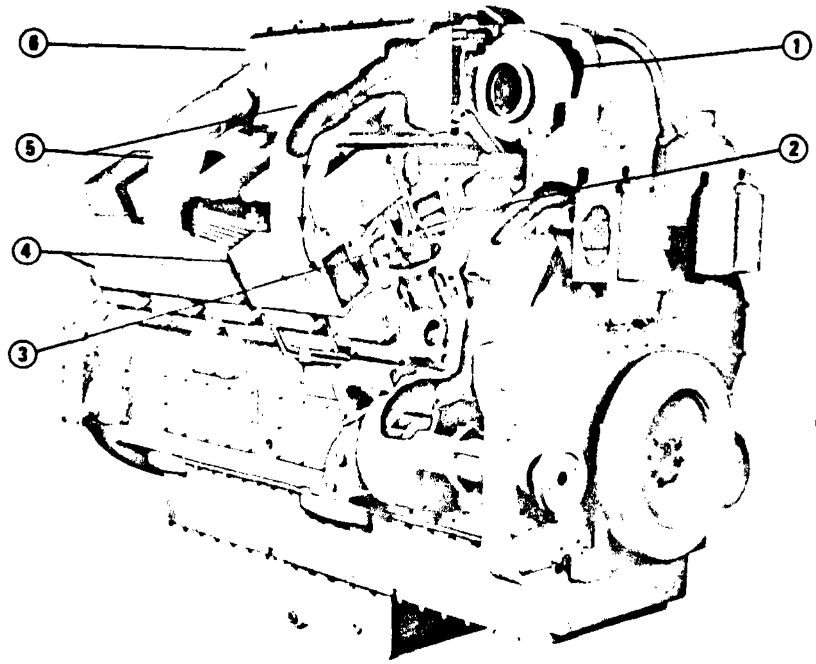


Fig. 5-30, (AWC-19). Intake air flow — KT(A)-2300 Engine

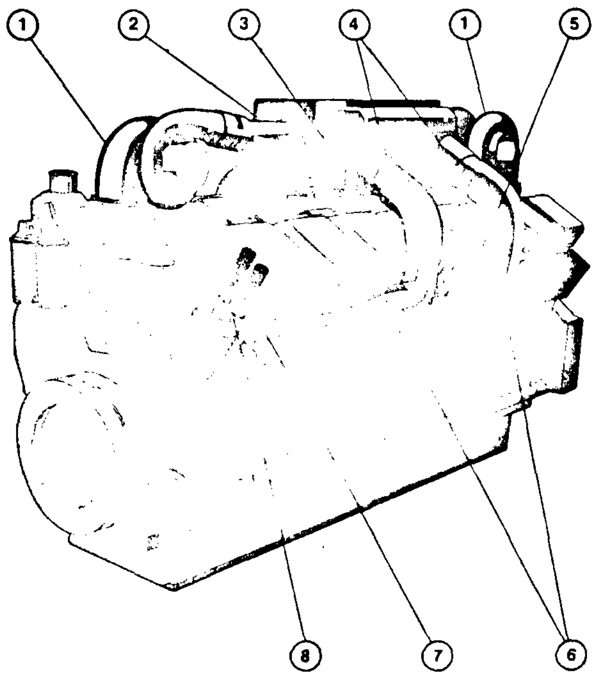
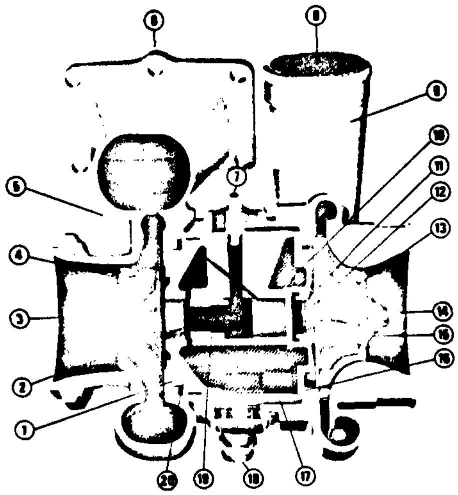
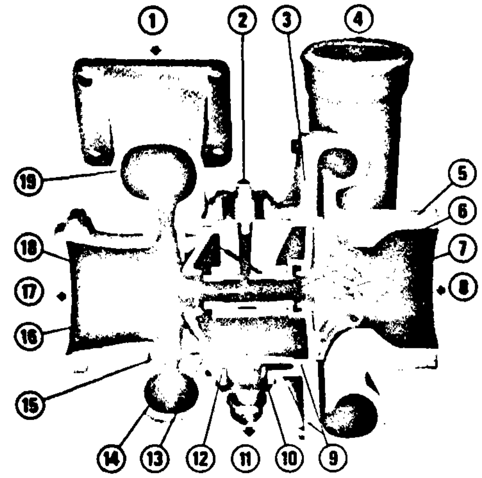


Fig. 5-31, (AWC-21). Intake air flow schematic — KTA-3067 Engine



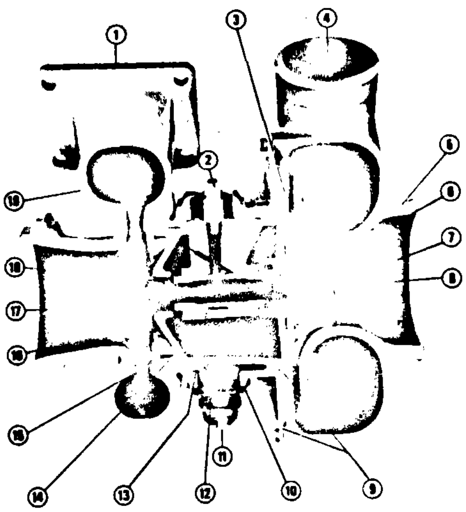
1. HEAT SHIELD
2. SEALING RING
3. EXHAUST OUT
4. TURBINE WHEEL AND SHAFT
5. TURBINE CASING
6. EXHAUST IN
7. OIL IN
8. AIR TO ENGINE
9. COMPRESSOR CASING
10. BEARING INSERT
11. OIL SEAL SLEEVE
12. SEALING RING
13. COMPRESSOR WHEEL
14. AIR IN
15. OIL SEAL PLATE
16. "O" RING SEAL
17. BEARING HOUSING
18. OIL OUT
19. FLOATING BEARING
20. INSULATION BATT

Fig. 5-32, (AWC-8). T-50 Turbocharger (cross section)



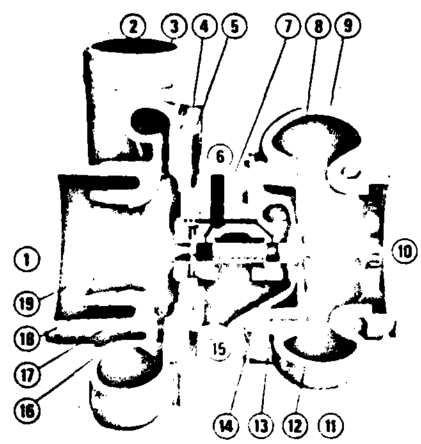
1. EXHAUST IN
2. OIL IN
3. DIFFUSER PLATE
4. AIR TO ENGINE
5. COMPRESSOR CASING
6. OIL SEAL SLEEVE
7. COMPRESSOR WHEEL
8. AIR IN
9. "O" RING SEAL
10. "V" BAND CLAMP
11. OIL OUT
12. BEARING HOUSING
13. FLOATING BEARING
14. INSULATION BATT
15. HEAT SHIELD
16. SEALING RING
17. EXHAUST OUT
18. TURBINE WHEEL AND SHAFT
19. TURBINE CASING

Fig. 5-34, (AWC-12). ST-50 turbocharger (cross section)



1. EXHAUST IN
2. OIL IN
3. DIFFUSER PLATE
4. AIR TO ENGINE
5. COMPRESSOR CASING
6. OIL SEAL SLEEVE
7. COMPRESSOR WHEEL
8. AIR IN
9. "O" RING SEAL
10. "V" BAND CLAMP
11. OIL OUT
12. BEARING HOUSING
13. FLOATING BEARING
14. INSULATION BATT
15. HEAT SHIELD
16. SEALING RING
17. EXHAUST OUT
18. TURBINE WHEEL AND SHAFT
19. TURBINE CASING

Fig. 5-33, (AWC-9). VT-50 turbocharger (cross section)



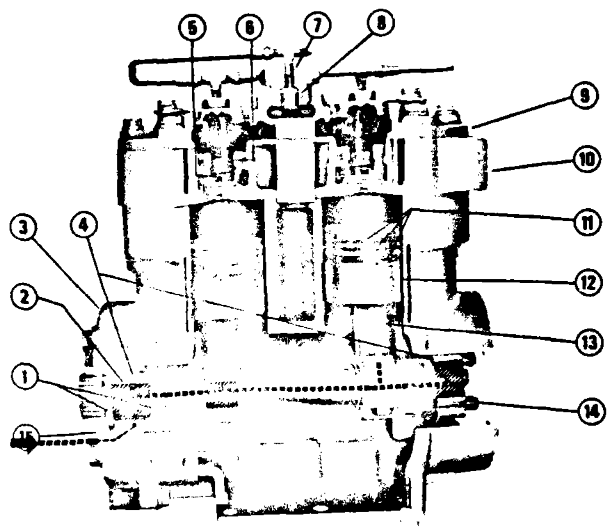
1. AIR IN
2. AIR OUT
3. COMPRESSOR HOUSING
4. V-BAND CLAMP
5. BACKPLATE
6. OIL IN
7. CENTER HOUSING
8. SHROUD
9. TURBINE HOUSING
10. EXHAUST OUT
11. EXHAUST IN
12. TURBINE WHEEL AND SHAFT
13. BEARINGS
14. SNAP RINGS
15. OIL OUT
16. THRUST WASHER
17. THRUST COLLAR
18. OIL SEAL ASSEMBLY
19. COMPRESSOR WHEEL

Fig. 5-35, (TA-1). T-18 turbocharger (cross section) ger pump mounted on the gear case cover and is driven by the lubricating oil pump drive gear. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

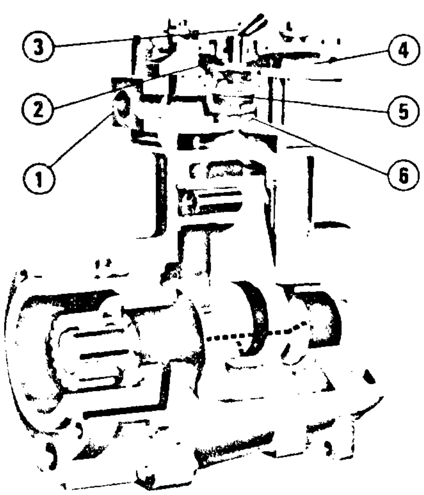
Air is drawn into the compressor through the engine intake air manifold or compressor mounted breather. As the piston moves down, a partial vacuum occurs above it.

The difference in cylinder pressure and atmospheric pressure forces the inlet valve down from its seat, allowing the air to flow through the intake port and into the cylinder. When the piston has reached the bottom of its stroke, spring pressure is sufficient to overcome the lesser pressure differential and forces the valve against its seat. Fig's. 5-36 and 5-37.



1 THRUST WASHERS
2 CRANKSHAFT
3 SUPPORT
4 BUSHINGS
5 EXHAUST VALVE
6 INTAKE VALVE
7 AIR GOVERNOR INLET
8 UNLOADER VALVE ASSEMBLY
9 CYLINDER HEAD COVER
10 CYLINDER HEAD
11 PISTON RINGS
12 PISTON
13 CONNECTING ROD
14 FUEL PUMP DRIVE
15 LUBRICATING OIL INLET

Fig. 5-37, (AWC-11). Cummins air compressor (two cylinder)



1 COOLANT
2 UNLOADER VALVE
3 AIR GOVERNOR CONNECTION
4 AIR INLET
5 INTAKE VALVE
6 EXHAUST VALVE

Fig. 5-36, (AWC-10). Cummins air compressor (single cylinder)

Compression

When the piston starts its upward stroke, the increased pressure of the air in the cylinder and head forces the outlet valve away from its seat. The compressed air then flows through the outlet ports and into the air tank as the piston continues its upward stroke. On the piston downstroke, the exhaust valve closes and the intake valve opens except during the unloading period.

Unloading

When the pressure in the air tank is at a predetermined level, air pressure is applied to the top of the unloader cap by a compressor governor. This pressure forces the unloader cap down and holds the intake valve open during non-pumping cycle.

When the pressure in the air tank drops, the unloader cap returns to its upper position and the intake and compression sequences begin once again.

Vacuum Pump

The Cummins Vacuum Pump, shown in Fig. 5-38, is an adaptation of Cummins Air Compressor; it is a single-cylinder unit driven from the engine gear train accessory drive. Lubrication is received from the engine lubricating system, with oil carried by internal drillings. The cylinder head is cooled by engine coolant. Operating functions are as follows:

Air Intake

As the piston moves downward on the intake stroke a vacuum occurs above the piston. The difference in cylinder pressure and atmospheric pressure forces the inlet valve from its seat allowing air to flow through

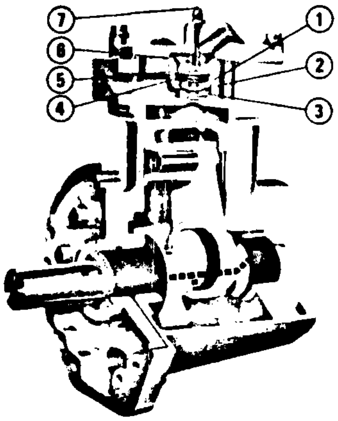


Fig. 5-38, (V11205). Cummins vacuum pump

the intake port into the cylinder from the vacuum tank thus creating vacuum in the vacuum tank. When the piston has reached the bottom of its stroke, spring pressure is sufficient to overcome the lesser pressure differential and forces the valve against its seat.

Compression

When the piston starts its upward stroke, the increased pressure of air in the cylinder and head forces the outlet valve away from the seat. Air then flows through the outlet port and is discharged into the vacuum pump crankcase or engine crankcase, as the piston continues its upward stroke. When the piston reaches the end of its stroke, air pressure in the head drops to a point where the spring forces the exhaust valve against its seat and closes the outlet passage.

Torque Converter Governor on PT (type G) VS Fuel Pump

When a torque converter is used to connect the engine with its driven unit, an auxiliary governor is driven off the torque converter output shaft to exercise control over the engine governor. The torque converter governor controls the converter output shaft speed. The engine governor and converter governor must be adjusted to work together.

The PT-G — VS governor and the torque converter governor are two separate mechanical variable-speed governors — one driven by the engine, the other by the converter.

A conventional VS governor allows variable speed governing when operating at low tailshaft speeds or with the tailshaft governor disconnected. The converter governor is in series with the automotive and VS governors and controls engine speed by sensing the converter tailshaft speed. Dual levers in the cab allow the operator to operate on either the tail-shaft governor or the VS governor. There is no automotive throttle lever.

An adjustable converter plunger stop prevents the tail-shaft governor from shutting off the engine, when the load motors and overspeeds the tailshaft, as is the case when moving vehicles down hill.

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Cummins Service Publications

The following Cummins Service Publications related to Operation and Maintenance can be purchased from any Cummins Distributor or Cummins Dealer.

Many publications have been translated into other languages. Cummins Distributors or Cummins Dealers have information on which publications are available in languages other than English.

For information about any Cummins publications, contact your local Cummins Distributor or Dealer.

Bulletin Number	Publication Description
3379116	Mechanic's Specifications Handbook (1976)
3379138	Mechanic's Specifications Handbook (1977)
3379156	Mechanic's Specifications Handbook (1978)
3379137	Automotive Operation and Maintenance Manual — United States and Canada
3379141	Automotive Operation and Maintenance Manual — International
3379052	Construction/Industrial Operation and Maintenance Manual
3379075	Marine Operation and Maintenance Manual
3379069	V/VT-378, V/VT-504, V/VT-555 C.I.D. Engine Shop Manual
3379067	H, NH-672, 743 Engine Shop Manual
3379076	NH/NT Engine Shop Manual
3379057	V/VT-903 C.I.D. Engine Shop Manual
3379088	V/VT/VTA-1710 C.I.D. Engine Shop Manual
3379078	KT/KTA-1150 C.I.D. Engine Shop Manual
3379053	KT/KTA-2300 and KTA-3067 Engine Shop Manual
3379084	Fuel Pump PT (type G and R) Rebuild and Calibration Instructions
3379071	Injectors PT (All Types) Rebuild
3379091	Turbochargers Component Shop Manual (T-18A, T-35, T-46, T-50, VT-50, and ST-50 Models)
3379056	Air Equipment Component Shop Manual
3379090	Guide to Troubleshooting
3379591	NT-855 Small Cam Parts Catalog
3379509	NTC-855 Big Cam Parts Catalog
3379589	NTC-855 Big Cam II Parts Catalog
3379632	KT/KTA-1150 Parts Catalog
3379518	KT/KTA-2300 Parts Catalog
3379581	KTA-3067 Parts Catalog
3379577	V-378 Parts Catalog
3379587	V/VT-378 Big Cam Parts Catalog
3379549	V-504 Parts Catalog
3379586	V/VT-504 Big Cam Parts Catalog
3379535	V/VT-555 Parts Catalog
3379588	V/VT-555 Big Cam Parts Catalog
3379532	V/VT-903 Parts Catalog
3379540	V/VT/VTA-1710 Parts Catalog

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Columbus, Indiana, U.S.A. 47201
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Coombe House, St. George's Square
New Malden, England
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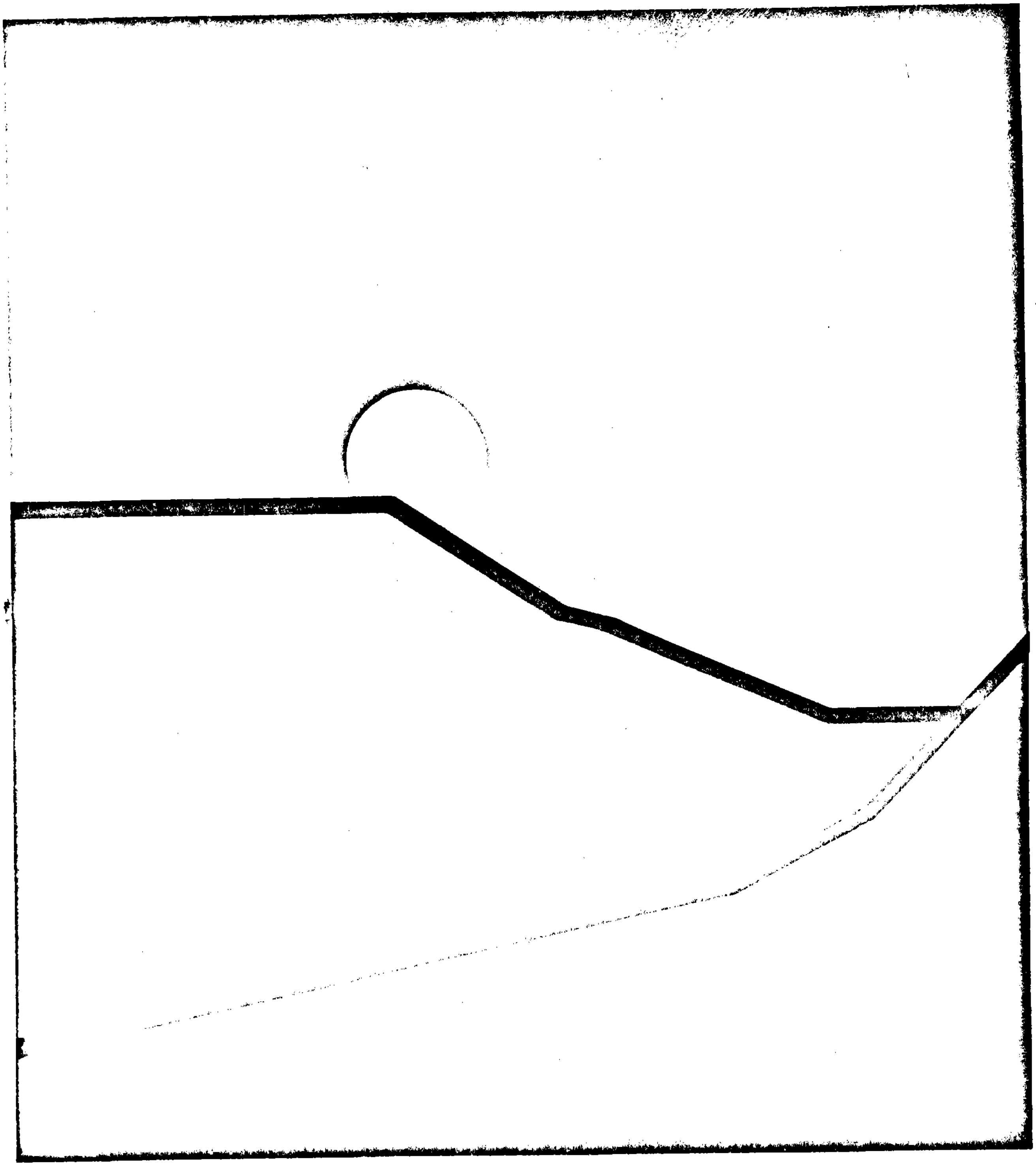
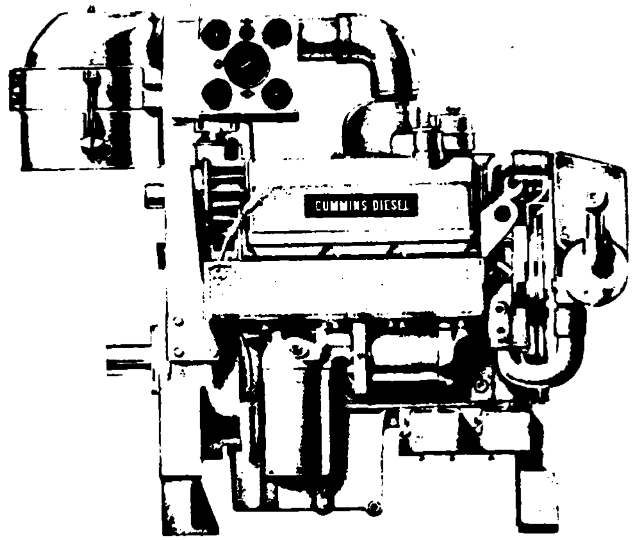


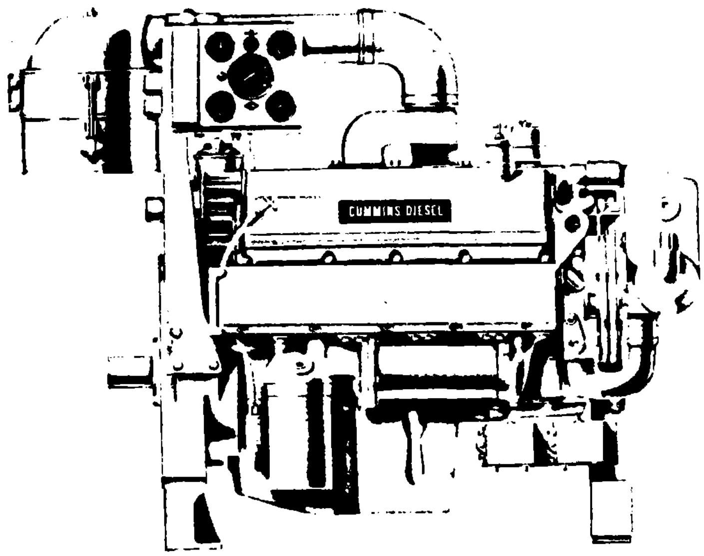
Cummins Parts Catalog

Model: V-378, V-504 F1, F2

Bulletin: 3379534-00

1.2.7.355





Parts Ordering for: V-378-F1,F2, V-504-F1,F2 Fire Pump Engines

Genuine Cummins Parts and service facilities are world-wide. There are more than 2700 Cummins Sales and Service locations in the principal cities of the United States and Canada, and more than 500 Sales and Service locations situated elsewhere throughout the free world. Each distribution outlet is thoroughly equipped with technical data, factory-trained mechanics, modern equipment and a full, adequate stock of Genuine Cummins Parts.

For quicker and better service, your parts requirements should be ordered from your nearest Cummins Distributor or Dealer. At any of the locations prompt, intelligent, courteous service is a basic trademark. Each is ready and eager to help in every possible way through personal contact or through the mail — at your convenience.

The satisfactory ordering and receiving of parts by the purchaser is greatly dependent upon the proper use of available information. In order that all avoidable errors may be eliminated, the following instructions are offered as the purchaser's guide:

1. Write your order clearly, using a typewriter if possible.
2. Be sure to list the correct part number. If in doubt as to the correct part number, state the model and serial number of the engine on which the part is to be used. Part numbers are usually located in various places on the part itself.
3. When possible, arrange your purchase order in part number numerical sequence.
4. Always specify shipping instructions — "Best Way" is satisfactory if you have no preference
5. State your company name and shipping address clearly.

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CUSTOMER SERVICE INFORMATION

This Parts Catalog contains standard parts information for the following Industrial Fire Pump Engines:

V-504-F1, F2; V-378-F1, F2

Part numbers appearing in ( ) are for identification purposes only and should not be used when ordering service replacement parts.

The form below is provided for your convenience and when properly filled out, will allow proper identification of your unit and the normal maintenance items. Parts information errors that could cause extended down time could be avoided if the information on this form is referred to when ordering parts from your Cummins Distributor or Dealer.

ALWAYS SPECIFY ENGINE MODEL AND SERIAL NUMBER
WHEN ORDERING PARTS FROM THIS CATALOG

Engine Model__________ Engine Serial No.__________

MFG Make__________ Model__________ Chassis No.__________

Fuel Pump Assembly No.__________ Injector No.__________

Belt, Water Pump__________ Belt, Gen.__________ Air Cleaner__________

Element, Fuel Filter__________ Full Flow Lub, Filter__________

Special Equipment

Cummins Distributor__________

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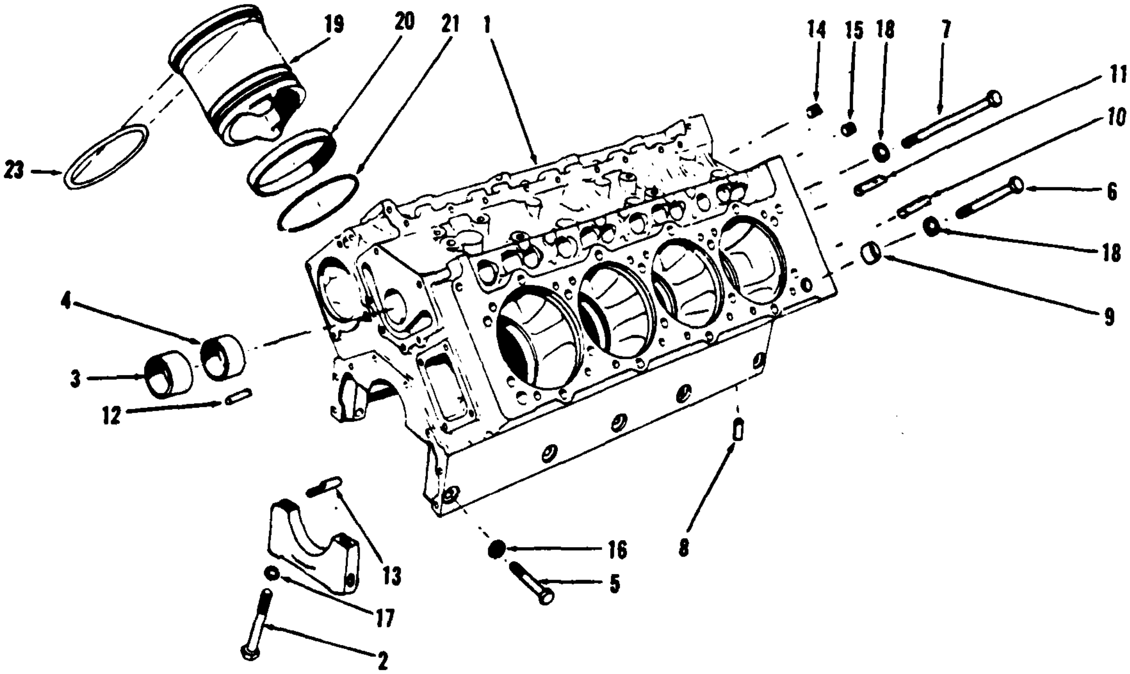
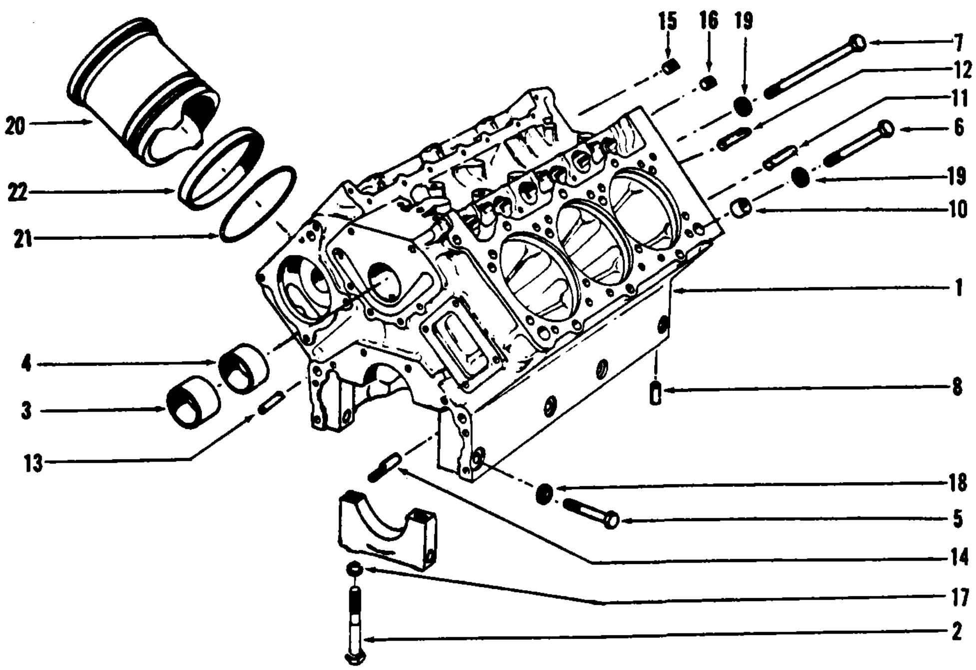


ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER BLOCK		
	V-504-F1, F2		
AR-60781	Block, cylinder (553580)	1	1
180676	Bolt, main bearing cap	10	2
554003	Bushing, camshaft (No. 1 and 5 position)	2	3
554004	Bushing, camshaft (No. 2, 3 and 4 position)	3	4
188395	Capscrew, main bearing side locking	10	5
162182	Capscrew, cylinder head (short)	26	6
162183	Capscrew, cylinder head (long)	10	7
148547	Dowel, rear main bearing cap	2	8
100973	Dowel ring, cylinder head to block	4	9
69562	Dowel, gear housing to block (Master)	2	10
102957	Dowel, gear housing to block (Diamond)	2	11
70645	Dowel, front cover to block (Master)	1	12
68568	Dowel, front cover to block (Diamond)	1	13
161825	Plug, cup	2	14
S-911-B	Plug, pipe	4	15
188394	Washer, main bearing side locking capscrew	10	16
164601	Washer, main bearing cap	10	17
153411	Washer, cylinder head capscrew	36	18

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
554311	Liner, cylinder	8	19
216283	Seal, crevice	8	20
216284	Packing, cylinder liner	8	21
	OVERSIZE FOR SERVICE		
171786	Shim, liner (.007")	A/R	23
171787	Shim, liner (.010")	A/R	23
171788	Shim, liner (.012")	A/R	23
171789	Shim, liner (.014")	A/R	23
171790	Shim, liner (021")	A/R	23
104470	Dowel housing to block (.125")	A/R	
	SEMI-FINISHED MAIN BEARING CAPS		
193010	Main bearing cap front	1	
193013	Main bearing cap intermediate No. 2	1	
193011	Main bearing cap intermediate No. 4	1	
193012	Main bearing cap intermediate No. 3	1	
193009	Main bearing cap rear	1	

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED



ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER BLOCK				**MOUNTING PARTS**		
	V-378-F1, F2			554311	Liner, cylinder	6	20
				171270	Packing, cylinder liner	6	21
				171880	Seal, crevice	6	22
AR-60778	Block, cylinder (553590)	1	1				
180676	Bolt, main bearing	8	2				
554003	Bushing, cam (No. 1 and 4)	2	3				
554004	Bushing, cam (No. 2 and 3)	2	4				
188395	Capscrew, main bearing side locking	8	5		**OVERSIZE FOR SERVICE**		
162182	Capscrew, cylinder head-short	20	6				
162183	Capscrew, cylinder head-long	8	7	171786	Shim, liner (.007")	A/R	
148547	Dowel ring main bearing cap (Diamond)	2	8	171787	Shim, liner (.010")	A/R	
100973	Dowel ring, cylinder head to block	4	10	171788	Shim, liner (.012")	A/R	
69562	Dowel ring, cylinder head to block (Master)	2	11	171789	Shim, liner (.014")	A/R	
				171790	Shim, liner (.021")	A/R	
102957	Dowel ring, cylinder head to block (Diamond)	2	12	104470	Dowel, housing to block (.125")	A/R	
70645	Dowel, front cover to block	1	13				
68568	Dowel, front cover to block	1	14		**SEMI-FINISHED MAIN BEARING CAPS**		
161825	Plug, pipe	2	15				
S-911-B	Plug, pipe	3	16				
164601	Washer, main bearing cap	8	17	193010	Main bearing cap front	1	
188394	Washer, main bearing, side locking	8	18	193013	Main bearing cap intermediate No. 2	1	
153411	Washer, cylinder head capscrew	28	19	193011	Main bearing cap intermediate No. 4	1	
				193009	Main bering cap rear	1	

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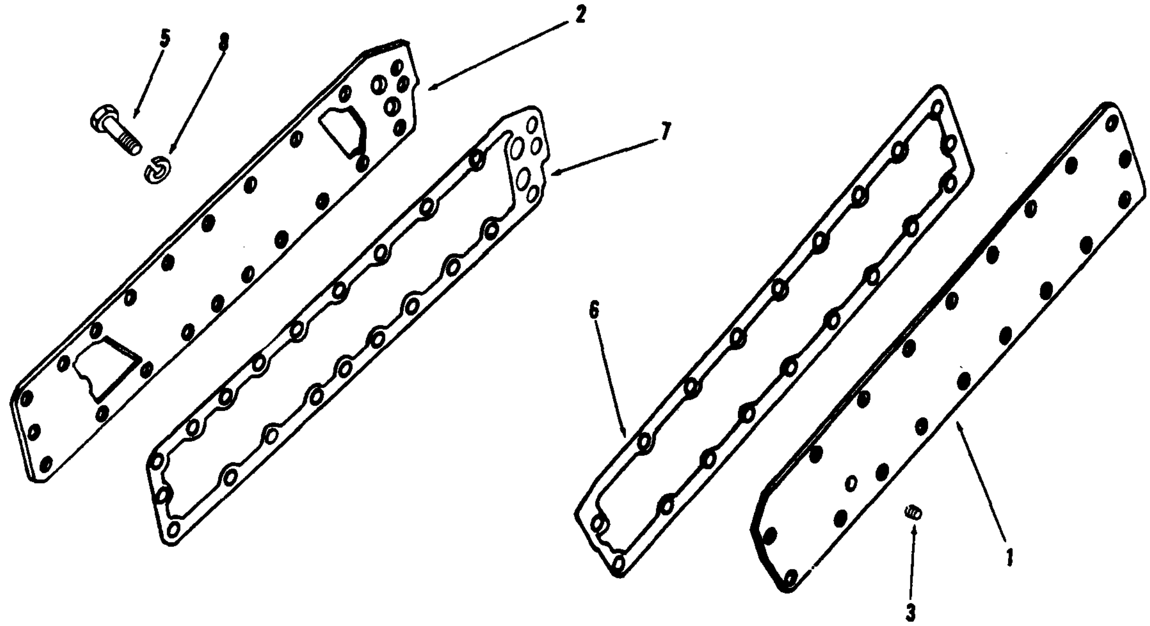

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER HEADER COVER				**MOUNTING PARTS**		
	V-504-F1, F2			S-109	Capscrew, cover to block	30	5
193557	Cover, water header (L.B.)	1	1	167800	Gasket, cover to block (L.B.)	1	6
172216	Cover, water header (R.B.)	1	2	176598	Gasket, cover to block (R.B.)	1	7
68606	Plug, pipe	1	3	S-604	Lockwasher cover to block	30	8

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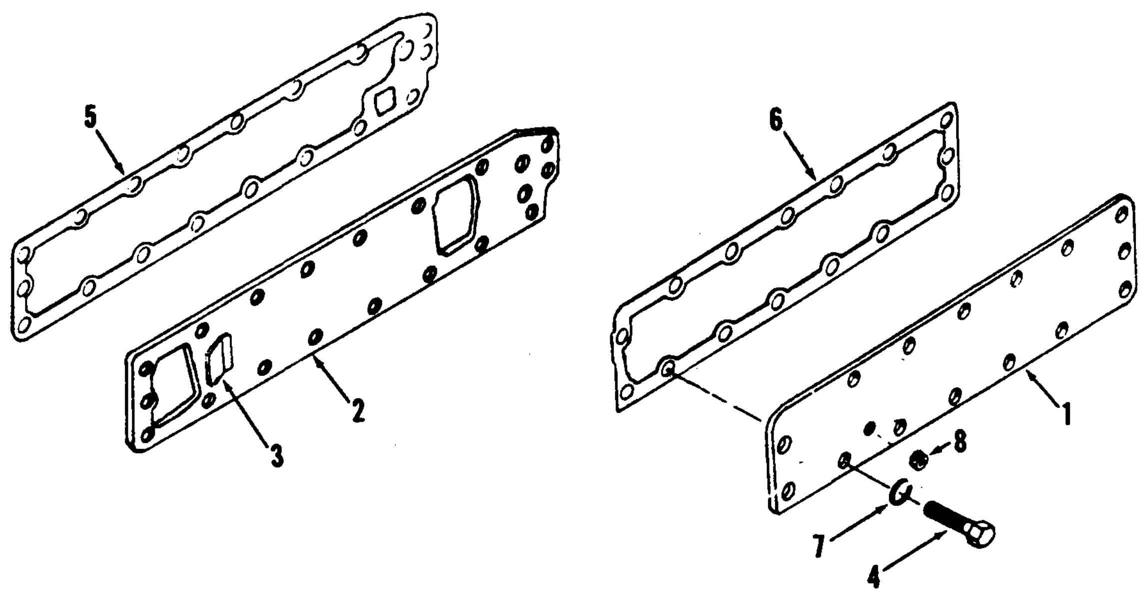

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER HEADER COVER		
	V-378-F1, F2		
167779	Cover, water header (L.B.)	1	1
AR-61629	Cover and baffle (R.B.)	1	
553813	Cover, water header	1	2
175428	Baffle	1	3

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
S-109	Capscrew	27	4
176597	Gasket, water header (R.B.)	1	5
167778	Gasket, water header (L.B.)	1	6
S-604	Lockwasher	27	7
68606	Plug, pipe	1	8

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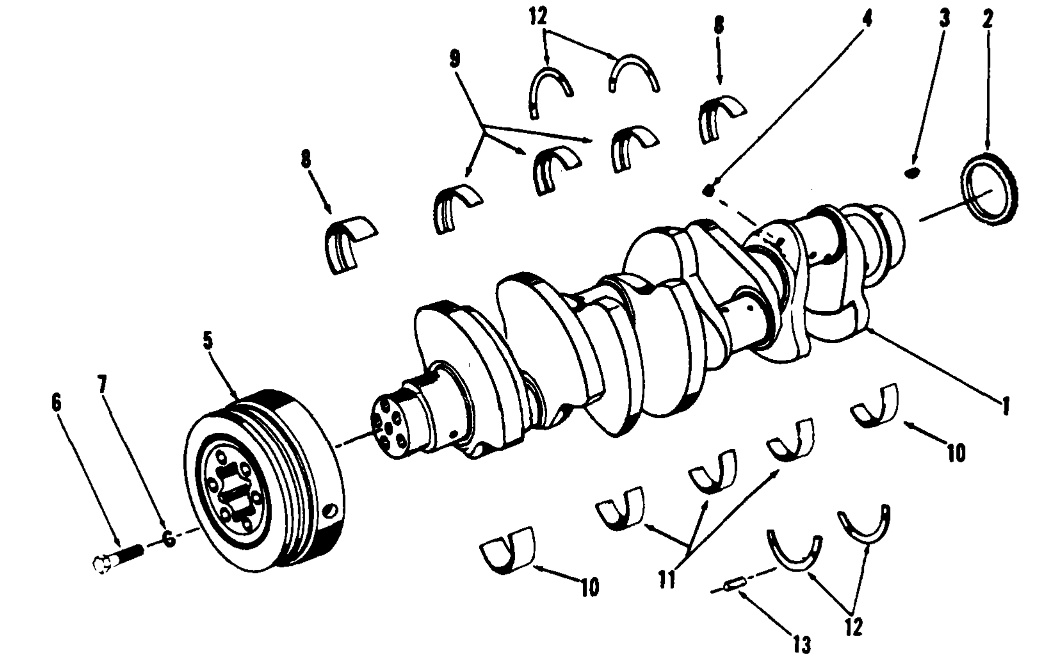

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CRANKSHAFT		
	V-504-F1, F2		
AR-60473	Crankshaft assembly	1	
194840	Crankshaft	1	1
177086	Gear, crankshaft	1	2
144131	Key, crankshaft gear	1	3
S-911-B	Plug, pipe	4	4
	VIBRATION DAMPER		
186375	Damper, vibration	1	5
S-149-B	Capscrew	5	6
S-608	Lockwasher	5	7
	MOUNTING PARTS		
556818	Guard, vibration damper	1	
S-110	Capscrew	2	
S-115	Capscrew	4	
S-605	Lockwasher	4	
S-119	Capscrew	2	

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MAIN BEARINGS		
BM-99820	*Bearing set, main (Std.)	1	
182320	Bearing, main (Upper 1 and 5)	2	8
182400	Bearing, main (Upper 2, 3 and 4)	3	9
182200	Bearing, main (Lower 1 and 5)	2	10
182210	Bearing, main (Lower 2, 3 and 4)	3	11
553670	Ring, half thrust (Upper)	2	12
173640	Ring, half thrust (Lower)	2	12
128765	Dowel, half ring	2	13
148547	Dowel, half ring	2	
	Note: Use 148547 after engine serial number F048195.		
	*Main bearings may be purchased in .010", .020" or .030" undersize.		
	OPTIONAL OVERSIZE		
173641	Half ring crankshaft thrust (.010")	2	
553671	Half ring crankshaft thrust (.010")	2	
173642	Half ring crankshaft thrust (.020")	2	
553672	Half ring crankshaft thrust (.020")	2	
BM-99821	Bearing set main (.010")	1	
BM-99822	Bearing set main (.020")	1	
BM-99823	Bearing set main (.030")	1	

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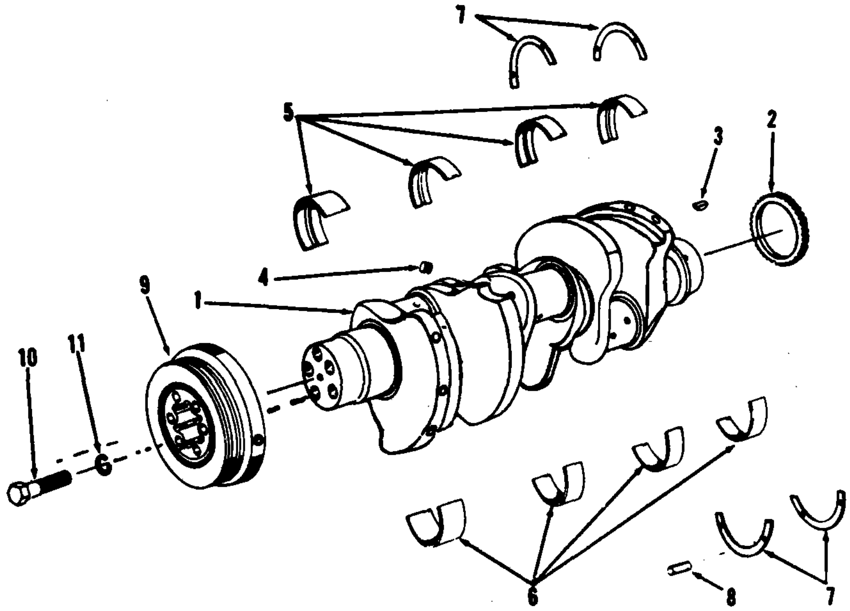

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CRANKSHAFT		
	V-378-F1, F2		
AR-60774	Crankshaft assembly	1	
195240	Crankshaft	1	1
177086	Gear, crankshaft	1	2
144131	Key, crankshaft gear	1	3
S-911-B	Plug, pipe	3	4
	VIBRATION DAMPER		
650380	Damper, vibration	1	9
S-149-B	Capscrew	5	10
S-608	Lockwasher	5	11
	MOUNTING PARTS		
556818	Guard, vibration damper	1	
S-110	Capscrew	2	
S-115	Capscrew	4	
S-605	Lockwasher	4	
S-119	Capscrew	2	

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MAIN BEARINGS		
BM-99830 *	Bearing set, main (Std.)	1	
182320	Bearing, main (Upper 1 and 4)	2	5
182400	Bearing, main (Upper 2 and 3)	2	5
182200	Bearing, main (Lower 1 and 4)	2	6
182210	Bearing, main (Lower 2 and 3)	2	6
173640	Ring, half thrust (Lower)	2	7
553670	Ring, half thrust (Upper)	2	7
128765	Dowel, half ring	2	8
148547	Dowel, half ring	2	
	Note: Use 148547 Dowel after engine serial Number FO48195.		
*	Main bearings may be purchased in .010", .020" or .030" undersize.		
	OPTIONAL OVERSIZE		
173641	Half ring crankshaft thrust (.010")	2	
553671	Half ring crankshaft thrust (.010")	2	
173642	Half ring crankshaft thrust (.020")	2	
553672	Half ring crankshaft thrust (.020")	2	
BM-99831	Bearing set main (.010")	1	
BM-99832	Bearing set main (.020")	1	
BM-99833	Bearing set main (.030")	1	

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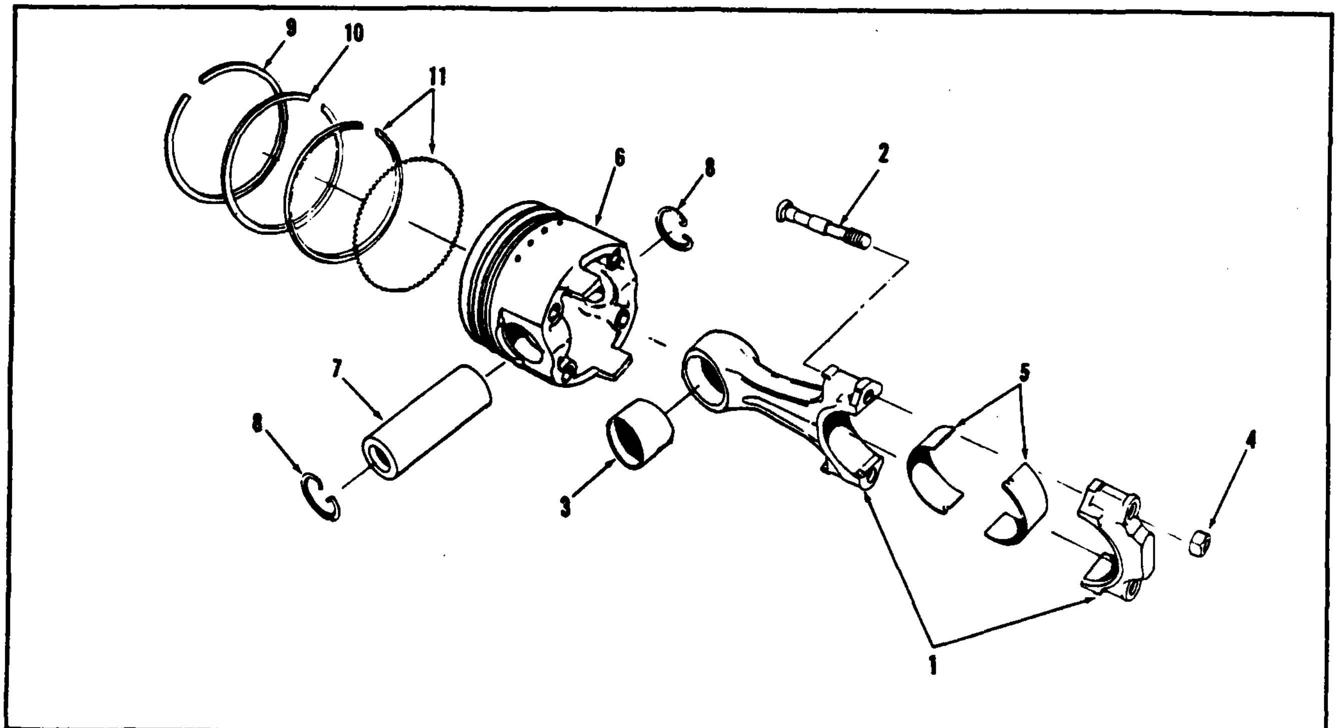

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CONNECTING ROD		
	V-504-F1, F2		
BM-78784	Rod, connecting (166452)	8	1
551143	Bolt, connecting rod	16	2
195360	Bushing, piston pin	8	3
152838	Nut, connecting rod bolt	16	4
157620 *	Bearing, connecting rod (Std.)	16	5
	PISTON		
AR-60740	Piston, assembly (Std.)	8	
200800	Piston	8	6
151770	Pin, piston	8	7
157978	Ring, snap	16	8
	RINGS		
AR-61500	Ring set, piston (Std.)	8	
201650	Ring, compression (Top)	8	9
208990	Ring, compression	8	10
201645	Ring, oil	8	11

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CONNECTING ROD		
	V-378-F1, F2		
BM-78784	Rod, connecting (166452)	6	1
551143	Bolt, connecting rod	12	2
195360	Bushing, piston pin	6	3
152838	Nut, connecting rod bolt	12	4
157620 *	Bearing, connecting rod (Std.)	12	5
	PISTON		
AR-60740	Piston, assembly (Std.)	6	
200800	Piston	6	6
151770	Pin, piston	6	7
157978	Ring, snap	12	8
	RINGS		
AR-61500	Ring set, piston (Std.)	6	
201650	Ring, compression (Top)	6	9
208990	Ring, compression	6	10
201645	Ring, oil	6	11
*	Connecting rod bearing shells may be purchased in .010", .020", .030" undersize.		

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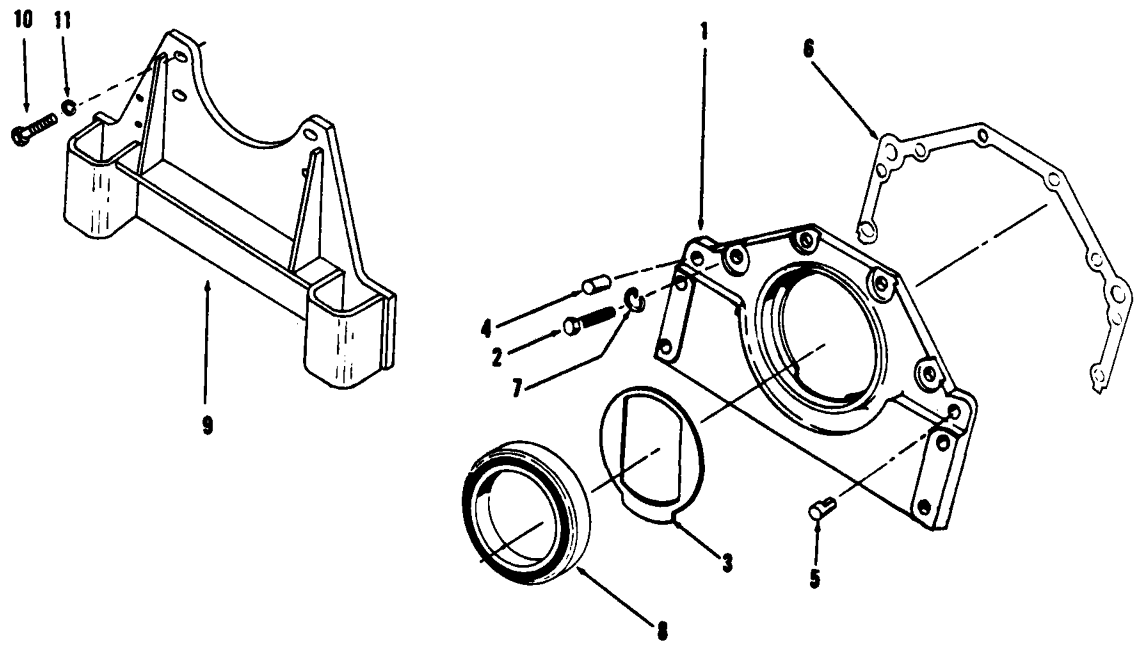

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	FRONT COVER				**FRONT ENGINE SUPPORT**		
	V-504-F1, F2				**V-504-F1, F2**		
	V-378-F1, F2				**V-378-F1, F2**		
188393	Cover, front	1	1	556809	Support, front	1	9
S-109	Capscrew, front cover	4	2				
173090	Deflector, oil	1	3		**MOUNTING PARTS**		
70645	Dowel (Master)	1	4				
68568	Dowel (Diamond)	1	5	106289	Capscrew, front support	4	10
188396	Gasket, front cover	1	6				
S-604	Lockwasher	4	7	S-608	Lockwasher	4	11
551514	Seal, oil	1	8				

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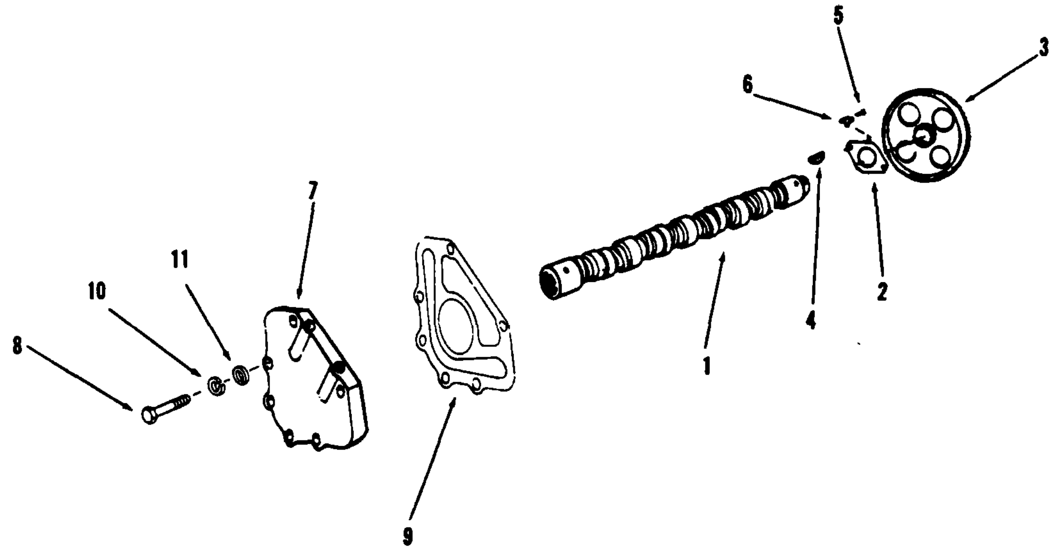

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CAMSHAFT		
	V-504-F1, F2		
201050	Camshaft	1	1
167305	Bearing, thrust plate	1	2
187649	Gear, camshaft	1	3
S-313	Key, camshaft	1	4
	V-378-F1, F2		
201060	Camshaft	1	1
167305	Bearing, thrust plate	1	2
187649	Gear, camshaft	1	3
S-313	Key, camshaft	1	4
	MOUNTING PARTS		
S-107	Capscrew, thrust bearing	2	5
68908-A	Lockplate, thrust bearing	2	6
	CAMSHAFT KEYS FOR ADVANCE AND RETARD TIMING		
200715	Key camshaft .006" offset	A/R	
200716	Key camshaft .012" offset	A/R	
200717	Key camshaft .018" offset	A/R	
200718	Key camshaft .024" offset	A/R	
200719	Key camshaft .030" offset	A/R	
200721	Key camshaft .036" offset	A/R	

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CAMSHAFT COVER		
	V-504-F1, F2		
	V-378-F1, F2		
167834	Cover, camshaft	1	7
108707	Capscrew, camshaft cover	6	8
550164	Gasket, camshaft cover	1	9
S-604	Lockwasher	6	10
S-602	Washer, plain	6	11

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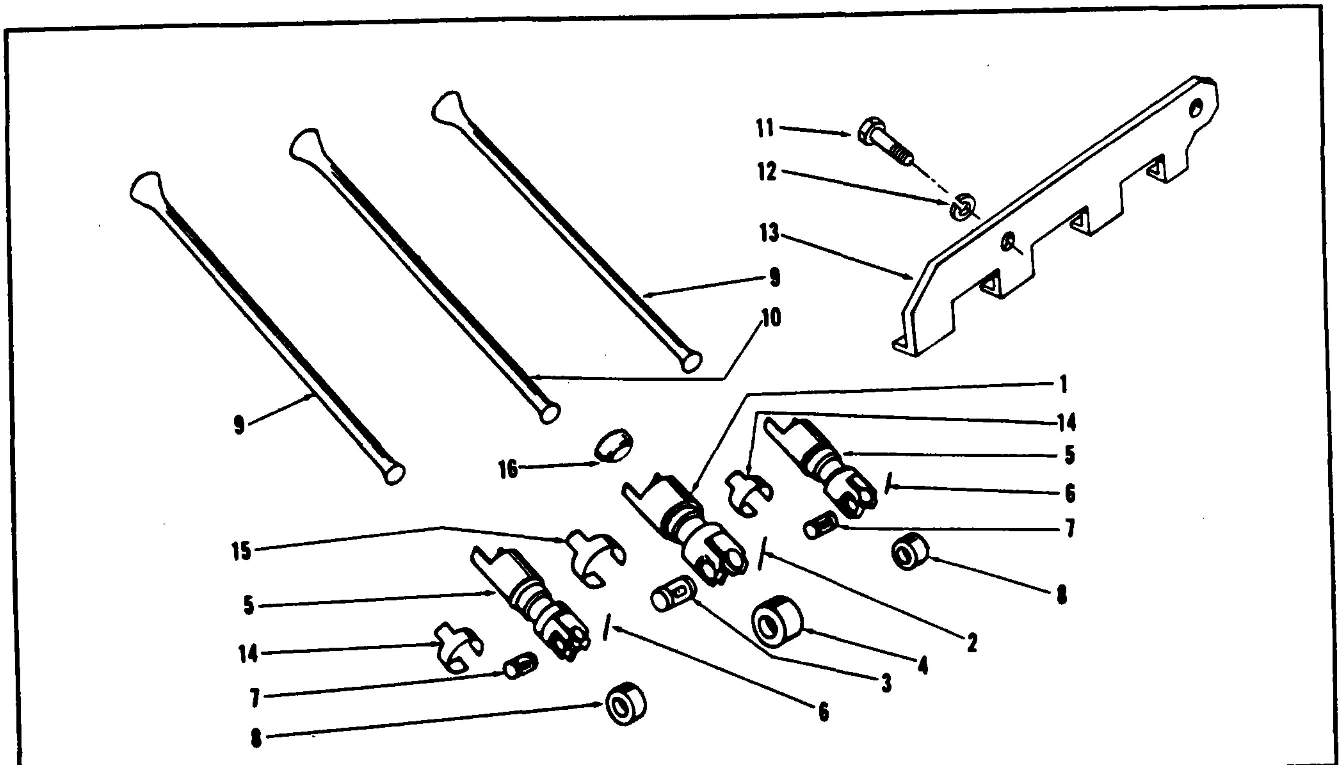

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	PUSH RODS AND TAPPETS		
	V-504-F1, F2		
BM-94016	Tappet, injector assembly (171936)	8	1
111272	Lockwire, tappet	8	2
114223	Pin, injector tappet roller	8	3
154571	Roller, injector tappet	8	4
107738	Socket	8	16
BM-94014	Tappet, valve (171937)	16	5
108186	Lockwire, tappet	16	6
169154	Pin, valve tappet	16	7
153679	Roller, valve tappet	16	8
168209	Rod, valve push	16	9
170326	Rod, injector push	8	10
	MOUNTING PARTS		
S-110	Capscrew, tappet guide plate	16	11
S-605	Lockwasher, tappet guide plate	16	12
		16	12
551084	Plate, tappet guide	8	13
156438	Spring, valve tappet	16	14
156439	Spring, injector tappet	8	15

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	PUSH RODS AND TAPPETS		
	V-378-F1, F2		
BM-94016	Tappet, injector (171936)	6	1
111272	Lockwire, tappet	6	2
114223	Pin, injector tappet roller	6	3
154571	Roller, injector tappet	6	4
107738	Socket, cam follower	6	16
BM-94014	Tappet, valve (171937)	12	5
108186	Lockwire, tappet	12	6
169154	Pin, valve tappet roller	12	7
153679	Roller, valve tappet	12	8
168209	Rod, valve push	12	9
170326	Rod, injector push	6	10
	MOUNTING PARTS		
S-110	Capscrew, tappet guide plate	12	11
S-605	Lockwasher, tappet guide plate	12	12
551084	Plate, tappet guide	6	13
156438	Spring, valve tappet	12	14
156439	Spring, injector tappet	6	15

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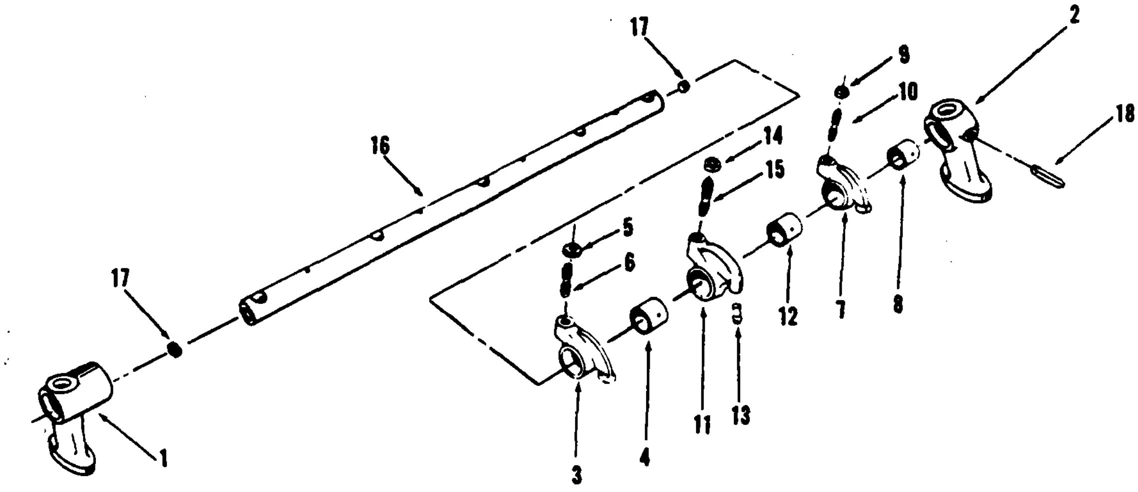

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	ROCKER LEVERS				**ROCKER LEVERS**		
	V-504-F1, F2				**V-378-F1, F2**		
154109	Bracket, rocker lever shaft	8	1	154109	Bracket, rocker lever shaft	6	1
551608	Bracket, rocker lever shaft	2	2	551608	Bracket, rocker lever shaft	2	2
BM-79723	Lever, exhaust valve rocker (168285)	8		BM-79723	Lever, exhaust valve rocker (168285)	6	
BM-79722	Lever and bushing	8	3	BM-79722	Lever and bushing	6	3
152937	Bushing, valve rocker lever	8	4	152937	Bushing, valve rocker lever	6	4
S-212	Nut, adjusting screw	8	5	S-212	Nut, adjusting screw	6	5
168306	Screw, adjusting	8	6	168306	Screw, adjusting	6	6
BM-79725	Lever, intake rocker (168255)	8		BM-79725	Lever, intake rocker (168255)	6	
BM-79724	Lever and bushing	8	7	BM-79724	Lever and bushing	6	7
152937	Bushing, valve rocker lever	8	8	152937	Bushing, valve rocker lever	6	8
S-212	Nut, adjusting screw	8	9	S-212	Nut, adjusting screw	6	9
168306	Screw, adjusting	8	10	168306	Screw, adjusting	6	10
BM-99987	Lever, injector rocker (194038)	8		BM-99987	Lever, injector rocker (194038)	6	
BM-99986	Lever and bushing	8	11	BM-99986	Lever and bushing	6	11
152936	Bushing, injector rocker lever	8	12	152936	Bushing, injector rocker lever	6	12
194037	Socket, injector link	8	13	194037	Socket, injector link	6	13
S-212	Nut, adjusting screw	8	14	S-212	Nut, adjusting screw	6	14
168306	Screw, adjusting	8	15	168306	Screw, adjusting	6	15
AR-61113	Shaft, rocker lever (553455)	2	16	AR-60595	Shaft, rocker lever (551606)	2	16
161825	Plug, rocker shaft	4	17	161825	Plug, rocker shaft	4	17
551609	Pin, rocker shaft locating	2	18	551609	Pin, rocker shaft locating	2	18

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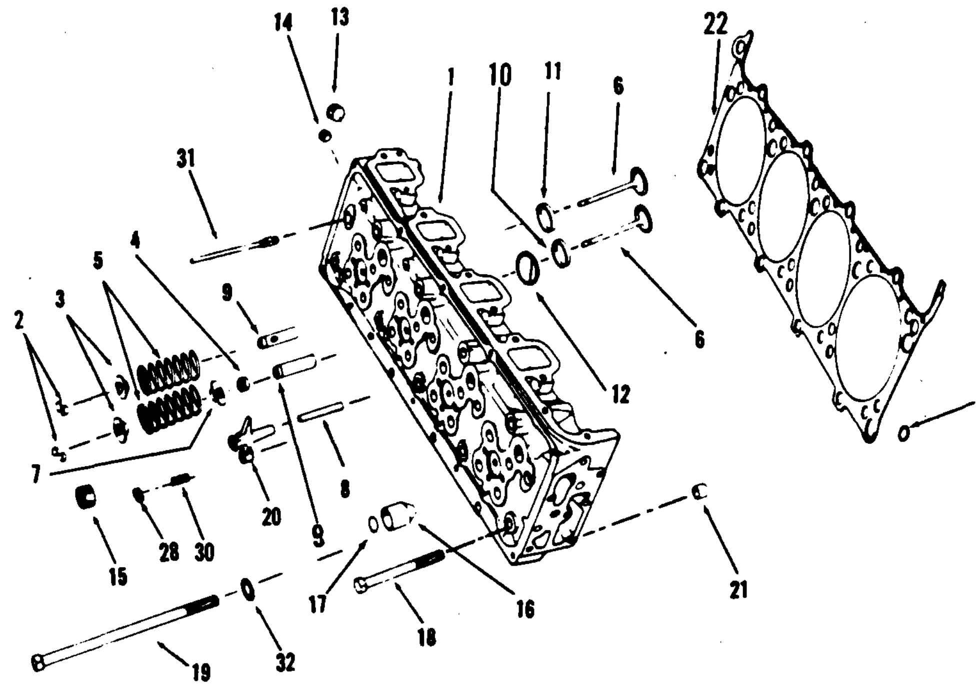

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER HEAD		
	V-504-F1, F2		
AR-60769	Head, assembly, cylinder (157782)	2	1
166772	Half collet, valve	64	2
155441	Retainer, spring	32	3
156541	Seal, intake valve	16	4
163037	Spring, valve	32	5
166774	Valve, intake and exhaust	32	6
553811	Wear plate	32	7
AR-60770	Head assembly, less valves	2	
154220	Guide, crosshead	16	8
154946	Guide, valve stem	32	9
195000	Insert, valve seat (intake)	16	10
154390	Insert, valve seat (exhaust)	16	11
553461	Plate, swirl	16	12
551475	Plug, cup	8	
554416	Plug, cup	16	
S-910-B	Plug, pipe	2	13
S-911-B	Plug, pipe	6	14
S-995	Plug, pipe	8	15
169630	Sleeve, injector	8	16
196641	"O" ring	8	17

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
162182	Capscrew, cylinder head (short)	26	18
162183	Capscrew, cylinder head (long)	10	19
156879	Crosshead, valve	16	20
100973	Dowel ring, cylinder head	4	21
214621	Gasket, cylinder head	2	22
214731	Cap, end	4	
S-273	Nut, crosshead adjusting	16	28
147389	Screw, crosshead adjusting	16	30
3275545	Tube, vent (3275131)	2	31
S-1003-1	Connector, tube	2	
S-1022-A	Nut, tube	2	
153411	Washer, cylinder head capscrew	36	32
	OPTIONAL		
AR-62074	Gasket, cylinder head	2	
AR-62075	Gasket, cylinder head	2	
171999	Guide, valve crosshead (oversize)	A/R	

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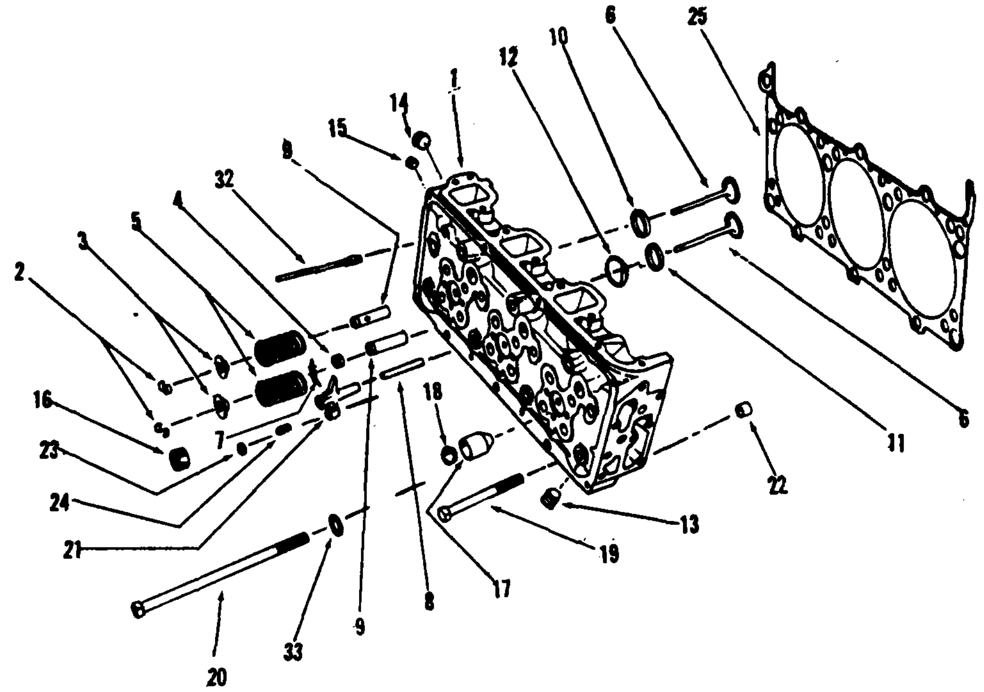
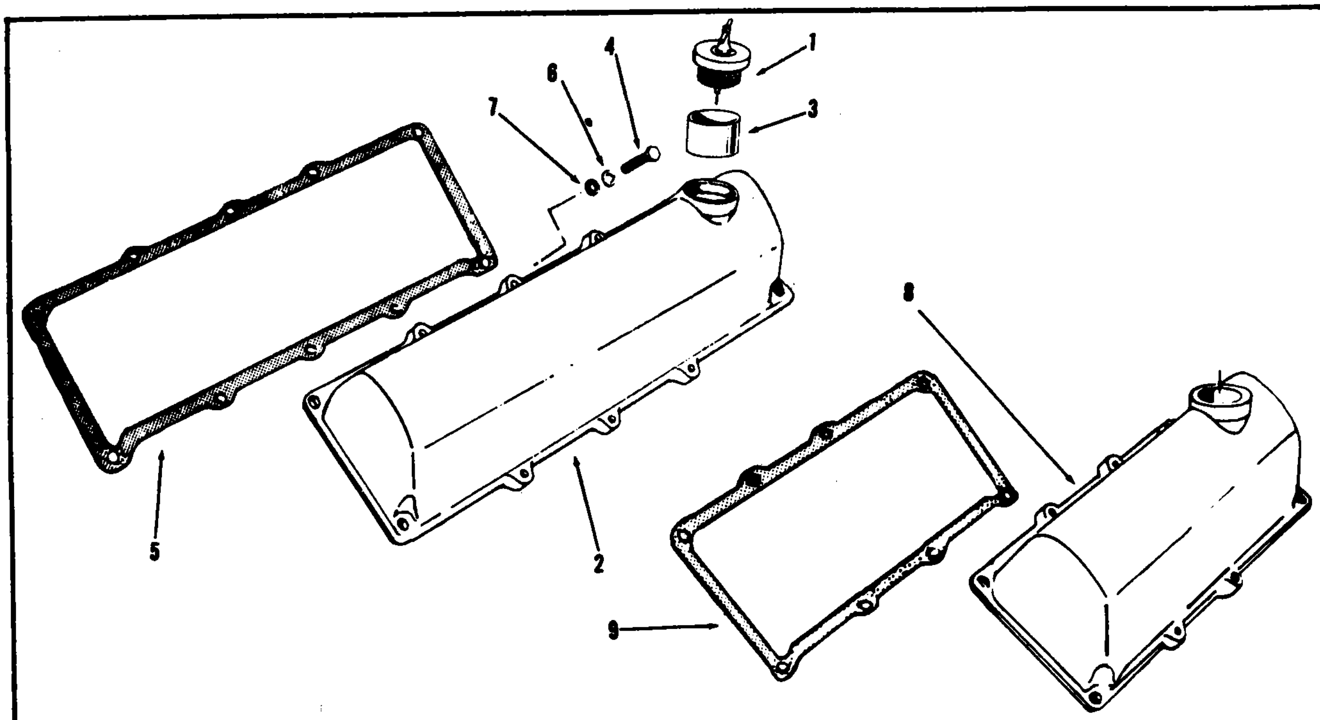


ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER HEAD				**MOUNTING PARTS**		
	V-378-F1, F2			162182	Capscrew, cylinder head (short)	20	19
				162183	Capscrew, cylinder head (long)	8	20
AR-60776	Head, assembly cylinder (152143)	2	1	156879	Crosshead, valve	12	21
166772	Collet, valve half	48	2	100973	Dowel ring, cylinder head	4	22
155441	Retainer, valve spring	24	3	S-273	Nut, crosshead	12	23
156541	Seal, intake valve	12	4	147389	Screw, crosshead adjusting	12	24
163037	Spring, intake and exhaust valve	24	5	556857	Gasket, cylinder head	2	25
166774	Valve, intake and exhaust	24	6	214731	Cap, end	4	
553811	Wear plate	24	7	3275545	Tube, vent (3275131)	2	32
AR-60777	Head, cylinder	2		S-1003-1	Connector, tube	2	
154220	Guide, crosshead	12	8	S-1022-A	Nut, tube	2	
154946	Guide, valve	24	9	153411	Washer, cylinder head capscrew	28	33
195000	Insert, valve seat (intake)	12	10				
154390	Insert, valve seat (exhaust)	12	11				
553461	Plate, swirl	12	12		**OPTIONAL**		
551475	Plug, cup	6					
554416	Plug, cup	12	13	AR-61586	Gasket, cylinder head	2	
S-910-B	Plug, pipe	2	14	AR-61589	Gasket, cylinder head	2	
S-911-B	Plug, pipe	2	15	171999	Guide, valve crosshead (oversize)	A/R	
S-995	Plug, pipe	2	16				
169630	Sleeve, injector	6	17				
196641	"O" ring	6	18				

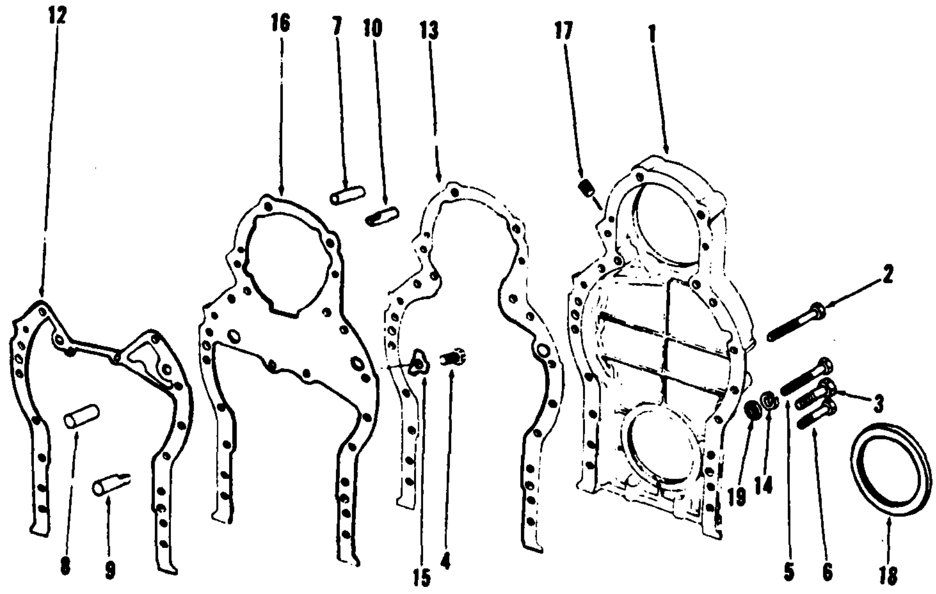
PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED



ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER HEAD COVER		
	V-504-F1, F2		
107981	Cap, oil filler	1	1
AR-60122	Cover and tube (R.B.)	1	
551786	Cover, cylinder head (R.B.)	1	2
550113	Tube, filler	1	3
553462	Cover, cylinder head (L.B.)	1	
	MOUNTING PARTS		
108707	Capscrew	20	4
157018	Gasket	2	5
S-604	Lockwasher	20	6
554833	Nameplate	3	
S-602	Washer, plain	20	7

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CYLINDER HEAD COVER		
	V-378-F1, F2		
107981	Cap, oil filler	1	1
AR-60375	Cover and tube (R.B.)	1	
552383	Cover, cylinder head (R.B.)	1	8
550113	Tube, filler	1	3
553521	Cover, cylinder head (L.B.)	1	
	MOUNTING PARTS		
108707	Capscrew	16	4
154019	Gasket, cover	2	9
S-604	Lockwasher	16	6
554833	Nameplate	3	
S-602	Washer, plain	16	7



ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	GEAR HOUSING						
	V-504-F1, F2 **V-378-F1, F2**						
168644	Housing, gear	1	1				
S-102-D	Capscrew, housing to block	1	2				
S-104	Capscrew, housing to block	6	3				
S-109	Capscrew, plate to block	2	4				
S-126	Capscrew, housing to block	2	5				
108707	Capscrew, housing to block	6	6				
9089	Dowel (Master)	1	7				
69562	Dowel (Master)	1	8				
102957	Dowel (Diamond)	1	9				
153807	Dowel (Diamond)	1	10				
168649	Gasket, plate to block	1	12				
168650	Gasket, gear housing to plate	1	13				
S-604	Lockwasher, housing to block	14	14				
175282	Lockplate, plate to block	2	15				
551467	Plate, gear housing	1	16				
69901	Plug, pipe	2	17				
S-965-E	Plug, pipe	1					
551515	Seal, oil	1	18				
S-602	Washer, plain	14	19				

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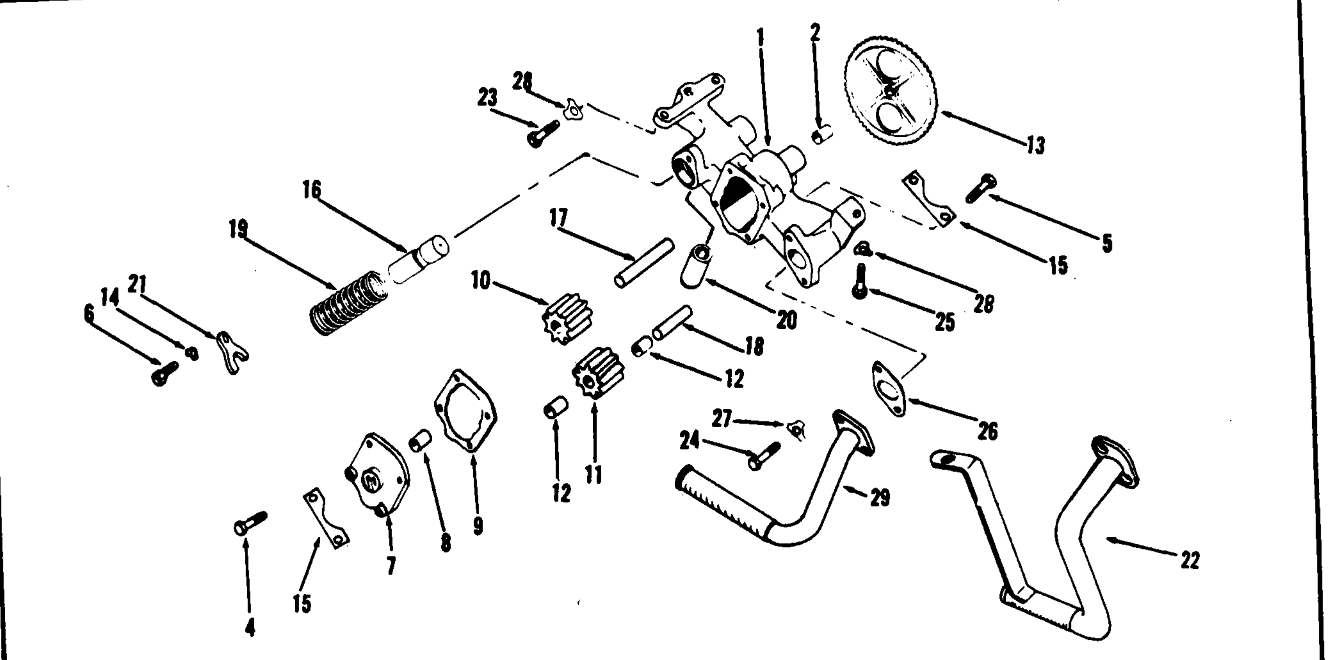

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	LUBRICATING OIL PUMP		
	V-504-F1, F2		
AR-62181	Pump, lubricating oil	1	
AR-60089	Body, and bushing (187011)	1	1
68586	Bushing	1	2
S-107	Capscrew	2	4
S-155-A	Capscrew	2	5
S-109	Capscrew	1	6
AR-60092	Cover and bushing (181165)	1	7
68586	Bushing	1	8
178283	Gasket, cover	1	9
187012	Gear, idler drive	1	10
AR-60090	Gear, idler (187013)	1	11
68586	Bushing	1	12
184044	Gear, main drive	1	13
109319	Lockplate, regulator	1	14
551117	Lockplate, cover to body	2	15
175805	Plug, by-pass valve	1	
183014	Plunger, pressure regulator	1	16
178284	Shaft, drive	1	17
190138	Shaft, idler	1	18
135627	Spring, regulator	1	19
554616	Tube, by-pass	1	20
126304	Yoke, pressure regulator	1	21
AR-62048	Tube, oil suction assembly	1	22

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	V-378-F1, F2		
	Same as V8 except:		
OMIT:			
AR-62181	Pump, lubricating oil	1	
135527	Spring, regulator	1	19
AR-62048	Tube, oil suction assembly	1	22
ADD:			
AR-60801	Pump, lubricating oil	1	
551079	Spring, regulator	1	19
AR-60762	Tube, oil suction assembly	1	29
	MOUNTING PARTS		
S-103-D	Capscrew, pump to block	2	23
S-109	Capscrew, tube to pump	2	24
S-112	Capscrew, pump to block	1	25
164916	Gasket, tube to pump	1	26
109319	Lockplate, tube to pump	2	27
175282	Lockplate, pump to block	3	28

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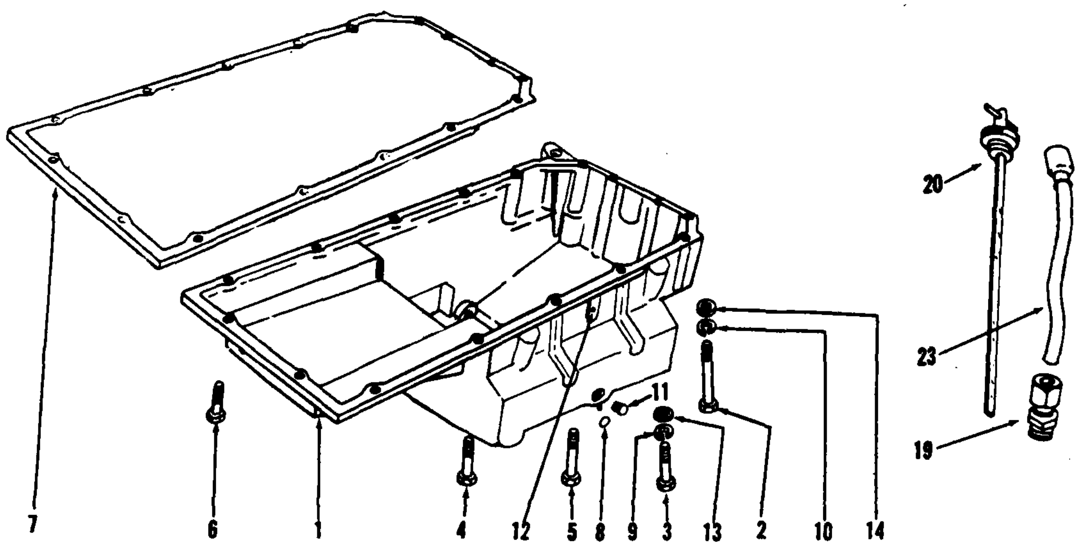

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	OIL PAN				**DIPSTICK AND TUBE**		
	V-504-F1, F2			3275184	Connector, dipstick tube	1	19
554038	Pan, oil	1	1	556071	Dipstick	1	20
550389	Capscrew	2	2	556069	Tube, dipstick	1	23
S-199-A	Capscrew	2	3				
S-103-D	Capscrew	8	4				
S-124-C	Capscrew	2	5				
S-102	Capscrew	2	6				
175727	Gasket, oil pan	1	7				
553856	Gasket, drain plug	1	8				
553854	Helicoil, insert	1					
S-604	Lockwasher	10	9				
S-605	Lockwasher	4	10				
553855	Plug, oil drain	1	11				
555601	Plug, pipe	1					
161704	Plug, pipe	1					
69901	Plug, pipe	1	12				
S-602	Washer, plain	10	13				
S-626	Washer, plain	6	14				

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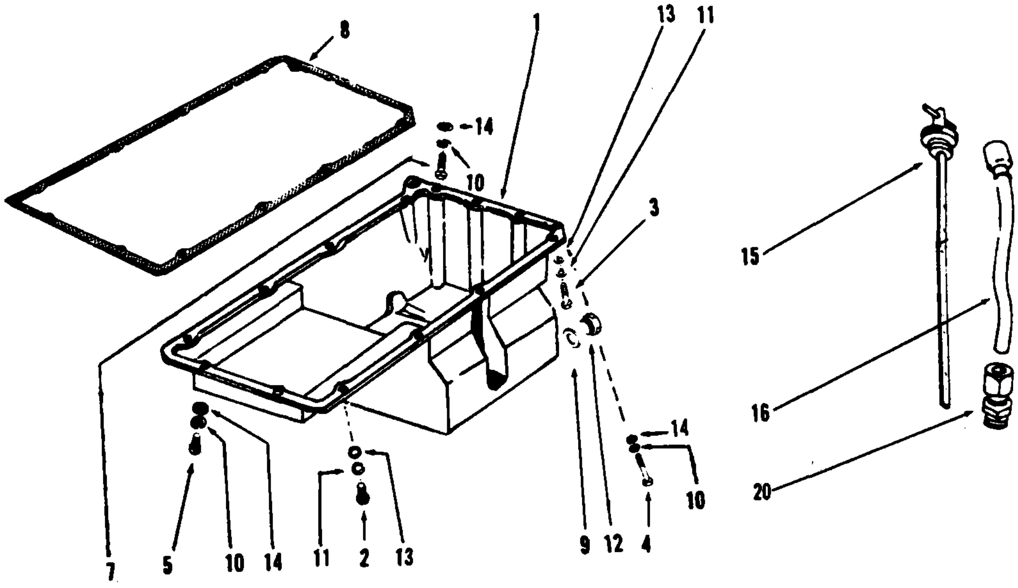

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	OIL PAN		
	V-378-F1, F2		
553496	Pan, oil	1	1
S-103-D	Capscrew	6	2
S-199-A	Capscrew	2	3
S-124-C	Capscrew	2	4
S-119	Capscrew	2	5
S-117	Capscrew	2	
550389	Capscrew	2	7
175726	Gasket, oil pan	1	8
553856	Gasket, oil pan	3	9
553854	Insert, drain boss	3	
S-605	Lockwasher	6	10
S-604	Lockwasher	8	11
109319	Plate, lock	2	
553855	Plug, oil drain	3	12
69901	Plug, pipe	1	
161704	Plug, pipe	1	
555601	Plug, pipe	2	
S-962	Plug, pipe	1	
S-602	Washer, plain	8	13
S-626	Washer, plain	6	14

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	DIPSTICK AND TUBE		
556068	Dipstick	1	15
556069	Tube, dipstick	1	16
3275184	Connector, dipstick tube	1	20

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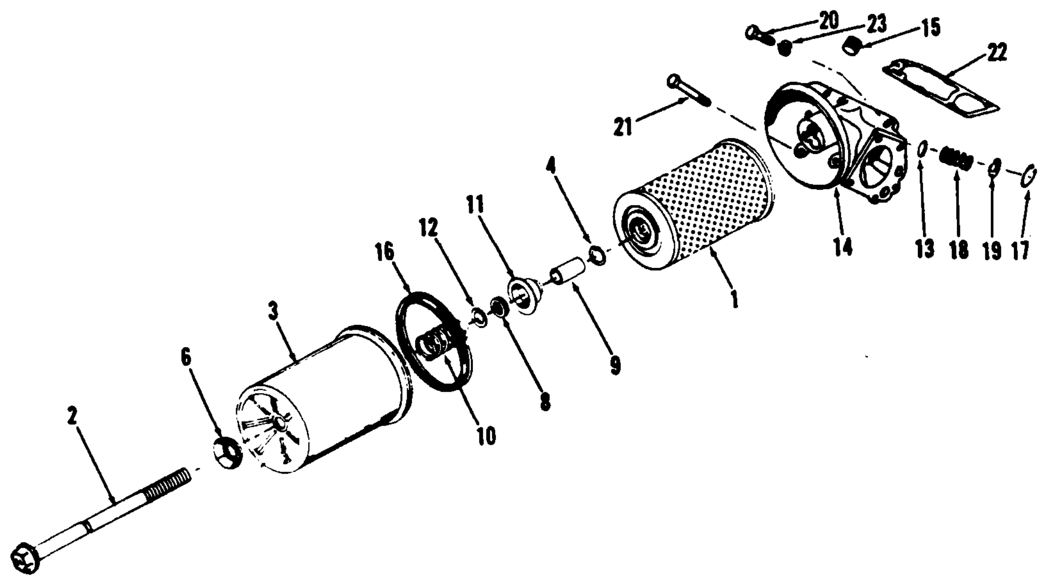

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	LUBRICATING OIL FILTER		
	V-504-F1, F2		
	V-378-F1, F2		
AR-60253	Filter, lubricating oil		
173174	Element	1	1
555378	Shell assembly, filter	1	
556507	Bolt, center	1	2
551681	Can, filter	1	3
556506	Circlip	1	4
554374	Plate	1	6
554375	Retainer, seal ring	1	
551685	Seal, bolt	1	8
554377	Spacer	1	9
551683	Spring, cartridge	1	10
554376	Support, cartridge	1	11
551684	Washer, bolt seal	1	12
200819	Disc, by-pass	1	13
175623	Head, filter	1	14
S-908	Plug, pipe	1	15
193302	Ring, sealing, head	1	16
156676	Ring, snap disc	1	17
188476	Spring, by-pass	1	18
S-689	Washer, disc	1	19

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
108707	Capscrew	5	20
S-126	Capscrew	2	21
176924	Gasket	1	22
S-604	Lockwasher	7	23

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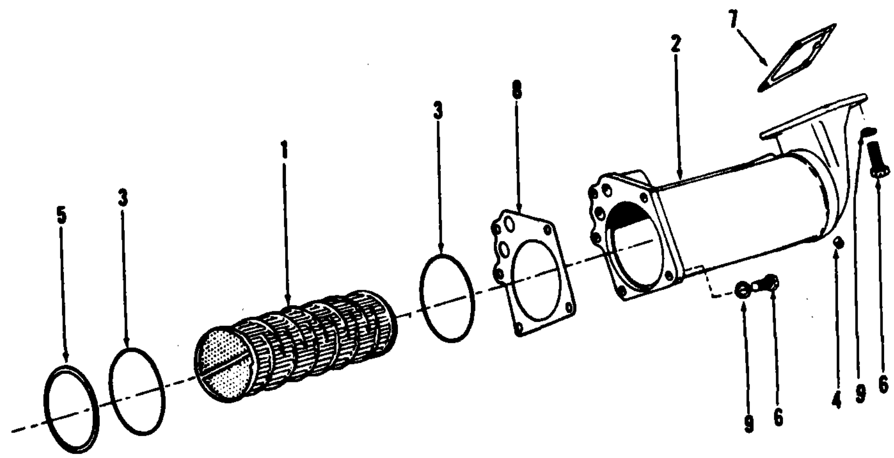

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	LUBRICATING OIL COOLER				**MOUNTING PARTS**		
	V-504-F1, F2			S-103-D	Capscrew	9	6
				165153	Gasket, housing to block	1	7
AR-01670	Cooler, lubricating oil	1		166407	Gasket, housing to junction	1	8
146052	Element	1	1	S-604	Lockwasher	9	9
172207	Housing	1	2				
148293	"O" ring	2	3				
S-910-B	Plug, pipe	1	4				
110827	Retainer, element	1	5				

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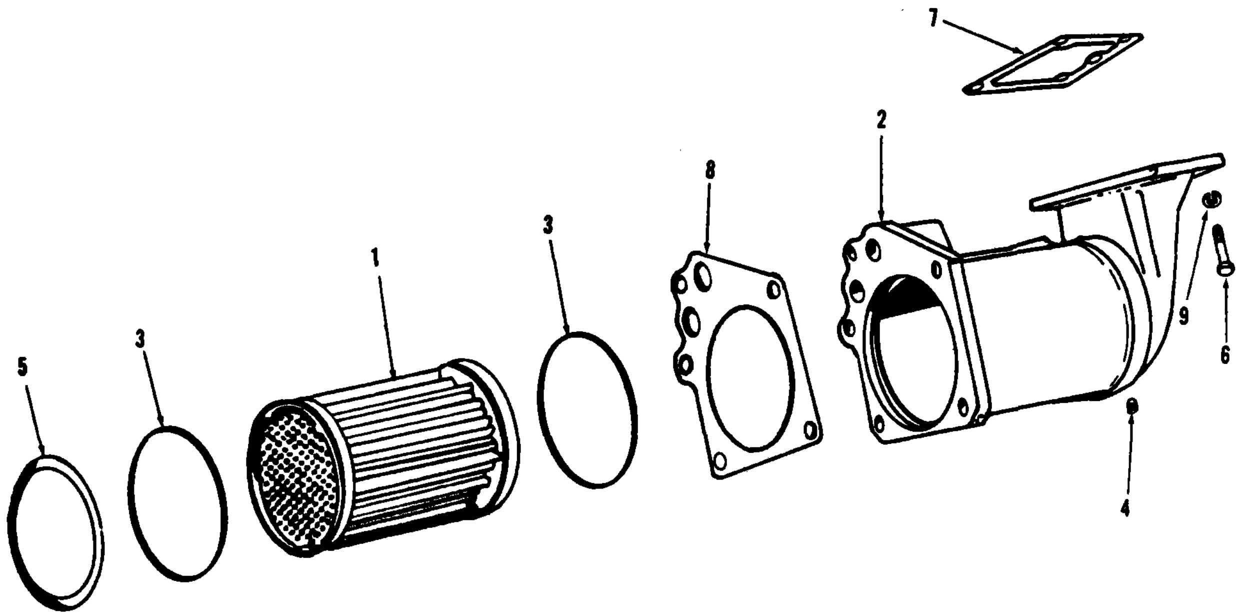

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	LUBRICATING OIL COOLER		
	V-378-F1, F2		
BM-91604	Cooler, lubricating oil	1	
110848	Element	1	1
166401	Housing	1	2
148293	"O" ring	2	3
112076	Plug, pipe	1	4
110827	Retainer, element	1	5

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
S-103-D	Capscrew, mounting	9	6
165153	Gasket, housing to block	1	7
166407	Gasket, cooler to filter	1	8
S-604	Lockwasher	9	9

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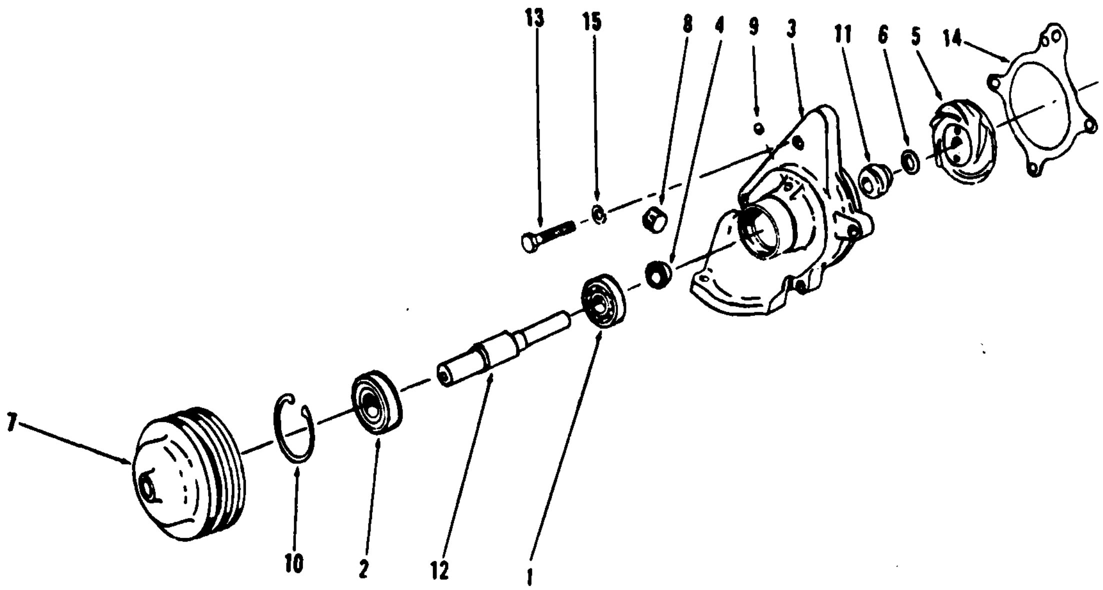

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER PUMP		
	V-504-F1, F2		
	V-378-F1, F2		
AR-60677	Pump, water	1	
552335	Bearing, ball	1	1
177596	Bearing, ball	1	2
552332	Body, water pump	1	3
107776	Flinger, water pump	1	4
200515	Impeller	1	5
AR-12732	Assembly, seal and seat	1	
217366	Seal	1	6
217367	Seat	1	11
173228	Pulley	1	7
S-995	Plug, pipe	1	8
69901	Plug, pipe	1	9
160586	Ring, retaining	1	10
552334	Shaft, water pump	1	12
S-915-A	Plug, pipe	1	
	MOUNTING PARTS		
178660	Belt, drive	2	
108707	Capscrew, water pump to block	4	13
169042	Gasket, water pump to block	1	14
S-604	Lockwasher	4	15

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER PUMP REPAIR KIT		
AR-60698	Kit, water pump repair	1	
552335	Bearing, ball	1	1
177596	Bearing, ball	1	2
200515	Impeller	1	5
AR-12732	Assembly, seal and seat	1	
217366	Seal	1	6
217367	Seat	1	11
169042	Gasket	1	14
107776	Flinger, water pump	1	4

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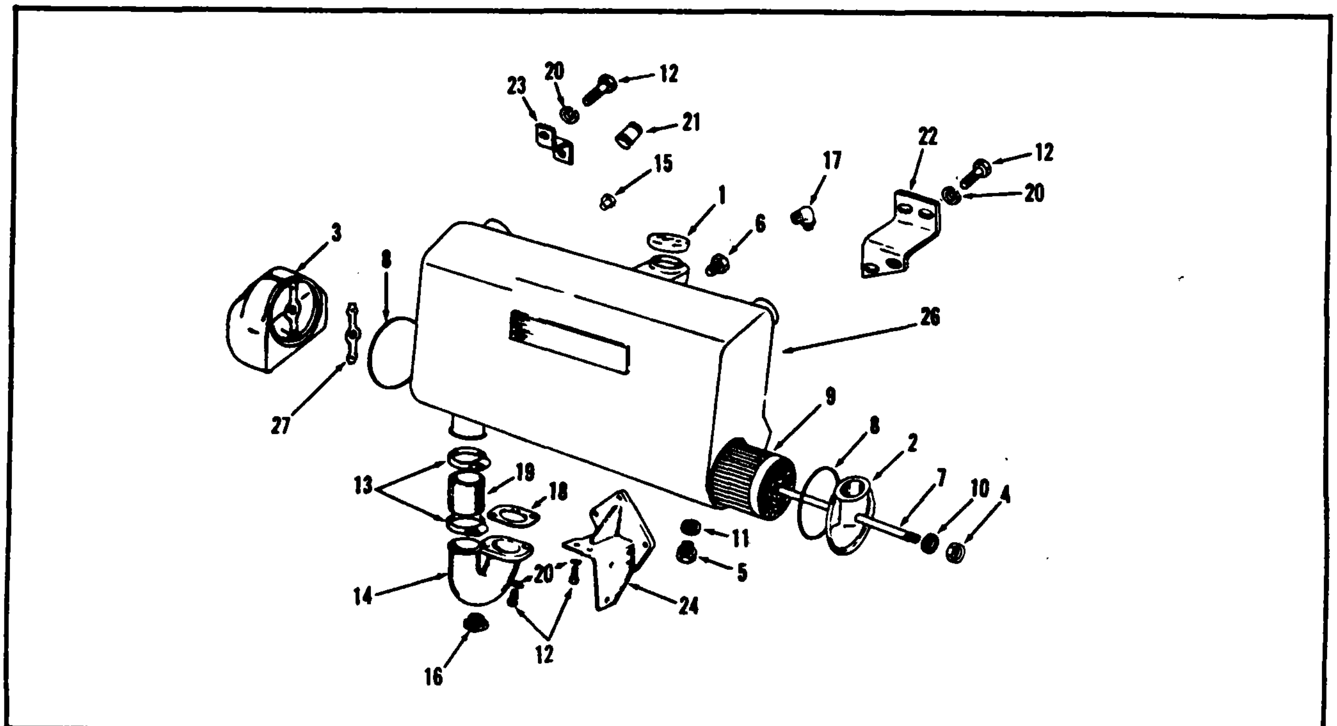

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	HEAT EXCHANGER		
	V-504-F1, F2		
	V-378-F1, F2		
556806	Heat, exchanger	1	
555407	Cap, filler	1	1
555999	Cover, end	1	2
557006	Cover, end	1	3
555636	Nut, tie rod cap	1	4
650604	Plug, drain	1	5
650605	Plug, drain and vent	2	6
650599	Rod, tie	1	7
650600	Seal, tube stack	2	8
650595	Stack, tube	1	9
556067	Washer, cap nut	1	10
555707	Washer, copper	1	11
554499	Body, heat exchanger	1	26
555908	Gasket	1	27

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
S-112	Capscrew	7	12
43828-D	Clamp, hose	6	13
650371	Connection, water inlet	1	14
S-1003-1	Connection	2	15
S-962-E	Cock, drain	1	16
S-1004-1	Elbow, pipe	1	17
167802	Gasket	1	
9221	Gasket	1	18
110980	Hose	1	19
S-604	Lockwasher	8	20
188572	Nipple, pipe	2	21
555034	Support	1	22
556814	Support	1	23
556811	Support	1	24
554995	Pipe, vent	1	
3275206	Tube, vent	1	
83241-E	Hose	1	
554996	Hose	1	
S-172-B	Capscrew	1	
3275217	Tube, water over flow	1	
555079	Clip, tube	3	

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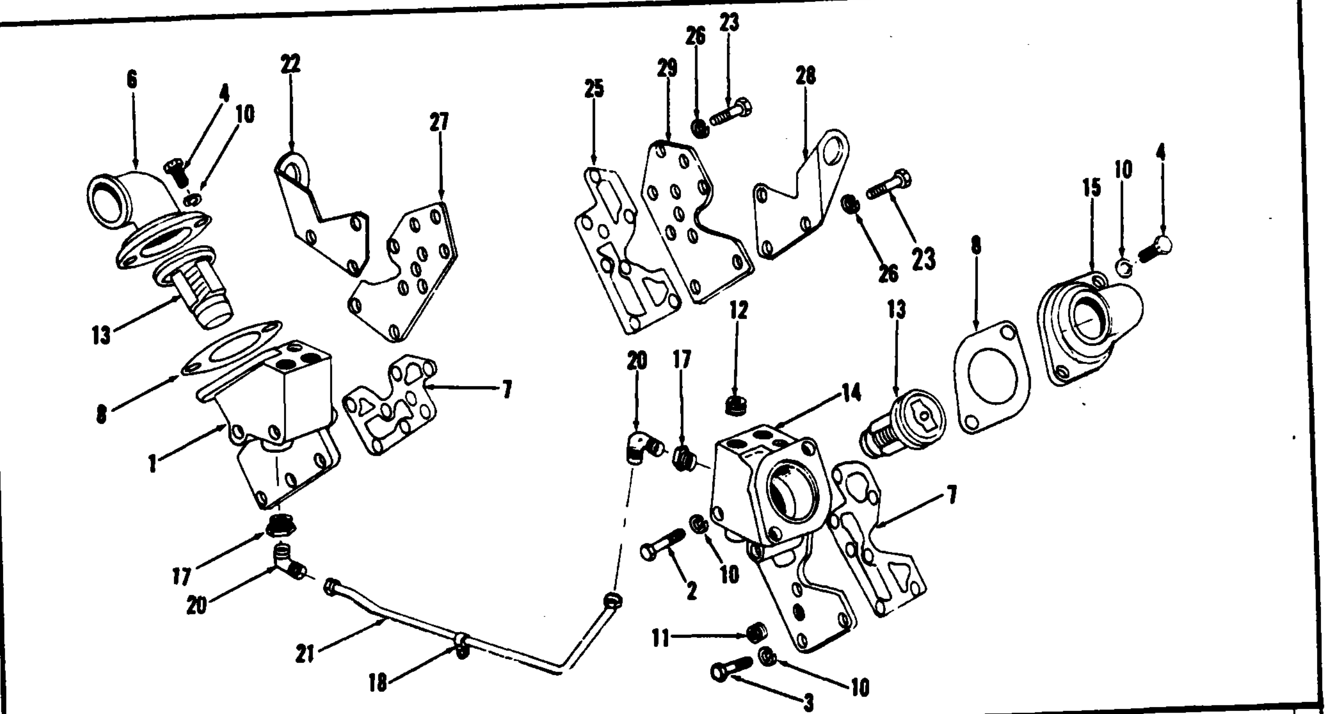

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	THERMOSTAT HOUSING		
	V-504-F1, F2		
	V-378-F1, F2		
	Right Bank Front		
556810	Housing, thermostat	1	1
S-197	Capscrew	1	2
S-103-D	Capscrew	2	3
S-112	Capscrew	2	4
188565	Connection	1	6
157290	Gasket, cylinder head cover plate	1	7
140329	Gasket, thermostat	1	8
S-604	Lockwasher	2	10
S-908	Plug, pipe	1	11
S-915-A	Plug, pipe	2	12
199530	Thermostat	1	13
S-163	Capscrew	1	
550789	Capscrew	3	
	Left Bank Front		
650804	Housing, thermostat	1	14
S-197	Capscrew	2	2
S-103-D	Capscrew	5	3
S-112	Capscrew	2	4
650394	Connection	1	15
157290	Gasket, cylinder head to cover plate	1	7
140329	Gasket, thermostat	1	8
S-604	Lockwasher	2	10
S-908	Plug, pipe	2	11
S-915-A	Plug, pipe	2	12
199530	Thermostat	1	13

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER CROSSOVER		
	V-504-F1, F2		
	V-378-F1, F2		
S-921-D	Bushing	2	17
554013	Clip, pipe	1	18
S-1005-A	Elbow 90°	2	20
554156	Tube	1	21
	LIFTING BRACKET R.B. FRONT		
556813	Bracket, lifting	1	22
S-109	Capscrew	7	23
157290	Gasket, cylinder head cover	1	25
S-604	Lockwasher	7	26
152398	Plate, cylinder head cover	1	27
	LIFTING BRACKET L.B. REAR		
187296	Bracket, lifting	1	28
S-109	Capscrew	7	23
157290	Gasket, cylinder head cover	1	25
S-604	Lockwasher	7	26
152398	Plate, cylinder head cover	1	29

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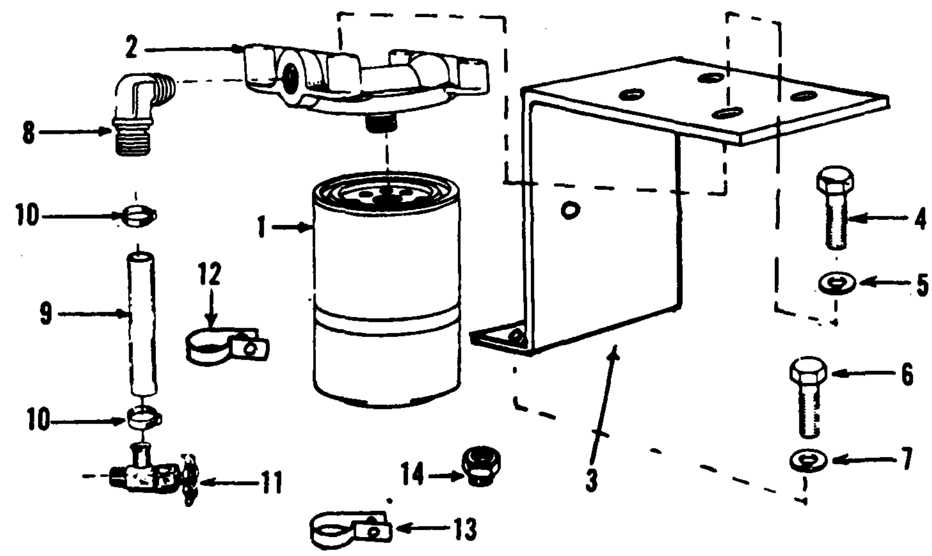

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	WATER FILTER		
	V-504-F1, F2		
	V-378-F1, F2		
258859	Filter, water assembly	1	
299082	Element (WF-2012) Precharge	1	1
299080	Element (WF-2010) Service	1	1
204163	Head	1	2
3000801	Decal	1	

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
556536	Bracket	1	3
S-103-D	Capscrew	4	4
S-604	Lockwasher	4	5
S-142	Capscrew	2	6
S-605	Lockwasher	2	7
179903	Elbow	2	8
179918	Hose	1	9
179908	Hose	1	9
179904	Clamp, hose	4	10
179901	Valve, shut-off	2	11
550692	Clip, hose	1	12
550299	Clip	1	13
S-983	Bushing, pipe	1	14
S-973	Elbow, street	1	
S-956-D	Elbow, street	1	

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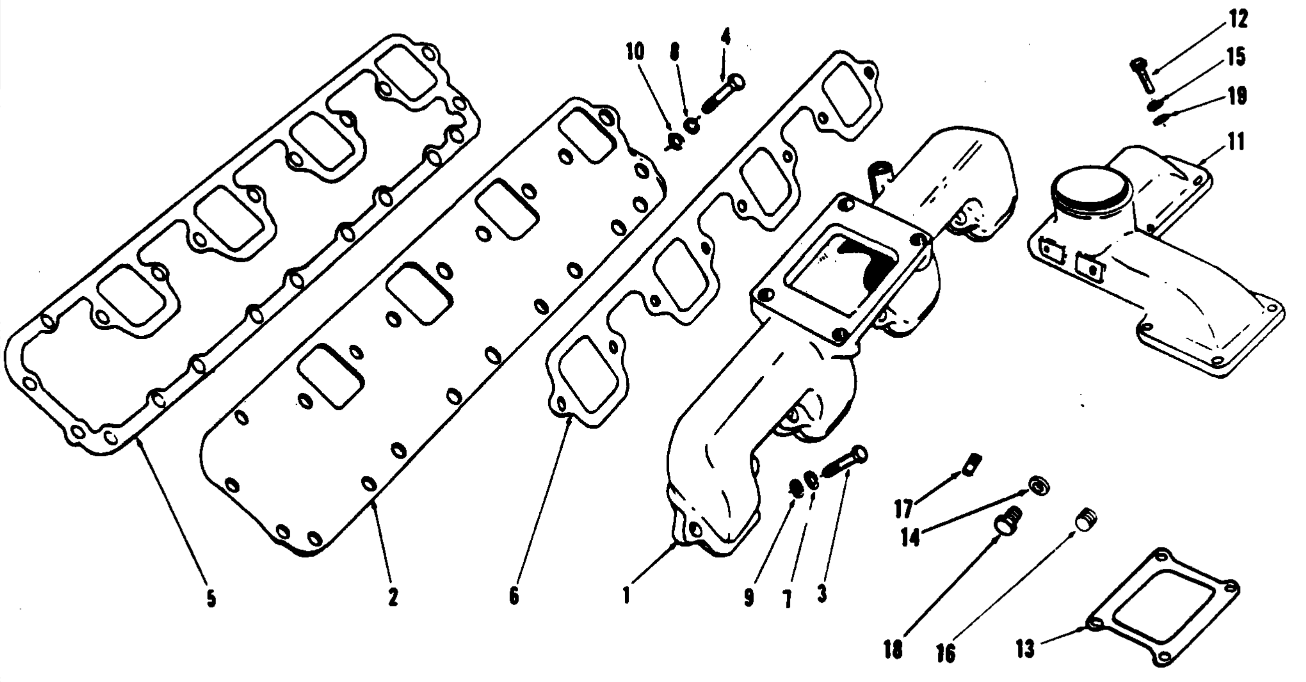

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	AIR INTAKE MANIFOLD				**CONNECTION, AIR CROSSOVER**		
	V-504-F1, F2				**V-504-F1, F2**		
168067	Manifold, air intake	2	1	168076	Connection, air crossover	1	11
159267	Plate, push tube cover	2	2				
	MOUNTING PARTS				**MOUNTING PARTS**		
				S-103-D	Capscrew, connection	8	12
S-102	Capscrew, plate to block	2		168069	Gasket, connection	2	13
S-103-D	Capscrew, manifold to plate	16	3	66292	Gasket, plug	2	14
S-110	Capscrew, plate to block	24	4	S-604	Lockwasher	8	15
AR-62294	Gasket, push tube cover	2	5	69901	Plug, pipe	1	16
156996	Gasket, intake manifold	2	6	S-995	Plug, pipe	1	17
S-604	Lockwasher, manifold	16	7	66030	Plug, pipe	2	18
S-605	Lockwasher, plate	26	8	S-602	Washer, plain	8	19
S-602	Washer, plain, manifold	16	9	S-910-B	Plug, pipe	1	
S-626	Washer, plain, manifold	26	10				

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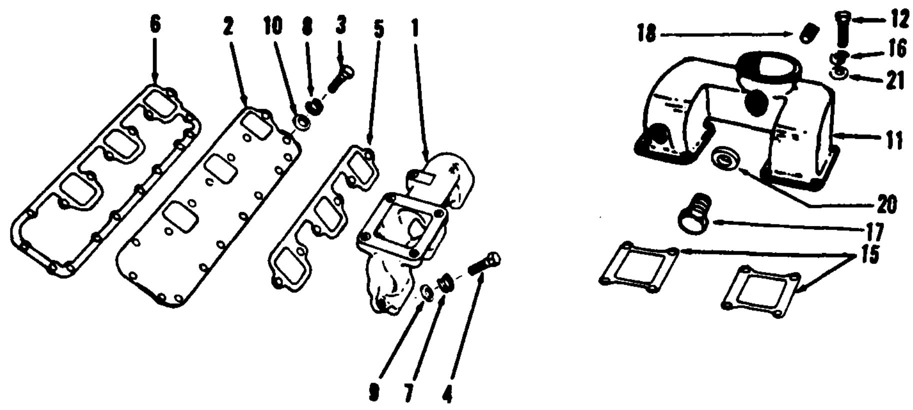
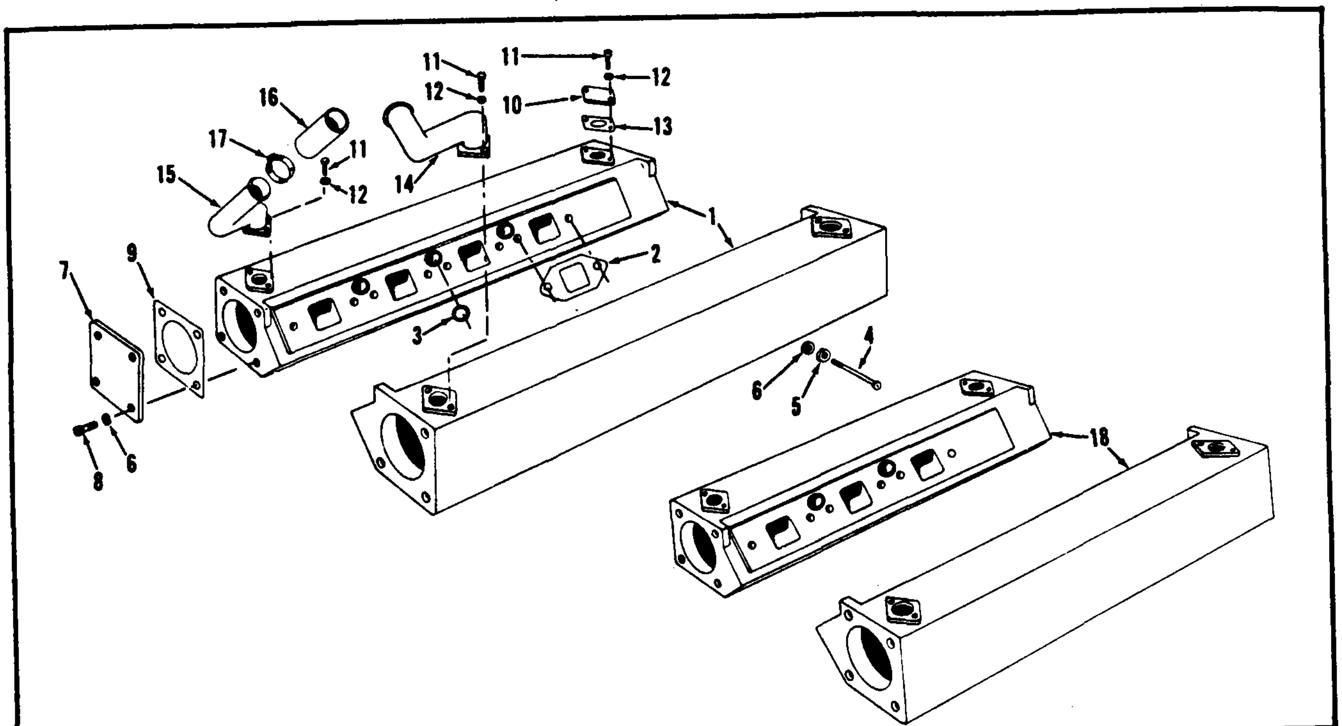


ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	AIR INTAKE MANIFOLD		
	V-378-F1, F2		
168066	Manifold, air intake	2	1
160509	Plate, push tube cover	2	2
	MOUNTING PARTS		
S-110	Capscrew, plate to block	22	3
S-103-D	Capscrew, manifold to plate	12	4
154415	Gasket, intake manifold	2	5
AR-62293	Gasket, push tube cover	2	6
S-604	Lockwasher, manifold	12	7
S-605	Lockwasher, cover plate	22	8
S-602	Washer, plain manifold	12	9
S-626	Washer, plain, cover plate	22	10

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	CONNECTION, AIR CROSSOVER		
	V-378-F1, F2		
168068	Connection, air crossover	1	11
	MOUNTING PARTS		
S-103-D	Capscrew, connection	8	12
168069	Gasket, connection	2	15
S-604	Lockwasher, connection	8	16
S-995	Plug, pipe	1	
66030	Plug, pipe	2	17
69901	Plug, pipe	1	18
66292	Gasket, plug	2	20
S-602	Washer, plain	8	21
S-910-B	Plug, pipe	1	

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED

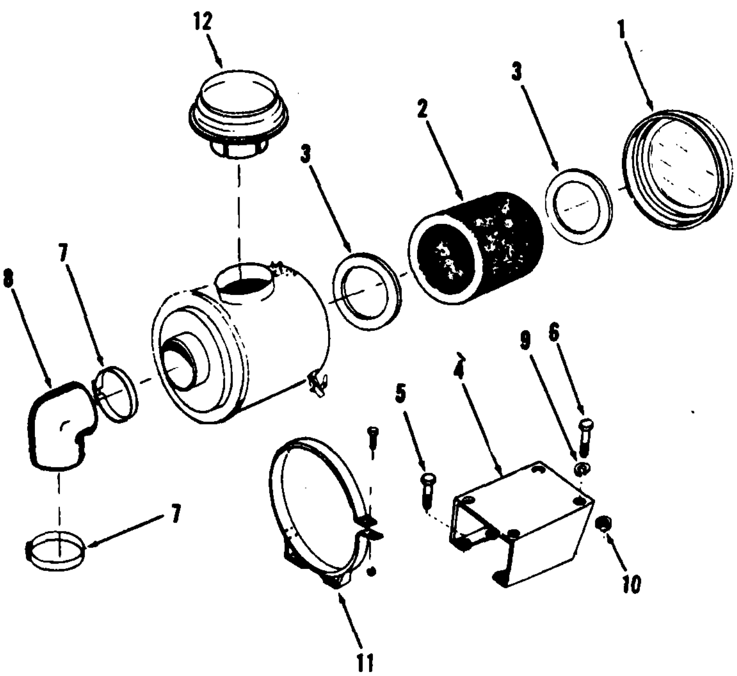


ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	EXHAUST MANIFOLD		
	V-504-F1, F2		
553825	Manifold, exhaust	2	1
	MOUNTING PARTS		
168003	Gasket, exhaust manifold	8	2
178817	"O" ring	6	3
S-166-B	Capscrew	16	4
146161	Washer, plain	16	5
S-604	Lockwasher	24	6
554446	Plate, blanking	2	7
S-112	Capscrew	8	8
191984	Gasket, plate	2	9
554447	Plate, blanking	2	10
S-115	Capscrew	8	11
S-605	Lockwasher	8	12
651046	Gasket, plate	4	13
554443	Connection, water outlet (L.B.)	1	14
554444	Connection, water outlet (R.B.)	1	15
553414	Hose	2	16
550547	Clamp, hose	4	17
S-910-B	Plug, pipe	7	
S-962	Plug, pipe	10	
S-995	Plug, pipe	10	
S-962-E	Cock, drain	1	

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	EXHAUST MANIFOLD		
	V-378-F1, F2		
554400	Manifold, exhaust	2	18
	MOUNTING PARTS		
168003	Gasket, exhaust manifold	6	2
178817	"O" ring	4	3
S-166-B	Capscrew	12	4
146161	Washer, plain	12	5
S-604	Lockwasher	20	6
554446	Plate, blanking	2	7
S-112	Capscrew	8	8
191984	Gasket, plate	2	9
554447	Plate, blanking	2	10
S-115	Capscrew	8	11
S-605	Lockwasher	8	12
651046	Gasket, plate	4	13
554443	Connection, water outlet (L.B.)	1	14
554444	Connection, water outlet (R.B.)	1	15
553414	Hose	2	16
550547	Clamp, hose	4	17
S-910-B	Plug, pipe	5	
S-995	Plug, pipe	8	

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED

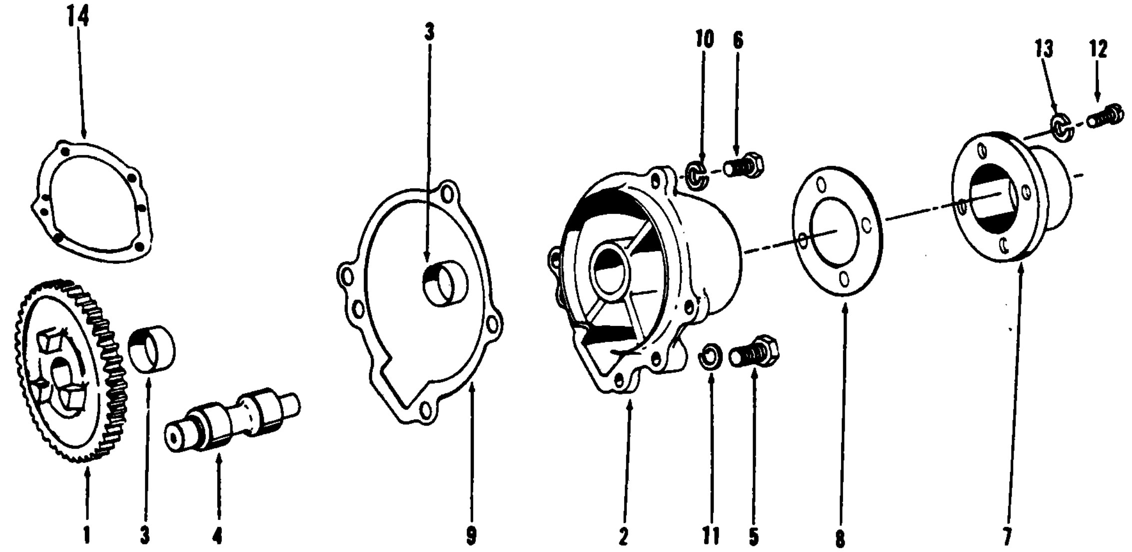


ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	AIR CLEANER		
	V-504-F1, F2		
	V-378-F1, F2		
650051	Air cleaner	1	
650056	Cover	1	1
650055	Element	1	2
650058	Seal	2	3
	MOUNTING PARTS		
	V-504-F1, F2		
650665	Bracket	1	4
108707	Capscrew	4	5
S-129	Capscrew	4	6
125740	Clamp, "T" bolt	2	7
105312	Elbow, 90 deg.	1	8
S-604	Lockwasher	4	9
S-205	Nut	4	10
650041	Strap	2	11
650059	Hood, air cleaner	1	12

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
	V-378-F1, F2		
650667	Bracket	1	4
108707	Capscrew	4	5
S-166	Capscrew	4	6
125740	Clamp, "T" bolt	1	7
650356	Elbow, 90 deg.	1	8
S-604	Lockwasher	4	9
S-205	Nut	4	10
650041	Strap	2	11
650059	Hood, air cleaner	1	12
140311	Clamp	1	
140312	Clamp	1	

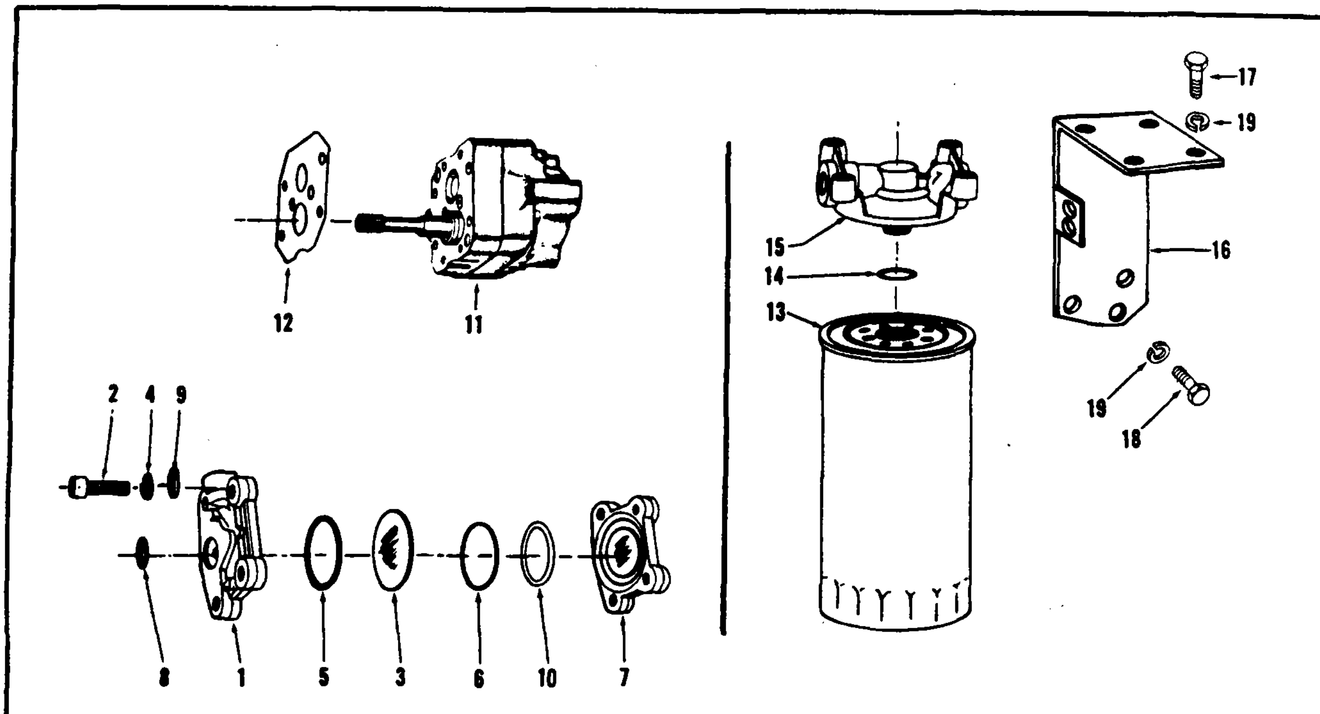
PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED



ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	FUEL PUMP DRIVE				**MOUNTING PARTS**		
	V-504-F1, F2			S-105-A	Capscrew, drive	2	5
	V-378-F1, F2			S-105	Capscrew, drive	2	6
				551160	Cover, drive shaft	1	7
BM-93760	Drive, fuel pump	1		164059	Gasket, cover	1	8
177097	Gear, drive	1	1	153433	Gasket, support	1	9
BM-93759	Housing, drive (171635)	1	2	S-604	Lockwasher	2	10
147610	Bushing, shaft	2	3	S-610	Lockwasher	4	11
171636	Shaft, drive	1	4	131449	Screw, cover	4	12
				S-607	Lockwasher	4	13
				167993	Gasket, fuel pump	1	14
				S-622	Washer	2	
				100915	Capscrew	2	
				109859	Spider, coupling	1	

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED



ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PT FUEL PUMP

Each Cummins PT Fuel Pump is calibrated to obtain the best performance and fuel economy for your engine. Your Cummins Distributor or Dealer has the special tools required for complete rebuild and calibration. Caution: Do Not disturb the fuel pressure settings or the throttle screw settings, as serious damage to your engine may result.

Only PT Fuel System parts which can be replaced without pump calibration are listed here. Your Cummins Distributor will record the specific part number of your complete PT Fuel Pump in the front of this catalog.

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	FUEL PUMP DAMPER		
	ALL MODELS		
BM-76340	Damper, fuel pump	1	
153336	Body, damper	1	1
S-105-C	Capscrew	2	2
202897	Diaphragm	1	3
S-600	Lockwasher	2	4
139988	"O" ring	1	5
100099	"O" ring	1	6
153338	Plate, damper	1	7
151900	Seal	1	8
70704	Washer	2	9
160514	Washer, nylon	1	10

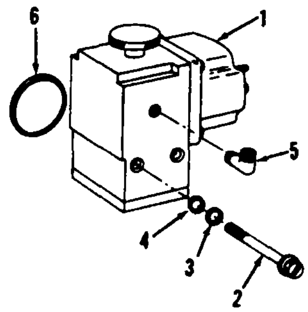
PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	GEAR PUMP		
AR-73621	Pump, gear	1	11
210647	Gasket	1	12
	FUEL FILTER		
156171	Filter, fuel	1	
156172	Cartridge (FF-105-D)	1	13
255622	Gasket, cover	1	14
142784	Head	1	15
	MOUNTING PARTS		
651026	Bracket, sump pump and fuel filter	1	16
S-103-D	Capscrew	4	17
S-112	Capscrew	4	18
S-604	Lockwasher	8	19
129859	Elbow 90 deg.	2	20
	OVERSPEED SWITCHES		
	V-504-F1; V-378-F1		
210314	Overspeed switch	1	
	V-504-F2; V-378-F2		
210315	Overspeed switch	1	

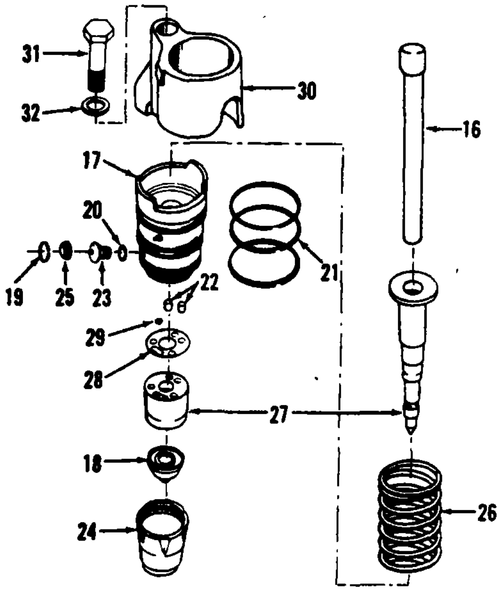
PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.	PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	FUEL TUBING						
	ALL MODELS						
553057	Adapter	2					
S-1003-1	Adapter	3					
S-929-B	Bushing	1					
148376	Bushing	2					
551394	Clamp	2					
555079	Clamp	1					
114850	Spacer	1					
68368-A	Spacer	1					
S-1006	Tee, piece	1					
554313	Tube, fuel (V6)	1					
554343	Tube, fuel (V8)	1					
650513	Pipe, L.B F.	1					
650512	Pipe, R.B.F.	1					
185505	Valve check	1					
178079	Valve check	1					
555366	Tube, fuel	1					
555367	Tube, fuel	1					
555368	Tube, fuel	1					
650679	Elbow	1					
3275207	Tube, fuel	1					
553056	Tee, piece	1					
69465-A	Clamp	1					
552358	Tee, piece	1					
218052	Clip, hose	1					
S-964	Bushing	1					
556152	Tube, fuel	1					

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED





ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	SHUTDOWN VALVE		
	ALL MODELS		
216930	Valve, shutdown	1	1
	MOUNTING PARTS		
S-189-C	Capscrew	2	2
67684	Washer, plain	2	3
181466	Lockwasher	2	4
S-1004-1	Elbow, tubing	1	5
154087	"O" ring	1	6
	INJECTOR		
	V-504-F1, F2		
3275273	Injector	8	
194041	Link, injector	8	16
AR-73716	Injector (less link)	8	
556895	Adapter, injector	8	17
3275266	Cup, injector	8	18
174299	Clip, filter screen	8	19
173086	Gasket, orifice	8	20
101754	"O" ring	24	21
165296	Pin, roll	16	22
556894	Retainer, cup	8	24
174298	Screen, filter	8	25
166009	Spring, injector	8	26
AR-40063	Barrel and plunger	8	27
185782	Gasket	8	28
167157	Ball, check	8	29
*	Plug, orifice	8	23

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	MOUNTING PARTS		
552458	Clamp, injector	8	30
166392	Capscrew, hex head	8	31
69280	Washer, plain	8	32
	INJECTOR		
	V-378-F1, F2		
3275273	Injector	6	
194041	Link, injector	6	16
AR-73716	Injector (less link)	6	
556895	Adapter, injector	6	17
3275266	Cup, injector	6	18
174299	Clip, filter screen	8	19
173086	Gasket, orifice	6	20
101754	"O" ring	18	21
165296	Pin, roll	12	22
556894	Retainer, cup	6	24
174298	Screen, filter	6	25
166009	Spring, injector	6	26
AR-40063	Barrel and plunger	6	27
185782	Gasket	6	28
167157	Ball, check	6	29
*	Plug, orifice	6	23
	MOUNTING PARTS		
552458	Clamp, injector	6	20
166392	Capscrew, hex head	6	31
69280	Washer, plain	6	32

* Not sold separately.

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED

ENGINE APPLICATION	AUTOMOTIVE	B - OFF-HIGHWAY	C - CONSTRUCTION & INDUSTRIAL	P - INDUSTRIAL POWER

PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	STANDARD FLYWHEEL HOUSING		
	ALL MODELS		
551462	Housing, flywheel	1	
108601	Capscrew	2	
S-106	Capscrew	4	
106289	Capscrew	9	
69562	Dowel	1	
102957	Dowel	1	
556346	Seal, dust	1	
S-608	Lockwasher	13	
S-670	Washer	13	
S-187	Capscrew	4	
S-136	Capscrew	2	
	REAR SUPPORT		
	ALL APPLICATIONS		
553627	Support, rear	1	
S-145	Capscrew	4	
S-608	Lockwasher	4	

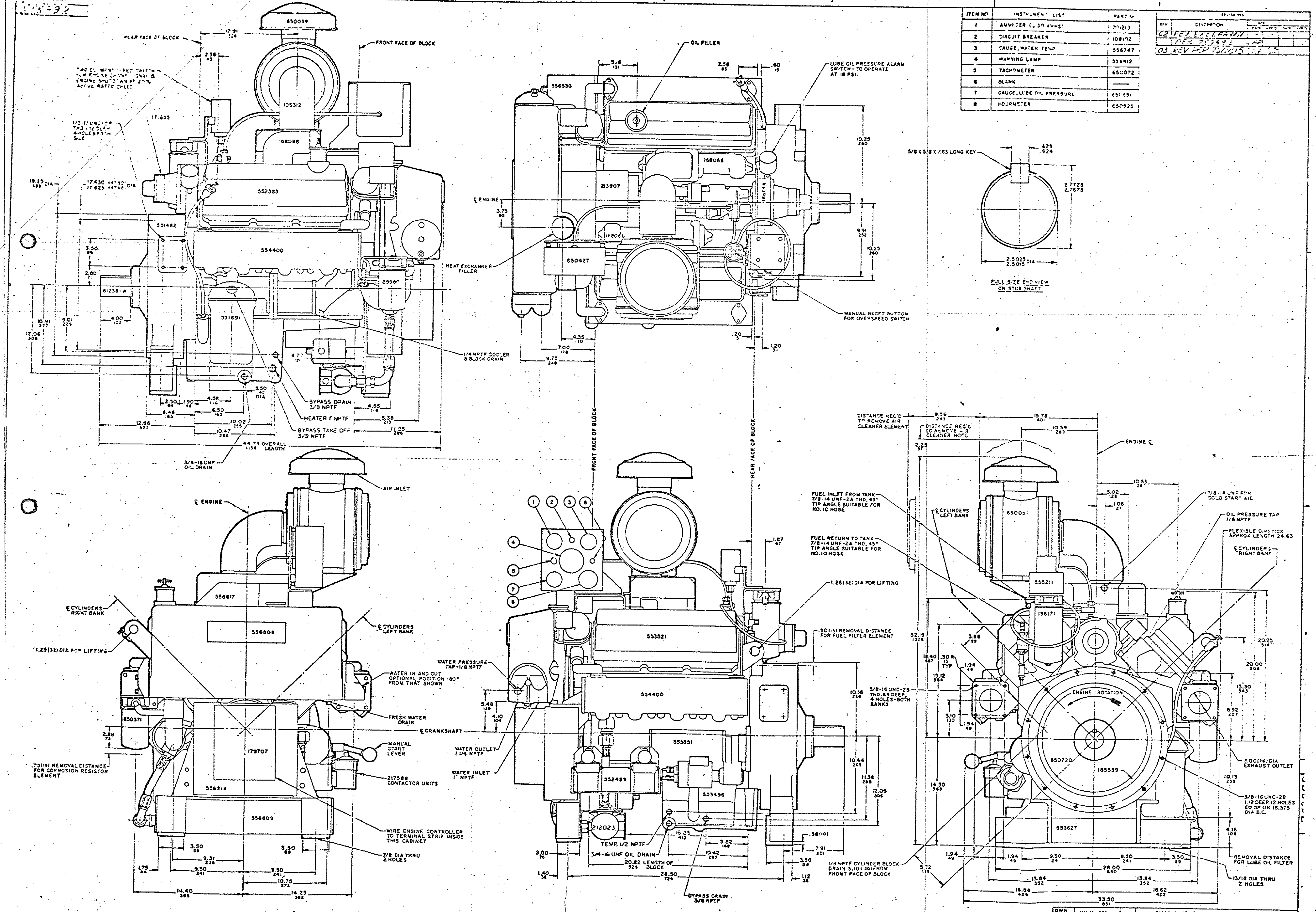
PART NUMBER	PART NAME	NO. REQ'D.	REF. NO.
	FLYWHEEL AND RING GEAR		
	ALL MODELS		
BM-99705	Flywheel and ring gear (185539)	1	
154849	Ring gear	1	
554316	Capscrew	8	
	DRIVE SHAFT		
	ALL MODELS		
650722	Flange	1	
61238-W	Shaft, flywheel stub	1	
555144	Key	1	
108707	Capscrew	8	
S-604	Lockwasher	8	
	GASKET SETS		
	V-504-F1, F2		
AR-09604	Engine Gasket Set	1	
AR-09603	Cylinder Head Gasket Set	1	
	V-378-F1, F2		
AR-09606	Engine Gasket Set	1	
AR-09605	Cylinder Head Gasket Set	1	

PARTS INDENTED ARE INCLUDED IN THE PART UNDER WHICH THEY ARE INDENTED

Cummins Engine Company, Inc.
Columbus, Indiana, U.S.A. 47201

Registered Office:
Cummins Engine Company, Ltd.
Coombe House St. George's Square
New Malden, England
Cable: INTCUMLON MALDEN
Registration No. 573951 England

Printed in USA



ITEM NO	INSTRUMENT LIST	PART No
1	AMMETER (± 30 AMPS)	701213
2	CIRCUIT BREAKER	108102
3	GAUGE, WATER TEMP	556347
4	WARNING LAMP	556912
5	TACHOMETER	650072
6	BLANK	—
7	GAUGE, LUBE OIL PRESSURE	650651
8	HOURMETER	650525

REVISIONS

REV	DESCRIPTION
02	[illegible]
03	REV PER [illegible]

NOTE: ALL DIMENSIONS ARE IN INCHES & MILLIMETERS

DO NOT SCALE DRAWING

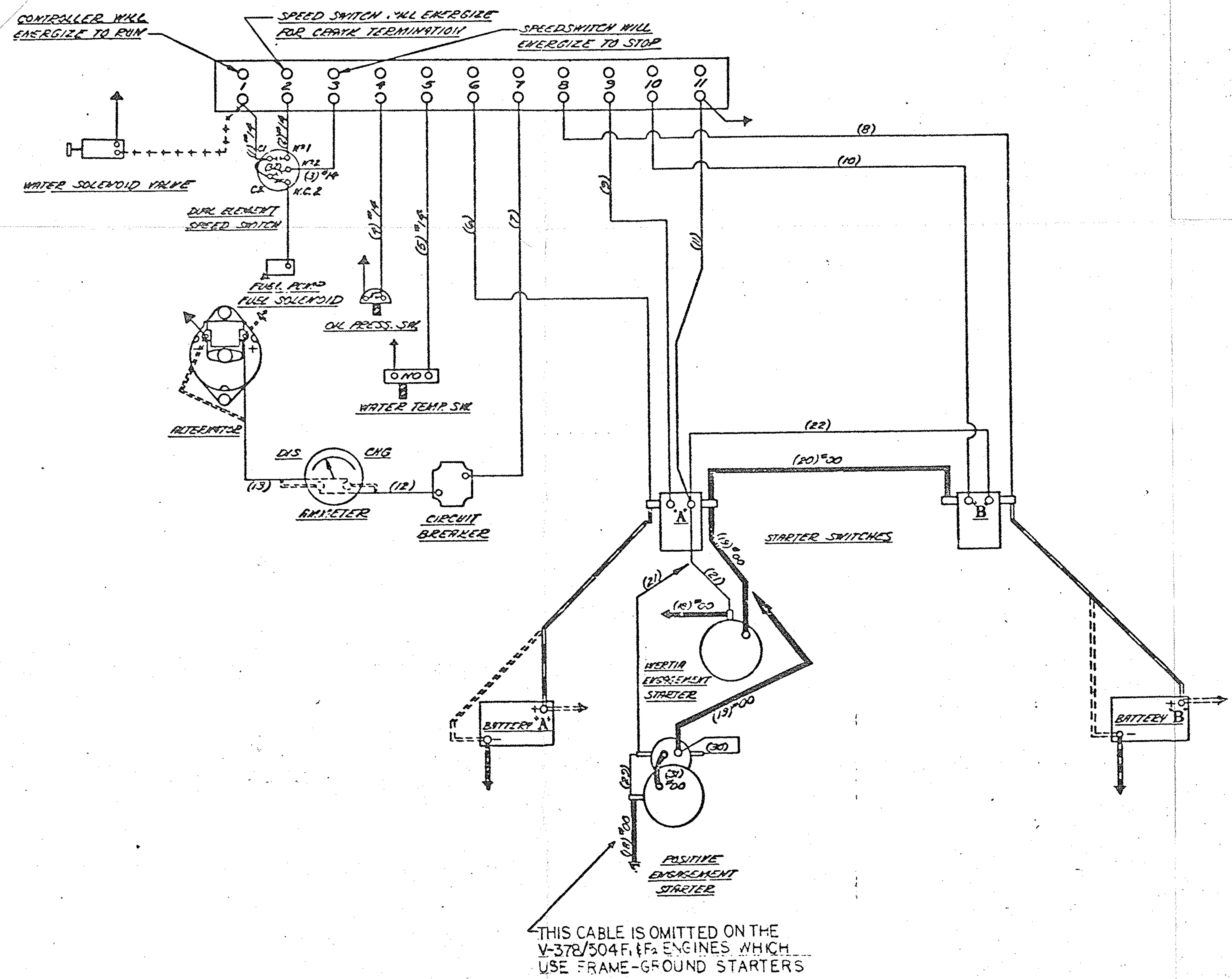
DWN JAN 15, 1975
CHD
REV
APPD
APPD
APPD
APPROVED DATE

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

DIAGRAM, INSTALLATION
V-378-F1, F2

CODE IDENT NO. SIZE E DWG. NO. 556892
SCALE WT. SHEET ___ OF ___

218147



7. THESE LINES - - - - INDICATE POSITIVE GROUND

6. THE FOLLOWING MANUFACTURERS SUPPLY FIRE PUMP CONTROLLERS:
KING-KNIGHT; EMERYVILLE, CALIFORNIA
MASTER CONTROL SYSTEMS; SKOKIE, ILLINOIS
CUSTOM BUILT CONTROLS; DENVER, COLORADO
LEXINGTON STD. CORP.; NEWARK, NEW JERSEY.

5. WIRES INDICATED BY SOLID LINES ARE INSTALLED BY CUMMINS ENGINE CO., INC.; WIRES INDICATED THUS + + + + ARE INSTALLED BY PUMP MANUFACTURER; AND WIRES INDICATED THUS ARE INSTALLED BY OTHERS.

4. NUMBERS IN PARENTHESIS ARE WIRE IDENTIFICATION NUMBERS. WIRING ON V-378 & V-504 F_1/F_2 IS TO BE A.W.G. OR EQUIVALENT.

3. ALL WIRES TO BE #10 A.W.G. UNLESS OTHERWISE SPECIFIED.

2. NEGATIVE GROUND ONLY IS SUPPLIED.

1. BATTERIES ARE NOT MOUNTED & CABLES ARE NOT FURNISHED FROM BATTERY TO ENGINE.

UNLESS OTHERWISE SPECIFIED THE FOLLOWING GENERAL NOTES SHALL APPLY.

ALL PARTS MUST BE PERMANENTLY AND CLEARLY IDENTIFIED IN THE LOCATION NOTED, AS TO COUNTRY OF ORIGIN AND PART NUMBER, BY ONE OF THE FOLLOWING METHODS.
1. FOR U.S.A. MFG'D PARTS "U.S.A."
2. FOR ALL OTHER SOURCES OF MFG'D PARTS "MADE IN (FULL NAME OF COUNTRY)".
3. EXCEPTIONS TO BE IDENTIFIED BY PACKAGES OR TAGS WITH ABOVE RULES APPLYING.
(A) WHEN PART IS TOO SMALL.
(B) WHEN IDENTIFICATION IS DETRIMENTAL TO FUNCTION OF PART.
ALL IDENTIFICATION TO BE THE RESPONSIBILITY OF THE SUPPLIER UNLESS OTHERWISE SPECIFIED.

BREAK SHARP CORNERS AND REMOVE BURRS	
PATTERN DIE NO	
PATTERN MADE IN COMBINATION WITH	
MADE FROM ROUGH CASTING FORGING NO.	
	REF DRAWING NO. 212461
	LAYOUT NO
	RELEASE NO 731440-1
DRAFT ANGLES	S.C. NO
	MATERIAL
	MFG METHOD
DIVISION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON DECIMALS ±
ANGLES ±
FRACTIONS ±

DWN KOESTER
CHD

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

DIAGRAM, ENGINE WIRING

E 218147

DO NOT SCALE DRAWING

1.2.7.397

PART NUMBER 204827

KIM HOTSTART WATER HEATER

CUMMINS PART NO.	SUPPLIER PART NO.	VOLTAGE	WATT	WIRING DIAGRAM NO.	LOW OIL PRESSURE SWITCH	PRESSURE SWITCH & RELAY ASSEMBLY
212021	AS 010	115	1000	1	196074	
212022	AS 020	230	1000	2	196074	
213730	LS 010	115	1500	1	196074	
212023	BS 010	115	2500	1	196074	
212024	BS 020	230	2500	2	196074	
212025	BS 046	460	2500	3	———	212017
212026	ES 020	230	4000	2	196074	
212027	ES 046	460	4000	3	———	212017
212028	3PS037	230-3Ø	3750	4	———	212016

LUB OIL HEATER (OPTIONAL)

CUMMINS PART NO.	SUPPLIER PART NO.	VOLTAGE	WATT
167618	OL 61515	115	150
167619	OL 6315	115	300
167620	OL 61523	230	150
167621	OL 6323	230	300
3000213	OL6[illegible]46EP	460	150
3000214	OL6346EP	460	300
3000351	OL 6615	115	600
3000352	OL 6623	230	600

REVISIONS

REV.	DESCRIPTION
A	REV & REDRAWN
	PER 720701
	ADDED P/N'S 3000213,
	3000214, 3000351,
	3000352 FOR 7403

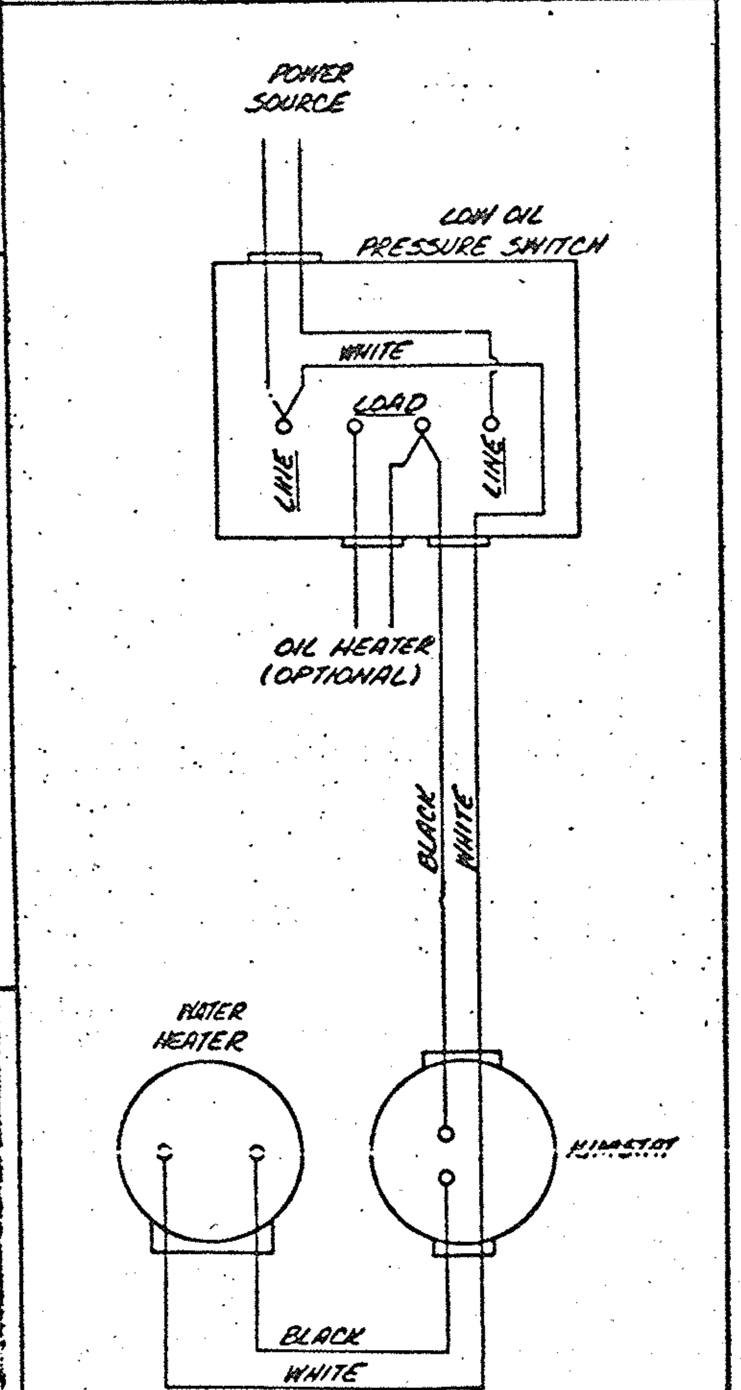


DIAGRAM #1

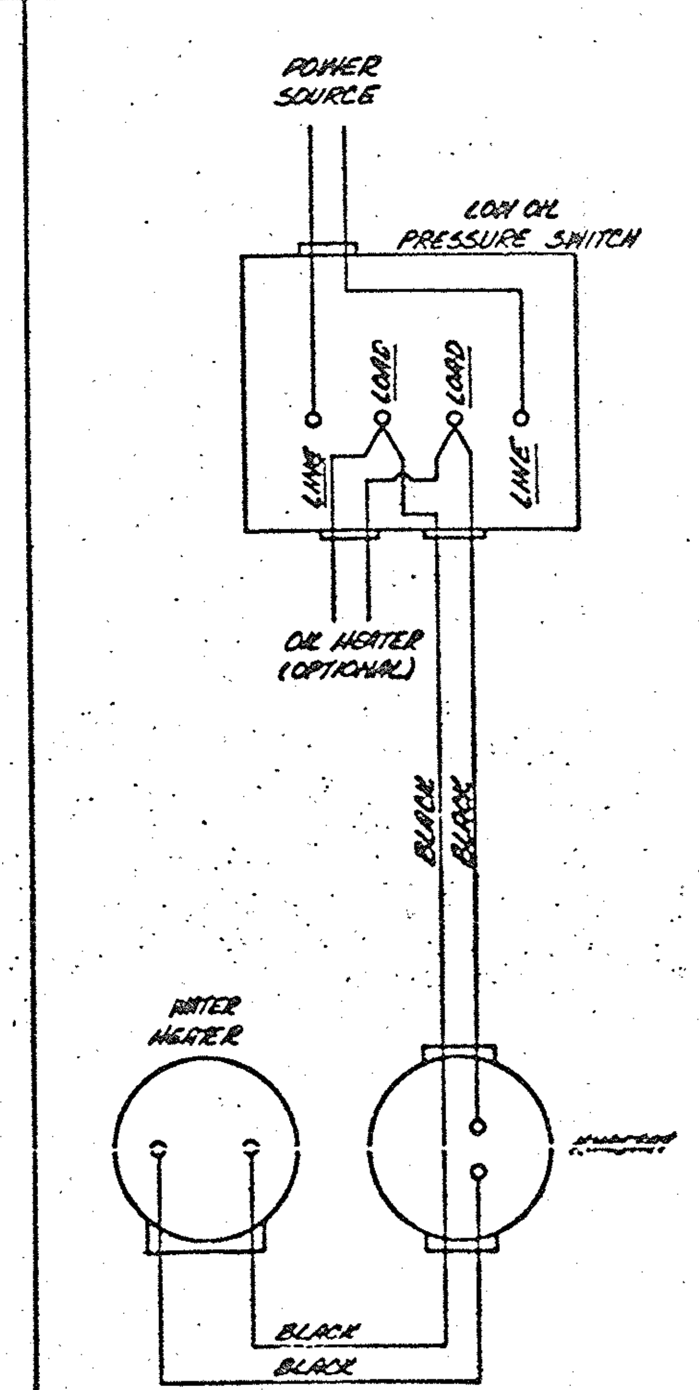


DIAGRAM #2

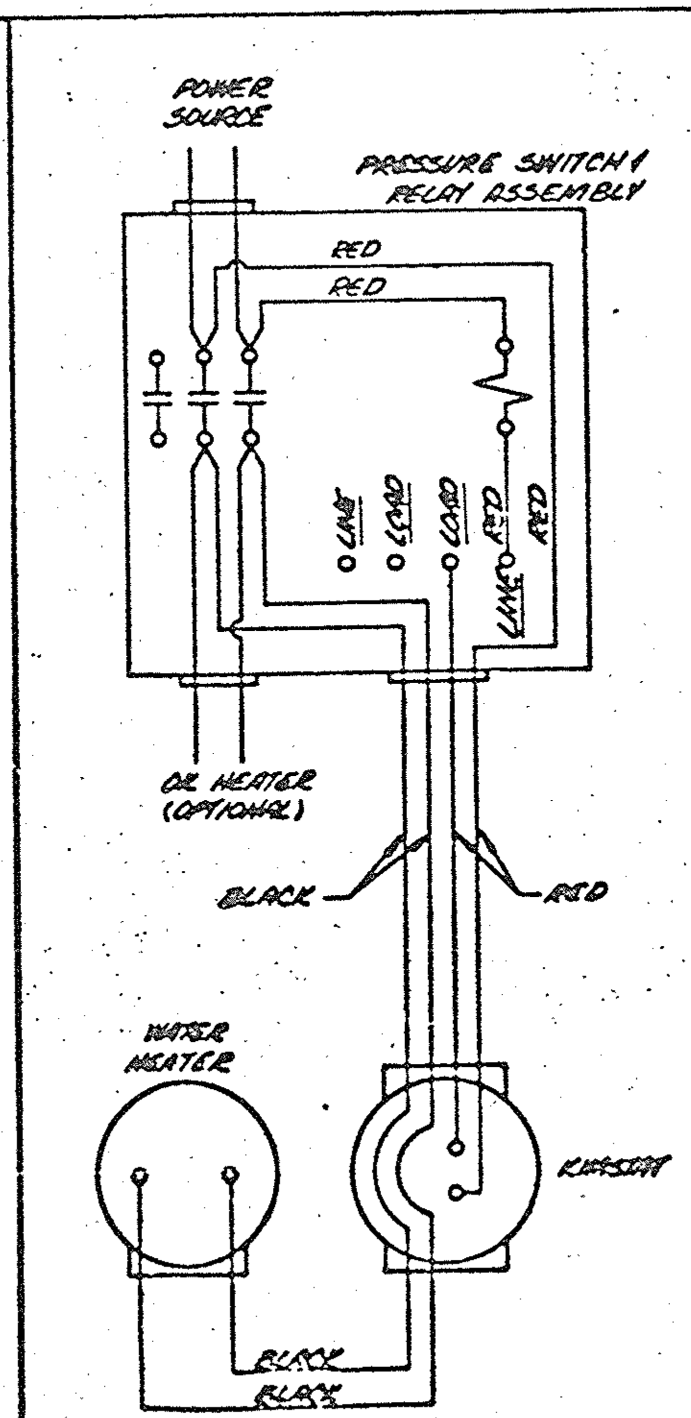


DIAGRAM #3

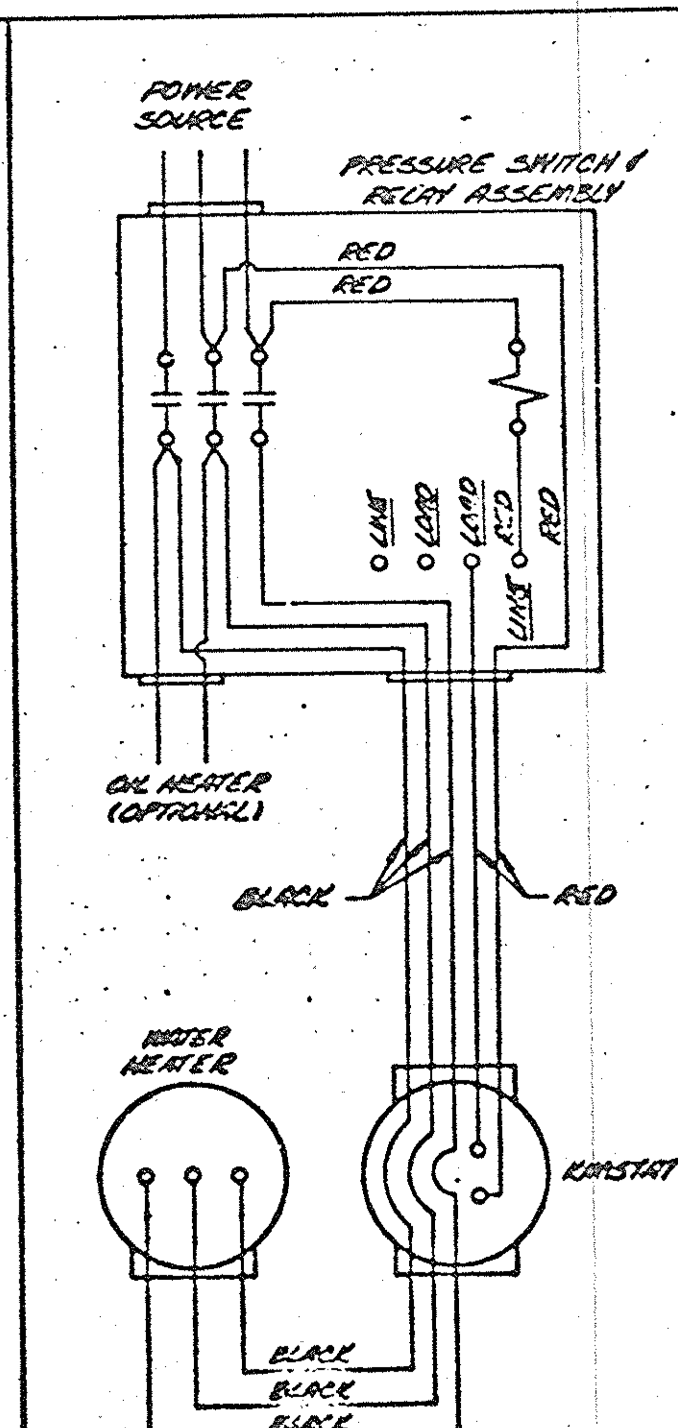


DIAGRAM #4

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED THE FOLLOWING GENERAL NOTES SHALL APPLY.

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON DECIMALS ± ANGLES ± FRACTIONS ±

RELEASE NO 69432

CUMMINS ENGINE COMPANY, INC.
COLUMBUS, INDIANA

DIAGRAM WIRING (KIM HOT START)

SIZE C

204827

1.2.7.399

Cummins Fire Pump Engines
Initial Start-up And Operation — Instructions

Cummins engines are run-in on dynamometers before being shipped from the factory and are ready for immediate use. However, certain pre-start procedures and operational practices will be beneficial to extended service life of the engine.

The following recommendations are for initial start-up and normal operation procedures, assuming the pumping unit installation has been correctly completed in accord with procedures established by the quality agency having jurisdiction. Consult Cummins Operation and Maintenance Manual for detailed instructions.

Initial Start-Up

1. Remove heat exchanger cap, check or fill engine coolant supply; open water filter inlet and outlet valves.
2. Pre-lubricate engine with oil meeting specification Mil-L-46152 (API-CC/SC) viscosity 10W30. This includes removal of turbocharger oil inlet line on turbocharged engines to pre-lubricate housing by adding 2 to 3 ounces (60 cc) of clean engine lubricating oil.
3. Check crankcase oil level and fill to high mark on dipstick.
4. Remove fuel pump solenoid lead and crank engine through both cranking cycles.
5. If engine is equipped with "Vernier throttle", place in idle position; if not place MVS throttle in idle position. On turbocharged models the delay cylinder line may be disconnected at the block and the block opening plugged.
6. Reconnect fuel solenoid lead and start engine; run at idle speed.
7. Verify lubricating oil pressure has been established, normally in 6 to 8 seconds.

Note: Some automatic controllers require lubricating oil pressure higher than the normal pressure at 600 RPM idle. Increase idle to 800 to 900 RPM if this condition is encountered. All turbocharged engines should be set to 800 to 900 RPM idle.

8. Continue to operate engine and review all systems for leaks or unusual conditions; correct as required.
9. Stop the engine and install ST-1224 Adapter.
10. Check crankcase oil level and fill to high mark.
11. Start engine and adjust overspeed.
12. Remove ST-1224 and replace original adapter.
13. Clean raw water strainer.
14. Start engines and adjust operating speed.
15. Adjust raw water pressure regulator.
16. Engine is now ready for normal operation.

Normal Operation

1. Daily or normal operation would include checking of fuel, lubricating oil, coolant and correcting any leaks or unusual conditions as required.
2. Check coolant and oil heaters to assure at least 120 deg. F water temperature has been maintained.
3. Manually start engine using prescribed starting procedure.
4. Operate engine the prescribed period of time or 5 minutes after stabilization of coolant temperature.
5. Shut engine down using normal test shut-down procedures.

Maintenance Schedule

Cummins Diesel Industrial Fire Pump Engines

EQUIPMENT NO. ____________________
MECHANIC ____________________
TIME SPENT ____________________
PARTS ORDER NO. ____________________

ENGINE SERIAL NO. ____________________
HOURS, CALENDAR ____________________
CHECK PERFORMED ____________________
DATE ____________________

Check each operation as performed.

A-CHECK

Daily

- ☐ Check engine operating log
- ☐ Check engine:
  - oil level
  - coolant level
- ☐ Check engine lubricating oil and coolant heaters
  - * oil bath cleaner oil level
- ☐ Visually inspect engine for damage, leaks, loose or frayed belts

Weekly

- ☐ Repeat Daily "A" Check
- ☐ Check air cleaner
  - clean precleaner dust pan
  - check restriction indicator
  - clean/change air cleaner element
  - * change oil bath cleaner oil
- ☐ Drain water/sediment from fuel tanks & fuel filters
- ☐ Check raw water strainer
- ☐ Check starter battery
- ☐ Start engine & check for unusual noise

B-CHECK

Repeat "A" (Daily/Weekly)

- ☐ Change engine oil
- ☐ Change filters
  - oil full flow
  - fuel filter
- ☐ Check coolant
  - check engine coolant DCA concentration level. Add make-up DCA and change element if required
- ☐ Clean/change
  - crankcase breather
- * Clean oil bath air cleaner tray/screen

C-CHECK

Repeat "A" & "B"

- ☐ Adjust valves & injectors
- * Clean oil bath air cleaner

D-CHECK

Repeat "A", "B" & "C"

- ☐ Clean & calibrate injectors, fuel pump
- ☐ Check and/or rebuild and/or replace the following assemblies:
  - turbocharger
  - vibration damper
- ☐ Rebuild or replace the following assemblies:
  - water pump

SEASONAL

Fall

- ☐ Clean & flush cooling system
- ☐ Replace hose as required
- ☐ Check cold start & thermal aids
- ☐ Clean electrical connections and check batteries
- ☐ Clean engine water heater

Spring

- ☐ Steam clean engine
- ☐ Tighten mounting bolts
- ☐ Check crankshaft end clearance
- ☐ Check heat exchanger zinc plugs annually or as required
- ☐ Check overspeed switch

OTHER

- ☐ + Starter
- ☐ + Alternator
- ☐ + Batteries
- ☐ + Voltage regulator
- ☐ + Switches
- ☐ + Gauges
- ☐ + Tachmometer
- ☐ + On these components follow the manufacturer's procedure

Engine Series	**Interval**	**B**	**C**	**D**		
All	Hours Calendar	250 6 mos.	1500 1 year	4500 2 years		

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time

***Cummins Engine Company, Inc. recommends the use of dry type air cleaners.**

Cummins Engine Company, Inc.
Columbus Indiana U.S.A. 47201
Bulletin I 379004-02 Printed in U.S.A. 2-79

1.2.7-402

AURORA PUMP
A UNIT OF GENERAL SIGNAL
ENGINEERING DEPT.
NORTH AURORA, ILLINOIS· 60542

METRON FIRE PUMP CONTROLLER

FIRE PUMP F.O.# 4G0-65706

FIRE PUMP CONTROLLER
COMBINATION MANUAL/AUTOMATIC
24 VOLT DUAL BUILT-IN
BATTERY CHARGER

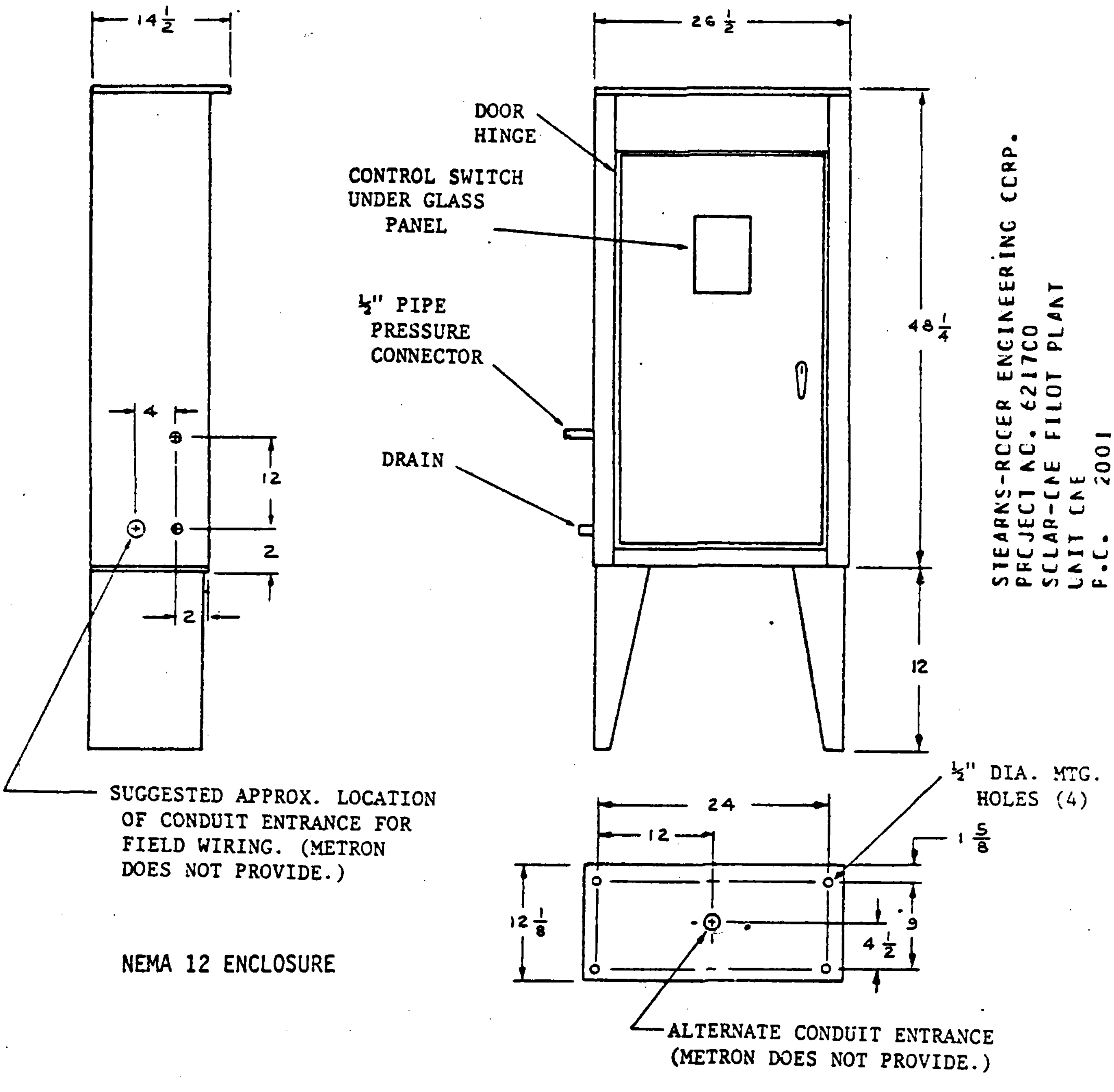
1. CHARGER MALFUNCTION ALARM
2. WEEKLY TEST START
3. NEMA 12 ENCLOSURE
4. LOW FUEL LEVEL ALARM W/ FLOAT SWITCH
5. SPACE HEATER
6. POWER-FAILURE START
7. AUTO-STOP
8. DUAL BATTERY VOLTMETERS
9.
10.

CONTROLLER TO BE USED W/CUMMINS
V-378-F2 DIESEL ENGINE
24 VOLT NEG. GROUND.
AUTOMATIC OPERATION PRESSURE
SWITCH 0-300 RANGE

BY: W/W

DATE: 12-10-80

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
1.2.7-403 P.C. 2001



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 6217CO
SOLAR-ONE PILOT PLANT
UNIT ONE
F.C. 2001

CERTIFIED CORRECT DRAWING James S. Hathaway

DRAWN	Metron — METRON INSTRUMENTS, INC.
CHECK	
APPD	

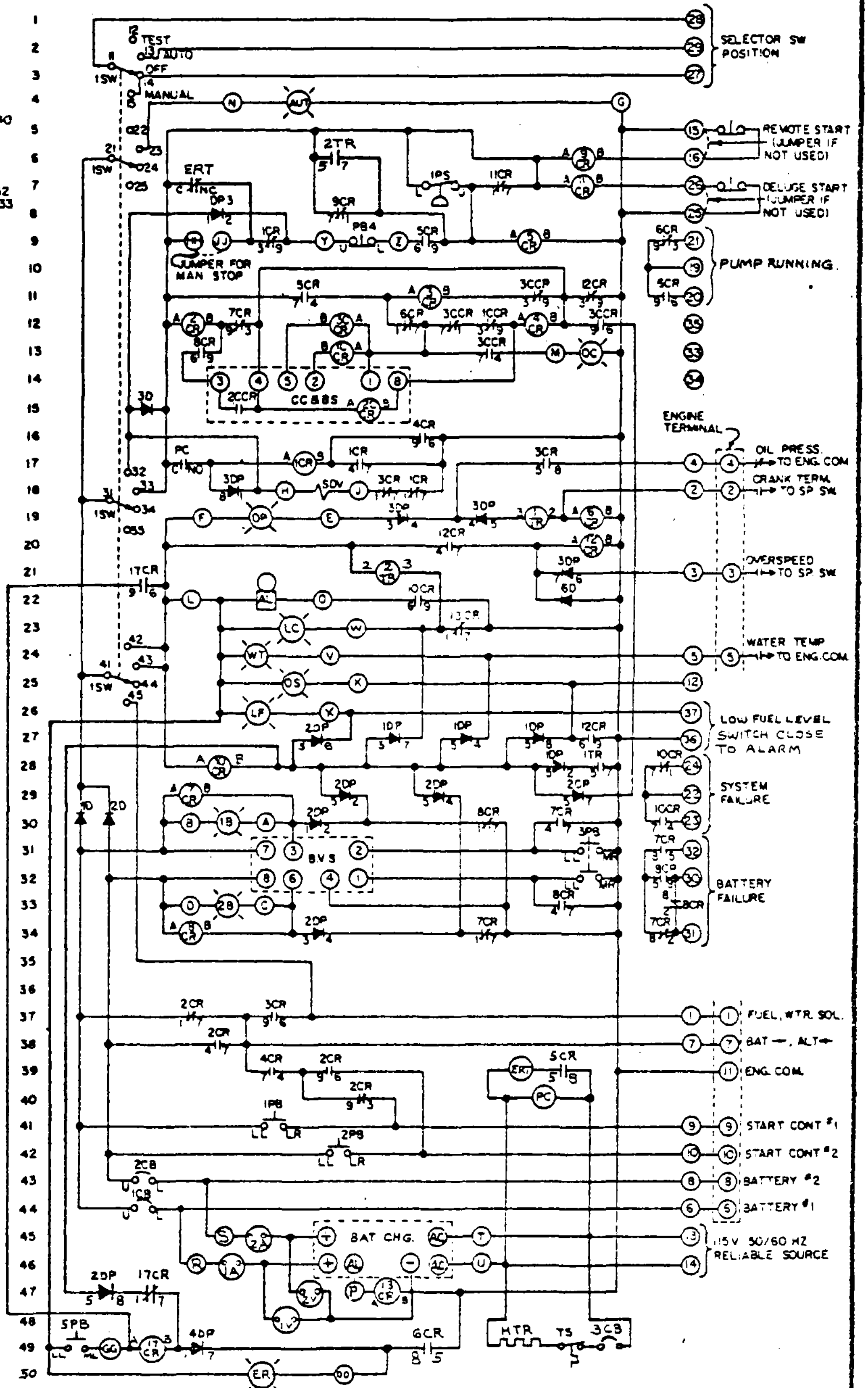
ENGINE FIRE PUMP CONTROLLER
OUTLINE DIMENSIONS
1.2.7-404

CODE IDENT NO 40021		
SIZE A	10391D	
SCALE		SHEET

COMPONENT	FUNCTION	LOCATION	CONTACTS
1CCR	CRANKTIMING	13	12
2CCR	BAT LATCH	15	15
3CCR	OVERCRANK	12	11,12,13
1CR	WEEKLY TEST	17	9,17,18
2CR	BAT. SWITCH	12	37,38,39,40
3CR 3P	FUEL SOL.	11	17,18,37
4CR	CRANK	12	16,39
5CR 3P	AUTO START	9	9,11,39
6CR 3P	ENG. RUNNING	19	9,11, 49
7CR 3P	BAT #1 FAILURE	29	12,30,31,32
8CR 3P	BAT. #2 FAILURE	34	13,30,32,33
9CR	REMOTE START	6	8
10CR	ALARM	28	22,28,30
11CR	DELUGE START	7	7
12CR	OVERSPEED	20	11,20,27
13CR (OP. J)	LOSS OF CHARG.	47	23
17CR (OP. K)	ALARM SILENCE	49	21, 47
1TR	OIL PRES.	19	28
ERT (OPT. R)	ENGINE RUN TIMER	39	7
2TR (OPT. P)	POWER FAILURE	21	6
1D	ISOLATION DIODE	30	
2D	ISOLATION DIODE	30	
3D	BLOCKING DIODE	15	
6D	DAMPING DIODE	22	
1DP	DIODE PACK	27,28	
2DP	DIODE PACK	29,30,34, 47, 27	
3DP	DIODE PACK	8,18,19	
4DP (OP. K)	DIODE PACK	49	
1A	AMMETER	46	
2A	AMMETER	45	
1V (OP. V)	VOLTMETER	48	
2V (OP. V)	VOLTMETER	47	
AUTO	AUTO LIGHT	4	
1B	BAT #1 LIGHT	30	
2B	BAT #2 LIGHT	33	
WT	WATER TEMP LT.	24	
OC	OVERCRANK LT.	13.	
OP	OIL PRES LIGHT	19	
OS	OVERSPEED LT.	25	
LC (OP. J)	LOSS CHARG. LT.	23	
ER (OP. K)	ENGINE RUN. LT.	50	
LF (OP. F)	LOW FUEL LT.	26	
1PB	MAN. CR #1	41	
2PB	MAN. CR #2	42	
3PB	BAT. RESET	31,32	
4PB	STOP	9	
PS	PRESSURE SW.	7	
1SW	SELECTOR SW.	3,6,18,25	
1CB	BAT #1 C B	44	
2CB	BAT #2 C B.	43	
5PB (OP. K)	ALARM SILENCE	49	
PC	PROGRAM CLOCK	40	17
SDV	SOL. DRAIN VALV.	18	
VS	BAT VOLT SENSE	31	
AL	ALARM BELL	22	

NOTES:

2. 1CCR AND 3CCR ARE HALF VOLTAGE RELAYS



CERTIFIED CORRECT DRAWING

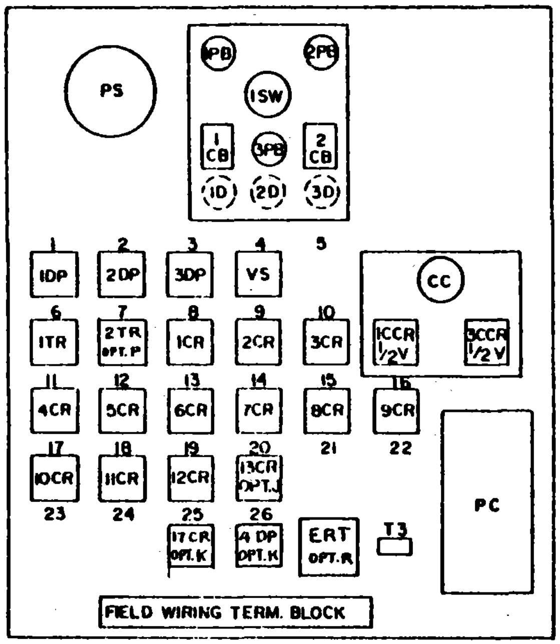
James S. Hathaway

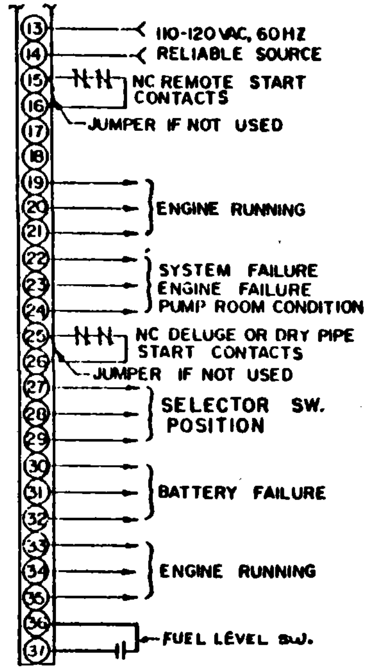
METRON INSTRUMENTS, INC.
DENVER, COLORADO

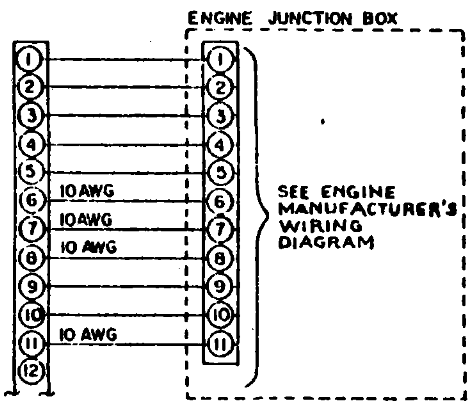
ENGINE DRIVEN FIRE PUMP CONTROLLER
MODEL FD2
SCHEMATIC WIRING

C 30713-3488

1.2.7-406







STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.C. 2001

CERTIFIED CORRECT DRAWING James S. Hathaway

NOTES:

1. ALL WIRE 14 AWG EXCEPT AS NOTED (STRANDED ONLY).
2. ALL DRY CONTACTS SUPPLIED ARE RATED AT 10-AMP., 28VDC/115VAC

DRAWN	M.V.N	3-6-79
CHECK	[illegible]	8-15-79
APPD	[illegible]	8-15-79

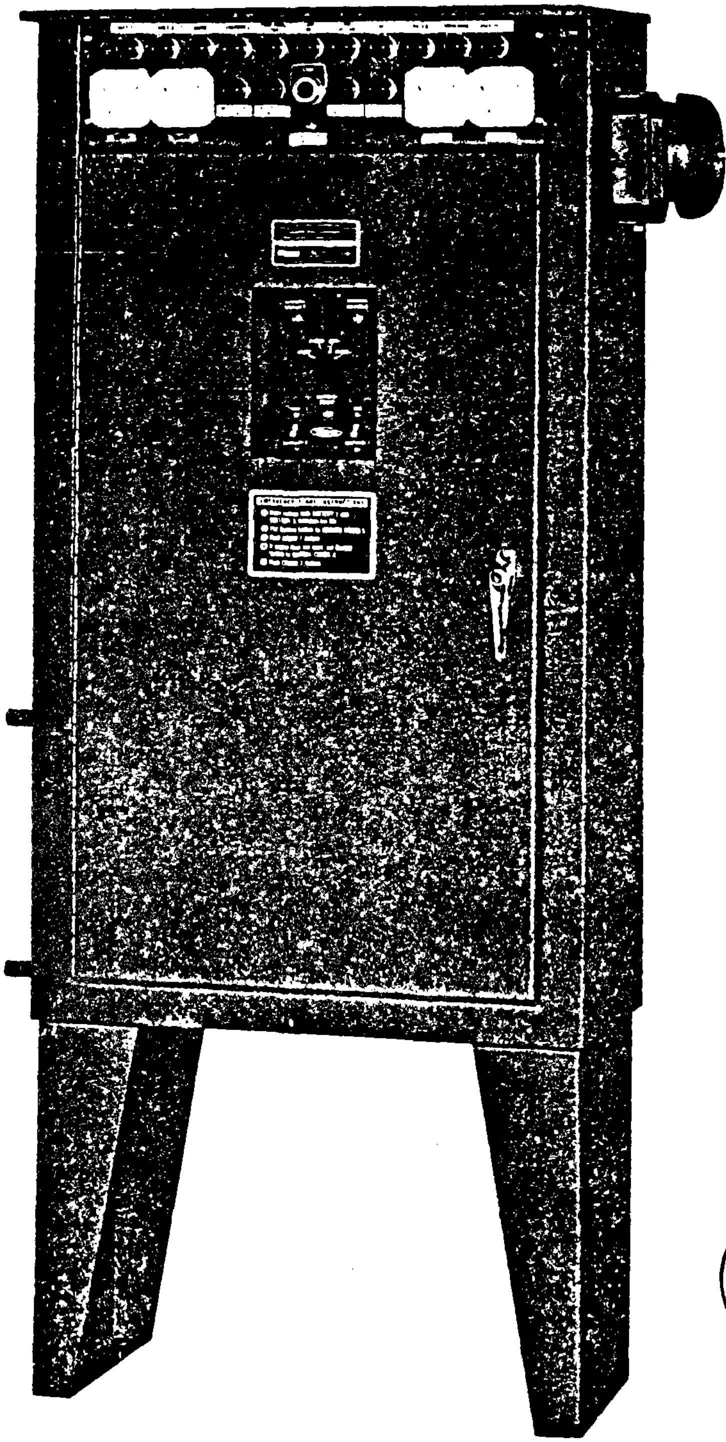
Metron — METRON INSTRUMENTS, INC.

EXTERNAL CONNECTION DIAGRAM
FD2 CONTROLLER
FOR ENGINE DRIVEN FIRE PUMPS

CODE IDENT NO. [illegible] — SIZE C — 30520 A-3486 — SCALE — SHEET

FIRE PUMP CONTROLLERS
FOR ENGINE DRIVEN FIRE PUMPS

BULLETIN FD-12-76

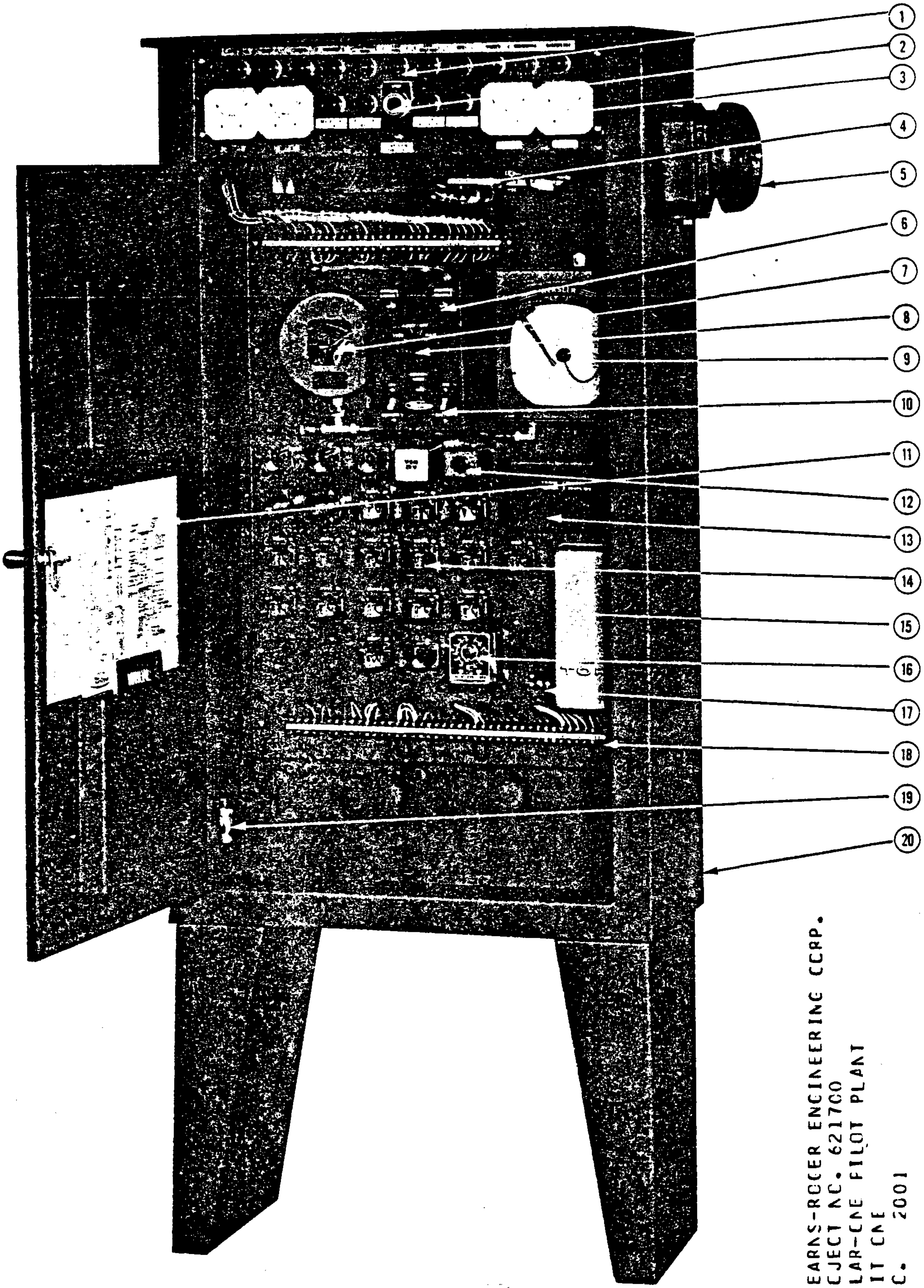


Metron Fire Pump Controllers are listed by Underwriters Laboratories Inc., Underwriters' Laboratories of Canada, as well as approved by the Factory Mutual Engineering Corp. These controllers are for use with all approved types of engine driven fire pumps. Manufactured in accordance with the standards established by the National Fire Protection Association, 1976 Pamphlet 20, they are designed and constructed to provide the highest measure of reliability.

The basic function of a Fire Pump Controller for engine driven fire pumps is to automatically start the engine upon a drop in pressure in the water supply, or from a number of other demand signals. The controller provides automatic cycled cranking and alarm protection for various engine failures when running. Stopping the engine after the demand period is terminated may be either manual or automatic. Several optional features are available which may be required by the local authority having jurisdiction. These options are desribed further in this bulletin.

For over 20 years Metron has manufactured automatic control equipment for all types of engine applications. Our policy has always been to stress dependable operation in field use because of the inherent vital nature of these installations.

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001



STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
F.C. 2001

Standard Features Included On All Controllers

STARTING

Controller will start the engine from any or all of the following demand signals:

> Drop in water line pressure. The Mercoid pressure switch has independently adjustable (10-300 PSI) high and low set points. Higher range available, see Option "G". The controller will also start the engine from remote start stations, deluge valve switches, dry pipe valve switches, etc.

The four position selector switch is labeled "TEST-AUTO-OFF-MANUAL".

- "TEST" —momentarily drops water pressure closing pressure switch, starting engine.
- "AUTO" —controller in standby mode, all automatic functions ready for operation.
- "MANUAL" —all automatic functions of controller are by-passed when started with manual pushbutton. Two manual start pushbuttons for manually cranking the engine from either set of batteries or depress both switches simultaneously increasing battery potential to starter in event of adverse battery condition.

MANUAL STOP PUSHBUTTON

Mounted outside of controller. By-passes selector switch allowing engine shutdown after starting demands have returned to normal. Controller is automatically reset for standby mode.

AUTOMATIC WEEKLY TEST

Includes a 7-day program clock which can be set to give automatic test runs on any day of the week and any time of day desired. The clock is adjustable to 60 minutes. Any demand signal will override the automatic shutdown of this feature. The clock opens the solenoid drain valve momentarily, relieving pressure to the pressure switch. This drop in pressure starts the engine and the length of the test run is timed by the clock (30 minutes is recommended). Since the valve is opened only momentarily, only a very small amount of water is released.

SOLID STATE CRANK CONTROL AND BATTERY ALTERNATING CIRCUIT

Six fifteen second fixed crank periods separated by five fifteen second fixed rest periods are provided. This control is fail-safe in that should a failure occur within the crank control the engine will be cranked continuously until it starts or the batteries fail. Solid State Battery Alternating: Should the engine fail to start during any given crank cycle the controller will automatically switch to the other set of batteries for the next starting attempt after the rest period. The controller will continue this alternating until the engine starts. If the engine fails to start at the end of the six crank attempts, the overcrank lamp will be lighted and the audible alarm will sound.

BATTERY FAILURE LOCKOUT

Should one set of batteries fall below 60% of its rated voltage during cranking, the controller will automatically lock on to the other set of batteries for the remaining cranking cycles. The appropriate battery lamp will go out.

FAILURE ALARMS ON CONTROLLER

Circuits are supplied to provide local lights, alarm and 1 set of dry contacts (N.O. and N.C.) for the following: (1) Failure to Start (overcrank), (2) Low Oil Pressure (alarm only), (3) High Water Temperature (alarm only), (4) Overspeed (alarm and shutdown), (5) Loss of Battery Charger Output. This last alarm also provides a means of monitoring loss of A.C. power (115VAC). Loss of 115VAC results in loss of charger output. Shutdown on Oil and Water during weekly test available upon request. See Option "U".

FAILURE ALARMS FOR REMOTE INDICATION

Dry contacts (N.O. and N.C.) are brought out to the field wiring terminal bar for remote indication of the following: Pump Running (2 sets), System Failure, Switch in Off or Manual and Battery Failure. The System Failure contacts provide a common alarm for (1) Overcrank, (2) Low Oil Pressure, (3) High Water Temperature, (4) Overspeed, (5) Loss of Battery Charger. Individual dry contacts for each alarm are available, see Option "A".

STATUS LIGHTS

Three green lights are provided on the controller indicating battery power is available from Battery 1 and Battery 2. The third lamp indicates that the control switch is in "Auto" position.

ENCLOSURE

Nema 2, heavy duty (14 gauge steel), moisture resistant, drip-proof, free standing with locking door (gasketed) and break glass panel over control switch and manual start pushbuttons. Enclosure is available with wall mounting brackets or without legs for base mounting. Swing out hinged relay panel for ease of servicing and field modifications.

CONTROL RELAYS

Relays are dust-tite, plug-in for ease of servicing from front of cabinet.

TESTING

Each controller is factory wired and tested, ready for immediate installation.

ILLUSTRATION NUMBERS SHOW STANDARD FEATURES AND MOST COMMON OPTIONS.
SEE BACK PAGE FOR DETAILED INFORMATION ON OPTIONS.

1. STATUS AND FAILURE LAMPS. GREEN LAMPS INDICATE BATTERY POWER AVAILABLE, SWITCH IN AUTOMATIC, AND RED LAMPS FOR FAILURE SIGNALS.
2. STOP PUSHBUTTON.
3. BATTERY CHARGER AMMETERS AND VOLTMETERS.
4. DUAL BATTERY CHARGER (BEHIND LIGHT PANEL).
5. AUDIBLE ALARM BELL.
6. MANUAL CRANK PUSHBUTTONS.
7. MERCOID PRESSURE SWITCH.
8. CONTROL SWITCH.
9. PRESSURE RECORDER.
10. BATTERY CIRCUIT BREAKERS.
11. WIRING DIAGRAMS PERMANENTLY ATTACHED, LAMINATED IN PLASTIC.
12. SOLID STATE SEQUENTIAL START TIMER.
13. SOLID STATE CRANK CONTROL AND BATTERY SWITCHING CIRCUIT.
14. CONTROL RELAYS.
15. PROGRAM TIMER FOR WEEKLY AUTOMATIC TEST STARTS.
16. MINIMUM RUN PERIOD TIMER FOR AUTOMATIC STOP OPTION "R".
17. JUMPER FOR FIELD CONVERSION TO MANUAL STOP WHEN OPTION "R", AUTOMATIC STOP, IS PROVIDED.
18. FIELD WIRING TERMINAL BAR.
19. SOLENOID DRAIN VALVE TO INITIATE WEEKLY TEST START.
20. ENCLOSURE IS HEAVY DUTY FREE STANDING NEMA 2 CABINET, WITH GASKETED DOOR AND BREAK GLASS OVER CONTROL SWITCH.

Optional Features Supplied Only When Specified

Option A. Individual Alarm Contacts. Provides dry contacts (N.O. and N.C.) for remote indication of any failure. This option allows the five failure alarms which are common under "System Failure" to be brought out individually. In addition, up to seven more individual pump room alarm contacts can be supplied. Metron can supply a remote alarm panel for indication of any combination of the above failure alarms.

Option B. Pressure Recorder. A recording pressure gauge with 7 day chart provides a permanent record of water pressure fluctuations and also records engine starts. Standard range is 0 to 300 PSI.

Option D. Energized To Stop Circuit. Certain non-approved engines have a fuel solenoid which must be energized to stop the engine. This option provides the circuit for this purpose.

Option E. Engine Lockout Circuit. This option is used with multiple pump installations when more than one pump should not run simultaneously. Upon receipt of an external signal this option will prevent the engine from starting, or will stop it if running. It is also used with Low Suction Cutoff Panels when authorized. When used for this purpose, power to the Low Suction Cutoff Panel is provided by the controller (this power circuit is fused).

Option F. Low Fuel Level Alarm. This option provides an alarm in event the fuel in the storage tank reaches a low level. A light and audible alarm will provide indication at the controller, and the "System Failure" contacts will operate for remote alarm. A float switch is supplied with this option which must be mounted in a threaded two inch opening on the top of the tank. The dimensions of the tank must be specified so that the depth of the float switch in the tank can be determined. This switch will be factory set to alarm when the fuel level drops to 80% of tank capacity unless otherwise specified.

Option G. High Pressure Plumbing. Pressure Switch, Solenoid Drain Valve, Pressure Recorder (if provided) and interconnecting plumbing are rated at 600 PSI.

Option H. Space Heater. If the ambient atmosphere is especially damp, a space heater rated at 100 or 150 watts may be supplied to reduce moisture in the cabinet. A thermostat is supplied as standard with this option. A humidistat may be supplied if specified.

Option J. Integral Battery Charger. This option provides an integral dual battery charger for simultaneously charging both sets of batteries. This is an all solid state charger which continuously monitors both batteries. Rate of charge, up to 35 amperes, is dependent on the state of charge of the batteries, and tapers to less than 500 milliamperes at full charge. The charger is line voltage regulated and current limited to provide full protection during engine cranking. Two ammeters in the front of the cabinet indicate rate of charge.

Option K. Pump Room Alarms. NFPA Pamphlet 20 allows additional alarms to be provided in the controller to monitor various pump room conditions. Specifically, these alarms are noted as follows: Low Pump Room Temperature, Reservoir Low, Reservoir Empty, Low Suction Pressure, Relief Valve Open, Flow Meter On. These alarms will automatically reset. An Alarm Silence pushbutton is provided for these alarms only.

Option L. Stainless Steel Plumbing. All water bearing parts and piping may be supplied made of stainless steel.

Option N. Step-Down Transformer. When 117 V.A.C. is not available, a transformer may be provided for operation at 208, 230, 380 or 460 V.A.C. input voltages.

Option P. Automatic Start On Loss Of D.C. Output Of Charger. With this option, if for some reason battery charging current is lost, the controller will automatically start the engine after a time delay. This option replaces the previously used option which started the engine upon loss of A.C. power to the controller. However, this new option serves a dual purpose since either a charger failure or loss of A.C. will start the engine. The time delay may be either fixed or adjustable, with times from 15 seconds to 5 minutes.

Option R. Automatic Stop. After a specified minimum run time (at least 30 minutes) the engine will stop automatically if starting causes have returned to normal. If at a later date it is desired to change to manual stop, field conversion is easily accomplished by removal of a jumper.

Option S. Sequential Start. This option is for use on multiple pump installations to keep all pumps from starting simultaneously. It is accomplished by use of an adjustable timer supplied in all controllers except the one for the lead pump. These timers should be adjusted to 5 to 10 second intervals in order to allow a preceding pump to start. Failure of a preceding pump to start will not prevent a subsequent pump from starting.

Option U. Shutdown On Weekly Test Run. This Option Is Not Approved By Factory Mutual. This option provides shutdown during weekly test runs for low oil pressure or high water temperature if all other starting demands are normal. This feature will not interfere with normal automatic demand operation, "Test" operation, or "Manual" operation of the controller.

Option V. Battery Voltmeters. Two voltmeters may be supplied in addition to the ammeters to indicate battery voltage.

Option W. Omit Legs. For systems where the controller is mounted on a common skid with the pump and engine, the legs of the controller may be omitted, resulting in lower cost.

ORDERING INFORMATION

Specify Model FD2 followed by options required as described on page 4 of this bulletin. Be sure to specify make and type of engine, battery voltage and ground polarity. Shipping weight approximately 300 lbs.

PRINTED IN U.S.A.

CUSTOM BUILT CONTROLS DIVISION OF
METRON INSTRUMENTS, INC.
1051 SOUTH PLATTE RIVER DRIVE DENVER, COLORADO 80223
PHONE 303 744-1791 TELEX 4-5729

1.2.7-410

MANUAL FOR MODEL FD-2 FIRE PUMP CONTROLLERS

This manual provides General Information, Installation Operation, Maintenance, and Trouble-Shooting Information for Metron Model FD-2 Engine Driven Fire Pump Controllers

TABLE OF CONTENTS

External Hookup, Schematic, and Engine Wiring Drawings are in the back of this Manual

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001 1.2.7-411

GENERAL INFORMATION

The basic function of the Model FD-2 Fire Pump Controller for Diesel engine driven fire pumps is to automatically start the engine upon a drop in pressure in the water main, or from a number of other demand signals. This controller provides automatic cycled cranking and alarm or shutdown protection for various engine failures. Stopping of the engine after the demand period is over may be either manual or automatic. This controller includes an automatic weekly test starting feature. Sixteen standard approved options may be provided.

FUNCTIONS

Equipment is provided in the Controller to provide the following functions:

1. *Automatic starting from:*

   a. *Drop in water line pressure.*
   b. *Loss of battery charger output (Option P).*
   c. *Operation of optional remote start switches, such as remote start switch, deluge valve switch, fire alarm switch, etc.*
   d. *Weekly test timer.*

2. *Control Switch - A four position switch is provided marked "Test Automatic-Off-Manual."*

3. *Automatic cranking - A solid state crank control provides six fixed crank periods separated by five rest periods each of approximately 15 seconds duration.*

4. *Alarms and signal lights - Eight to fifteen lights are provided to give visual signals for Overcrank, Low Oil Pressure, High Water Temperature, Loss of Charger Output, Low Fuel Level (Option F), control switch in "Automatic" position, two lights for "Battery On," Overspeed, and one to six additional pump room alarms (Option K). In addition, an alarm bell is mounted on the side of the cubicle to give audible alarm in event of failures. Terminals are provided for remote failure alarms, indicating "Switch in Off or Manual," "System Failure," "Engine Running," and "Battery Failure." Option A provides individual alarm contacts for remote indication of each alarm.*

5. *A Weksler recording instrument with 7-day chart is provided when specified as Option B. This records continuously the line water pressure.*

6. *A weekly test timer is supplied to automatically start the engine any set day of the week, at a set time of day, and let it run for the time set.*

7. *Stop Pushbutton - A pushbutton switch is provided to stop the engine only after starting causes have returned to normal. This returns the controller to the automatic position*

8. *Integral Battery Charger (Option J). This is a fully automatic solid state charger for maintaining full charge on the dual sets of engine batteries. Charging current ammeters are included and battery voltage voltmeters may also be provided (Option V).*

9. *Cabinet - a heavy gage steel cubicle encloses the Controller. The lights, stop button and meters are mounted on the front of the cubicle. The control switch, battery circuit breakers, and manual start pushbuttons are mounted behind a break-glass in the door of the cabinet.*

OPERATION OF THE CONTROLLER

A. *When the four position control switch is in the "Automatic" position and both circuit breakers are in the "On" position, the control is in standby condition ready to start the engine automatically. A green pilot light marked "Auto" will light in this position. Also, Battery No. 1 and Battery No. 2 green lights will light indicating that battery power is available. If both battery lights are not on, push "Battery Reset" button.*

When water pressure drops below a level which is preset on the internal water pressure switch, the pressure switch contacts will close, and the Controller will actuate the starter motor and the cranking cycle will commence. If the engine starts and runs, cranking will cease and the protective circuits will be operative. If the engine fails to start after six crank periods, cranking will cease, the Overcrank light will light, and alarm bell will sound. The battery alternating circuit alternates batteries on each crank attempt unless one battery is in a discharged state and incapable of cranking the engine. In this instance the control will lock onto the other battery for the remaining cranking attempts. This nonoperative battery lockin circuit is reset by pushing the "Battery Reset" pushbutton. Dry contacts for remote indication of "Battery Failure" are provided.

After an Overcrank or Overspeed failure it is necessary to turn the control switch to "Off" to reset. On Overspeed, the speed switch on the engine must be manually reset before the Overspeed alarm on the controller can be reset. Water Temperature and Oil Pressure failure alarms are self resetting when the trouble condition is corrected at the engine.

The panel is wired so that optional remote start switches may be used, such as Deluge Valve Switches, Remote Start pushbutton, Fire Alarm switches, etc. In addition, when Option P is provided, the Controller will automatically start the engine upon loss of Battery Charge Output after a time delay of 15 seconds. The loss of charger light and bell are energized without delay.

While the engine is running all protective circuits are operative. If the engine stops while running, the control will attempt to restart the engine. Failing in this, the Overcrank light will be lit and alarm sounded. If, while the engine is operating, the oil pressure drops below a safe limit, the oil light will light immediately. After 15 seconds the alarm will sound. Should the engine temperature exceed a safe limit while running, the alarm will sound and the water light will light to indicate *overheating. The alarm will continue to sound and the light to burn until the failure corrects itself, or until the control switch is turned to "Off." In case of Overspeed, the engine will be stopped and the Overspeed light and alarm energized. It will remain energized until the engine speed switch is manually reset and the Overspeed alarm on the controller is reset by turning the switch to "Off."*

The Controller may be provided with either "Manual" or "Automatic" stop (Option R) as required. If "Automatic" stop is provided, terminals T3-1 and T3-2 on the relay panel must be jumpered for manual stop. These terminals are to the right of the Engine Run Timer. With "Manual" stop, the engine will continue to run even though the pressure switch or other remote starting switch returns to its normal position. The control will be stopped only by pressing the stop button or moving the control switch to "Off," at which time the engine stops immediately. If set up for "Automatic" stop, the engine will be stopped automatically upon restoration to normal of whatever demand switch started the engine providing it has run at least 30 minutes or for the period of time set on the Engine Run Timer. If the demand period was less than the time set on the timer the engine will continue to run until the timer times out and will then stop.

B. When the control switch is in the "Test" position, the engine will be started and operated through the Controller by causing a drop in water pressure. Failure circuits will be operative in the "Test" position. This method of starting provides a test of the Controller, thereby assuring proper operation when required. The engine will run continuously in this position until the switch is moved to "Off."

C. Placing the control switch in the "Off" position stops the engine when running, as explained in preceding paragraphs. It also prevents the engine from starting when stopped. The switch should always be placed in this position when servicing the engine.

D. The Manual position of the control switch is for manually starting the engine from either battery. The throttle solenoid is energized in this position, and the engine must be cranked by pushing one of the buttons above the control switch. Manual crank 1 cranks from Battery 1 and Manual crank 2 cranks from Battery 2. Pressing both buttons will result in cranking from both batteries simultaneously.

E. Periodic Self Testing - The program clock can be set to give test runs on any day of the week and time of day desired. A timing element is incorporated in the controls so that when the engine starts in this manner, it will run for a definite time before it shuts down. This time is controlled by the Program Clock and should be set for 30 to 60 minutes.

F. The water pressure recorder is a Weksler instrument which is provided when specified as Option B. Its purpose is to provide a permanent chart recording of fluctuations of water main pressure. A record of engine starts is shown by a sharp rise in pressure each time the engine starts. a 1/2 inch pipe connection is brought out the side of the cubicle for connection of the water line.

G. *Provision for sequential starting (Option S) is accomplished by the use of adjustable time delay relays installed in each controller except the leading pump. These timers, set sequentially and progressively longer in time, prevent more than one pump from starting simultaneously with another pump. Failure of a leading pump to start will not prevent subsequent pumps from starting.*

INSTALLATION AND TEST PROCEDURE

Installation

The Fire Pump Controller has been assembled and wired at the factory in accordance with the highest workmanship standards. All circuits and functions have been thoroughly tested to assure correct operation when properly installed. The installer should completely familiarize himself with the external hookup of the engine components to the terminal bar in the Controller. Engines of different make may not always be wired to the engine junction block alike, and it is very important that the various engine components be wired to the proper terminal in the controller, using the correct size stranded wire. The cubicle and chassis are not grounded, and a 10 gauge wire must be run from the proper terminal on the terminal bar to a good ground on the engine.

In most cases, the engines are furnished by the manufacturer with all accessories installed and wired to the connection box; in which case it is only necessary to wire from the engine connection box to like numbered terminals in the controller. Note proper wire size. All wire must be stranded.

A drain valve is provided to relieve water pressure to the pressure switch, thus closing its contacts and starting the engine. This system simulates an actual demand start. Since the drain valve is actuated only momentarily by the Controller, a small amount of water is drained off. If adequate floor drainage is provided in the pump room the drain valve outlet may be left open.

The water pressure line to the Controller from the pump should be thoroughly flushed, before connection to the Controller, in order to remove chips, particles, or other matter which could enter the Controller. Controllers provided with "Automatic" stop (Option R) may be changed to "Manual" stop by connecting a jumper between T3-1 and T3-2.

Terminals 15-16 and 25-26 have jumpers installed at the factory. If remote start or deluge valve switches are to be used for starting, remove the appropriate jumper and wire to normally closed contacts of the remote start switch.

Test Procedure

After all external wiring is completed, install the plug-in relays and component packages which have been shipped loose. These units are packed in a separate carton inside the cubicle. They are numbered and should be plugged into the corresponding numbered socket in the panel.

All of the following tests should be made on each unit after installation. If each test is satisfactory, the operator may place the control switch in "Auto" position and depend upon the panel operating properly when the occasion arises. Also, any one or all of these tests may be carried through at any time after installation, if so desired.

NOTE: If 115 Volts A.C. is not connected to Controller, remove CR-13 to prevent Loss of Charger Output light and alarm from being energized.

I. Battery Lockout Test.

A. Turn on Battery 1 switch, Battery 1 light should be on.

B. Turn on Battery 2 switch, nothing should happen.

C. Press the Battery Reset Button. Battery 2 light should come on.

D. Turn Battery 1 switch off for a couple of seconds and back on. Battery 1 light should go off and remain off.

E. Press Battery Reset. Battery 1 light should come on.

II. Cranking Cycle Test

This test simulates a condition where the engine refuses to start.

A. Disconnect terminal No. 1 on engine panel.

B. Place control switch in "Test" position to crank engine. Time crank and rest periods, count number of cranks. There should be six crank periods separated by five rest periods each of approximately 15-second duration. The overcrank light should come on and the alarm bell should ring.

C. Turn Control Switch to "Off" and properly reconnect all leads.

NOTE: In order to prevent discharging the starting batteries this same test can be made without actually cranking the engine by disconnecting the starter cable and observing the action of the starter contactor.

III. Checking Starting Motor Release

A. Place control switch in "Test" position. Engine should start promptly and starting motor should release at approximately 1/3 engine speed.

NOTE: A convenient method of determining the exact instant the starter releases is to connect a battery test light or voltmeter across the starter terminals and observe when circuit goes dead.

B. Return switch to "Off" to stop engine.

IV. Oil Pressure Failure Test

A. Place control switch in "Test" position to start engine.

B. When engine is starting and oil pressure is not yet up to full pressure, the Oil Pressure Light will light, but the bell will not ring. When pressure builds up, and the switch opens, the light will go out. This feature provides indication that the pressure switch contacts are actually operating in a normal manner.

C. After the engine is running, connect temporary jumper between terminal of oil pressure switch and ground.

D. Oil light should come on immediately. Wait approximately 15 seconds. Alarm bell should ring.

E. Turn control switch to "Off" to stop engine and remove jumper from oil switch.

F. Wait at least 30 seconds for elements to reset before making any further tests.

V. Water Temperature Failure Test

A. Place Control switch in "Test" position to start engine.

B. Jumper contacts on water temperature switch on engine.

C. Alarm bell rings and water light on controller comes on immediately.

D. Turn control switch to "Off" to stop engine, and remove jumper on water switch.

VI. Overspeed Failure Test

A. Turn control switch to "Test" to start engine.

B. Momentarily short contacts on engine speed switch.

C. Alarm bell rings and Overspeed light comes on immediately. Engine comes to stop.

D. Turn Control switch to "Off."

VII. Automatic Starting Tests

A. If program clock is in running position, turn dial to an off setting.

B. Place control in "Auto" position.

C. Bleed off pressure in system until pressure switch closes.

D. *Engine should start automatically and continue to run after switch has opened if arranged for manual stop. If arranged for automatic stop, engine will continue to run for time set on engine run timer and then stop.*

E. *Turn control switch to "Off" to stop engine.*

F. *Repeat tests for each demand switch such as deluge valve, etc.*

VIII. *Periodic Starting Test*

A. *Pressure must be up and pressure switch open and all other demand switches closed.*

B. *110 V.A.C. power must be alive to panel.*

C. *Place control switch in "Auto" position.*

1. *If drain valve operates and if engine starts at once, the program clock is tripped to the operating position, and engine will run for the remaining time on the program clock.*

2. *If engine does not start immediately, turn dial of program clock until it trips on. The drain valve will relieve pressure, the engine will start and then run for the time setting of the program clock and stop.*

IX. *Adjust Setting of Engine Run Timer (Option R only)*

Turn pointer on front of Engine Run Timer. Set to desired time. Do not reset while timer is operating. Never set time less than 30 minutes.

X. *Setting Program Clock*

Loosen screw on the white tab on the edge of the dial and move tab to desired starting time and tighten screw. Set the black tab in the same manner for at least 30 minutes later.

Turn the dial counter-clockwise until correct time of day shows opposite arrow on name plate. To omit days of the week, install screw in points of small star wheel corresponding to days desired. Six screws are furnished for this purpose.

NOTE: Make sure the screw is omitted on the star wheel on the day the engine is to be started. Make sure screws are inserted on those days the engine is not to start. If all seven screws are in place, the engine will never start automatically on weekly test runs.

XI. *Remote Start Switch Circuits*

Field wiring terminals are provided on this panel so that optional normally closed remote start switches such as Remote Pushbutton Stations, *Deluge Valve Switch, Fire Alarm Switch, etc., may be used to start the engine. Two sets of terminals are provided. Terminals 15 and 16 are used for remote manual start pushbuttons. Terminals 25 and 26 are used for remote Deluge Valve Switch or other remote automatic start switches. Upon automatic start from this type of switch, the engine will be stopped either automatically after the demand switch closes and Engine Run Timer times out, or manually at the controller. If remote start switches are not to be used, the terminals must be jumpered. When shipped from the factory, jumpers are installed.*

XII. Power Failure Starting - (Option P)

To test this optional feature, disconnect normal 120 V.A.C. to the Controller. After a 15 second time delay, the controller will commence cranking the engine. The "Loss of Charger Output" lamp will light and alarm sound without delay.

XIII. Normal Operation - Automatic

Place control switch in "Auto" position. Green Auto light will burn and engine will automatically start upon drop in pressure or operation of other start switches. If provided with manual stop feature engine must be turned off at Controller. The engine will also start periodically from the Program Clock and run for length of time set on the Program Clock, then stop. On Automatic stop Controllers, upon termination of the demand signal, the engine will overrun for the length of time left on the Engine Run Timer and then will stop automatically.

XIV. Adjust Sequence Start Timers When Option S is Supplied for Multiple Pump Installation

Normally, the leading pump controller will not have a delay timer and will commence cranking the engine immediately upon operation of a demand signal (other than Power Failure which is time delayed). The subsequent controllers will have a solid state time delay relay adjustable from 3 to 300 seconds. The dial on the top of each delay relay should be set with progressively longer times on each subsequent pump. The recommended time interval is 10 to 15 seconds; however, this may be extended or shortened as required by the local authorities having jurisdiction. If the length of adjustment time required is other than 3 to 300 seconds, a suitable timer will be supplied as required.

NOTE: If time delayed power failure starting (Option P) is also supplied in addition to sequential start (Option S) all of the power failure timers will add an additional 15 seconds delay before the sequence timers start functioning. Upon power failure, all of these timers will begin and end timing at the same time. However, the pumps will not start at the end of this time, but will be delayed in accordance with the time set on the sequential start timers. If power is restored before all pumps are started, the pumps which are running will continue to run until stopped in the normal manner. Those pumps which have not started will not start.

XV. Low Fuel Supply (Option F)

Field terminals have been provided for low fuel level contacts. The controller is arranged so the alarm will sound and the low fuel light will come on when the low fuel contacts close.

XVI. Pump Room Alarms (Option K)

Field terminals may be provided for up to seven pump room alarms. These alarms include: Low Fuel, Low Pump Room Temperature, Reservoir Low, Reservoir Empty, Low Suction Pressure, Relief Valve Discharge and Flow Meter On. The controller is arranged so that the alarm will sound, and the light will come on when alarm sensor contacts close.

TROUBLE SHOOTING HINTS

This controller has been carefully engineered and built to give years of dependable trouble-free service. However, sometimes due to various reasons, difficulty may be encountered in the operation. For this reason, the following information is submitted as a guide for locating troubles which are easily corrected. If the trouble proves to be beyond the scope of this book, consult the factory before proceeding further.

NOTE: Check to see that all relays are firmly seated in their sockets.

I. Engine Refuses to Crank

A. Check with voltmeter or battery test light between terminals No. 2 and No. 11 on the lower chassis terminal bar. If No. 2 is "hot" the crank termination speed switch is closed. Check or replace speed switch.

B. If there is no voltage at terminal No. 2 and engine still does not crank, the crank relay, engine running relay, or battery switchover relay may be defective. Replace.

C. Check batteries to be sure they are fully charged. VOLTAGE MEASUREMENTS WITHOUT ACTUAL CRANKING LOAD IS NOT A SUFFICIENT CHECK FOR BATTERY CONDITION.

D. Check all battery and ground connections from battery to junction box to panel. Also, check circuit breakers to be certain they are turned on. Also, check starting motor cables and contactor connections.

II. Engine Cranks But Does Not Start

A. Check fuel and throttle solenoid.

B. If no current to throttle solenoid, check with voltmeter or test light to see if terminal No. 1 is "hot." If not, Fuel Solenoid Relay may be defective. Replace.

C. When engine does not start, cranking time is limited as previously described. If cranking does not stop and overcrank signal does not come on, check Solid State Crank Control.

III. Engine Starts But Starter Does Not Release

A. Connect voltmeter between terminals No. 2 and No. 11 on the lower terminal bar of the panel. Voltmeter should indicate no voltage while the engine is cranking and should come up to full battery value when engine starts and before it reaches 1/2 normal speed. The speed switch used for starter disconnect should close contact at about 1/3 engine speed to put battery into terminal No. 2. If not, replace switch.

B. If above test indicates voltage on No. 2 is satisfactory, engine running relay may be defective. Replace.

C. If starter does not release, check contacts to make sure the main contacts have not welded together.

IV. Engine Will Not Start on Test Runs

NOTE: On these test runs, the engine starts from the program clock. Instructions for setting and operating are covered under installation and test procedures.

A. Make sure screw on star wheel is removed on day engine is to start.

B. Turn Clock Dial until switch trips on and drain valve operates.

1. If drain valve does not operate the Program Clock, Relays CR1 or CR3 could be defective. If drain valve operates but engine does not start, check to see if pressure switch trips. Also check CR5.

V. Engine Will Not Stop On Test Runs or Starts Every Time Control Switch is Placed in "Auto" Position

A. Stop engine by turning control switch to "Off."

B. Check pressure switch making certain that its contacts are open and that all other demand switches are closed.

C. Check to be sure A.C. voltage is on.

D. Be sure Program Clock is not tripped on.

E. If Solenoid Drain Valve opens each time, the Program Clock may be defective.

F. If Remote Start Switches are used make sure they are closed. If not used, check to see if terminals 15-16 and 25-26 are jumpered.

VI. *Low Oil Pressure Alarm Does Not Operate*

A. *Check wire from panel to oil pressure switch and also from switch to ground on two-wire switches.*

B. *Simulate oil pressure failure by shorting oil pressure switch. Oil light should come on immediately. Wait approximately 15 seconds for time delay to operate alarm.*

VII. *High Water Temperature Alarm Does Not Operate*

A. *Check wire from panel to water temperature switch and also from switch to ground on two-wire switches.*

B. *Simulate high water temperature by shorting terminals of temperature switch.*

C. *If operation is secured on this test but not under actual high water temperature conditions, replace water switch.*

D. *If operation is not secured check water temperature light and diode package DP1.*

VIII. *Overspeed Alarm and Shutdown Does Not Operate*

A. *Check wire from panel to overspeed switch.*

B. *Simulate overspeed by momentarily shorting terminals of speed switch.*

C. *If engine stops, light and alarms operate on this test, but not under actual conditions by overspeeding engine, replace overspeed switch.*

D. *If operation is not secured, check relay CR12, CR13, and diode package DP3.*

IX. *Circuit Breakers in Controller Trip*

A. *Check to see if Voltage Regulator is sticking.*

B. *Check to see if engine generator or alternator is charging above the capacity of the breaker - 20 amperes.*

C. *Check for external short circuits to ground in all wires from panel.*

X. *Loss of Battery Charger Output*

A. *Check A.C. voltage to charger.*

B. *Check charger input and output fuses.*

C. *Check connections to charger.*

SEQUENCE OF OPERATION

Introduction

Refer to schematic wiring Diagram. All relay contacts are shown in the de-energized position. Control relays are designated CR, relays associated with the crank control and battery switching circuit (CC) are designated CCR (CCR1 and CCR3 operate at one-half the battery voltage). Diodes designated DP are located in one of four diode packages, diodes designated D are stud mounted on the chassis and time delay relays are designated TR. Circles with numbers designate field wiring terminals and those with letters designate terminals for connections within the controller.

Controller Battery Power

Power to operate the controller comes from the two-engine batteries. Battery No. 1 is connected to field terminal 6 and is fed through circuit breaker CB1 to diode D1, the voltage sensing circuit (VS-7), the Manual Crank push button (PB1), and the battery switching relay CR2-1. Battery No. 2 is connected to field terminal 8 and is fed through CB2 to D2, VS-8, the Manual Crank 2 push button (PB2) and CR2-4. Diodes D1 and D2 allow the controller to receive battery power from the battery with the higher potential.

Relays CR7 and CR8 are battery failure relays and are energized through a solid state Voltage Sensing switch (VS). If both batteries are fully charged CR7 and CR8 are held energized through the VS and both battery lamps B1 and B2 will be lighted. The voltage sensing circuit allows the battery failure relay to drop out when the battery potential drops below a level of about 60 percent of nominal for a period of several seconds. The purpose of this delay is to keep the battery cranking. If a low battery voltage is sensed, the appropriate battery failure relay will drop out and lock the other one in.

If Battery No. 1 goes low or fails, CR7 will drop out. Its N.C. contacts close and keep CR8 energized independent of the VS circuit. Also CR7 N.C. contacts close and lock the battery switching relay CR2 in the energized position. With CR2 held energized its N.O. contacts will be held closed so that cranking power can be provided only by Battery No. 2 through CR4 contacts to field terminal 10. CR7 N.C. contacts 1-7 energizes the Alarm Relay CR10 through DP2-4-5 and sounds the alarm. If Battery No. 2 fails, CR8 drops out and locks in CR7 and CR8 N.O. contacts 9-6 open and keep CR2 from energizing. The N.C. contacts of CR2 remain closed so that cranking power can be provided only by Battery No. 1 through CR4 contacts to terminal 9. CR8 N.C. contacts 1-7 energizes the alarm relay C-10 through DP2-2-5 and sounds the alarm.

When the two batteries are turned on, the first one on will energize its battery failure relay and lock out the other one. Pressing the Battery Reset push button, PB3, will pull in the second battery failure relay if the battery voltage is high enough. Anytime a battery failure is sensed and one of the relays drop out, the Battery Reset push button must be pressed to reset the circuit.

Diodes DP2-1-2 and DP2-3-4 are used to isolate the voltage sensing circuit from the alarm circuit.

Automatic Operation

For automatic operation, the selector switch is in the "Auto" position. The controller is then in a standby mode and all automatic functions ready for operation. The "Auto" light and both battery lights should be on. The controller will start from any of the following demand signals:

1. *Closing of pressure switch contacts due to drop in water pressure.*

2. *Remote start switches.*

3. *Deluge switch.*

4. *Power failure start (Option P).*

All automatic starting is accomplished through the auto start relay CR5. In sequential start controllers, all auto starts except 2 above are delayed by the sequential start timer, (TR3).

I. Drop in Water Pressure

On drop in water pressure, the pressure switch contacts close, applying power to the coil of auto start relay CR5. In sequential start controllers, the pressure switch contacts apply power to the coil of the sequential start time delay relay, (TR3) and the contacts of TR3 operate the coil of CR5, after the time delay set on TR3. CR5 will lock in through its own N.O. contacts, the "Stop" push button, CR1 N.C. contacts and, if provided, the Engine Run Timer (ERT) contacts. CR5 is locked in and remains energized even after the pressure switch contacts open until either the "Stop" push button contacts are open, the ERT contacts open, or the selector switch is turned to off. If the pressure switch contacts remain closed the "Stop" push button and ERT contacts will have no effect.

With CR5 energized, its N.O. contacts 7-4 close to apply power to the Fuel Solenoid relay CR3, to the Crank Control unit through CR6 N.C. contacts and to the Crank relay CR4. At this time the Crank Control unit starts timing the first crank period and CR4 energizes closing its contacts 7-4 to apply Battery power through CR2 N.C. or N.O. contacts to field terminal 9 or 10 depending on whether or not CR2 is energized. Battery power on terminal 9 or 10 energizes the engine starter contactor and thus cranking of the engine starts as soon as the pressure switch closes.

After a period of approximately 15 seconds, if the engine has not started, the Crank Control unit energizes CCR1. When CCR1 energizes, its N.C. contacts open and CR4 de-energizes, thus stopping the crank cycle. Relay CCR2 is a latching relay and is activated when CR4 is energized. When CCR2 energizes, its contacts close or open to energize or de-energize CR2. CR2 contacts on transfer to switch to Battery 2 power and to field terminal 10. After approximately 15 seconds rest, CCR1 de-energizes and CR4 energizes, thus completing the circuit from the other Battery to field terminal 9 or 10. The engine now cranks on the alternate battery power. If the engine fails to start, this cycle repeats for a total of six crank periods alternating batteries each time.

After six crank periods the overcrank relay CCR3 is energized. Its N.O. contacts 9-6 close to energize the alarm relay CR10 through diode DP2-7-5. One set of N.C. contacts 7-1 opens to stop the cranking and another set 3-9 opens to drop out the fuel solenoid relay CR3. A set of N.O. contacts 7-4 closes to light the overcrank light (OC).

If the engine starts, the engine speed switch applies battery voltage to field terminal 2 and energizes Engine Running relay CR6. CR6 N.C. contacts 1-7 open and cut off power to the cranking circuits. CR6 contacts connected to field terminals 19, 20, 21, 33, 34, and 35 are used for remote indications of the engine running.

The engine oil pressure light is powered only when the controller is in the run mode and CR3 contacts 9-6 are closed or when the selector switch is in the Manual position. This prevents the oil pressure light from coming on when the controller is in Auto and in the standby mode with the engine not running. It also allows the light to come on during the cranking while the oil pressure switch is still closed, thus giving an indication that the oil pressure switch is working. When the engine starts, battery power is applied to one side of the Oil Pressure Alarm Delay Timer, TR1. If the oil pressure is low, the oil pressure switch is closed and completes the circuit through terminal 4 and DP3-4-5 to TR1. If the oil pressure remains low TR1 will time out and its N.O. contacts will close and energize the alarm relay CR10 through diode DP1-2-5. The oil pressure light will remain on as long as the oil pressure switch is closed. Normally the oil pressure comes up as soon as the engine starts so TR1 does not remain energized long enough to time out.

The water temperature switch is N.O. and closes on high engine water temperature. When it closes it operates the water temperature light on the controller through field terminal 5 and energizes the alarm relay through diode DP1-4-5.

If an overspeed condition should develop while the engine is running, a speed switch on the engine closes and puts battery voltage on field terminal 3. This energizes the Overspeed relay CR12 through diode DP3-6-7. CR12 locks in on its own N.O. contacts and thus remains energized until reset by switching the controller to OFF. CR12 N.O. contacts 6-9 close to turn on the Overspeed light and energize CR10 through diode DP1-8-5. CR12 N.C. contacts 3-9 open to de-energize the fuel solenoid and disable the cranking circuits and shutdown the engine.

If the controller is wired for "Automatic Stop" and the water pressure has returned to normal, CR5 will drop out after the ERT times out and its contacts open. The ERT starts timing when CR5 is energized by the closure of N.O. contacts 3-8 to the ERT motor. If the controller is wired for "Manual Stop" CR5 will remain locked in until the control switch is turned to OFF or the stop push button is pressed. The ERT is installed to assure that the engine runs for a minimum time and should be set to at least 30 minutes. If the pressure switch remains closed for a longer period than set on the ERT, the ERT will time out but CR5 will remain energized through the pressure switch until the pressure switch contacts open.

A controller may be provided with an Energize to Stop feature (Option D). With this feature, terminal 12 will be energized for a period of time established by TR4. When the controller goes to the start mode CR3 energizes and its N.O. contacts 9-6 close and apply battery to CR15. CR15 then locks in on its own contacts through TR4 N.C. contacts to CR3-9 which is at battery potential. When the controller goes to the stop mode CR3 de-energizes and its N.C. contacts 3-9 close and energize TR4 through the selector switch and CR15 N.O. contacts which are now closed; this also applies battery to terminal 12. When TR4 times out its N.C. contacts open and let CR15 de-energize. CR15 N.O. contacts open and de-energize TR4 and terminal 12.

The alarm circuit consists of a bell mounted on the outside of the enclosure and is controlled by CR10 N.O. contacts 6-9. CR10 is energized by one any of the following failures:

- *a. Engine overspeed.*
- *b. Low oil pressure.*
- *c. High water temperature.*
- *d. Loss of battery charger output.*
- *e. Overcrank.*
- *f. Battery failure.*
- *g. Low fuel level (Option F).*
- *h. Pump room alarms (Option K).*

The diodes in the alarm circuit are used to isolate the various alarm contacts so that one set of contacts may be used for more than one function.

II. Remote Start

The remote start switch or switches are N.C. switches and keep remote start relay CR9, energized. Depressing a remote start switch de-energizes CR9. The N.C. contact of CR9 then closes to energize CR5. The remaining sequence of operation is the same as for a start from water pressure drop described above.

III. Deluge Switch

The deluge switch or switches are N.C. switches and keep the deluge relay CR11 energized. Opening a deluge switch contact de-energizes CR11 to allow its contacts to close and energize CR5. The remaining sequence of operation is the same as for a start from water pressure drop described above.

IV. Power Failure Start (Option P)

This option automatically starts the engine after a delay time upon loss of battery charger output. Relay CR13 is held energized by an alarm output of the battery charger. If the battery charger output should fail CR13 will drop out and its N.C. contacts 1-7 will energize TR2, a fixed time delay relay. When TR2 times out its N.O. contacts will close and energize CR5. The remaining sequence of operation is the same as for a start from water pressure drop described above.

V. Weekly Test Start

The weekly test is initiated by a 7-day program clock (PC) operated from the A.C. line. At the time and day of week programmed, its N.O. contacts close and energize a solenoid drain valve (SDV) through DP3-8-1, CR3 and CR1. The SDV is normally closed and is connected to the water line to the pressure switch. When it is energized it opens and drains the water line to the pressure switch causing a drop in the pressure. This in turn causes an automatic start as described above. When the fuel solenoid relay CR3 energizes its N.C. contacts 1-7 open and de-energize the SDV. These contacts also keep the SDV from energizing while the engine is running. The SDV is open just long enough to drop the pressure and initiate the start sequence, minimizing the amount of water discharged.

When the crank relay CR4 energizes its N.O. contacts close to energize CR1, the weekly test relay, which locks in on its own N.O. contacts. CR1 N.C. contacts 3-9 open to keep CR5 from locking in on those controllers wired for manual stop. CR5 is held energized by the P.C. contacts through DP3-8-1 and DP3-1-2 for the duration of time set on the P.C. The purpose of DP3-1-2 is to isolate CR1 contacts from the SDV. The purpose of DP3-8-1 is to isolate the test position of the selector switch from CR1. When the P.C. contacts open CR1 drops out and if all starting causes are normal CR5 also drops out and the engine stops.

VI. Test Start

Switching the controller selector switch to the Test position initiates an automatic start by energizing the solenoid drain valve as described above to drop the water pressure to the pressure switch. The starting sequence is the same as described above. Diode DP3-1-8 keeps CR1 from energizing. Diode D3 is used to isolate the Automatic position of the selector switch from the Test position. The engine will continue to run until the selector switch is switched to OFF.

VII. Manual Start

The Manual position of the controller disconnects all automatic circuits of the controller and permits manual starting of the engine on either or both batteries by pressing the appropriate crank push button. The engine will continue to run until the selector switch is switched to OFF.

VIII. Additional Features

A. Engine Lockout (Option E)

Relay CR14 is an Engine Lockout relay which when energized will keep the engine from starting or stop the engine that is already running. This feature may be used to lock out one pump in a two-pump system, when the other is running or to lock out the pump in case of low suction pressure when this is a requirement.

Relay CR14 is connected directly across terminals 17 and 18. This arrangement requires that CR14 receives its power from the controlling device. This arrangement can be made fail-safe by fusing the *power at the controlling end so that neither shorting or opening the interconnecting wires will cause the engine to lock out. The fuses are provided for protection of the power circuits to a low-suction panel when provided.*

B. Remote Alarm Contacts

Terminals 27, 28, and 29 provide contacts for a remote indication that the switch is not in the Auto position.

Terminals 19, 20, and 21 and 33, 34, and 35 provide two sets of Engine running contacts. One set can be used for remote alarm indications and the other for any other required control function.

Terminals 22, 23, and 24 provide a set of contacts for a remote indication of a system failure.

Terminals 30, 31, and 32 provide a set of contacts for remote indication of the failure of either battery.

Terminals 36 through 43 are used to provide for an alarm signal in case of low fuel level (Option F), or any other pump run alarm condition (Option K). These alarm functions require N.O. contacts that close to represent an alarm condition. Terminal 36 is a common terminal for all alarm sensor contacts. Terminal 37 through 43 connects to one side of the pump room alarm sensor contacts. Relay CR17 is an alarm silence relay energized by Alarm Silence Push Button PB5. CR17 is held energized by its own N.O. contacts as long as the alarm condition is present. CR17 N.C. contacts 1-7 open and let CR10 drop out.

C. Individual Alarm Contacts (Option A)

Contacts for individual indication of each alarm condition may be provided by Relays CR51 through CR60 and one pole of CR12 and CR13. These contacts are wired to terminals 51 through 86. Relays CR51 through CR60 and terminals 51 through 86 are mounted on a separate panel mounted below the controller panel.

D. Pressure Recorder (Option B)

A pressure recorder may be furnished to provide a 7-day continuous recording of the water pressure. This recorder will have either a 300 or 600 psi full scale rating and will operate from the AC voltage to the controller. It is designated CD on the schematic.

E. Battery Charger Operation (Option J)

The battery charger is mounted in the engine controller and is factory wired to the controller terminal block from which it obtains its 120 volt, 50-60 HZ supply voltage and through which it provides charging current to the batteries. The charging current to the two batteries is monitored by means of two ammeters mounted in the *controller light panel. Optional voltmeters (Option V) may also be provided to monitor the two battery voltages.*

The battery charger is line voltage regulated and will operate over a voltage range of 102 volts to 132 volts at 50-60 HZ. Below about 110 volts the charger output will be slightly reduced. The charger output is current limited and provides full protection during the engine cranking cycle. The charger input and output are fused for protection in case of a failure of the control circuit or other internal component.

The battery charger is fully automatic and will simultaneously charge two batteries at a rate of up to 25 amperes total current to the two batteries. The current will be distributed to the two batteries according to the battery demands. As the batteries approach full charge, the current will taper off to a predetermined level at which the charge automatically switches to the float mode of operation. In the float mode the charger maintains the batteries at the float potential (approximately 13 volts for a 12-volt battery or 26 volts for the 24-volt battery).

The only adjustment on the charger is the float voltage potentiometer which is factory set for a typical fairly new battery at normal room temperature of 65° to 80°F. This adjustment may have to be altered for older batteries or for high or low temperatures. If, with no load on the batteries, the charger draws current in excess of 0.5 amps when in the float mode, the float potential should be decreased (counter-clockwise adjustment). If the charger does not maintain the batteries at a full charge, the float potential should be increased (clockwise adjustment).

The charger provides a means of monitoring the charger output to sound an alarm in case of loss of charger output on the output side of the fuse. This also provides a means of monitoring the A.C. power since a loss of A.C. power results in a loss of charger output.

PARTS LIST FOR METRON FD-2 ENGINE CONTROLLER

DESCRIPTION	PART NUMBER	REC. SPARES
Alarm Silence Switch (PB5) (Opt. K)	81087J, Arrow-Hart-Hagerman or Equiv.	
Alarm Bell (Alarm)	12V, -2223, 24V, -2224, Jenkins	
Lamp Bulb	12V, -756, 24V, -757, Norelco, Chicago Miniature or Equiv.	10
Relays CR1, CR2, CR4 CR9 thru CR17 CR51 thru CR60 (Opt. A)	12V, -68R2-12, Sigma 24V, -68R2-24, Sigma	3
Relays CR3, CR5 thru CR8	12V, -68R3-12, Sigma 24V, -68R3-24, Sigma	1
Relays CCR1 & CCR3	12V, -68R2-6, Sigma 24V, -68R2-12, Sigma	1
Sockets for Sigma and KUP Relays	AD40-21125, Sigma	1
Octal Sockets	60SR2P51, IDEC	1
Crank Control & Battery Switching Unit	*12V, -C30491-12, Metron *24V, -C30491-24, Metron	1
TR1 (Oil Pressure)	12V, -12N015, Amperite 24V, -26N015, Amperite	1
TR2 (Opt. P) - Fixed **Adjustable (See Below)	12V, -12N015, Amperite 24V, -26N015, Amperite	1
TR3 (Opt. S)	12V, -TIK-30-466, NCC 24V, -TIK-30-462, NCC	1
TR4 (Opt. D)	12V, -12C45, Amperite 24V, -26C45, Amperite	1
Voltage Sensing Unit (VS)	*12V, -B20876-12, Metron *24V, -B20876-24, Metron	1
DP1 & DP2 Diode Modules	*12V & 24V, -B20877, Metron	1
DP3 Diode Module	*12V & 24V, -B20880, Metron	1
DP4 Diode Module	*12V & 24V, -B20885, Metron	1

*Specify Battery Voltage and Ground Polarity
**Specify Battery Voltage, Ground Polarity and Time Range Required

PARTS LIST FOR METRON FD-2 ENGINE CONTROLLER

DESCRIPTION	PART NUMBER	REC. SPARES
Circuit Breaker (CB1 & 2)	JAI-B3-20-50-2A, Heinemann	1
Selector Switch (SW-1)	3100 4A 4 Deck, Electro-Switch 3100 5A 5 Deck, Electro-Switch	1
Crank Pushbuttons (PB1 & 2)	81087J, Arrow-Hart-Hagerman	1
Reset Pushbutton (PB3)	81087J, Arrow-Hart-Hagerman	
Stop Pushbutton (PB4)	KRIR-KA3-KN302, Square "D"	1
Pressure Switch (PS)	DA31-2, Mercoid	1
Program Clock (PC)	7100, 120VAC/60 HZ., Tork 7100, 120VAC/50 HZ., Tork	1
Engine Run Timer (ERT) (Opt. R)	CSF60M-115/60, Industrial Timer CSF60M-115/50, Industrial Timer	1
	BR110A6-03-120/60, 60 Min., Eagle	1
	Note: Specify Manufacturer of Timer	
Diodes (D1-D4)	IN1192, Motorola	2
Pressure Recorder (CD) (Opt. B)	06PL-IBM4, 110VAC/60 HZ., Weksler 06PL-IBM4, 110VAC/50 HZ., Weksler	
Recorder Pen (Opt. B)	25-19, Weksler	1
Cleaning Wire for Pen (Opt. B)	25-22, Weksler	1
Weksler Charts (Opt. B)	W7-300-0-6, Weksler	100
Solenoid Drain Valve (SDV)	*LC-2DB-415, Skinner	1
Battery Charger (Opt. J)	*1808-12-25, Metron *1808-24-25, Metron	
Battery Charger P.C. Board (Opt. J)	*12V, -B30683-12, Metron *24V, -B30683-24, Metron	1
Diodes (Opt. J)	IN1183, Motorola	1
SCR (Opt. J)	GEC35B, General Electric	1
Fuse (35 AMP) (Opt. J)	NON35, Bussman	2

*Specify Battery Voltage and Ground Polarity
**If Low Suction Lockout Panel is provided

PARTS LIST FOR METRON FD-2 ENGINE CONTROLLER

DESCRIPTION	PART NUMBER	REC. SPARES
Fuse (.1 AMP) (Opt. J)	MDA .1, Bussman	2
Fuse (Opt. J)	12V, -MDA10, Bussman 24V, -MDA15, Bussman	2
Fuse (4 AMP) (F1, F2)	**KTK-4AMP, Limitron	1
Fuse (1 AMP) (F3, Opt. E)	KTK-1AMP, Limitron	1
Ammeter (30 AMP)	440D5, Electro-Mechanical	1
Voltmeter (Opt. V)	12V, 445D5-15 24V, 445D5-30 Mfg. Electro-Mechanical	1
Heater (Opt. H) (Specify Wattage)	SCB-100W, SCB-150W Mfg. Emerson-Chromalox	1
Thermostat (Opt. H)	WR65, Emerson-Chromalox	1
Humidistat (Opt. H)	H46-C, Honeywell	1
Circuit Breaker (Opt. H)	JAI-A3-2-250VAC-2, Heinemann	
Switch Box (Opt. H)	C30534, Metron	
Lamp Assy. with Lens (Red)	41-1310-0111-301, Dialco	1
Lamp Assy. with Lens (Green)	41-1310-0112-301, Dialco	1
Lens (Red)	41-0111-301, Dialco	2
Lens (Green)	41-0112-301, Dialco	2
Oil Tight Lamp Assy. (Red)	80-0410-1331-303, Dialco	1
Oil Tight Lamp Assy. (Green)	80-0410-1332-303, Dialco	1
Door Handle With Keys	68-0294CH, National	
Break Glass	6-3/4" X 8-3/4"	1

*If Low Suction Lockout Panel is Provided

STEARNS-ROGER ENGINEERING CORP.
PROJECT NO. 621700
SOLAR-ONE PILOT PLANT
UNIT ONE
P.O. 2001 1.2.7-432

QUALITY CONTROL VERTI-LINE

Procedure: Hydrostatic Test 2006

Scope: This procedure describes the inspection and recording for hydrostatic test per commercial and government requirements.

1008. All pressure parts of all pumps will be given a hydrostatic test when the specifications on a contract require it; the suction bell is not considered a pressure part and will not be hydro tested.

1008.1 The test pressure shall be in accordance with contract referenced specification, or to a minimum pressure of one and one half times shutoff head, for a minimum period of 30 minutes (1/2 hour).

1008.2 The Production Control Processor shall request the hydrostatic test to the Hydro Operator with a "Hydro Work Order" (Form V-L QC18).

1008.2.1 The Production Control Processor shall indicate on the "Hydro Work Order" (Form V-L QC18) the following information:

A. Aurora Pump serial number

B. Customer P.O. number

C. Desk number (processing order)

D. Customer name

E. Quantity of items or components requiring hydro

F. Pattern number

G. Finish part number

H. Item description

I. Date released to be hydro tested

J. Pressure Required on Contract or Specifications

K. Time Pressure to be Held

L. Witness by a Customer or Representative Inspector

1008.3 The hydrostatic tests are set up in the Main Hydro Lab under the direction or instructions of the Quality Control Technician or the Test Supervisor.

1008.4 The hydro test will be made on individual components of the pump (not completely assembled).

1008.4.1 The pressure medium: City water at ambient temperature at 50 to 75 PSIG. The pressure is boosted as desired by an air operator booster diaphragm pump with check valves at inlet and outlet side to prevent reverse flow; components are vented to permit air from escaping during filling with water.

1008.4.2 The components of the pump to be tested shall be placed on a proper pedestal under the electric or manual hoist for proper handling and position so that all air can be eliminated from the components before hydrostatic pressure is applied.

1008.4.3 Close off the suction and discharge of the pressure retaining boundaries using flanges so designed as to withstand 150% of pump shutoff head, sealed by the use of gaskets and grease.

1008.4.4 An indicating gauge shall be connected directly to the component or item being tested. If the indicating gauge is not readily visible to the operator controlling the pressure applied, an additional indicating gauge shall be provided where it will be visible to the operator throughout the duration of the test.

1008.4.5 Indicating pressure gauges used in testing shall have dials graduated over a range of about double the intended maximum test pressure, but in no case shall the range be less than one and one half (1-1/2) times that pressure.

1008.4.5.1 All gauges shall be calibrated against the National Bureau of Standards and a certification shall be maintained in the Quality Control Office for reference purposes.

1008.5 Attach the pump filter housing to the fixture.

1008.5.1 Attach the air vent tube assembly at the highest point in order to vent all air from components.

1008.5.2 After water begins flowing from air vent tube, close the petcock on the air vent tube assembly.

1008.5.3 Disconnect the filler hose.

1008.6 The Quality Control Technician or Test Supervisor, after the pump or components are set at the required test pressure, will visually inspect the pressure boundaries of the pump or components for leakage.

1008.7 Accept or reject criteria: Any water leaking throughout the external surface of the components during the hydro test will be subject to rejection.

1008.8 The results of the hydrostatic test shall be recorded on form V-L QC18 (Hydro Work Order) by the Hydro Operator with the following information:

A. Date received at Hydro

B. Date test performed

C. Operator's initials or clock number

D. Witnessing Supervisor's initials

E. Gauge number used in test

F. Gauge calibration record

G. Remarks

H. Date of approval

I. Signature of the Quality Control Technician or Test Supervisor approving test

1008.8.1 The results of the hydrostatic test shall also be recorded by the operator on the daily hydro log or daily operation with the corresponding remarks of "failure or pass".

1008.8.2 In the event of any rejection due to leakage or any other discrepancies, the component shall be scrapped and replaced with another of the same required in the Hydro Work Order. The Order Processor shall provide the Hydro Operator with a new work order.

1008.9 Hydro certifications (form V-L QC6) shall be provided in every test performed. They will be prepared by the Quality Control Department, stating the following:

A. Customer Name

B. Customer P.O. number

C. Aurora serial number

D. Quantity and item description

E. Statement of conformance

F. Date of test

G. Gauge number

H. Gauge calibration

I. Certified by

J. Witnessed by

1008.10 The test pressure requirement to contract specifications will be available on the nameplate, which is attached to the head of the pump.

NOTES: A legible copy of this procedure shall be in the Hydro Test Lab at all times, attached to the Hydro Machine for your verification.

MGrh 2/1

RELATED FORMS ____ PROCEDURE EN-005

FIRE PUMP

REF. PROCEDURES ____

DATE 9/7/79 PAGE 1 OF 3

PREPARED BY A. Cordia DATED ____

APPROVED BY K. S. Fang SUP'SDS PROCEDURE

APPROVED BY ____ DATED 3/2/79

A standard performance test is run on the purchased bowl assembly, using standard test laboratory column, discharge head and motor.

Readings are taken at a minimum of five capacity points, including one point within ± 2 percent of the design capacity.

Test Arrangement

Attached Dwg. No. 1 shows the general arrangement of the test. The points of measurement for four basic quantities are marked. The four quantities are:

- Capacity
- Head
- Force (used for the calculation of BHP)
- RPM

The sump is approximately a 20 x 72 foot rectangle, with a maximum depth of 35 feet below the pump mounting positions. It contains approximately 200,000 gallons of water. Pumps can be set in one of four positions according to size, and are arranged to pump through a discharge manifold, meters, and into a full width return channel that increases in depth gradually from 10 feet to the full 35 foot sump depth. In this manner, cascading tendencies and return velocities are low enough to eliminate any deliterious effects from this cause.

The bowls are suspended from five feet of column and operated as described. Prior to start up of the units the water level in the sump will be reduced to simulate the low water level required by the specifications. The test curves are plotted during operation and all calculations are checked while the pump is running.

The hoist equipment is a 10-ton capacity crane, bridge mounted approximately 24 feet above the floor. This allows the handling of one piece assemblies not in excess of 20 feet in length. Diameters as large as 46" can be lowered into the sump.

Capacity Measurement

The capacity of a pump is measured by means of the Venturi meter, manufactured by BIF, a division of General Signal Corporation. Six sizes are available, namely 2", 4", 8", 12", 20" and 30". By using singly or two in parallel combination, a range from 15 GPM ro 50,000 GPM can be covered.

A detailed description of these instruments is:

Pipe Size In.	Inlet Dia. In.	Throat Dia. In.	Scale Range GPM
2	1.9375	1.304	0-216
4	4.000	2.169	0-560
8	8.000	3.643	0-1550
12	12.000	6.160	0-4500
20	19.281	10.038	0-12000
30	29.985	21.750	0-40000

The smaller valves, 2" through 12", are operated manually. The 20" gate valve is operated by electric motor. For the 30" line, a gear adjusted butterfly valve is installed at the end of the line.

Head Measurement

The primary indicators are Mercury manometers. These manometers are placed approximately 25 feet from pump discharge. At this point heads, free of turbulence, up to 300 feet can be read. Bourdon-tube gages are used for heads from 300 feet to 1150 feet of water. Bourdon-tube gages are calibrated regularly on a dead weight tester. Extremely low heads are taken by water manometer. We are able to measure head as low as 5 feet.

Power Measurement

The power input to the pump is determined with vertical dynamometers as calibrated motors. Two dynamometers are available. The smaller size is used up to 250 HP and the larger one to 500 HP.

The dynamometer is essentially a turning table which is made to turn freely by the reactive torque of the driver. A moment arm of suitable length is attached to the turning table and a force is applied to stop the rotation. This force is registered on a scale or a load cell. Below is a formula for the calculation of power:

$$BHP = \frac{2LFN}{33000}$$

Where L = length of arm, ft.
F = force on scale or load cell, lbs.
N = RPM

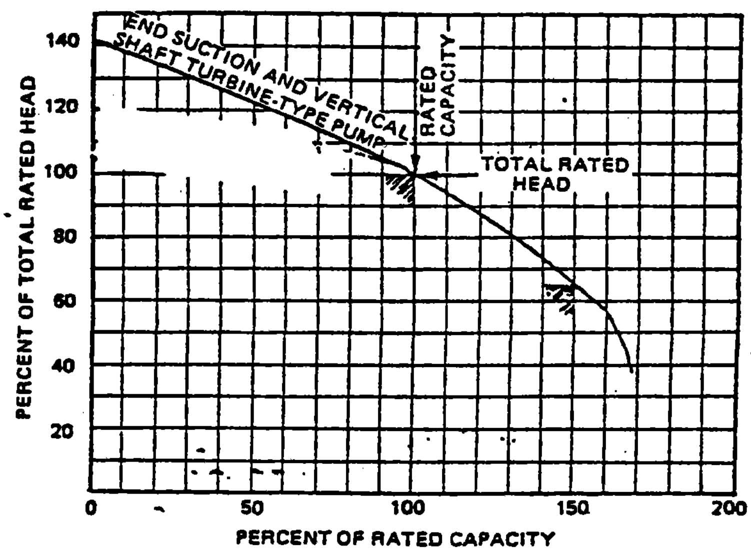
Below are the calibrated motors available in our laboratory.

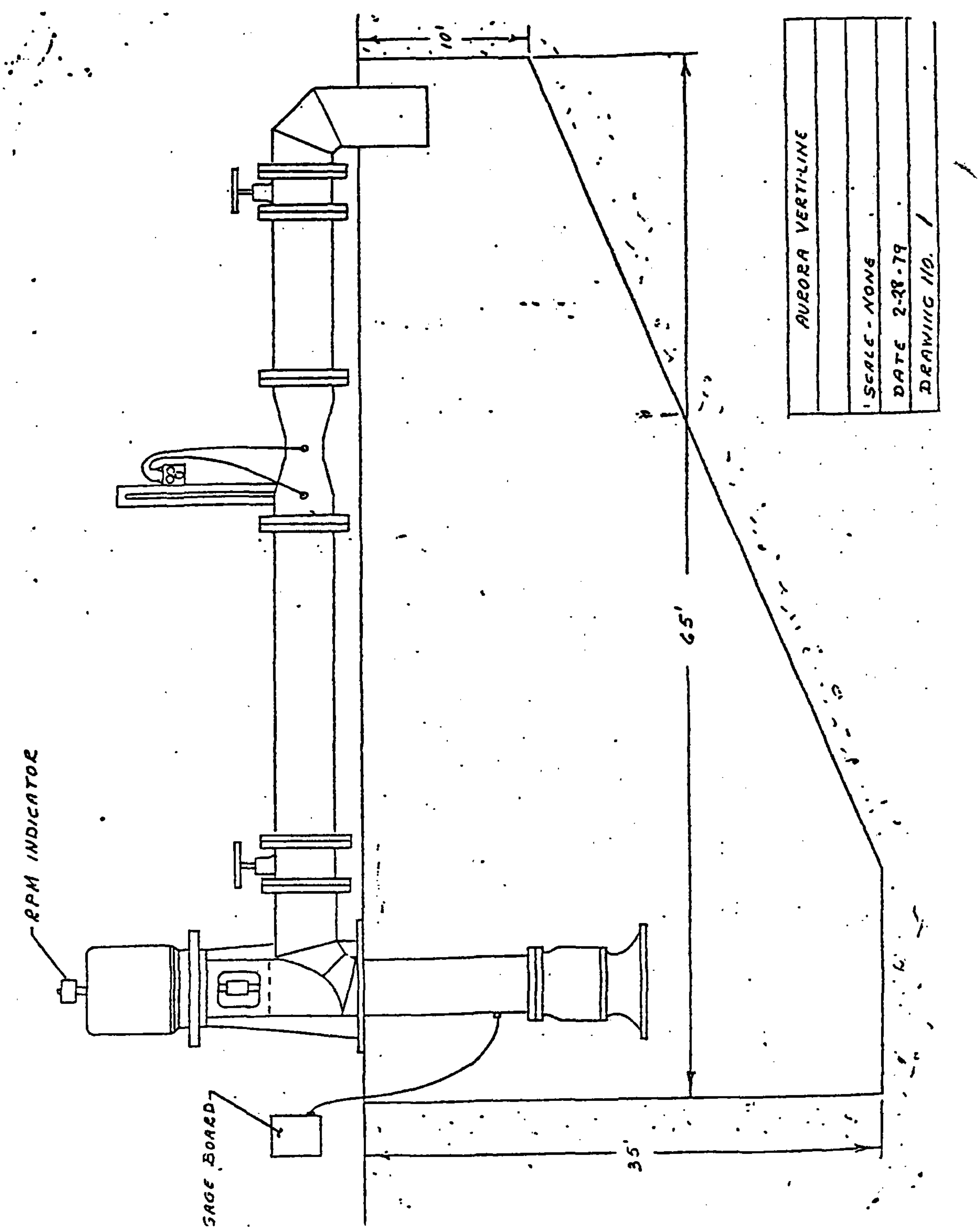
HP	2p 3600	4p 1800	RPM 6p 1200	8p 900	10p 720	12p ~~10p~~ 600	14p 514
20	X						
50			X				
60		X					
125		X				X	
200	X	X	X	X			
400						X	X
600		X	X	X	X	X	

Below is shown the power service available (60 Hz.)

440 volt	Max. 660 HP
2300 volt	Max. 1000 HP
4160 volt	Max. 1500 HP

FIRE PUMP
Below shows the special performance requirement of fire pumps(NFPA #20 para.3-2.1)




RPM INDICATOR
GAGE BOARD
10'
65'
35'
AURORA VERTI-LINE
SCALE - NONE
DATE 2-28-79
DRAWING NO. 1