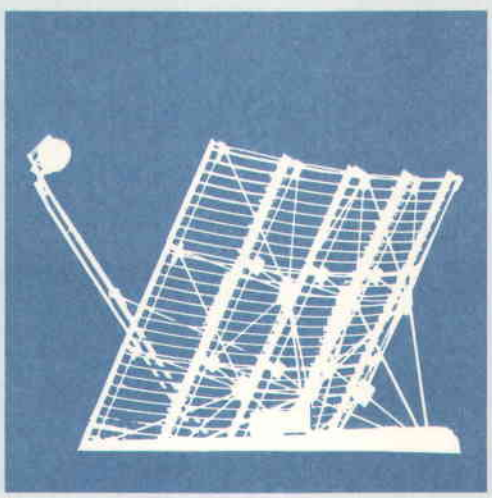
2051

53



P O W E R   K I N E T I C S ,   I N C .

1223 Peoples Ave., Troy, NY 12180, (518) 271-7743

POWER KINETICS, INC.

SMALL COMMUNITY SOLAR EXPERIMENTS

NUMBER DE-PN04-84AL25034

PHASE I ENGINEERING REPORT

TABLE OF CONTENTS

INTRODUCTION

This is a description of the design work undertaken for the Small Community Experiment to modify the PKI Square Dish in order for it to be able to power a Barber Nichols Organic Rankine Turbine/Alternator. Task 1, the construction of a scale model was completed prior to the contract and is not included in this report.

Task 2: TRACK

The track is a structure located at the base of the primary concentrator which transfers the force loads into the foundation while permitting the concentrator to rotate as it acquires and follows the sun. The track is composed of a built up ring-shaped boxbeam structure connected to an inner hub by means of 8 (spoke) members. See Figure 1. All members are A-36 steel with a galvanized coating. The ring is supported on 8 caster wheels attached to 8 individual steel piers located at octagonal points on the ring diameter below it. The central hub is supported on a ninth pier located at the center of the ring. See also Task 16: Foundation/Pier design page 39. The hub is designed to accommodate all lateral loads.

The size and design of the track is similar to that used in previous applications but with slight modifications to accommodate greater loads and a different (25°) bank angle of the concentrator face.

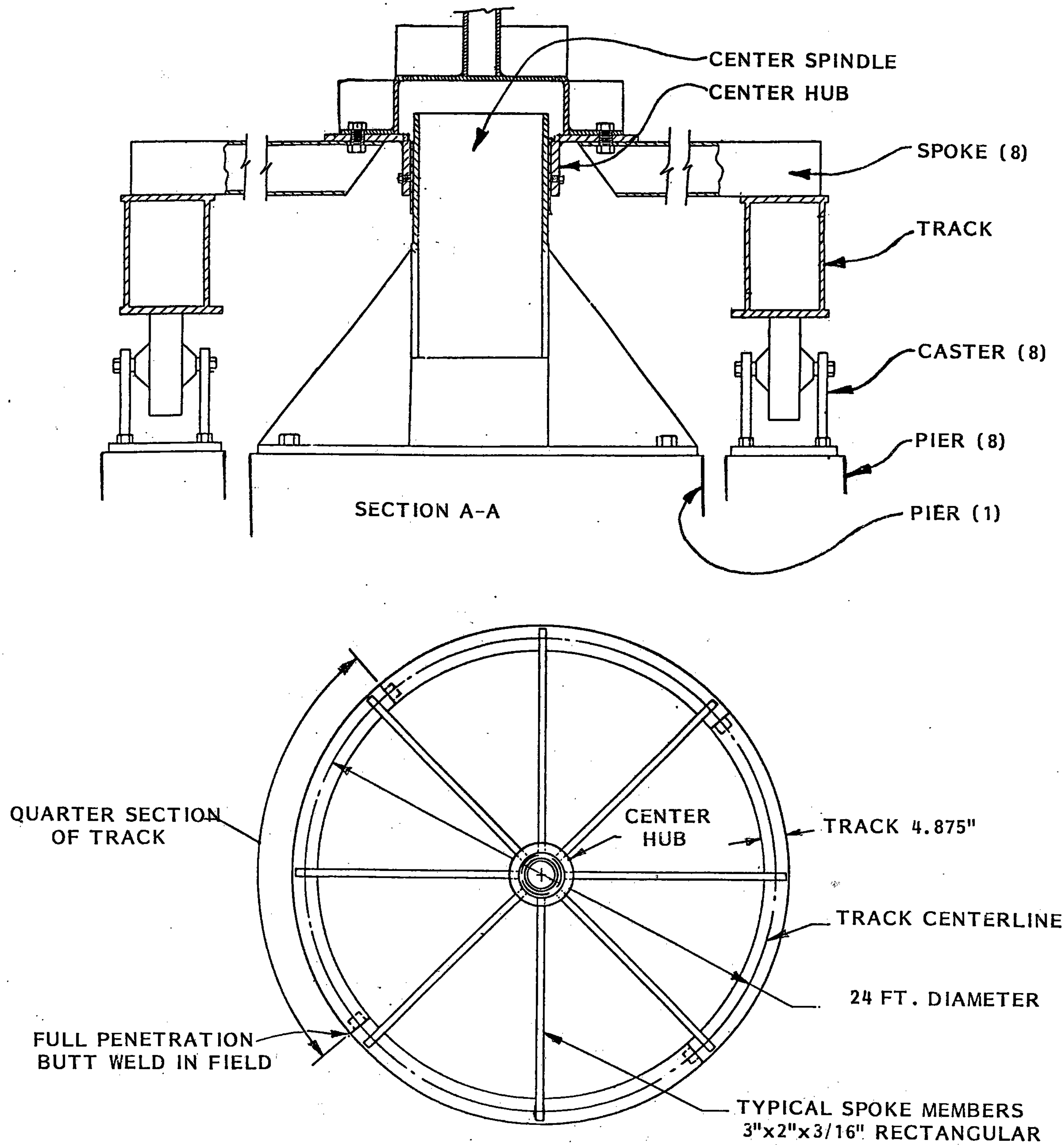


FIGURE 1: TRACK DETAILS

Task 3: STRUCTURE

The primary support structure for the Mirror Assemblies is a galvanized steel articulated spaceframe similar to that used in a previous application. It has been modified, however, to contain 141 tubular members and 43 joints. Some of the members have been increased in size and two members have been added to support the increased loadings applied by the engine at the focus. The spaceframe has four bays and is four tiers high and measures 35'4" x 42'8". See Figure 2.

A secondary support structure is attached to the spaceframe to carry the loads from the mirrors to the frame. Bearings which are incorporated in the mirror support beams are supported by this secondary structure so as to permit the rotation of the mirrors.

The mirror support beams (Mirror Assemblies) extend from the center of the spaceframe to the outer edge and, in half of the cases, cantilever over the outer edge of it. See Figure 3. As mentioned above, these beams, which hold the mirrors, rotate during the elevation tracking of the sun and return to an inverted stow when the machine is not operating. It can also be manually switched to "RAINWASH" which turns the mirrors to the proper attitude for this function.

The spaceframe itself is bolted to a track at points coincident with the spokes in such a way as to produce a 25° angle between the face of the spaceframe and the axis of rotation through the hub. The track, in turn, is designed to be oriented at a 15° angle from the horizontal. This results is a 40° angle between the face normal of the concentrator and the horizon when the concentrator is facing south.

Task 4: STRUCTURAL ANALYSIS

The structure has been analyzed for seismic loading, overturning, and stress loadings under the conditions of: dead load only, dead load together with wind at 100 mph with the mirrors stowed, dead load together with wind at 40 mph in the operating mode, and for the special condition when the concentrator is facing north and the engine is raised and lowered. See Figure 4.

Maximum stress conditions which occur during the last of these modes, require that certain members of the concentrator frame be increased in size and that two new members be added. Bolt connections must also be modified in some cases. Overturning is also critical in this mode and requires that a restraining load be incorporated into the rear area of the track. This will be accomplished with the addition of a concrete floor in that area.

Mirror stresses due to concavity are in the order of 300 psi and do not pose a problem.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

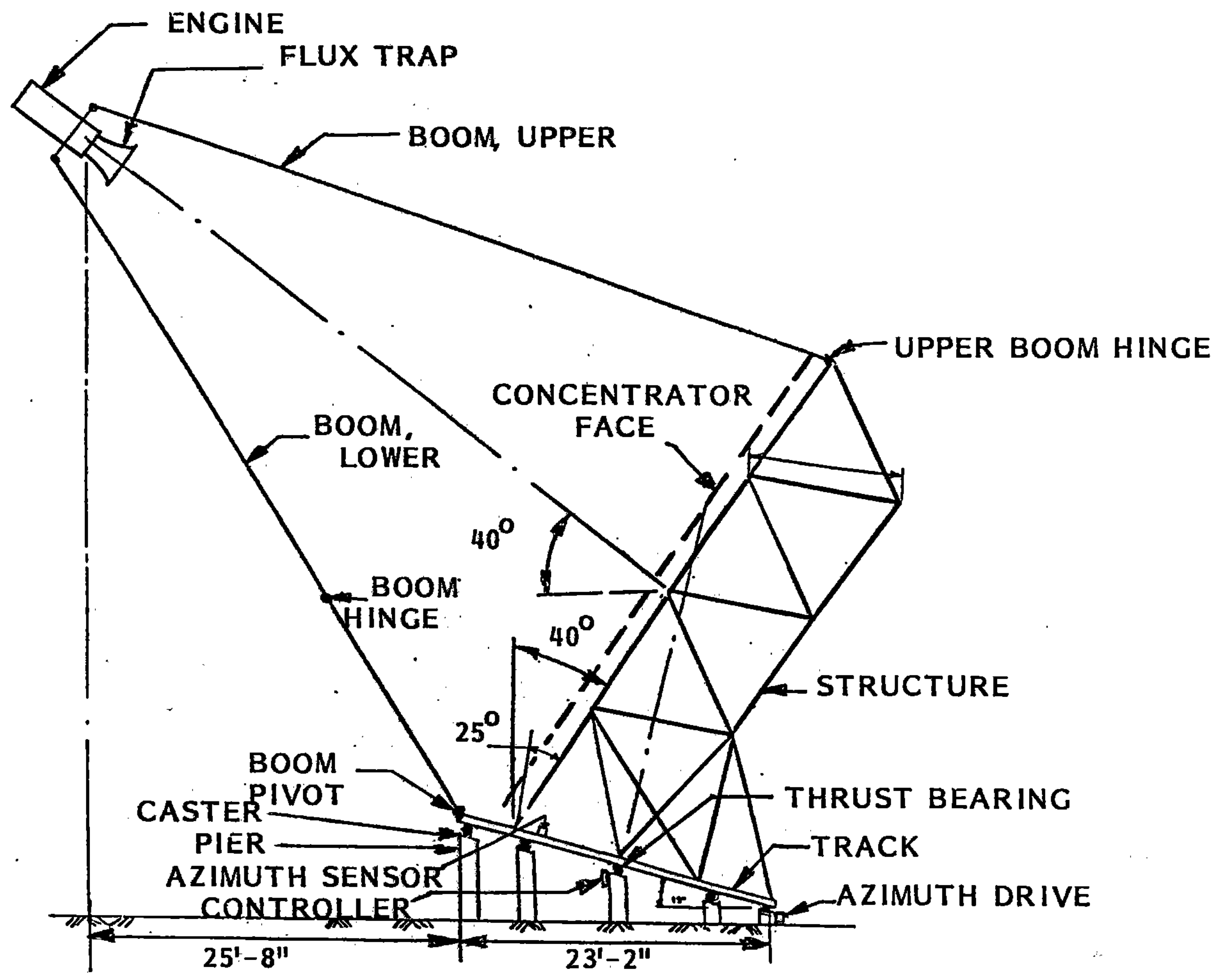


FIGURE 2: PKI SQUARE DISH CONFIGURED FOR B-N ENGINE

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

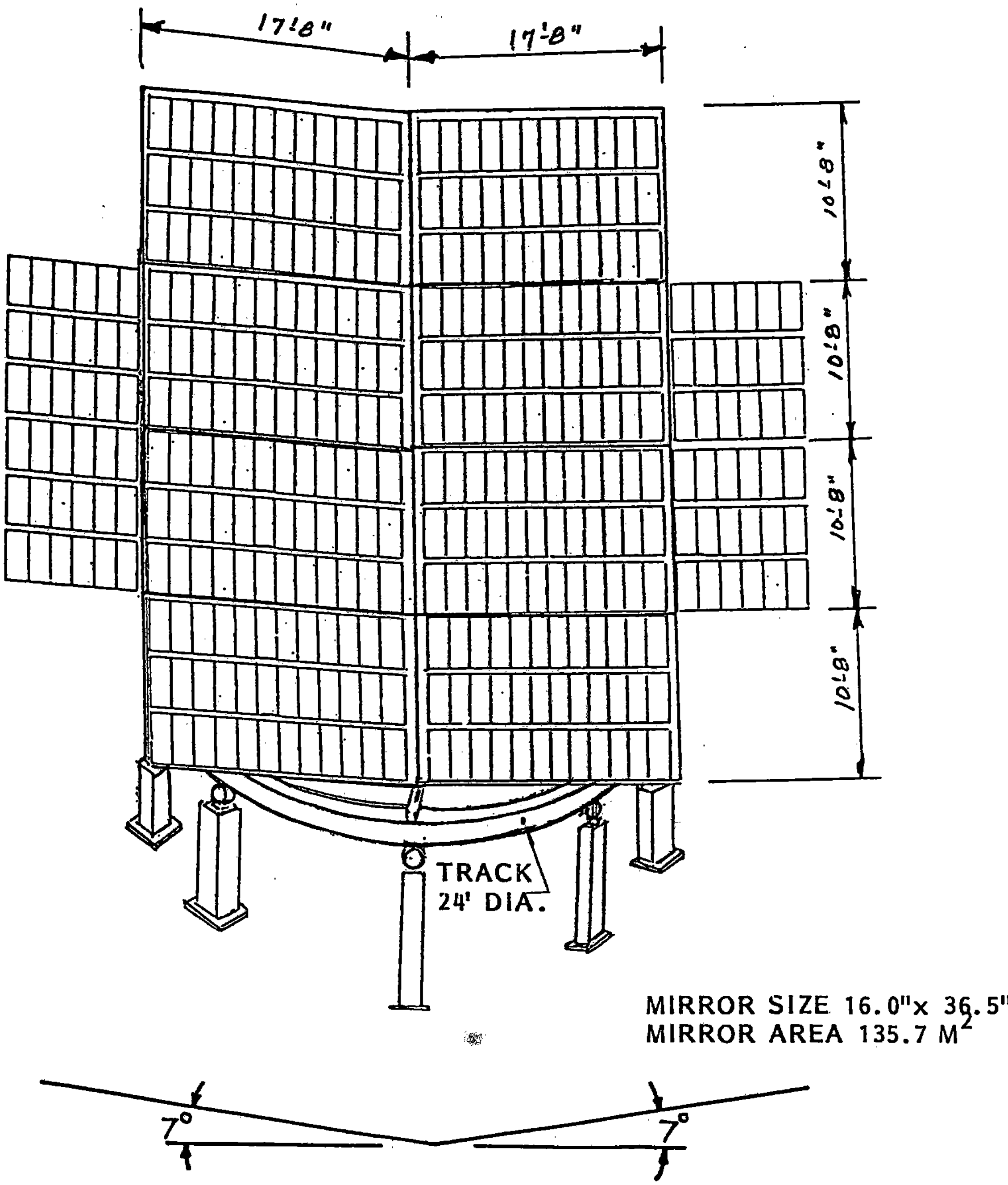


FIGURE 3: FACET ARRANGEMENT

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

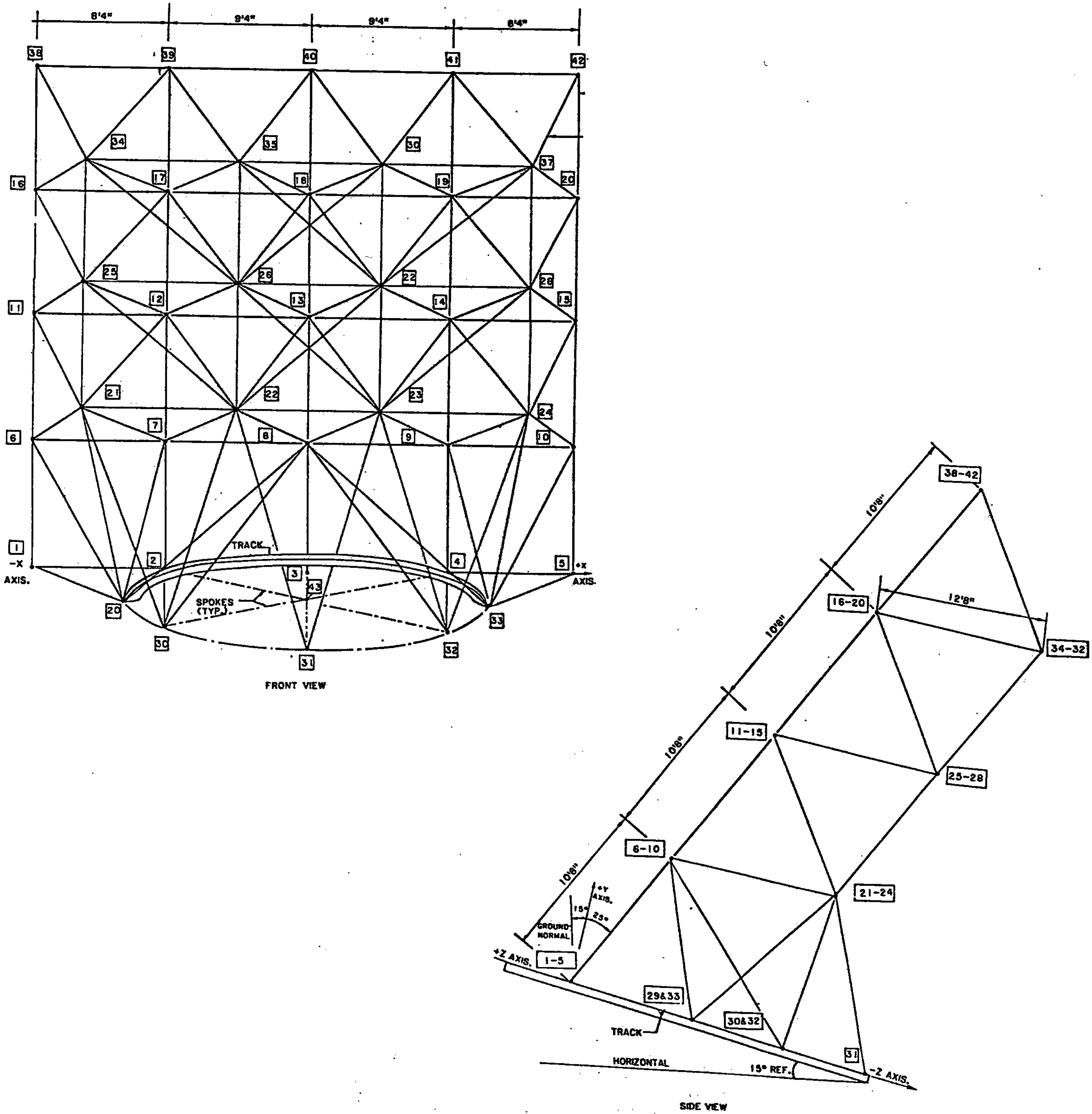


FIGURE 4: MAIN SUPPORT STRUCTURE, JOINT NOMENCLATURE

Task 5: ELEVATION DRIVE/DRAGLINK ASSEMBLY

Development of the 130M² enhanced size of the PKI 80M² Square Dish involves three aspects which establish the design of the Mirror Drive mechanism:

1. The enhanced width of the concentrator requires the development of a Mirror Assembly through which torque can be transmitted to forestall the addition of more elevation drive units.

2. The greater focal length of the machine (54 ft from 38 ft) along with the reduced receiver aperture (15 in. diameter from 24), requires more precise pointing accuracy (0.8 milliradians from 2).

3. Development of a Mirror Assembly technology, which allows torque to be transmitted from end to end without introducing intolerable deflections allows consolidating the two elevation drive units into one along the center line of the concentrator. This technology improves reliability and reduces parts count, parasitic power and maintenance. This task also includes the design of both the driven end and supported end of the Mirror Assemblies, their bearings and their attachment to the structure with required adjustable connections.

A. SIZE-SPACING

The geometry of the Square Dish structure establishes the vertical dimensions for various widths of Mirror Assemblies listed in Table I.

TABLE I:

Number/Section	MA width	Free Space	Total Drive Elements Req'd
9	12.0"	2.2"	72
8	13.5"	2.5"	64
7	15.4"	2.9"	56
6	18.0"	3.3"	48
5	21.6"	4.0"	40
4	27.0"	5.0"	32
3	36.0"	6.6"	24
2	54.0"	10.0"	16

Mirror facet and Mirror Assembly technologies have been developed which allow a 36" long facet to produce an image smaller than that produced by a 12 inch square flat mirror at a 54 foot focal length. This allows selection of three Mirror Assemblies per section with the resulting parts/ handling reduction. See Figure 5.

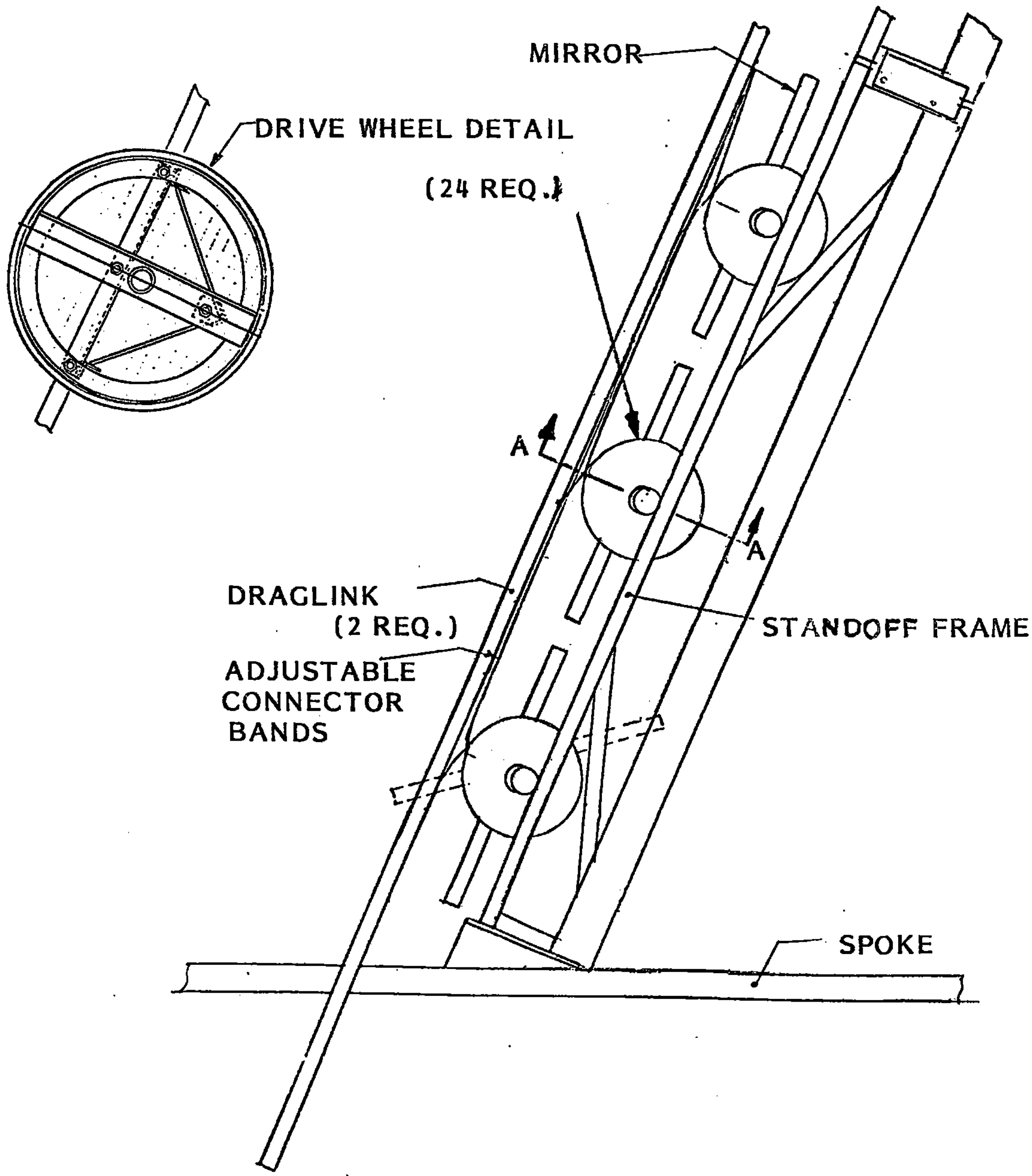


FIGURE 5: ELEVATION DRIVE ASSEMBLY (FOUR SECTIONS REQ.)

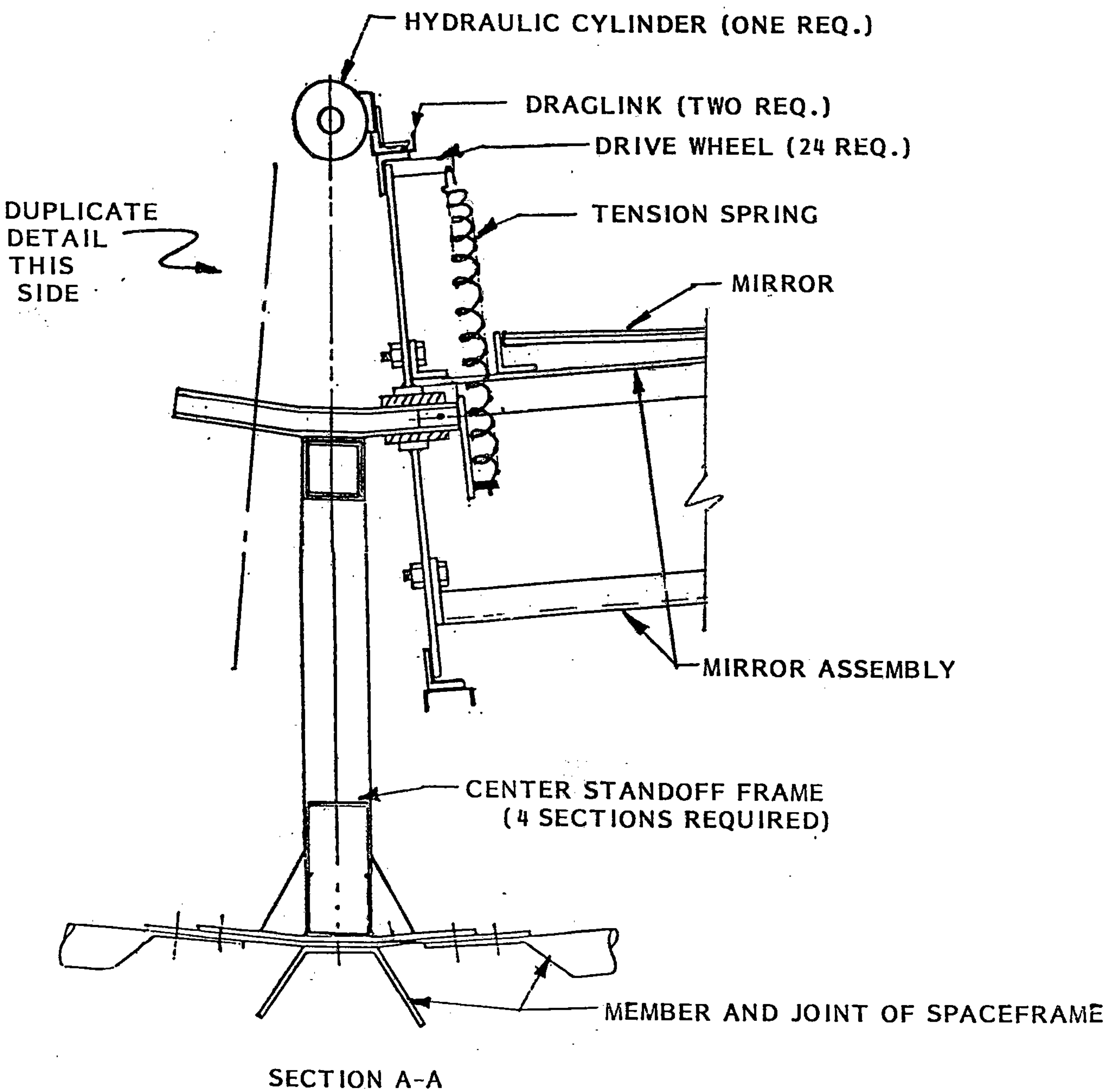


FIGURE 6: ELEVATION DRIVE ASSEMBLY/ INBOARD SUPPORT

B. TORQUE/ANGULAR TOLERANCE

Prior designs used cable/pulley systems that would be inadequate for maintaining, over the long term, tolerances on the order of 0.8 milliradians because of wear and cable stretch. A torsion spring has been used to eliminate backlash as well as help to return the mirrors to the "stow" position in the former design. A similar mechanism is included in this design with a tension spring used to eliminate possible backlash.

C. DRIVE METHOD

The precision of motion allowed by levers/draglinks was under consideration if less than 160° of motion was required between the "stow" and focusing region. The continuing requirement of this altitude/azimuth machine to focus and stow "over-the-top" of the receiver to prevent concentrated energy from focusing on the ground, means that the Mirror Assemblies must rotate 270°. A 20 inch wheel diameter consistent with Mirror Assembly width and hydraulic cylinder throw considerations will be implemented. See Figures 5 and 6. Using side by side metal bands to drive the wheel, one in focus direction and the other going in the other direction (stow), will be used in place of the 1/16" stainless steel cable. Ends will be fastened to the draglink and wheel respectively with a tensioning adjustment/focusing mechanism on the draglink end.

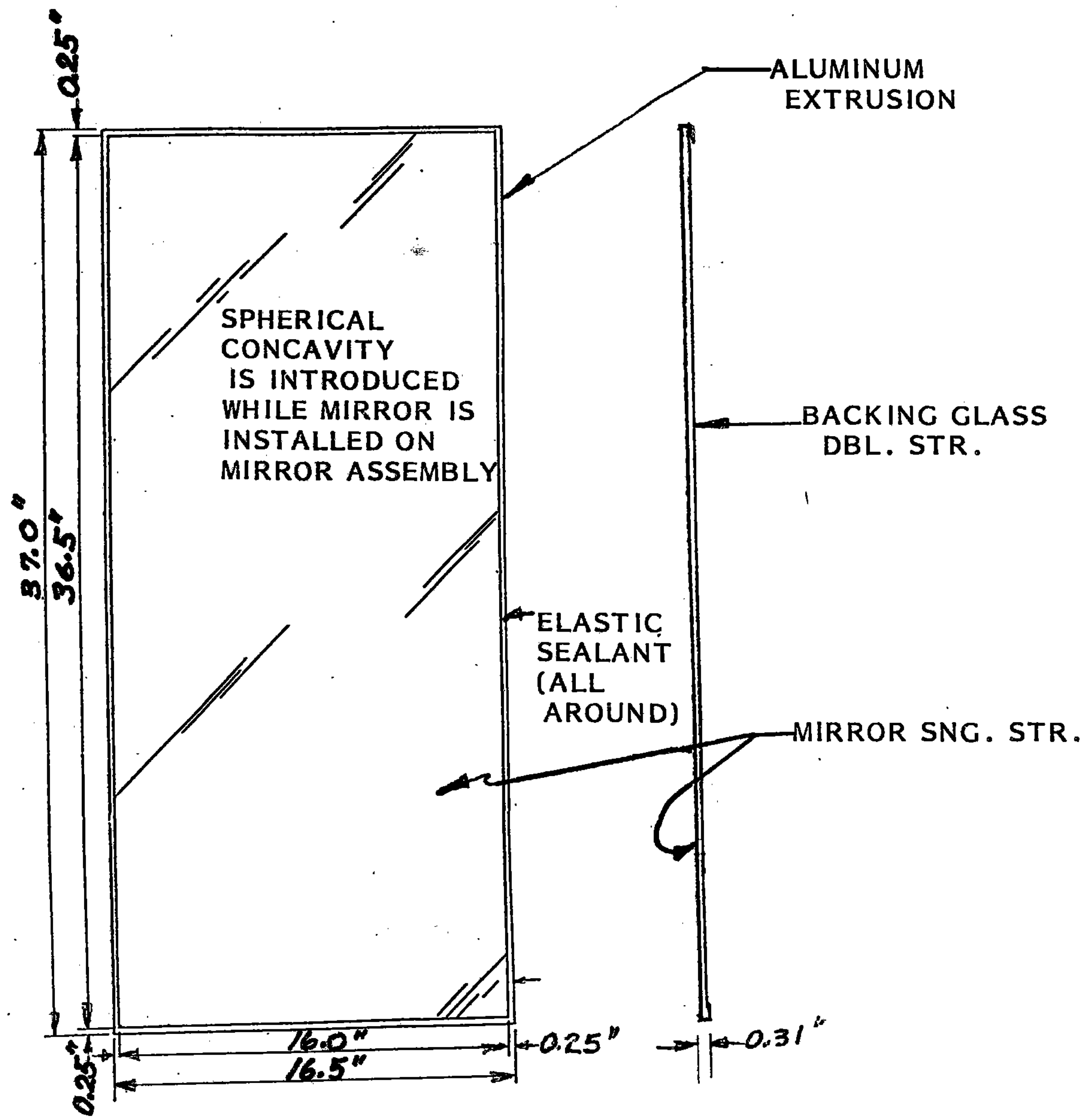
To insure that the Elevation Drive will be able to achieve better than 1 milliradian tolerance, both the drive plate mechanism (universal joint which accommodates the dihedral bank angle) and the field adjustable coupling between the Draglink and Mirror Assemblies, have been eliminated. This has been achieved by attaching each drive wheel to its Mirror Assembly together with the use of adjustable steel bands to connect the Draglink to the drive wheel. The two adjustable connections of the wheel to the Draglink, one for each side of the machine, permit the independent focusing of each side of the concentrator separately. In addition, links will be included halfway up the Draglink to enable upper and lower halves to be independently focused. A single hydraulic actuator will drive the Draglink.

The mirror support beam bearing has been designed. This design permits cantilevered extension of mirrors outside of the concentrator framing, as required for 6 of the 12 rows of mirrors.

Outboard adjustable bearing supports have been integrated with the vertical members which form the left and right edges of the collector. See Figure 11. The design includes a thrust bearing to accommodate axial loads developed in the Mirror Assembly.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS



GLASS SIZE: 16.0"x36.5"

FIGURE 7: MIRROR FACET

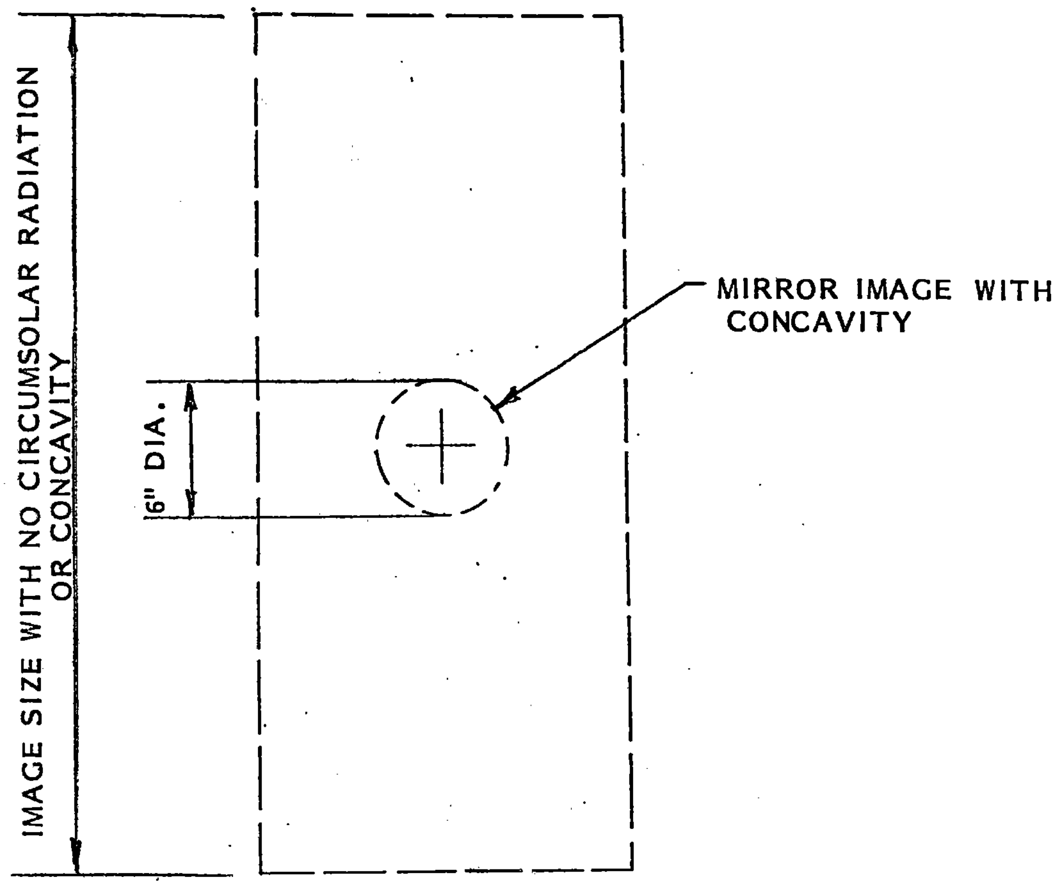


FIGURE 8: SCHEMATIC OF SPHERICAL CONCAVITY

Task 6: MIRROR FACET TECHNOLOGY

The given 15 inch diameter of the receiver aperture has been taken from past work with smaller concentrators. To achieve the performance goals, a laminating technique has been developed which utilizes a thin mirror backed by double strength glass, and edged with an aluminum extrusion. See Figure 7.

Concave mirror facets (nominal size 16" x 36") have been manufactured that when mounted in a mock up of a Mirror Assembly, produce images at the focal point of about 6" in diameter. See Figure 8. However, because of off-axis effects, the improvements brought about by the design, which are evident in the focusing of mirror facets in individual mirror assemblies (step 1) and the focusing of mirror assemblies in the concentrator array (step 2), will be constrained to the limits produced by one foot square flat facets of the same area. The smaller image size of the individual facets however, does permit the tailoring of the image within that envelope so as to bring about an overall improvement in performance. Analysis shows maximum bending stresses in the glass due to concavity of approximately 300 psi. Shear stresses are also minimized by the 2 to 1 ratio of the mirror.

Task 7: MIRROR ASSEMBLY

To support the mirror facets with enough rigidity in both bending and torsional mode, an open web triangular beam has been developed. Prototypes have been fabricated to demonstrate performance in order to arrive at the proper width for the 26 ft length. The open web triangular beam incorporates mounting provisions for laser alignment of the mirror facets, as well as accommodating the connection to the elevation drive wheel and outboard bearings. See Figures 9, 10, and 11.

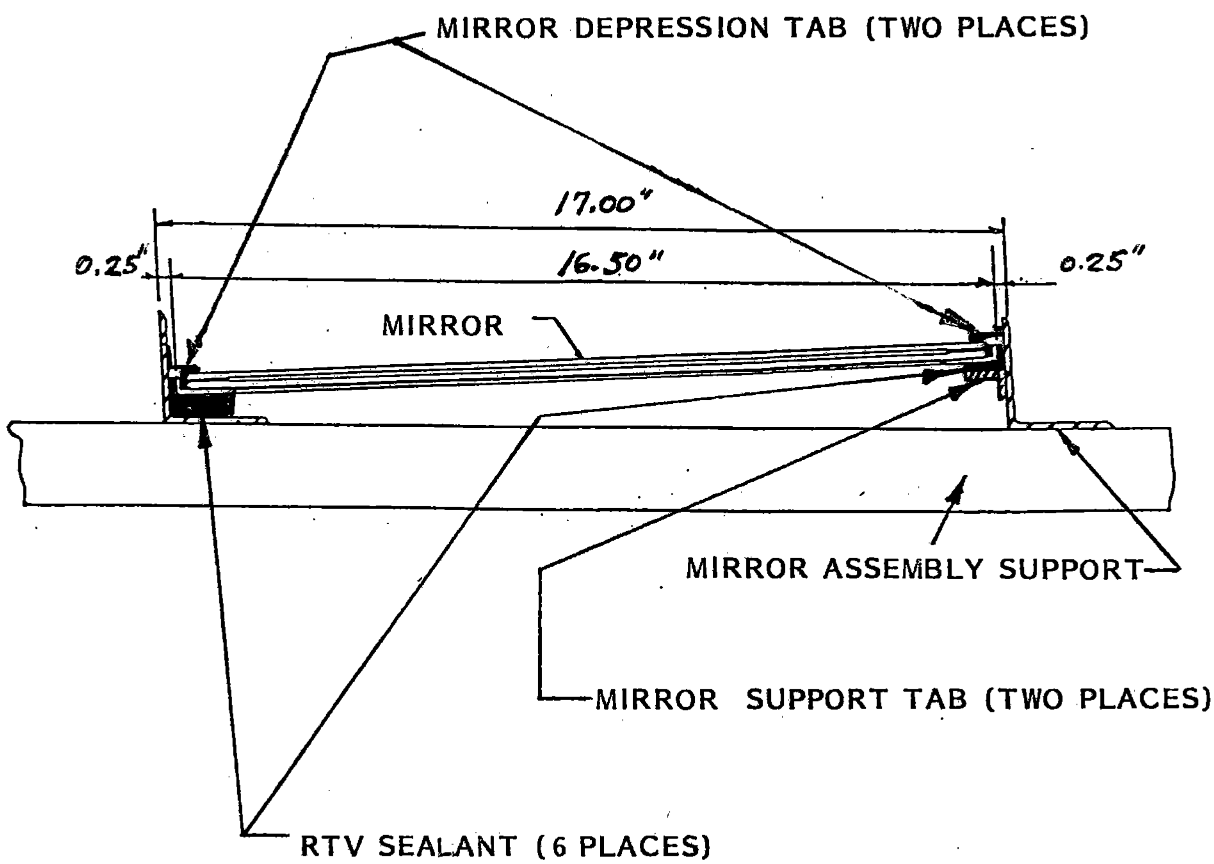


FIGURE 9; MIRROR ASSEMBLY FACET INSTALLATION DETAIL

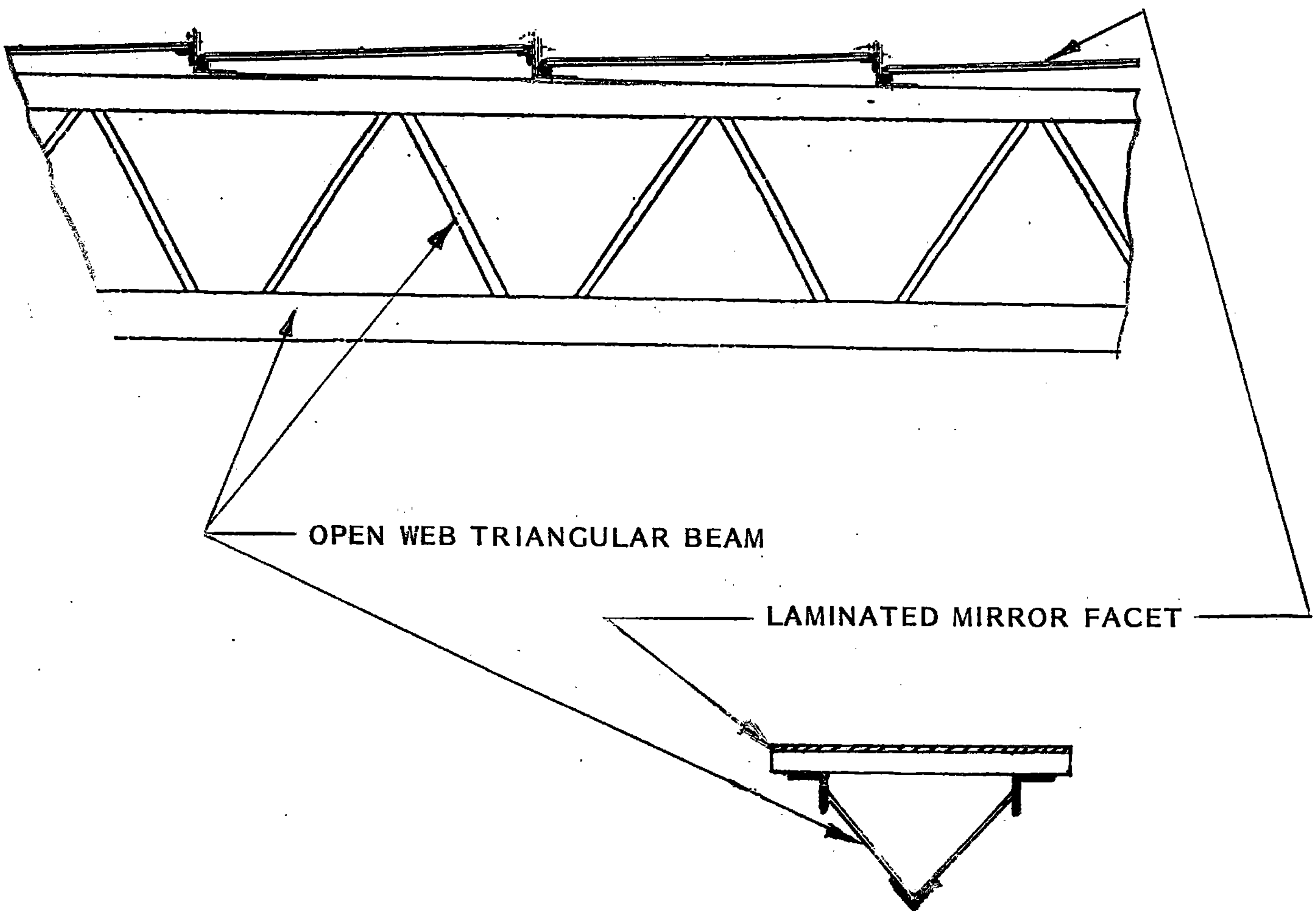


FIGURE 10: MIRROR ASSEMBLY

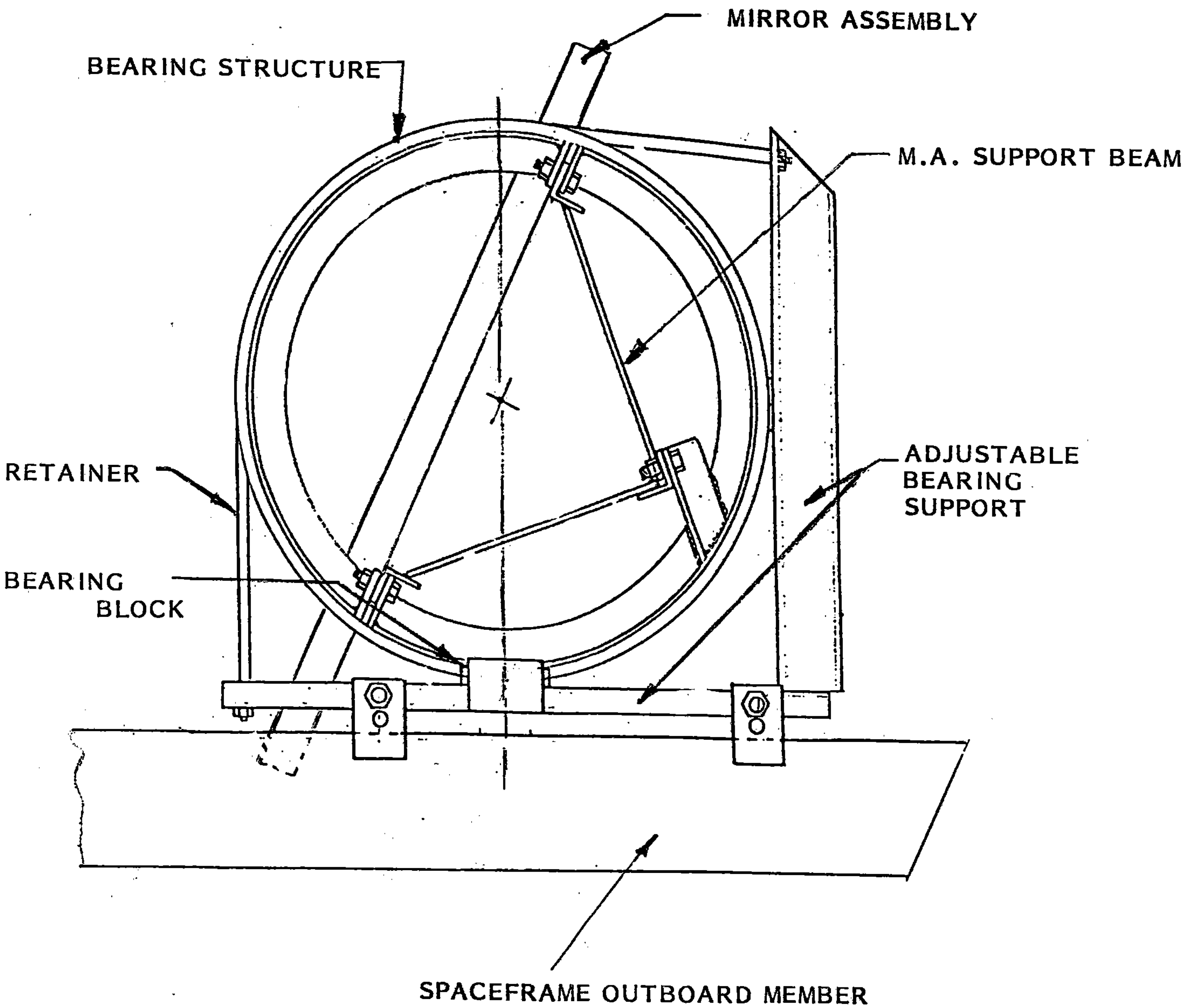


FIGURE 11: MIRROR ASSEMBLY OUTER BEARING

Task 8: FOCUSING TECHNIQUES

The Mirror Assemblies will be focused before being put on the concentrator (step 1). Each mirror will be aligned so that the reflected power will leave the Mirror Assembly at the correct angle. The angle will be determined by the location of a laser beam reflected off each mirror to a target. See Figure 12.

The Mrror Asemblies will be focused with respect to each other after they are attached to the concentrator frame (step 2). See Figure 13.

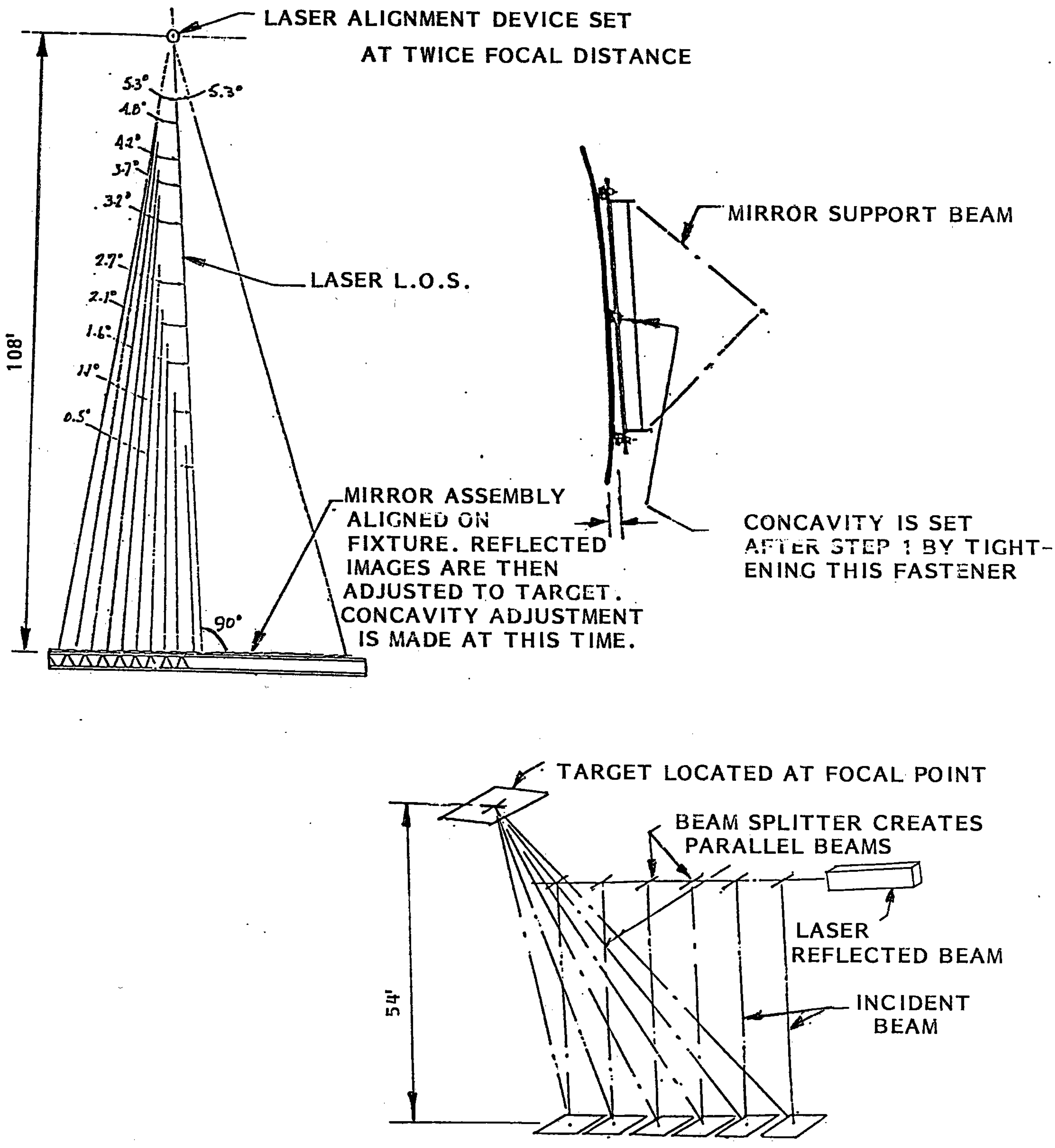
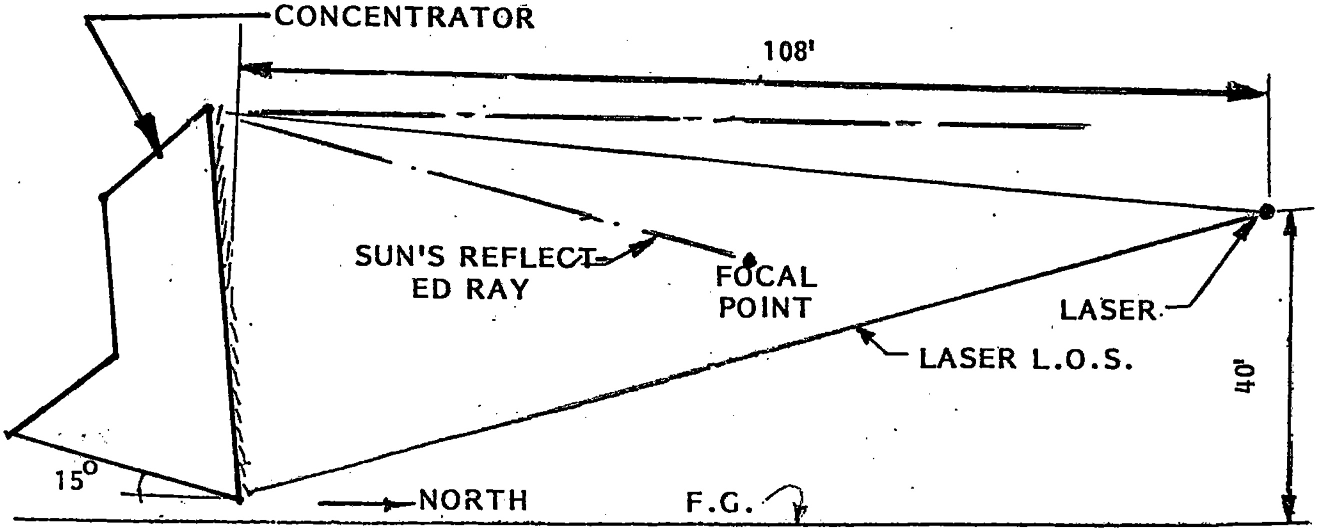


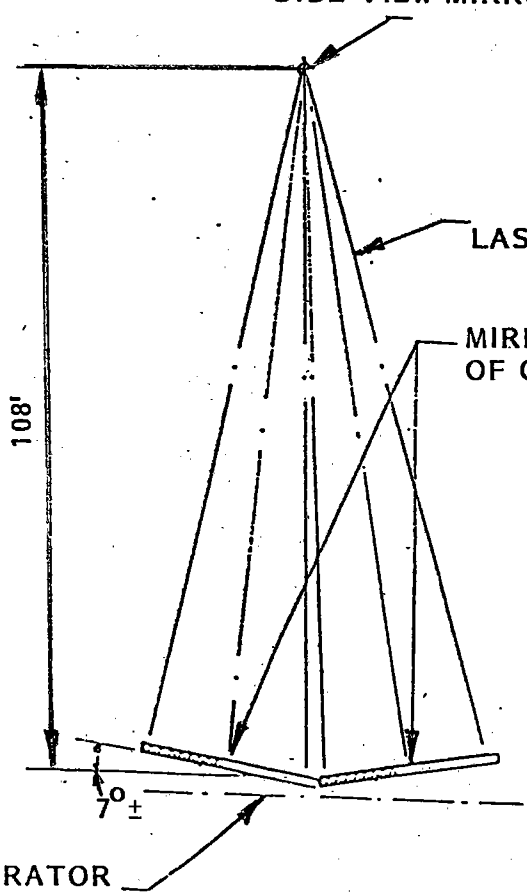
FIGURE 12:MIRROR FOCUSING FIELD PROCEDURE

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS



ORIENTED NORTH TO
MINIMIZE LASER ELEVATION



STEP 2 MAY BE ACCOMPLISHED WITH SUN'S REFLECTED RAY'S BY DIRECTING THEM TO THE FOCAL POINT WHILE THE CONCENTRATOR IS TRACKING

FIGURE 13: MIRROR FOCUSING FIELD PROCEDURES STEP 2

Task 9: SECONDARY CONCENTRATOR

The inner sections forming a hyperbolic trumpet are comprised of small heavy gauge copper plates with large radial outside edges for both mounting and cooling. The sections closest to the receiver will have a larger ratio of cooling fin to reflective surface than those farther out. The surface inside the trumpet will be plated and polished. See Figures 14 and 15.

The outer sections will make a conic frustum. The slope of the conic part will always be larger than the hyperbolic part it replaces, allowing for manufacturing and surface slope errors. The conic frustum requires a greater depth for a given radius since this part will be made out of commercially available electro polished aluminum sheet which cannot be reformed into a complex shape after manufacture.

Task 10: AZIMUTH DRIVE

The azimuth drive will be the same as used in past collectors. Once the center of gravity, its offset from the center of rotation, the total weight, and the power required to move the track on the casters has been established, a gearbox and motor will be specified.

Because the quantification of torque required to operate the azimuth drive is difficult to predict, it has been decided to incorporate oversized components with an integral torque transducer on the prototype. Once the graphs of the torque with the engine in place and during boom lowering have been plotted, proper size of the gear unit, motor and chain will be established for implementation in subsequent units. See Figure 16.

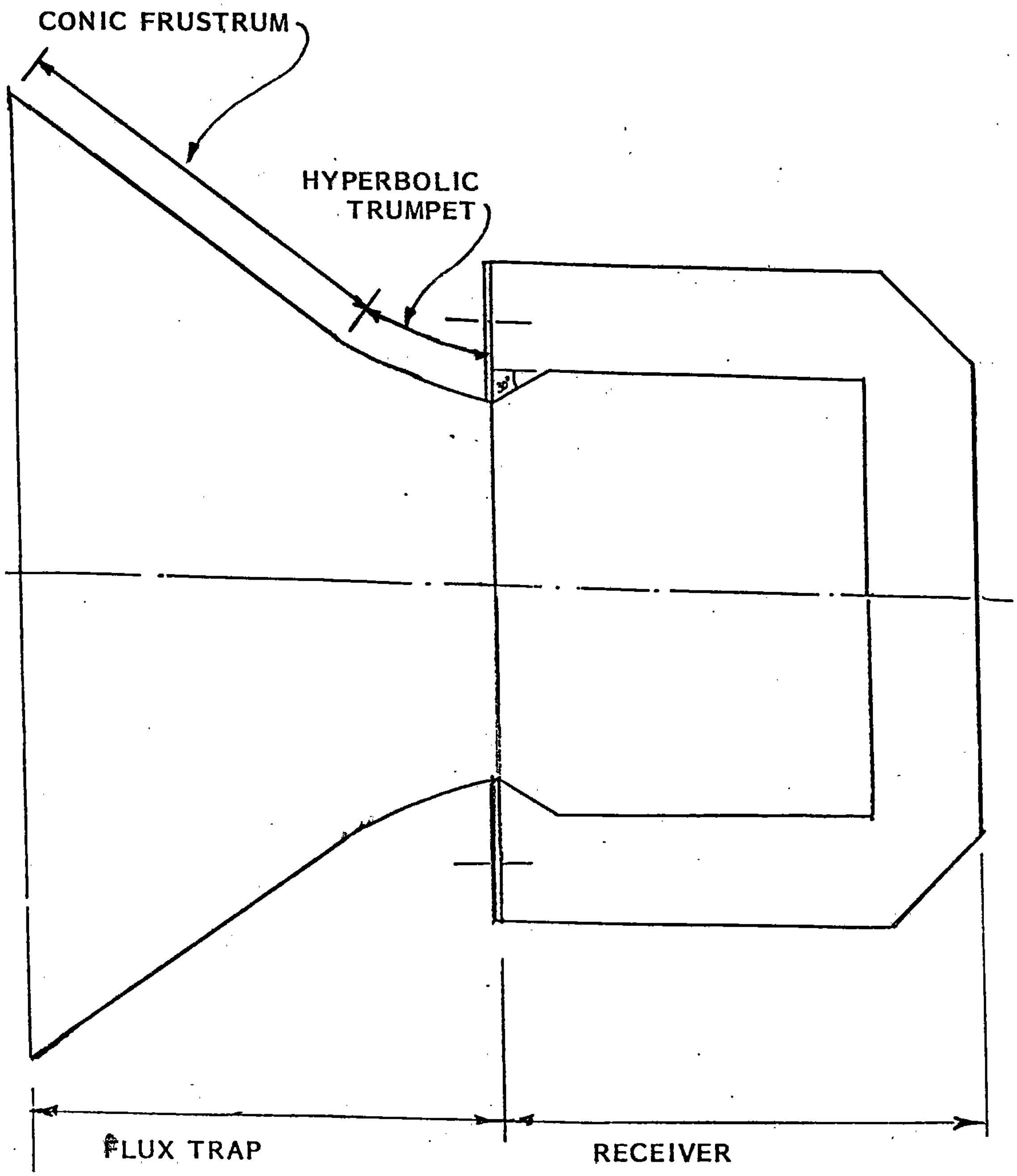


FIGURE 14: FLUX TRAP DESIGN

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

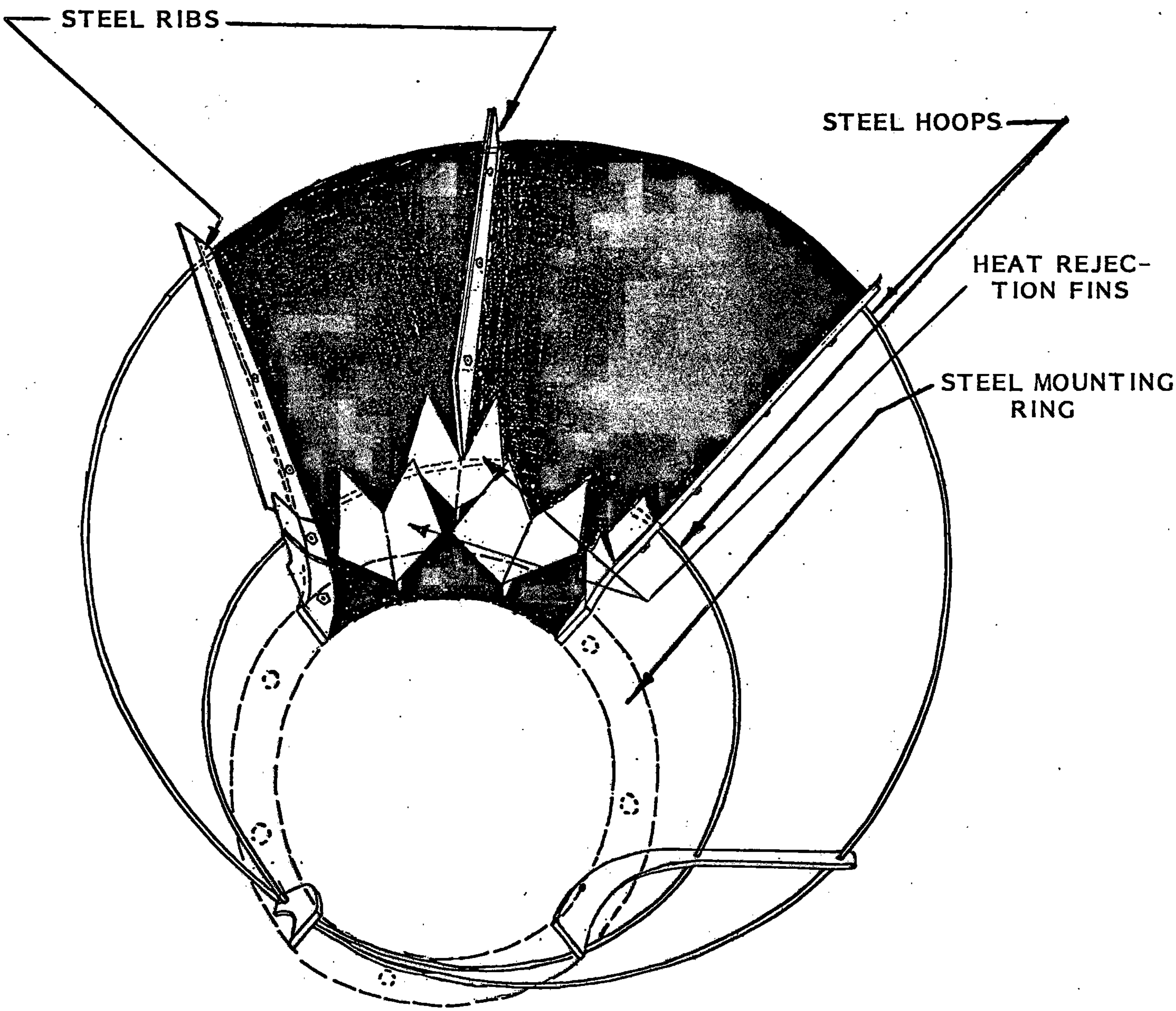
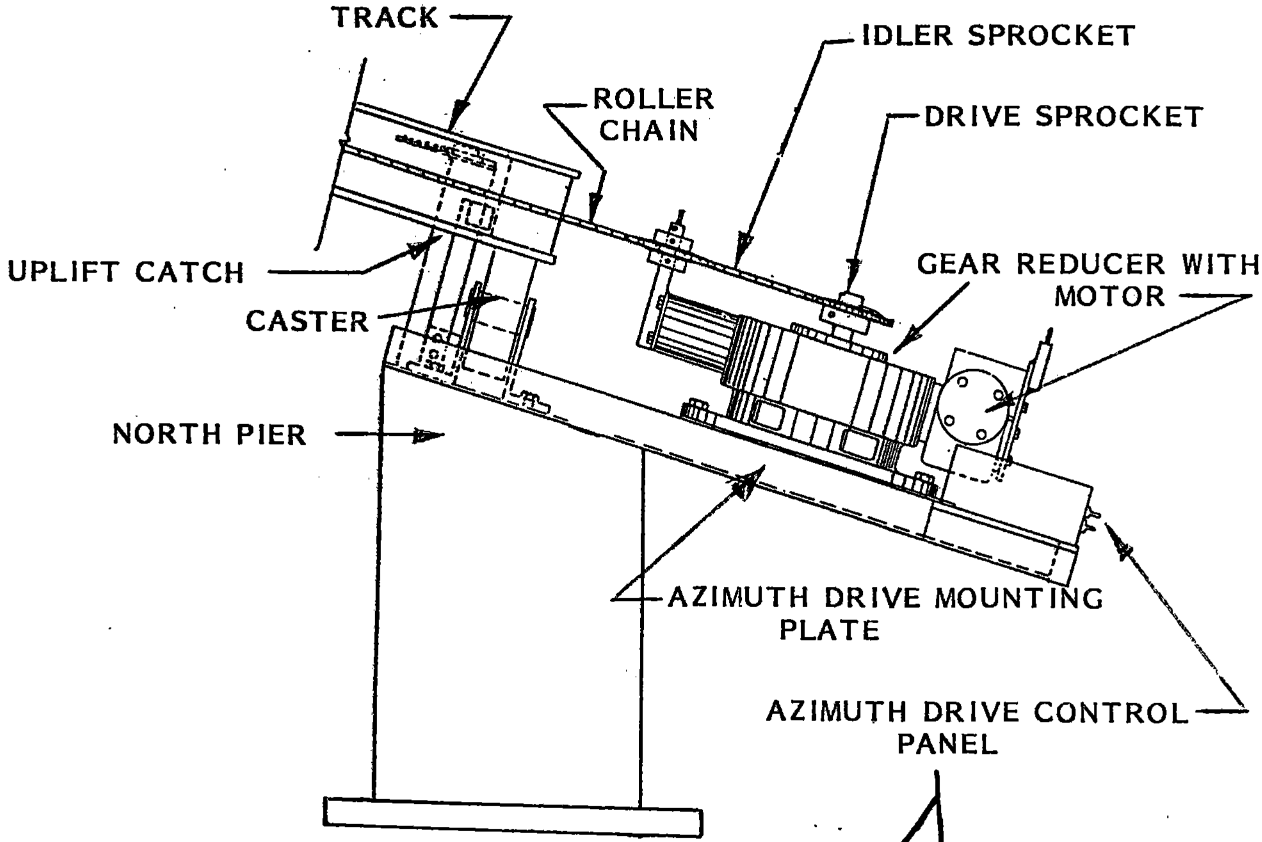


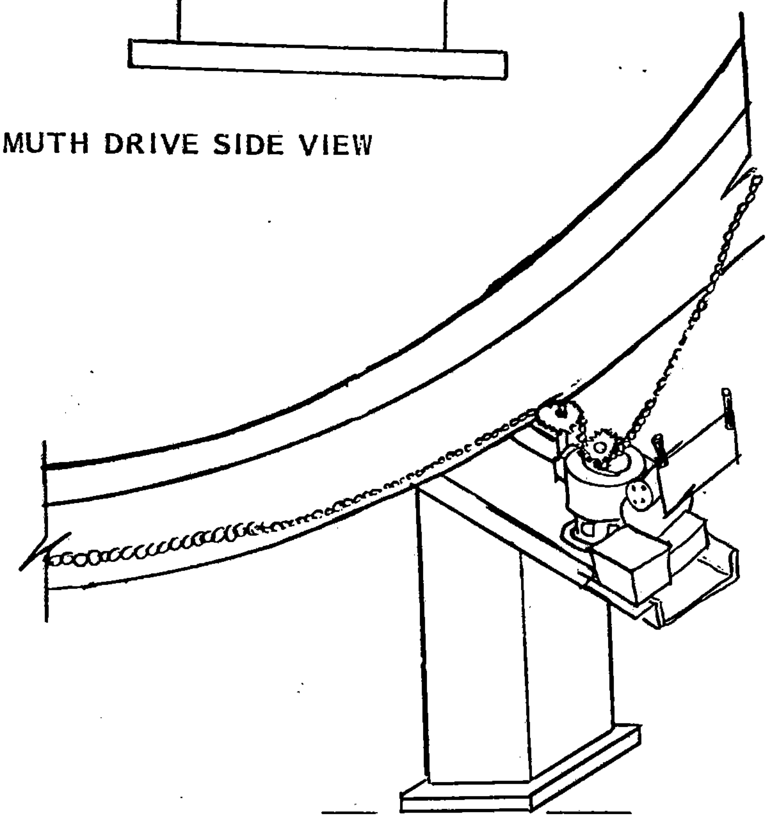
FIGURE 15: PROTOTYPE FLUX TRAP SKETCH

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS



AZIMUTH DRIVE SIDE VIEW



AZIMUTH DRIVE PERSPECTIVE VIEW, COVER REMOVED

FIGURE 16: AZIMUTH DRIVE SYSTEM

Task 11: SIMPLIFIED HYDRAULICS

The hydraulic package for the elevation drive has been greatly simplified from the SOLERAS generation PKI Square Dish. A motor driven hydraulic pump, when powered, drives the mirrors from stow to focus. See Figure 17. Deactivation of a two-way valve allows return to stow. Loss of power, or control, or insufficient pressure in the accumulator, or lack of hydraulic pressure implements stow. Pump capacity and speed will be specified once the force and stroke of the cylinder are established.

This design connects the bottom of the cylinder to the reservoir and utilizes the area differential between the two sides of the piston to provide the stow force. Pressures in the small reservoir as the cylinder drives the Mirror Assemblies from stow to focus are nearly constant since only the rod displacement tends to alter the pressure.

Final sizing of the components still awaits availability of a suitable small pump/motor package. For a 2 1/2" cylinder with a 2" rod, a 0.05 gallons/minute pump requiring a 1/30 HP motor would be specified, if available. A larger cylinder or a custom coupled gear motor/pump will be used if an off-the-shelf unit cannot be located.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

1. SIGHT GLASS
2. STOW PRESSURE: OK, LOW, NO-GO
3. SCHRAEDER VALVE
4. HYDRAULIC CYLINDER
5. PRESSURE GAGE
6. ONE WAY VALVE, NORMALLY OPEN
7. 10 MICRON FILTER
8. CHECK VALVE
9. PRESSURE RELIEF VALVE, ADJUSTABLE
10. RESERVOIR, PRESSURIZED
11. STRAINER
12. PUMP/MOTOR
13. FIXED RESTRICTION
14. HYDRAULIC PACKAGE ENCLOSURE

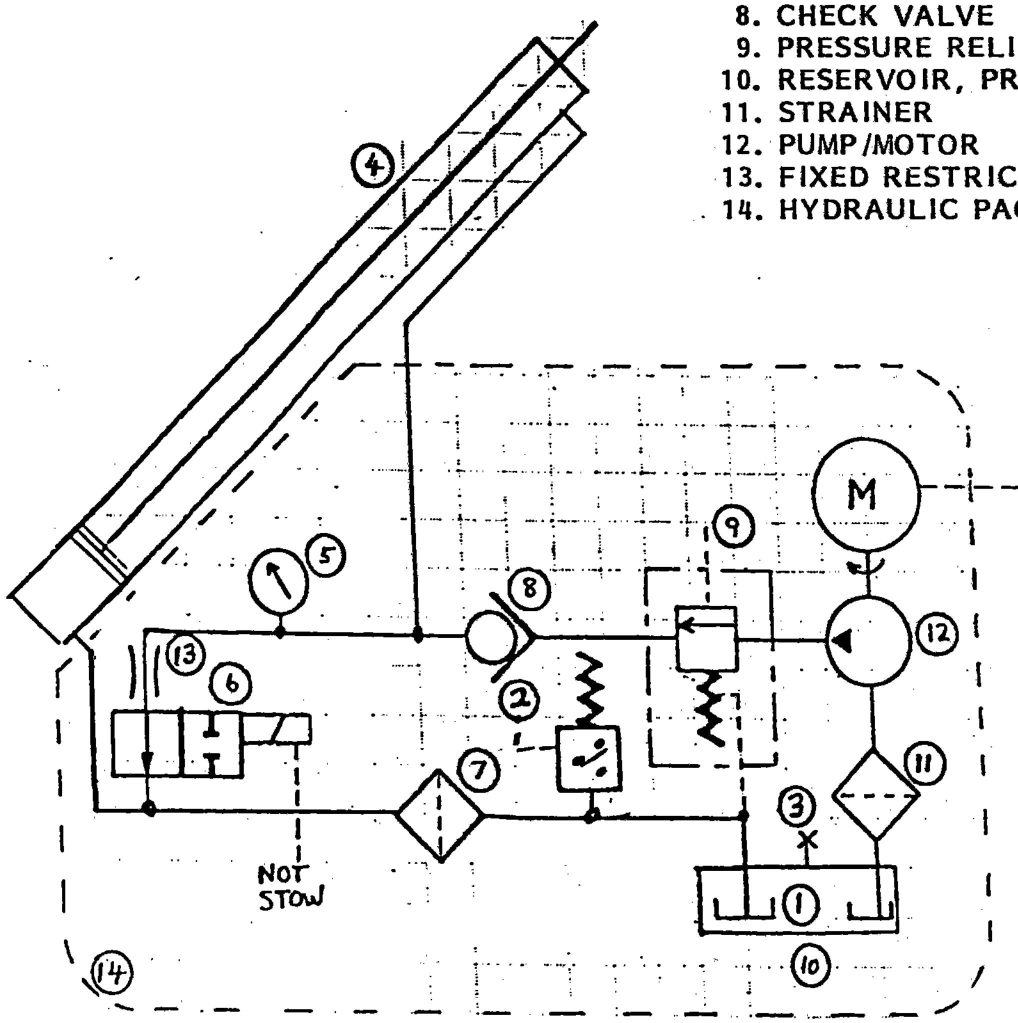


FIGURE 17: HYDRAULIC SCHEMATIC

Task 12: BOOM DETAIL

The boom is designed to support the 2500 pound solar engine located at the focal point (54' distant from the mirror face). To accommodate this load and the dynamic loading probabilities attendant therewith, a two member structure has been designed. Located along the central axis of the collector, this bi-pod arrangement assures that all the loads in the boom are axial and prevents oscillation of the engine. The boom is guyed from four points on the concentrator frame. The lower boom incorporates a joint to accommodate a scissor action which permits the raising and lowering of the engine. See Figure 18.

A copper heat shield is attached to the upper boom for a length of 15 feet from the upper end. This will prevent damage to the boom during acquisition when the sun's image is concentrated in this area. See Figure 19.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

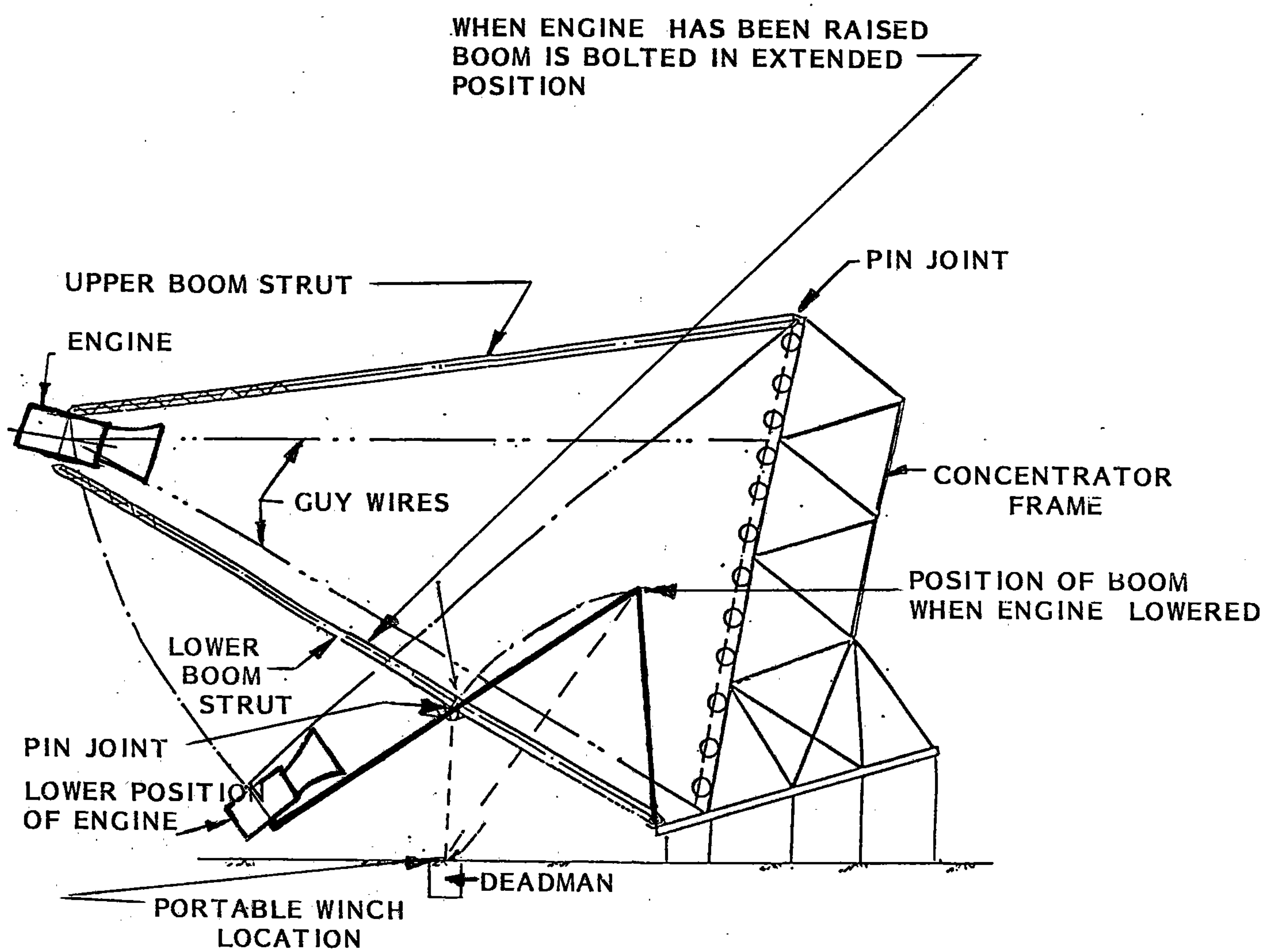


FIGURE 18: ENGINE SUPPORT BOOM (BIPOD)

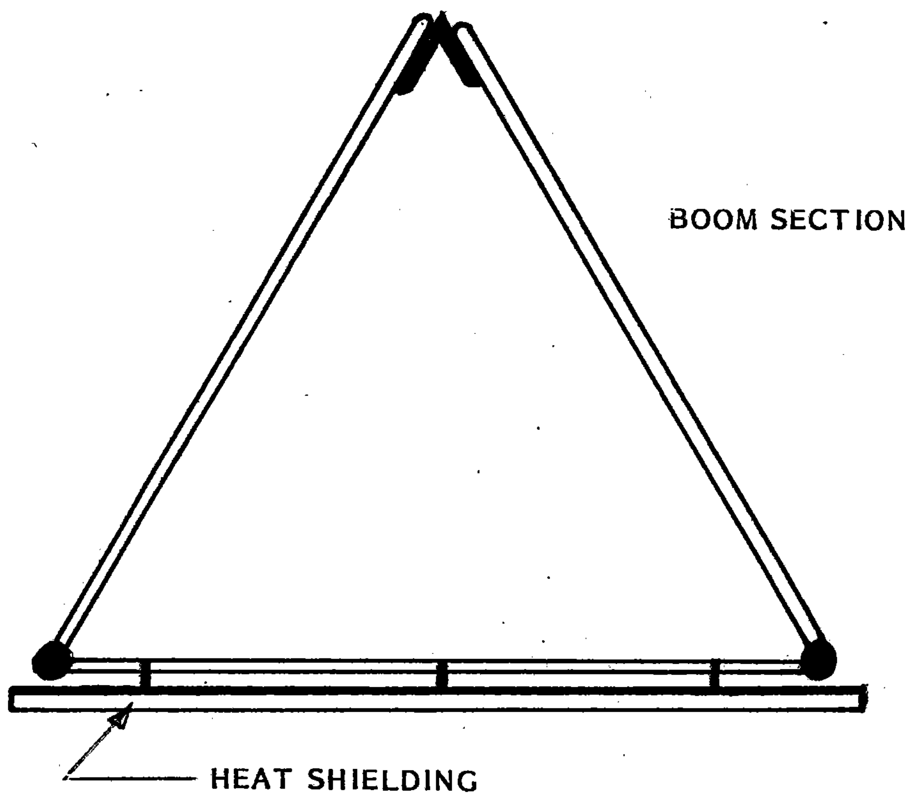


FIGURE 19: BOOM CROSS SECTION DETAIL

Task 13: CONTROLLER

The controller for the Small Community concentrator will be based on a single board microcomputer. Many such boards are appicable, but none offers the completeness and simple user interface provided by the chosen computer, the Superkim. A description of the board is attached as Figure 20. The controller resides in a raintight box and consists of the Superkim with additional components wire-wrapped on the board and a front panel with indicator lights and switches.

The Superkim board has a keyboard and 7 segment display which interface through the keyboard interface monitor (KIM) firmware. The wire-wrap area provides for digital inputs, analog inputs, and digital outputs for controlling the concentrator. The analog inputs will go to an 8 channel, 8 bit analog-to-digital (A/D) converter, the ADC 0808. The A/D resolves a voltage from 0-5 volts DC into 256 discrete levels. The advantage of this approach is that many inputs can be read with a high level of accuracy. The digital inputs are high-true, pulled-up logic which indicate the control features. One such input is the "Enable Track" switch closure which comes from the Barber Nichols ECA and will allow the concentrator to deliver energy to the engine if all operating conditions are met. The digital outputs go to inverting sinking drivers and then via the front panel to light emiting diodes, LED lights, or control relays. One digital output will be a relay switch closure signaling to the ECA an "Out Track" condition, meaning the concentrator is providing or might soon provide, power to the receiver. Other digital outputs control the positioning of the concentrator with respect to the sun.

The controller program allows user interface with the controller to input time, data, correct parameters or select information for display. Time of day is the standard display, although any of the analog input signals can be selected for display.

FIGURE 20:

Description of Superkim and 6502 Microprocessor

The uses of the Superkim are many and varied but mainly intended for use as a development tool in adapting micro-processor control to useful commercial and industrial applications.

This super controller can be applied to any situation where intelligent control is desirable, such as any manufacturing or production line process where automation is possible or to automatic machine tool operation or to real time data collection. The board has a large prototype area suitable for mounting Analog to Digital, Digital to Analog converters, relays and other interface devices.

The 6500 family of microprocessors and interfaces has established itself as the most popular third generation microprocessor family.

True Pipeline Architecture

Unusual in a low cost microprocessor, but even as the 6502 microprocessor is interpreting one instruction, it is accessing the next memory location. By doing its tasks in parallel, the 6502 attains tremendous system through-put. At 2MHz, the 6502 has a potential throughput equal to a 6800 or 8080 running at 4MHz — if they could.

Thirteen Addressing Modes

The thirteen different addressing modes include zero page and indirect indexed. The flexibility of these addressing modes allows you to write your program using an average of 20-40% less code. This means a savings in the amount of ROM required. The 6502 operates from a single 5 Volt power supply: it has true indexing capability, two interrupt modes and addressing memory range up to 65K bytes. It offers both decimal and binary arithmetic.

Outstanding Interface Chips

6500 interface chips combine functions which require several packages in first generation microprocessor systems; all feature an 8-bit bidirectional data bus for interface to the microprocessor. The 6530 has a 1K byte ROM, 64 byte RAM, interval timer and I/O.

The 6522 (VIA) Versatile Interface Adapter has two 8-bit bidirectional data ports, four peripheral control/interrupt lines plus latching inputs, two fully programmable inter-val timers an 8-bit shift register for serial interface.

Because of the multiple sources, you are assured of the continued availability of the 6500 microprocessor family with high performance and competitive prices. MOS Technology, Rockwell and Synertek are shipping identical parts on all members of the 6500 microprocessor family and interface chips.

Advantages of Superkim

- Total hardware and software compatibility with KIM-1* and most APPLE II** hardware interfaces.
- Fully socketed for maximum replacement flexibility and simple expanison to 4K RAM and 16K EPROM.
- Expansion capability to 65,536 bytes total RAM, ROM and I/O with fully decoded address space.
- User EPROM physically addressable anywhere in the memory space of 2000 hex to FFFF hex. No need to relocate existing Rom-able software.
- TTY serial interface onboard automatically adjusts for a variety of baud rates.
- Programs can be saved on audio tape or read into computer via the built-in audio tape interface (tapes are KIM-1 compatible.)

Interfacing Features

- Eight latched priority interrupts. Latches are individu-ually resetable under software control. Absolutely essential for implementing highly useful real time systems.
- All hardware necessary to implement real time clock onboard using one of the interrupts
- Four 6522 versatile interface adapter sockets available; one 6522 supplied A full complement of 6522's can provide:
  - Nine complete bidirectional 8-bit ports with hand shaking
- 95 individual I/O connections onboard which can be used with inexpensive single in-line ribbon cable connectors. No need to use expensive edge card connectors.
- 8 counter/timers or frequency generators (musical notes, etc.).
- Four 8-bit, bidirectional serial to parallel shift registers.
- Onboard but remotely mountable terminal comprised of an improved hexidecimal keyboard with separate injection molded, positive feedback ("click") keys and six digit LED display. The keyboard is one of the most critical elements of a computer as it is the normal point of man-machine interface. The keyboard has double-sided, gold plated pc board and is dust proof and drip proof.

Power Supply

- The basic board with the 6-digit LED displays "off" only draws 750 ma because of the extensive use of low power Schottky chips. The onboard 3 amp 5-volt regulator therefore will accommodate a considerable number of chips in the prototype area.
- All you need is a center tap filament transformer with 2 amp capability; readily available everywhere.

Software Available

The 6502 microprocessor has more books and documenta-tion available than any other and they are compatible with **microproducts** Superkim. For instance,
• "KIM MANUAL" • MOS Technology "Hardware Manual for 6502" • "First Book of Kim" by Butterfield, Ockers & Rehnke • "How to Program Microcomputers" by Barden • "Programming a Microcomputer, 6502" by Foster • "MICRO, the 6502 Journal" • "Kim-1/6502 User Notes".

Specifications of Superkim

Hardware Features

- The 11-½" X 11-½" pc board is double-sided with plated-through holes and solder mask.
- 4K bytes of RAM sockets, 1K byte RAM supplied.
- Sockets to accommodate up to 16K bytes of EPROM using 2732's or 8K bytes of EPROM using 5 volt 2716's
- Mini-jacks onboard to provide direct connection to audio tape recorder
- RS 232/TTY serial interface onboard.
- Onboard 5 volt regulator, rectifier diodes and filter capacitor
- Fully buffered data and address lines.
- Prototype areas onboard will take all dips with 0.3 inch or 0.6 inch pin spacing. Space for up to 46-16 pin dips; however, dips with up to 40 pins may be used.
- Provisions in prototype area for two 62 pin flat cable connectors or a combination of smaller connectors and a KIM-1 style edge card connector onboard which can be wired for compatibility with the many KIM-1 expansion buses
- Provisions onboard for a four slot APPLE II bus which can be used to interface to APPLE II peripherals
- 200 gold-plated wirewrap pins extending through the board for interconnections to prototype area onboard or offboard via ribbon cable and single in-line connectors

SUPERKIM/APPLE II DEVELOPMENT SYSTEM

LAMAR INSTRUMENTS can supply a hardware interface and a software downloading routine for the APPLE II and a firmware receiver routine, located in a 2716 EPROM, for installation in the Superkim. This greatly facilitates software development for the Superkim because of the powerful microproducts/APPLE II assembler and the large memory available in the APPLE II. The software can be instanteously transmitted from your APPLE II software development system to your Superkim RAM for instant checkout and use.

This Superkim/APPLE II development team concept constitutes the fastest, lowest cost microcomputer application prototyping system presently available.

CONTROL PANEL

Following is a diagram of the control panel for the PKI system. In the left-hand row are eight LED's (light emitting diodes). They convey information to the user on system status. The middle of the panel contains six, two or three position switches. The user controls the system with these switches when the switches at elevation and azimuth drives have been positioned from "local" to "remote". See Figure 21.

The display normally indicates the time of day. It is also used in conjunction with the key pad for troubleshooting.

The meanings of the eight LEDs are:

1. STOW: A local stow condition has been activated.

2. RAINWASH: The manual rainwash switch has been thrown.

3. RETURN: The collector is moving from west to east after the end of the day to be in position for the next day's operation.

4. SUN: There is enough solar energy incident to turn on the collector.

5. ELEVATION: The controller is checking both azimuth and elevation location. This will come on intermittently during normal operation.

6. DELAY: Sunlight incident on the collector has fallen below the threshold within the last 10 minutes. Mirrors will remain focused for 10 minutes elapsed time, and then stow.

7. ENABLE: A collector enable signal has been received from Barber Nichols' ECA.

8. OUT TRACK: A signal to Barber Nichols ECA indicating the concentrator is tracking or might soon be tracking.

The left switches allow operator manual selection of stow or rainwash positions for the mirror assemblies. The stow/normal switch should be in "normal". If thrown to "stow", it overrides all other functions for stow of the system, when the elevation switches are in "auto" and the drive switches are in "remote" with the controller running.

The middle switches permit selection of manual or automatic for each of the drive systems. The switches located at the interface panels for the two drives must be on "remote" for these to work. "Auto" is the normal operational setting for these switches. Moving them to "Manual" permits use of the switches to the right.

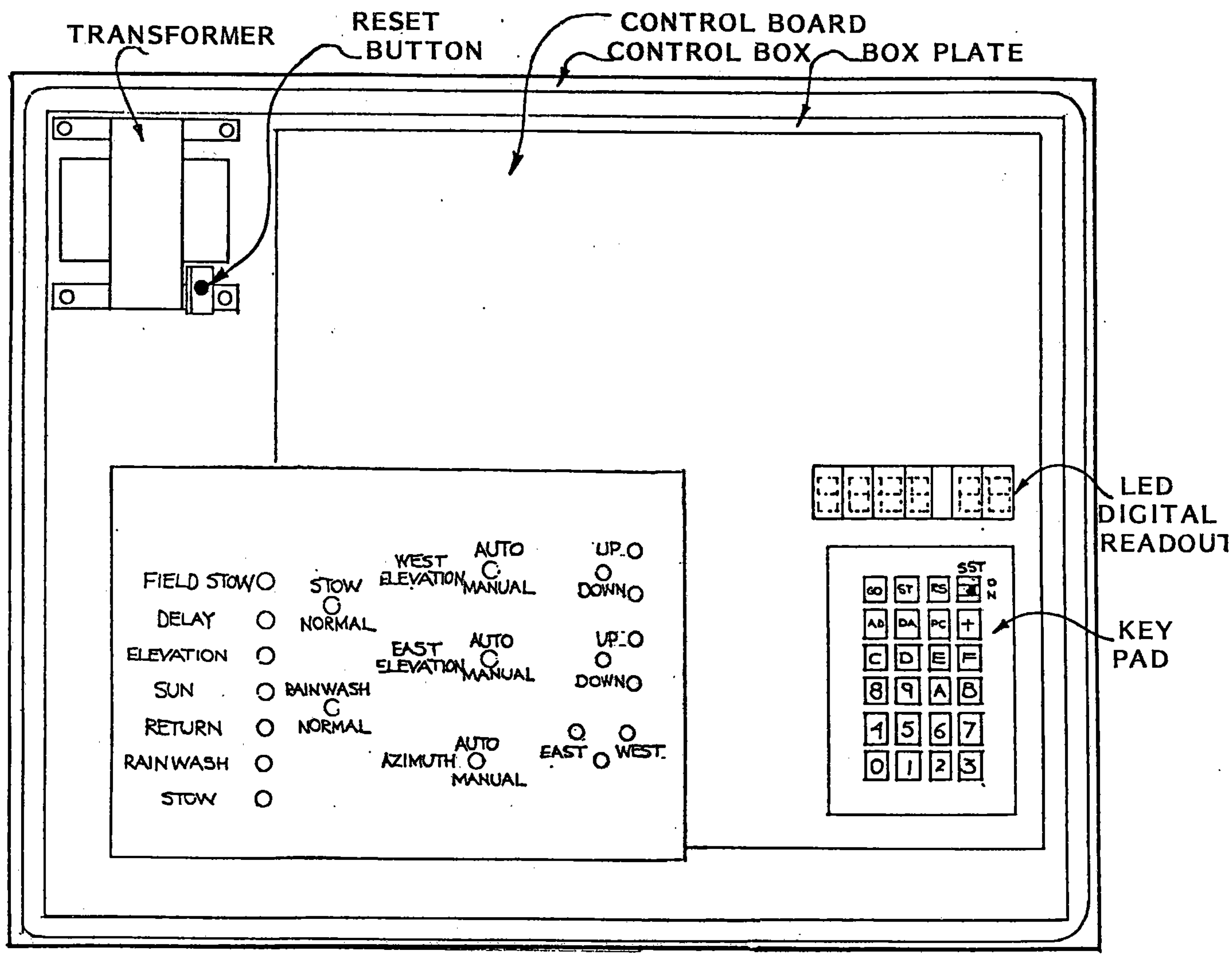


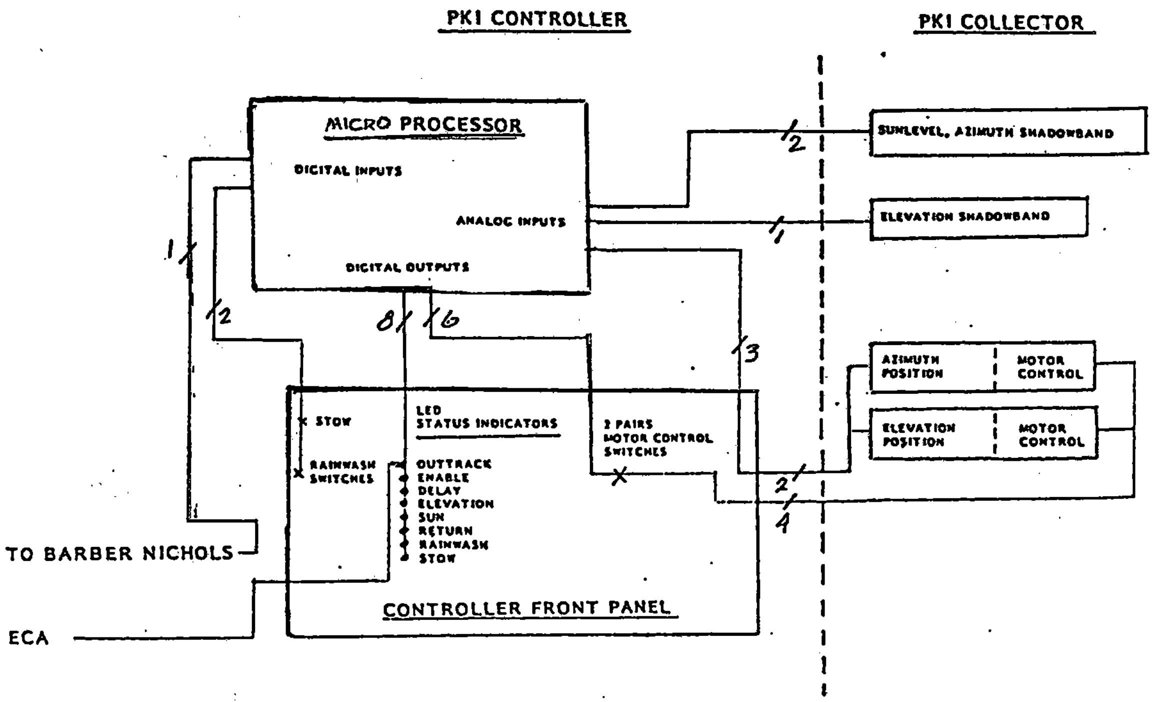
FIGURE 21: CONTROL PANEL

The prototype microcomputer-based controller for the small community concentrator is now running under test. The control schematic, wiring schematic and wire-wrap lists are completed and implemented. The board is being tested with a preliminary version of the control program. Software and control panel artwork are not yet complete. The circuit board schematic and connector pin assignments are done and the circuit board layout has been completed. Final bench testing of the controller requires a finished front panel.

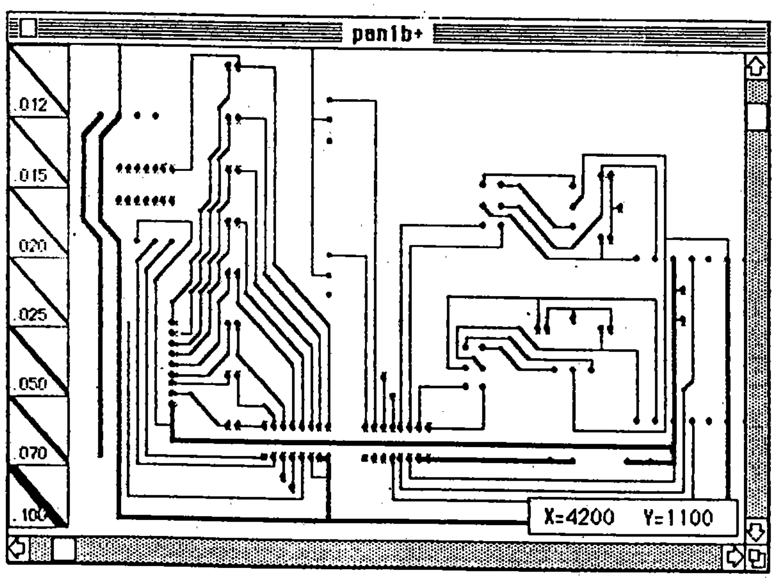
Controller, interface and sensor designs are at the point where they are no longer separate. The controller system requires all components to act together. The detail design of specific components have been connected and analyzed. This work includes making the artwork from which the hardware printed circuit boards will be made. The following figure 22 is part of the front panel circuit board on a CAD drawing board.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS



CONTROL SCHEMATIC



CAD DRAWING BOARD IMAGE

FIGURE 22: CONTROL SCHEMATIC AND FRONT PANEL P.C. BOARD

Task 14: SENSORS AND INTERFACES

Sensors and interfaces will provide the electrical connection between the physical solar concentrator and the digital electronic controller. The sensors provide a proportional electrical signal which can be read by the A/D and interpreted by the controller. The sun level (insolation) is the amplified output of an optoelectronic device and is read to a resolution of 1/256 or 0.4%. For tracking the sun, the concentrator uses shadowbands with phototransistors. The electrical output is approximately 2 volts per degree, which translates to an 8 bit in 5 volt resolution of 0.01 degrees. See Figure 23. The concentrator position is determined by a potentiometer turning about 240 degrees. With 8 bit resolution the accuracy is about 1 degree. This accuracy allows for low parasitic power drive motors and accurate limits to concentrator mechanical motion.

The concentrator drive motors are controlled by the digital outputs of the controller. The signals allow the motors to stop, to go one way, or go the other way, but never tries to go both ways at the same time. An interface provides optical isolation between the 0-5 VDC controller voltages and the 110 VAC concentrator motion controls.

The elevation position of the mirrors will be determined by a potentiometer physically attached to the elevation drive. The output of the potentiometer will be 0-5 volt signal proportional to the mirror position.

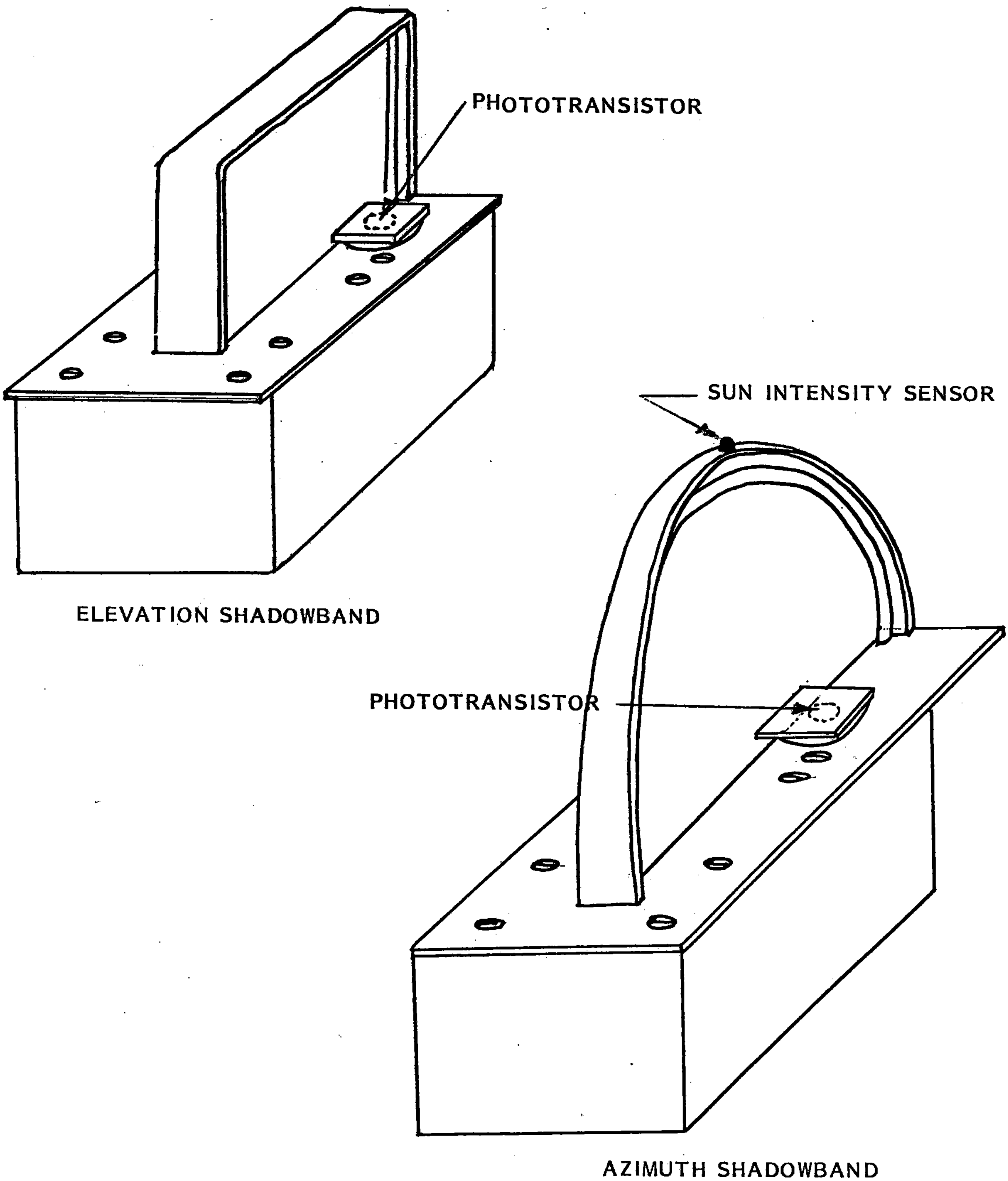


FIGURE 23: SHADOWBAND SENSORS

Task 15: ENGINE INTERFACE

The concentrator, including the foundation/piers, track, structure, mirrors, flux trap and booms, have been designed to accommodate the requirements of the engine. The engine module will be mounted on the structure members forming the apex of the two booms.

Task 16: FOUNDATION/PIER DESIGN

Vertical loads are carried through eight casters attached to steel piers supported on concrete footings. Horizontal loads are carried from these eight circumferential points by steel members to a central hub, also supported on a concrete foundation.

Piers similar to those used under previous applications will be used for this contract without change. Nine concrete footings have been designed to meet the loading conditions established under Task 4 and construction drawings have been completed. See Figures 24 and 25.

Power Kinetics, Inc.

SMALL COMMUNITY - KANSAS

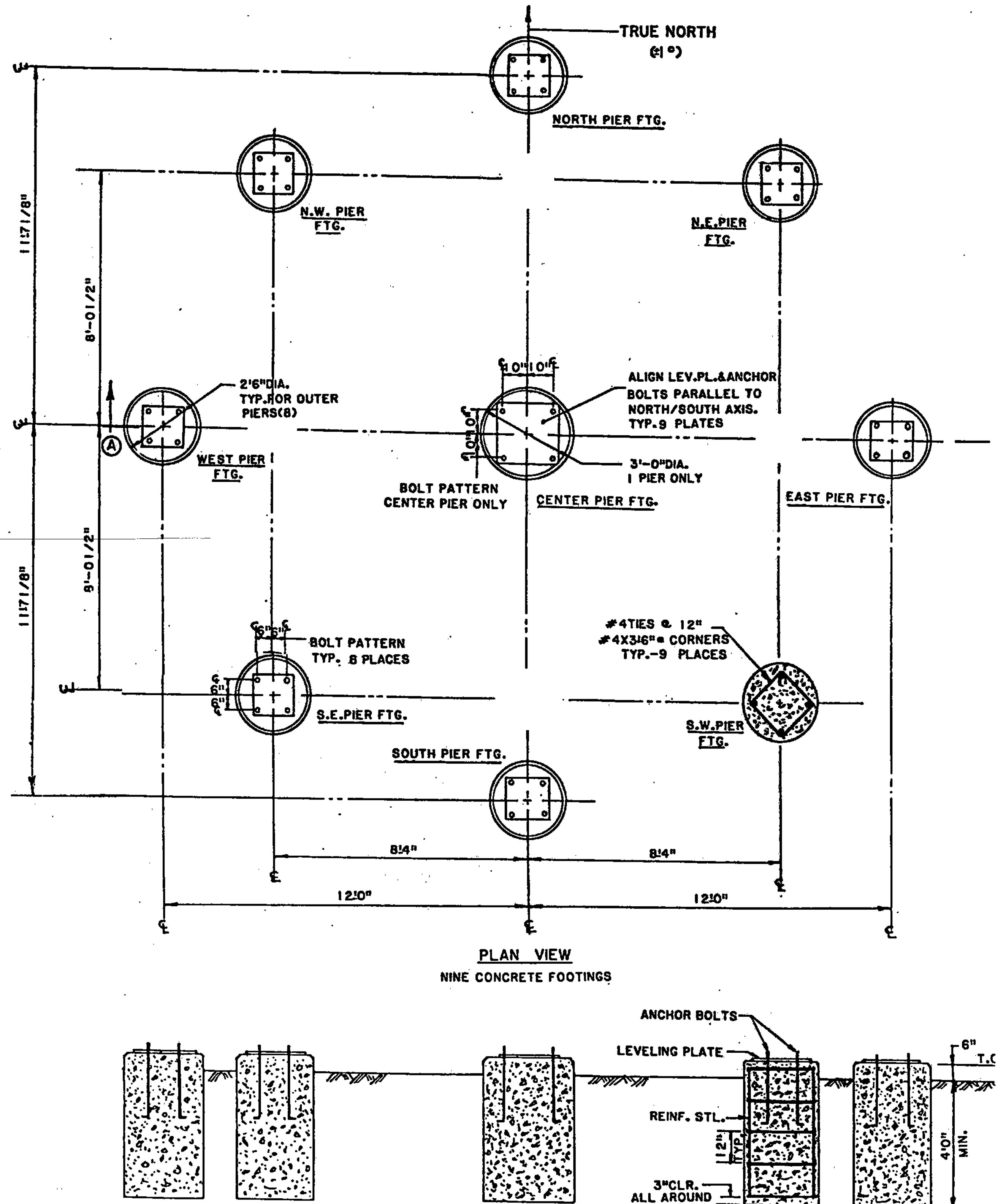


FIGURE 24: FOUNDATION PLAN

Power Kinetics, Inc.

SMALL COMMUNITY – KANSAS

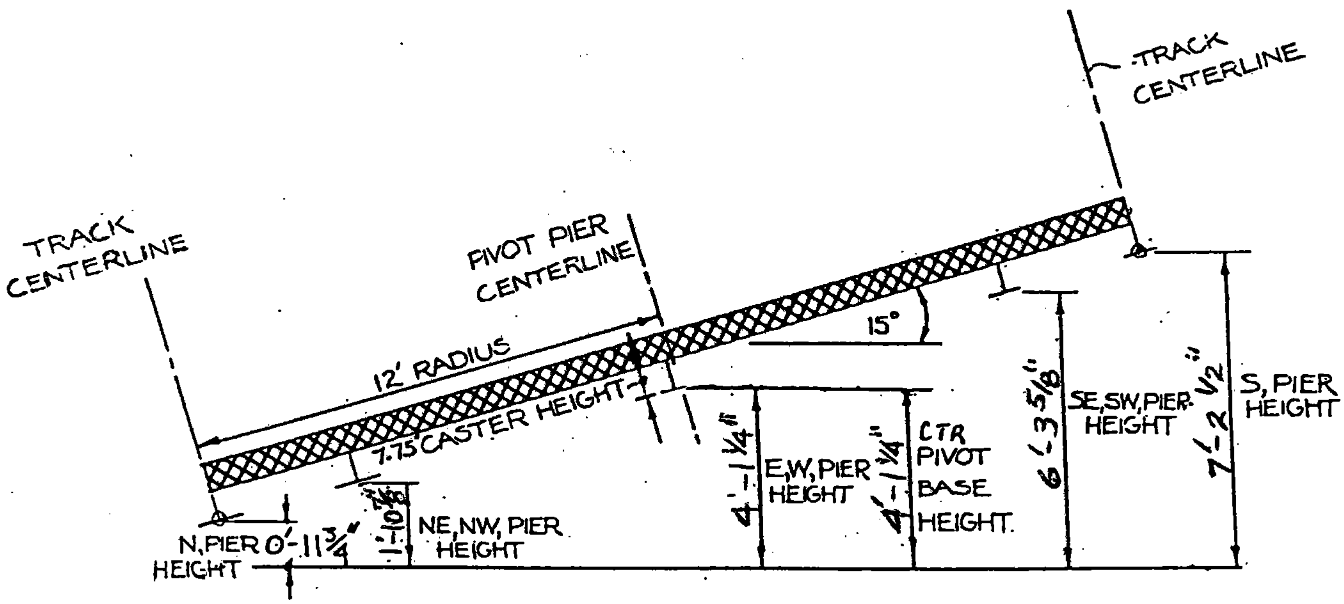


FIGURE 25 : PIER HEIGHTS