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Monthly Progress Report No. 2

SOYBEAN DRYING USING HEAT FROM SOLAR ENERGY

July 1976

TELEDYNE
BROWN ENGINEERING

Cummings Research Park • Huntsville, Alabama 35807

MONTHLY PROGRESS REPORT NO. 2
PERIOD: 5 JULY 1976 THROUGH 30 JULY 1976

SOYBEAN DRYING USING HEAT FROM SOLAR ENERGY

July 1976

Prepared For

DIVISION OF SOLAR ENERGY
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
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WASHINGTON, D.C. 20545

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Prepared By

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HUNTSVILLE, ALABAMA

ABSTRACT

Solar energy as a heat supplement for industrial grain processing is feasible with present technology. Requirements necessary to establish design criteria for a soybean drying process line utilizing solar energy have been identified and conceptual designs which meet these requirements are defined.

Approved

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Coordinator, Energy Programs

Submitted by

Henry F. Magill, PE
Program Manager

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1. INTRODUCTION

The Teledyne Brown Engineering Company (TBE) has been contracted by the U.S. Energy Research and Development Administration to provide for the analysis, design, fabrication, testing and demonstration of a solar energy drying process for soybeans. A conventional grain dryer will be used to process the soybeans; however, it will derive the energy required to heat the drying air principally from a solar collection and storage system.

A three phase program has been defined: Phase I will be a nine month program to design and analyze a solar drying process; Phase II, lasting one year, will be used to fabricate and install the system, and during Phase III, operational data will be acquired over a period of fifteen months to permit a comparison with a conventional fuel operated facility.

Phase I was initiated on June 26, 1976 with the fundamental objectives to: (a) identify and synthesize the most cost-effective solar drying system for the Gold Kist soybean processing plant in Decatur, Alabama, and (b) prepare detailed design and performance specifications. To satisfy these objectives, TBE has teamed with the Reisz Engineering Company for the generation of preliminary designs and Gold Kist, Incorporated for consultation support. Figure 1-1 illustrates the methodology to be followed to meet the program objective.

Task 1 of Phase I was completed on July 2, 1976. The specific output of this task was to define all of the requirements necessary to establist design criteria for a soybean drying process line utilizing solar energy. During this reporting period, Task 2 was initiated and completed. Guided by the dictates of Task 1, Task 2 had as it objective the synthesis of five conceptual designs for using solar energy for soybean drying at the Gold Kist Soy Facility, Decatur, Alabama. During the next reporting period, an evaluation of these concepts will be performed.

PHASE I

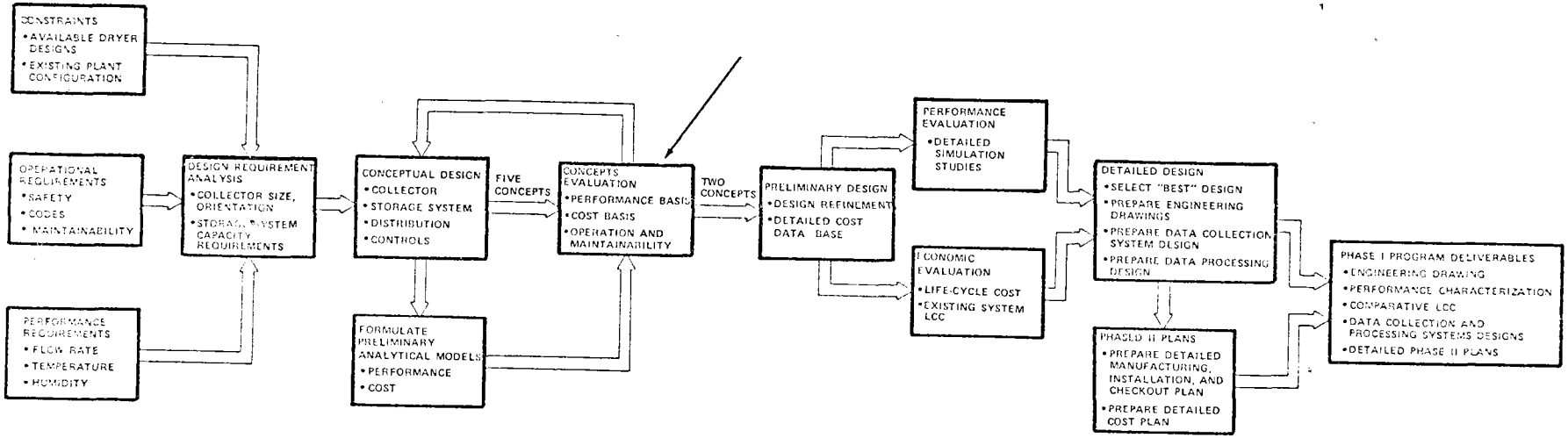


Figure 1-1

2. PROGRAM STATUS

2.1 SCHEDULE

The overall program schedule for Phase I is shown in Figure 2-2. During this reporting period, Task 2 (Conceptual Design) was initiated and conpleted on schedule. Design guidelines for solar systems, facilities and components for a soybean drying process using solar energy at the Gold Kist Soy Facility, Decatur, Alabama have been identified and documented. Five conceptual design (Figures 2.3; 2.4; 2.5; 2.6; and 2.7) considered to be economically and technically feasible for this application have been prepared for a comprehensive analysis to be performed during Task 3 (see arrow marker, Fig. 1-1).

2.2 DESIGN OPTIONS

Using the requirements defined in Task 1, five conceptual designs have been developed and presented in Reisz Engineering Company's Progress Report, subject: Conceptual Designs Report for Task 2. Both air and water energy transfer mediums are feasible and are considered. In each of the five designs presented the subsystems and components may be varied or modified to effect performance and cost. Tradeoff studies will be conducted during subsequent tasks to arrive at an optimum solution to minimize solar system cost and to maximize operational effectiveness. It is feasible to install approximately 22,000 ft^2 of collectors without imposing any serious modifications to the Decatur facility. The collectors can either be oriented to face due South or oriented in line with the cluster of concrete silos which is 24° west of south. In the latter case, the collectors would be aesthetically more attractive but solar energy collection would be reduced about 5%.

Solar energy storage will only be required if the 500 bu/hr dryer is selected with a collector larger than about 15,000 ft^2.

2.3 SOLAR COLLECTOR

Because collector cost and efficiency play such dominate roles in the solar system design, major attention has been given to such parameters as: collector area, collector efficiency, collector flow rate, temperature lift of the dryer air, insolation rate and pumping power. Figure 2-8 relates most of these variables through three interrelated graphs. The top graph is a typical format for expressing the efficiency of a solar collector. The top curve represents a good solar collector and the bottom curve represents a relatively poor collector. The second graph results from a heat balance between the collector and the collector fluid. The curve depends upon the efficiency curve plotted above it as well as the net effective area of the collector. The dashed line represents the poor collector and the solid curves represent the good collector for three different areas. The bottom curve indicates the temperature lift associated with the particular operating conditions and insolation rate. The abscissa of the three graphs are the same so that there is a vertical correspondence between the graphs.

2.4 SYSTEM MODELING

Modeling of the drying of soybeans using solar energy has been initiated. The preliminary tasks have involved defining the theoretical and numerical requirements for simulating the drying process and a review of existing storage and collector models to select those suitable for the design concepts being considered.

Review of the literature of grain and soybean (a legume) drying indicate the usual problems encountered in the modeling of physiological systems can be expected, i.e., paucity of property data, uncertainties as to synergistic responses of the physical and physiological aspects to state changes, etc. However, the basic theoretical models are cast in more or less conventional terms and a model adequate for the present purposes is anticipated.

2.5 PROGRAM COST

The program is under its cost projections due to the deferment of some engineering and computer support and consultative services until later tasks.

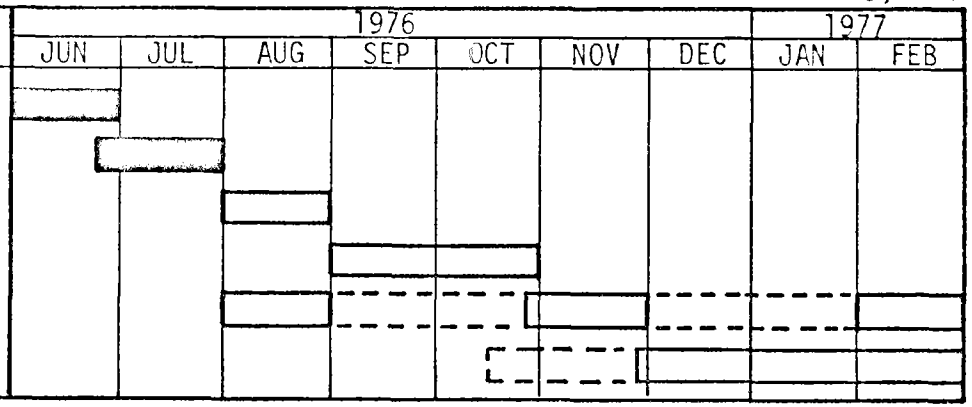
PROJECT PLAN AND PROGRESS REPORT

SOYBEAN DRYING USING HEAT FROM SOLAR ENERGY

SCHEDULE

AS OF DATE: JULY 30, 1976

WORK STATEMENT
I. REQUIREMENTS DEFINITION
II. CONCEPTUAL DESIGN
III. CONCEPT EVALUATION & SELECTION
IV. PRELIMINARY DESIGN
V. PERFORMANCE & ECONOMIC EVALUATION
VI. DETAILED DESIGN



LEGEND:
- SCHEDULED
- PROGRESS
- PLANNED
- ACTUAL
- EARLY START

PROGRAM PLAN		BUDGET	MANHOURS
TOTAL PROGRAM		$286,764	5,150
REPORTING PERIOD	PLANNED	44,622	522
	SPENT	33,371	166
	VARIANCE*	11,251	356
CUMULATIVE TO DATE	PLANNED	78,346	~~582~~ 852
	SPENT	62,177	~~688~~ 550
	VARIANCE*	16,169	~~106~~ 302
NEXT REPORTING PERIOD	PLANNED	21,654	324

*FAVORABLE (UNFAVORABLE)

COST

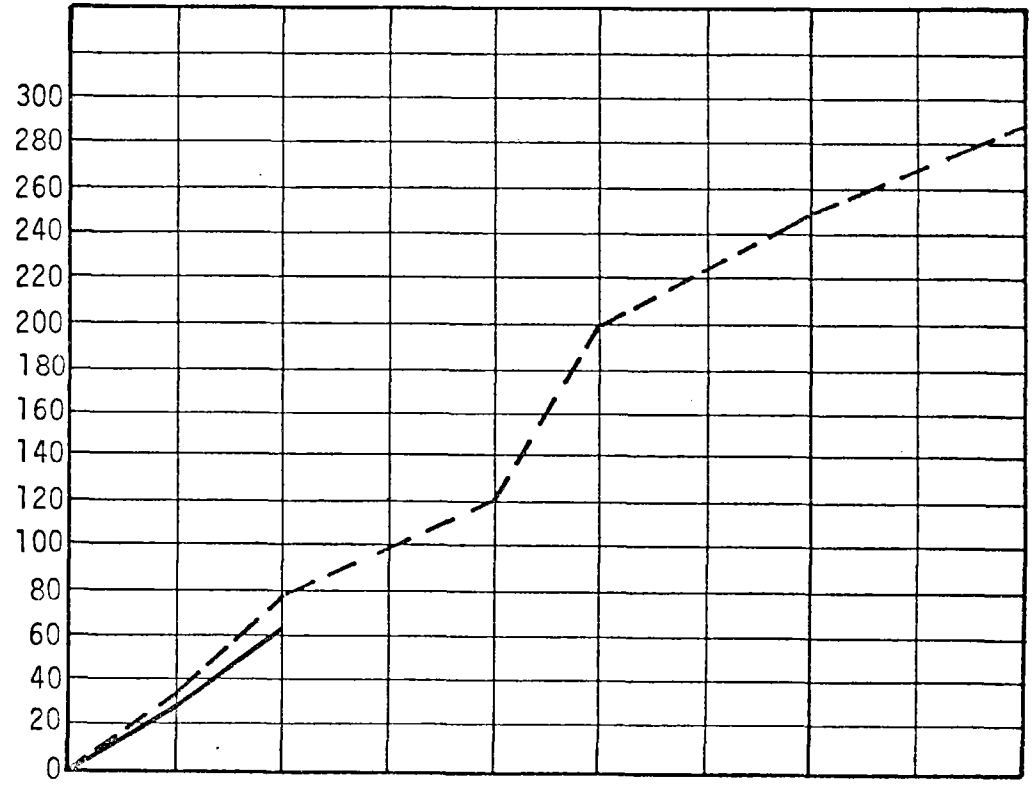


FIGURE 2-2

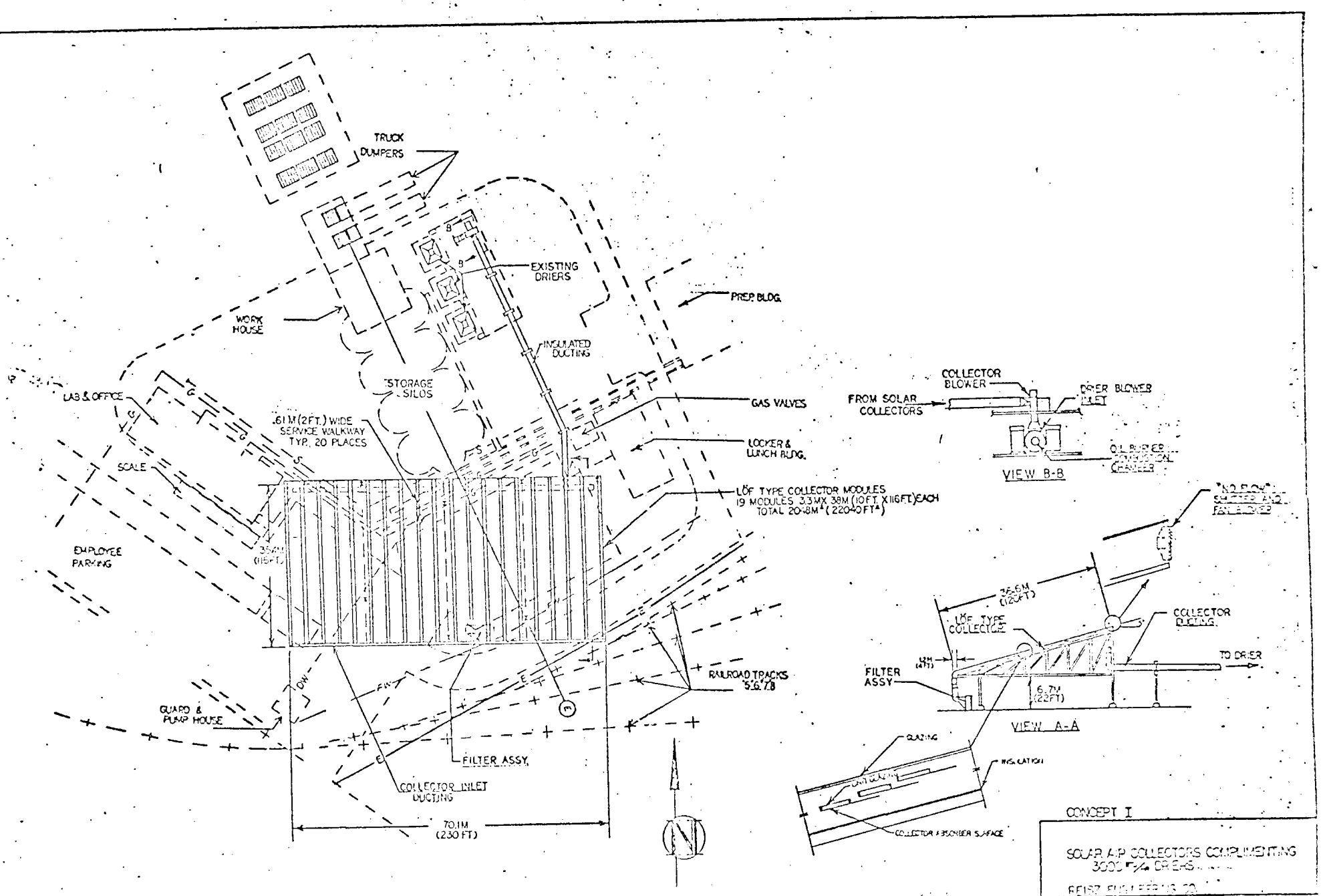

TRUCK DUMPERS
EXISTING DRIERS
PREP. BLDG.
WORK HOUSE
INSULATED DUCTING
STORAGE SILOS
LAB & OFFICE
GAS VALVES
.61 M (2FT.) WIDE SERVICE WALKWAY TYP. 20 PLACES
LOCKER & LUNCH BLDG.
SCALE
LOF TYPE COLLECTOR MODULES
19 MODULES 3.3 MX 38M (10FT. X 116FT.) EACH
TOTAL 2048M² (22040FT²)
EMPLOYEE PARKING
35.4M (116FT.)
RAILROAD TRACKS
GUARD & PUMP HOUSE
FILTER ASSY.
COLLECTOR INLET DUCTING
70.1M (230 FT)
FROM SOLAR COLLECTORS
COLLECTOR BLOWER
DRIER BLOWER INLET
OIL BURNER CONVECTION CHAMBER
VIEW B-B
"NO FLOW" LOUVERS AND FAN DAMPER
36.6M (120FT)
LOF TYPE COLLECTOR
COLLECTOR DUCTING
FILTER ASSY
1.2M (4FT)
6.7M (22FT)
TO DRIER
VIEW A-A
GLAZING
INSULATION
COLLECTOR ABSORBER SURFACE
CONCEPT I
SOLAR A.P. COLLECTORS COMPLIMENTING
3000 T/A DRIERS

FIGURE 2-3

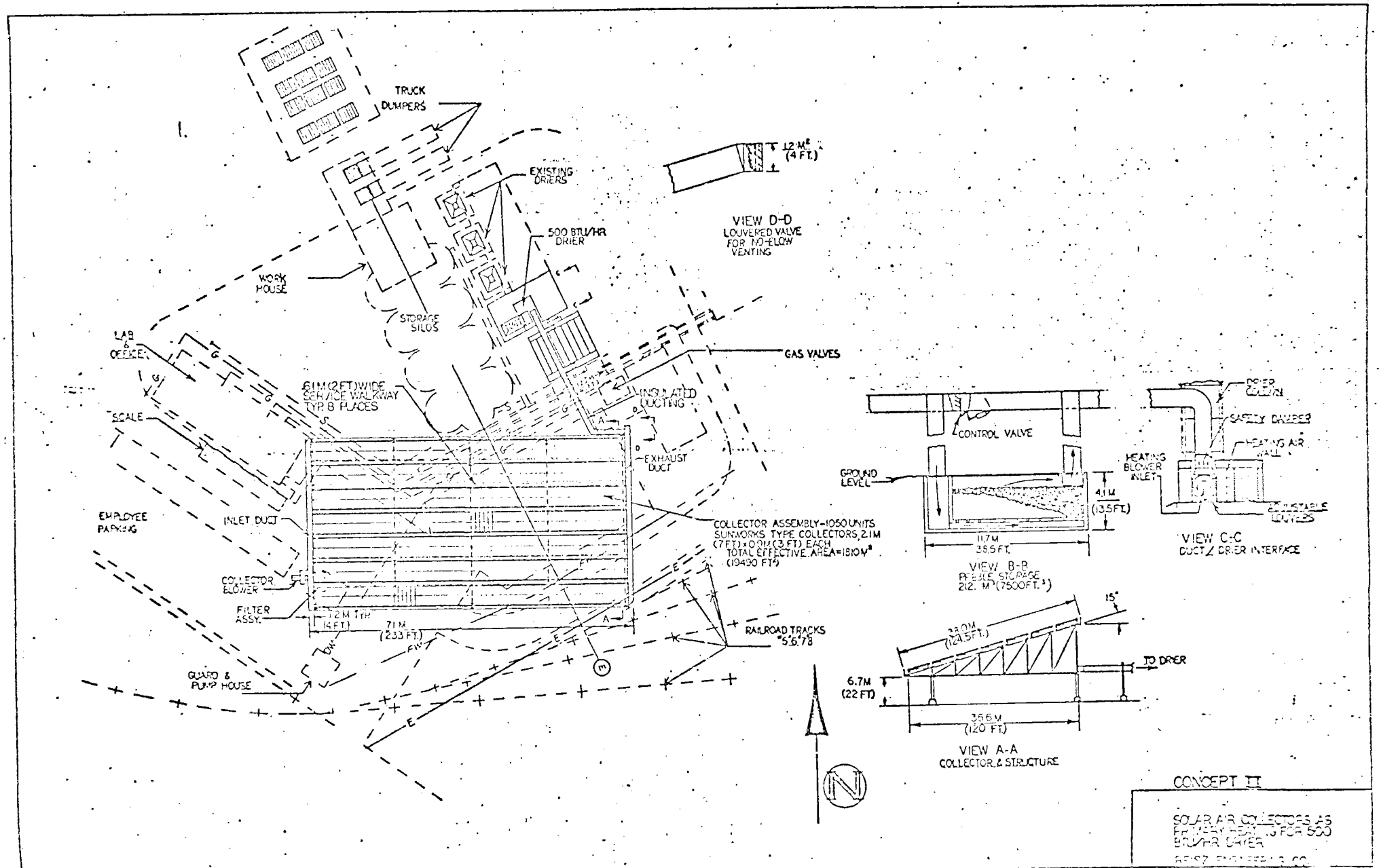

TRUCK DUMPERS
EXISTING DRIERS
500 BTU/HR DRIER
WORK HOUSE
STORAGE SILOS
LAB & OFFICE
SCALE
EMPLOYEE PARKING
INLET DUCT
COLLECTOR BLOWER
FILTER ASSY.
GUARD & PUMP HOUSE
GAS VALVES
INSULATED DUCTING
EXHAUST DUCT
COLLECTOR ASSEMBLY-1050 UNITS SUNWORKS TYPE COLLECTORS, 2.1M (7FT)x0.9M(3 FT) EACH TOTAL EFFECTIVE AREA=1810M² (19490 FT²)
RAILROAD TRACKS
VIEW D-D
LOUVERED VALVE FOR NO-FLOW VENTING
CONTROL VALVE
GROUND LEVEL
VIEW B-B
PEBBLE STORAGE
212. M³(7500FT.³)
HEATING BLOWER INLET
SAFETY DAMPER
HEATING AIR INLET
VIEW C-C
DUCT / DRIER INTERFACE
TO DRYER
VIEW A-A
COLLECTOR & STRUCTURE
CONCEPT II
SOLAR AIR COLLECTORS AS PRIMARY HEATING FOR 500 BU/HR DRYER

FIGURE 2-4

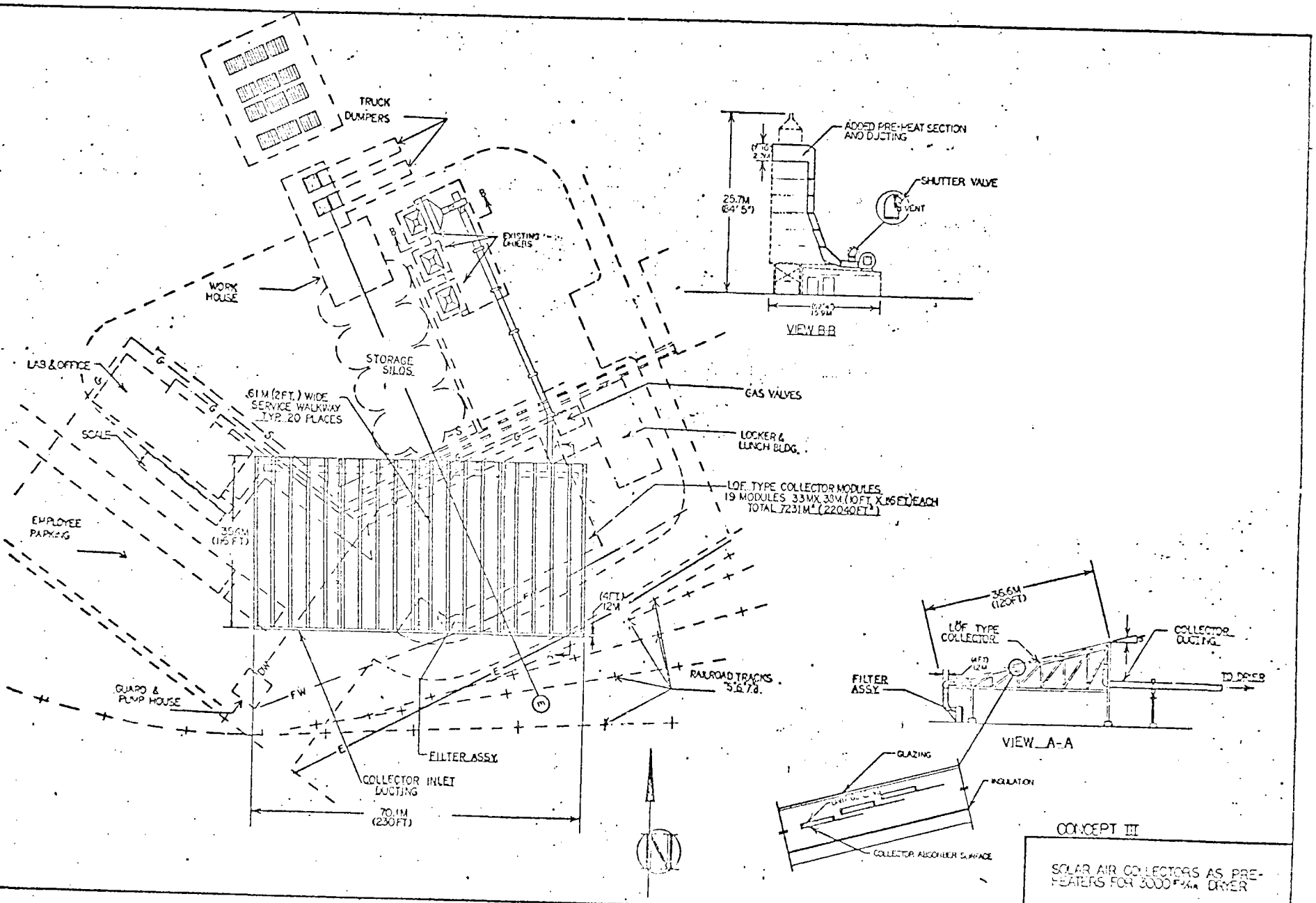

TRUCK DUMPERS
EXISTING DRYERS
WORK HOUSE
LAB & OFFICE
STORAGE SILOS
.61 M (2 FT.) WIDE SERVICE WALKWAY TYP. 20 PLACES
SCALE
GAS VALVES
LOCKER & LUNCH BLDG.
LOF TYPE COLLECTOR MODULES 19 MODULES 3.3M X 3.3M (10 FT X 10 FT) EACH TOTAL 723 M² (2204 SQ FT)
EMPLOYEE PARKING
35.6M (115 FT.)
(4FT.) 1.2M
RAILROAD TRACKS STD.
GUARD & PUMP HOUSE
FW
FILTER ASSY.
COLLECTOR INLET DUCTING
70.1M (230 FT)
ADDED PRE-HEAT SECTION AND DUCTING
SHUTTER VALVE
VENT
25.7M (84' 5")
VIEW B-B
35.6M (120FT)
LOF TYPE COLLECTOR
COLLECTOR DUCTING
FILTER ASSY.
TO DRYER
VIEW A-A
GLAZING
INSULATION
COLLECTOR ABSORBER SURFACE
CONCEPT III
SOLAR AIR COLLECTORS AS PRE-HEATERS FOR 3000 FPM DRYER

FIGURE 2-5

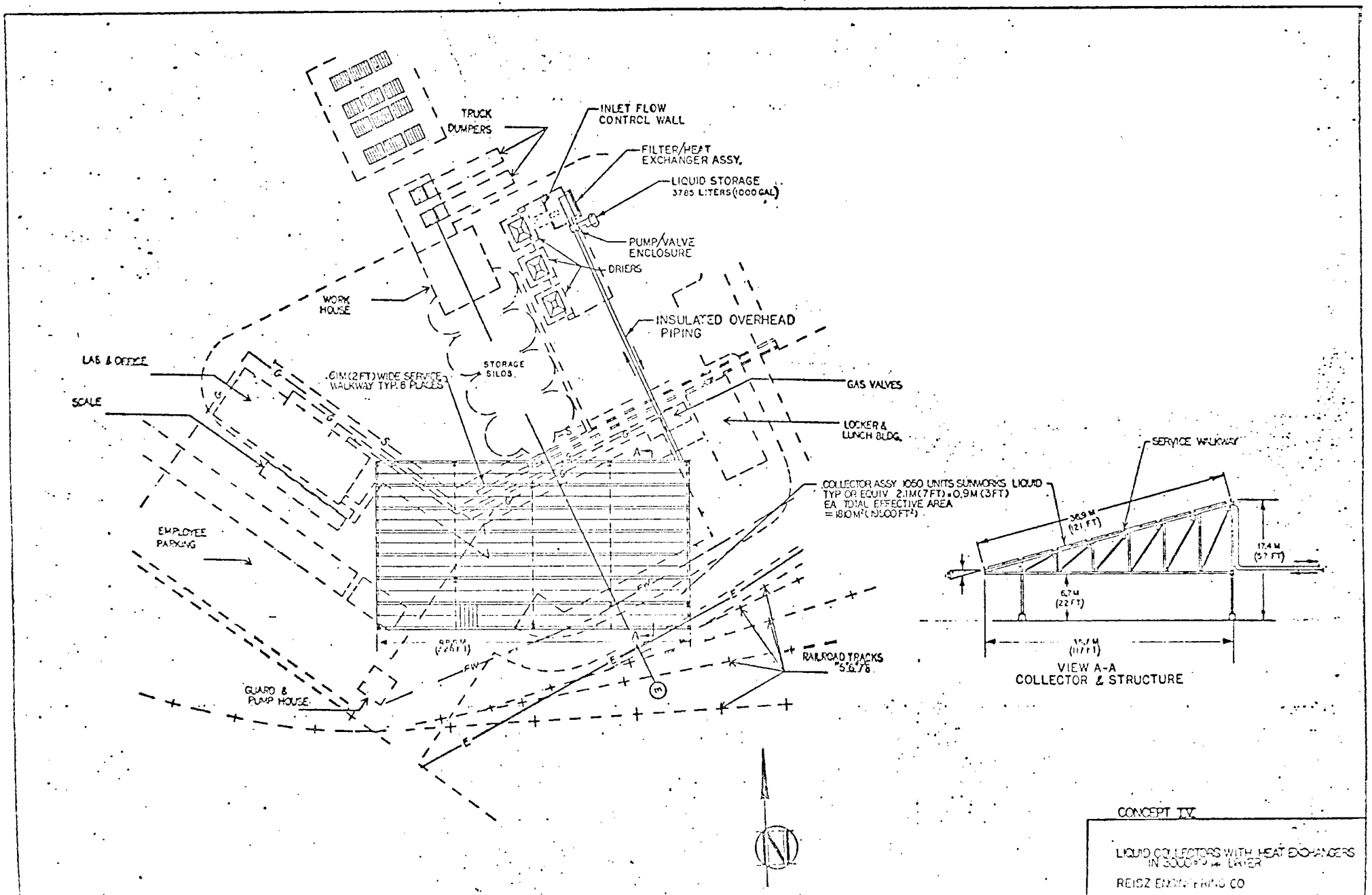

TRUCK DUMPERS
INLET FLOW CONTROL WALL
FILTER/HEAT EXCHANGER ASSY.
LIQUID STORAGE 3785 LITERS (1000 GAL)
PUMP/VALVE ENCLOSURE
DRIERS
WORK HOUSE
INSULATED OVERHEAD PIPING
LAB & OFFICE
SCALE
.61M (2 FT) WIDE SERVICE WALKWAY TYP. 8 PLACES
STORAGE SILOS
GAS VALVES
LOCKER & LUNCH BLDG.
COLLECTOR ASSY. 1050 UNITS SUNWORKS LIQUID TYP OR EQUIV. 2.1M (7FT) • 0.9M (3FT) EA. TOTAL EFFECTIVE AREA = 1810 M² (19,500 FT²)
EMPLOYEE PARKING
RAILROAD TRACKS "S.G."
GUARD & PUMP HOUSE
SERVICE WALKWAY
36.9 M (121 FT)
17.4 M (57 FT)
6.7 M (22 FT)
VIEW A-A
COLLECTOR & STRUCTURE
CONCEPT IV
LIQUID COLLECTORS WITH HEAT EXCHANGERS IN SOLID STATE LAYER
REISZ ENGINEERING CO

FIGURE 2-6

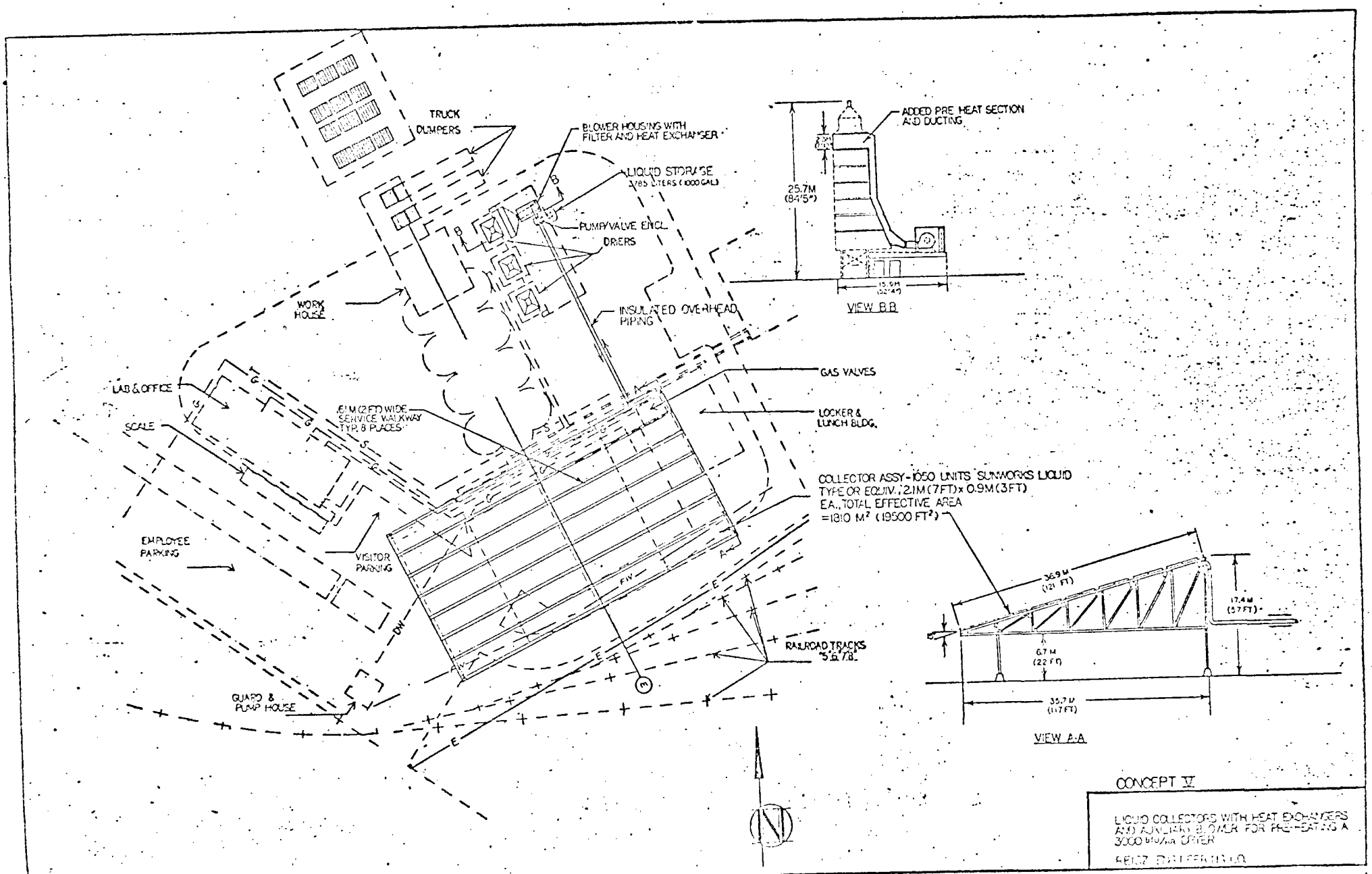

TRUCK DUMPERS
BLOWER HOUSING WITH FILTER AND HEAT EXCHANGER
LIQUID STORAGE 378.5 LITERS (100 GAL)
PUMP/VALVE ENCL.
DRIERS
WORK HOUSE
INSULATED OVERHEAD PIPING
LAB & OFFICE
SCALE
0.9M (3 FT) WIDE SERVICE WALKWAY TYP. 8 PLACES
GAS VALVES
LOCKER & LUNCH BLDG.
EMPLOYEE PARKING
VISITOR PARKING
QUARD & PUMP HOUSE
RAILROAD TRACKS STD. GAGE
COLLECTOR ASSY - 1050 UNITS SUNWORKS LIQUID TYPE OR EQUIV., 2.1M (7FT) x 0.9M (3FT) EA., TOTAL EFFECTIVE AREA = 1810 M² (19500 FT²)
ADDED PRE HEAT SECTION AND DUCTING
25.7M (84'5")
VIEW B-B
36.9 M (121 FT)
17.4 M (57 FT)
6.7 M (22 FT)
35.7 M (117 FT)
VIEW A-A
CONCEPT V
LIQUID COLLECTORS WITH HEAT EXCHANGERS AND AUXILIARY BLOWER FOR PRE-HEATING A 3000 lb/hr DRYER

FIGURE 2-7

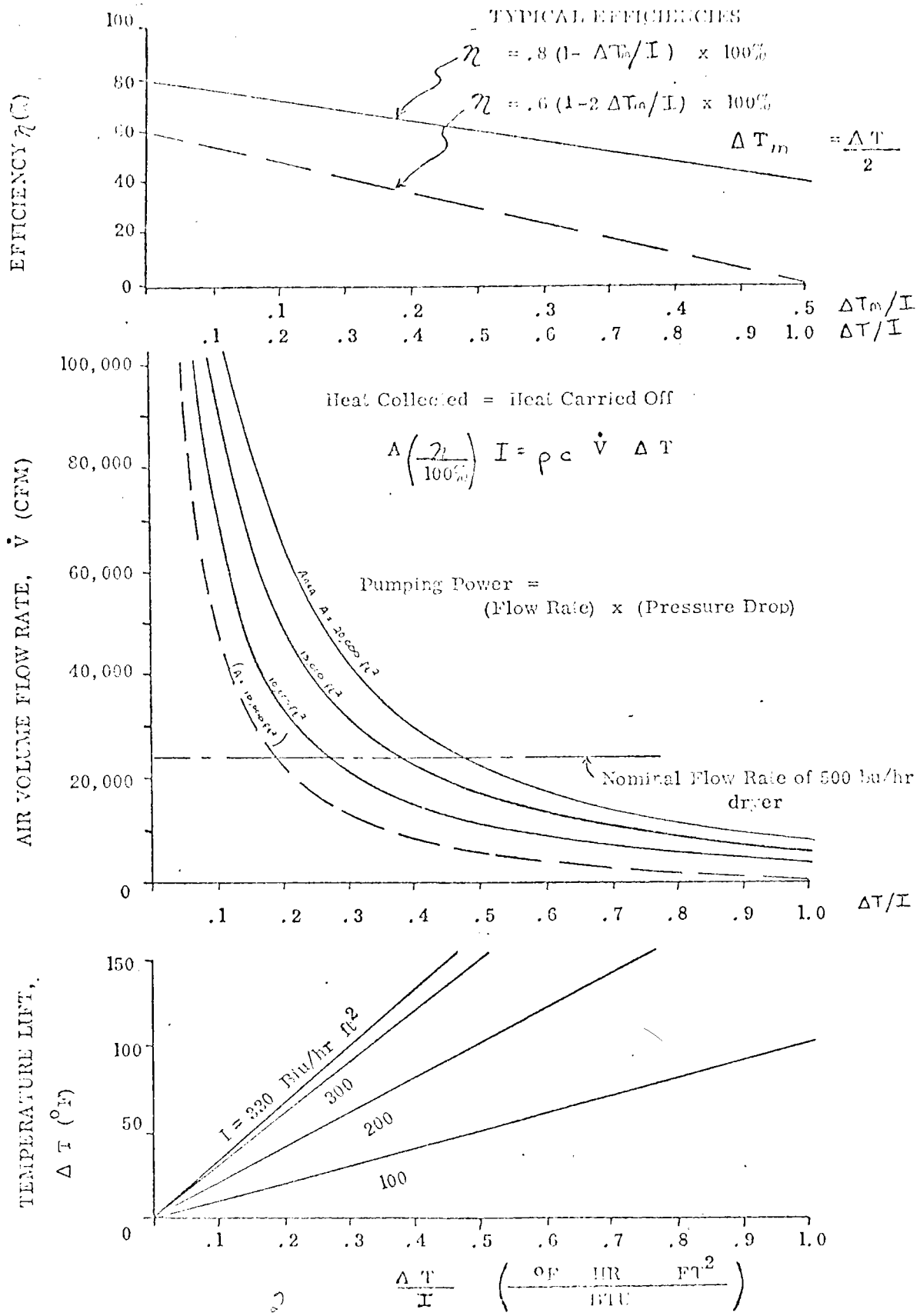


Figure 2-8 COLLECTOR PERFORMANCE CURVES

3. PLANNED ACTIVITY

3.1 During the next reporting period a comprehensive analysis of the five conceptual designs defined during Task 2 will be conducted to determine the two most promising designs. Such merit parameters as solar effectiveness, impact upon the existing facility, applicability to the drying of grains other than soybeans, producibility, reliability, operability and maintainability will be considered. Cost will be a dominant factor. The relative uncertainties, risks and implications associated with each design will be identified.

3.2 Planned costs and manhour loadings for the next reporting period are shown in Figure 2.2.

4. PROBLEMS ENCOUNTERED

No significant problems have been encountered.

5. ACTIONS REQUIRED BY ERDA

The problem identified in Progress Report No. 1 has been satisfied.

6. VISITORS

DATE	PERSON/OFFICE	PURPOSE OF VISIT
July 20, 1976	Mr. William Cherry ERDA, Washington	Program Review
	Mr. Jerry Blevins ERDA, Oak Ridge	Program Review
July 23, 1976	Mr. Henry Kirkwood Ferrell-Ross Company Saginaw, Michigan	Discuss Dryer Modifications