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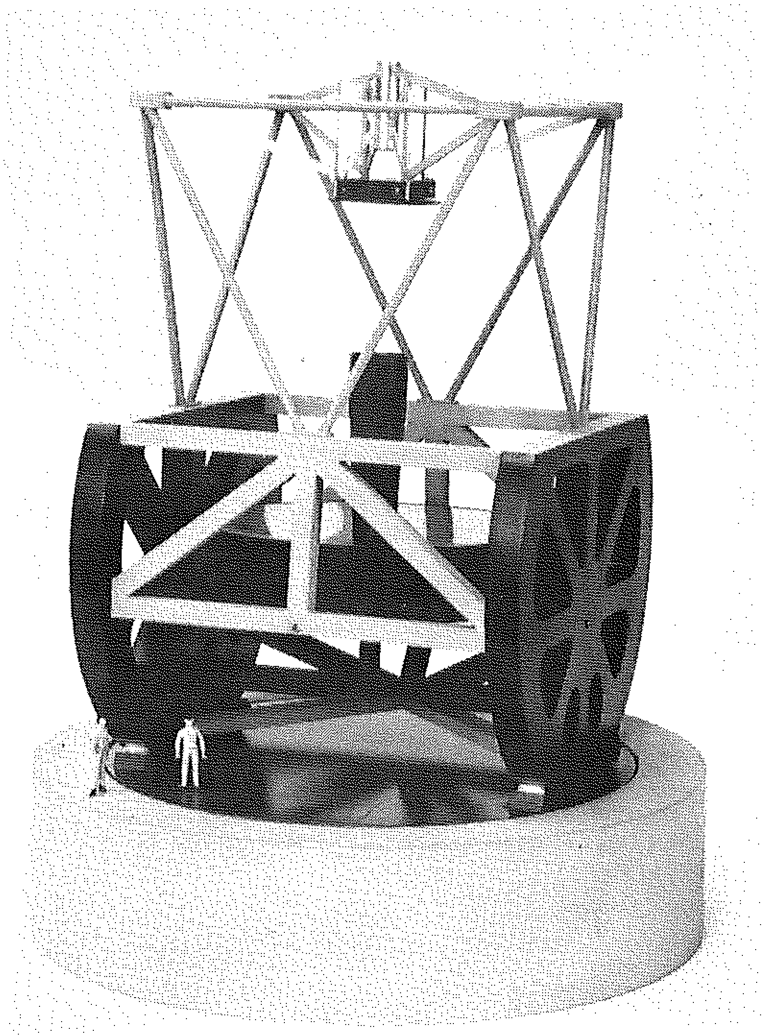

The Electrical Requirements of the Rotatable Enclosure

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The Observatories of the
Carnegie Institution of Washington
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1. Introduction

This report will concern itself principally with the electrical requirements of the rotating portion of the telescope enclosure.

2. Rotatable Enclosure Power Feed

In order to get 480 Volt three phase 60 Hz power to the rotating dome which is equipped with overhead lights and about 40 large motors, a system of sliding electrical contacts is needed.

The recommended rotating dome sliding contacts are those manufactured by the Duct-O-Wire Company of Corona, California.

All the Duct-O-Bar "figure 8 series" safety enclosed conductors have a 600 Volt AC rating. The catalog number FE-5008-2HT is rated at 500 Amperes continuous and 750 Amperes intermittent.

These conductors are the exact same physical size as the ones used so successfully for the past 15 years in the du Pont 100-inch dome. The proposed FE-5008-2HT conductors have a much higher current rating because they use an extruded solid copper bar as a conductor. The du Pont 100-inch uses galvanized steel conductors with a rating of only 90 Amperes continuous.

The four Duct-O-Bar conductors will be mounted on the rotatable portion of the enclosure, the collectors on the fixed part of the building. Three of the four conductors will have the three phase delta 480 Volt AC on them and the fourth is grounded.

Area of conductor cross-section = 315,000 circular mils.

Note: In this proper mounting orientation, with the contact slot pointing down, the Duct-O-Bar also has the advantage that it is difficult for falling debris to make contact with the 480 Volt conductors.

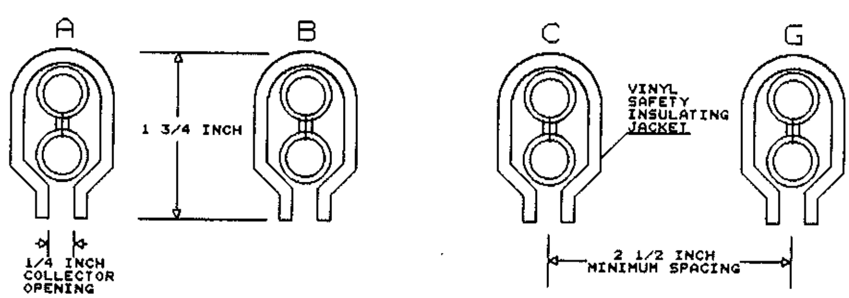

Figure 1 - End view of Duct-O-Bar conductors.

The recommended sliding collectors to be used with the above conductors are the Duct-O-Wire CB-400-2TLT. The individual collectors are similar to the single spring loaded long arm collectors used in the du Pont 100-inch, but have two collectors mounted on each spring loaded double long arm in a whiffle tree configuration. Each collector is rated at 100 Amperes, with four collectors in each configuration. This gives a total of 400 Amperes per conductor.

All of the long arm twin tandem collector assemblies are designed for vertical mounting. The du Pont 100-inch is using the proper vertical mounting configuration.

Additional reliability can be achieved by using two sets of sliding collectors feeding each of the conductors. The second sliding collector should be located about 180 degrees away from each other. The advantage of mounting the collectors as far apart as possible is to avoid any possible surface imperfections on the Duct-O-Bar conductors.

If the enclosure rotation motors are mounted on the fixed portion of the building the need to power them through the rotating sliding contact system will be avoided.

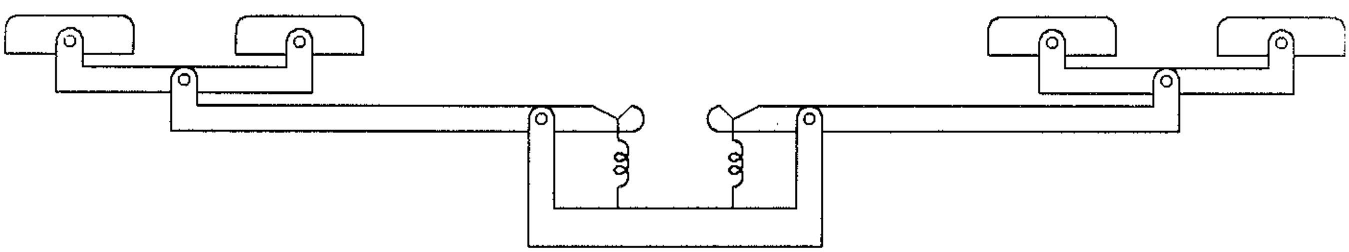

Figure 2 - Side view of the long arm twin tandem collector assemblies.

The suggested three phase main circuit breaker on the rotating dome load center would be a type 400A-LA.

3. Serial Communications

The serial communications (RS-485) going to the numerous control boxes will need a separate sliding contact system (see Magellan Project Report No. 23).

The recommended Duct-O-Wire modular four conductor low profile conductor system uses economical 1/4 inch copper tubing carefully installed in the M-40-4E extruded plastic cover.

The recommended sliding collector shoes are the M-40-MC2. These are paired in two collector modules with two spring loaded shoes riding on each conductor.

Identical Duct-O-Wire systems have been in use in both Solar Towers at Mt. Wilson for close to 10 years. Ed Snoddy discovered that careful installation was required. The 1/4 inch tubing must not be damaged or kinked when it is being installed.

The serial communications sliding contact system should be mounted with as much physical separation as possible from the previously discussed power system. The Duct-O-Wire modular low profile system is designed to mount 90 degrees to the power sliding contact system.

The RS-485 standard uses balanced differential receivers and drivers which give excellent common mode rejection. The concern is the 90 foot diameter unshielded loops of the 1/4 inch tubing.

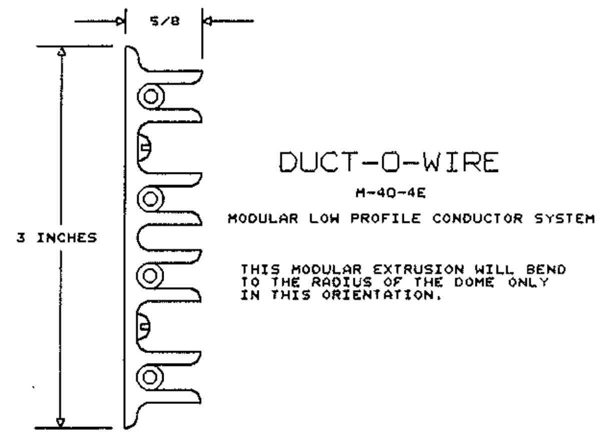

Figure 3 - RS-485 serial communications.

4. Dome Azimuth Encoder

The dome azimuth encoder system that has strong appeal is the one that would use some form of bar code on the skirt of the enclosure. The optical reader would then be mounted on the fixed portion of the building and read the code as it goes by. This system has the advantage of no additional moving mechanical parts, and no need to transmit the code over the slip rings.

The du Pont 100-inch dome uses a 50 turn rotary encoder. Its mount has a nice design feature in the ability to adjust it in or out on the radius of the dome for fine calibration. The spring loaded roller can easily be pulled free to set the encoder to the proper value. This design does have the disadvantage of moving mechanical parts.

5. Integral-Horsepower Motors

The physical arrangement of the integral-horsepower motors used to drive the shutter doors and windscreen (wind attenuators) has not been detailed yet.

The most interesting state of the art trend in integral-horsepower motors is the mass move to standard three phase AC motors rather than DC motors. This move has been promoted by the development of giant transistor technology. Virtually any three phase AC becomes an adjustable speed motor with the new microprocessor based controllers.

When connected to the new controllers, the three phase AC motor's speed is proportional to the frequency output of the controller. Also, when used with the new controllers, the motor produces constant torque and draws constant current over the output speed range (0-60 Hz). As the frequency of the output is ramped up from zero to the desired speed there is no excessive inrush current which is normally seen with a large three phase motor.

Table 1: Typical 10 Horsepower 460 Volt AC Three Phase Motor

Frequency (Hz)	RPM	VOLTS	AMPS	Torque (Lb.-ft.)
60	1800	460	14	30
50	1500	380	14	30
30	900	230	14	30
20	600	153	14	30
15	450	115	14	30

This elimination of the motor starting current surges results in a much smoother line voltage. The steady line voltage is appreciated by the local computers. The nearly constant line load is also appreciated by the generators in the power house.

The new controllers rectify the incoming AC voltage to DC then generates its own output frequency. The generators in the powerhouse are happy looking at power factors of 0.95 or better, regardless of the motors operating frequency, or the motor reflected load.

The new controllers can also be field programmed to produce proper output for the following three common load types: constant torque, constant power and variable torque, as the individual application dictates.

The giant switching transistors can easily generate a square wave output. The only problem with a square wave applied to a motor appears at low speeds. At low speeds the corners of the square wave show up as a torque pulsation called "cogging." Through the use of their internal microprocessors, AC motor speed controllers are now built with pulse width modulated (PWM) outputs. When PWM is used, motors run smoothly down to zero speed without cogging.

With PWM the high frequency, high current switching does generate radio frequency interference back on the AC feed line. Part of the solution is to mount the controller close to the motor, so the noisy output line to the motor is as short as possible. The other part of the solution is to install EMI/RFI line filters on the AC input line close to the controller.

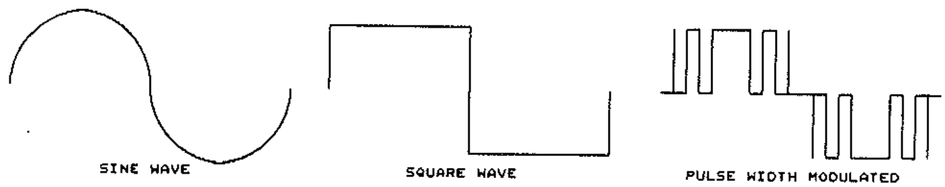

Figure 4 - Wave forms.

The debate between the use of integral-horsepower AC or DC motors comes down to the usual engineering trade-offs. AC drive controllers tend to cost more than DC drive controllers. On the other hand, DC motors cost more than AC motors for the same size and they require more maintenance. The trade-off is most easily expressed as: do you want to put your money into the motor or into the electronics? The continuing improvement in the performance of power semiconductors, coupled with their declining prices, is making variable speed AC drives more and more attractive in the larger sizes. The AC controllers have the additional advantage of having two-way digital communication built in. The Parajust controllers have ASCII, RS-232 as standard, but RS-485 is optional.

Frank Perez has been field testing a new controller from ASEA Brown Boveri on the du Pont 100-inch dome rotation motors. Before the installation of the Parajust E #6013 controller the line voltage would dip a considerable amount whenever the enclosure would rotate.

6. Passive Nighttime Ventilation

One of the more desirable features of the octagon shaped enclosure is the flat sides. The flat sides allow the use of economical conventional flat doors, without the added expense of conforming to compound curves.

Eight large bi-folding doors in addition to the two shutter doors that the telescope looks through will provide an excellent flow-through ventilation system. These bi-folding doors were originally designed as airplane hangar doors. These doors will be well insulated and will have weatherproofed seals around their edges when closed.

All eight bi-folding doors will be computer controlled. The computer can determine the optimum configuration, depending on where the dome is pointed, which way the wind is blowing and at what velocity.

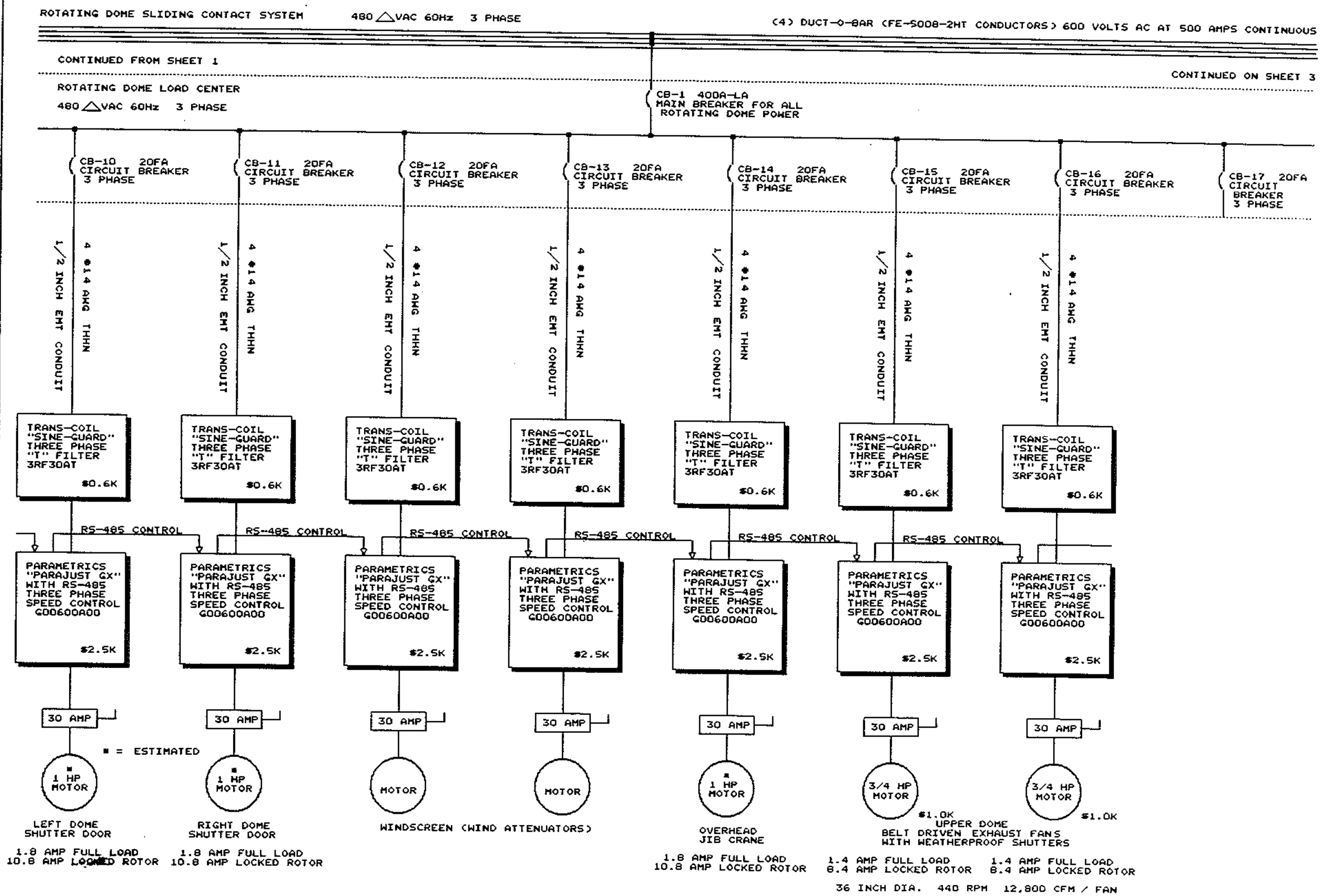

FIGURE 5: AC MOTOR CONTROLLERS

MAGELLAN 8-METER PROJECT
CARNEGIE INSTITUTION OF WASHINGTON
813 SANTA BARBARA STREET
PASADENA, CA. 91101-1232

Title	ONE LINE DIAGRAM	Scientist	WAH
		Engineer	MKC
Size 8	Document Number ROTATING DOME	File name E4B	REV
Date:	August 19, 1990	Sheet	2 of 4

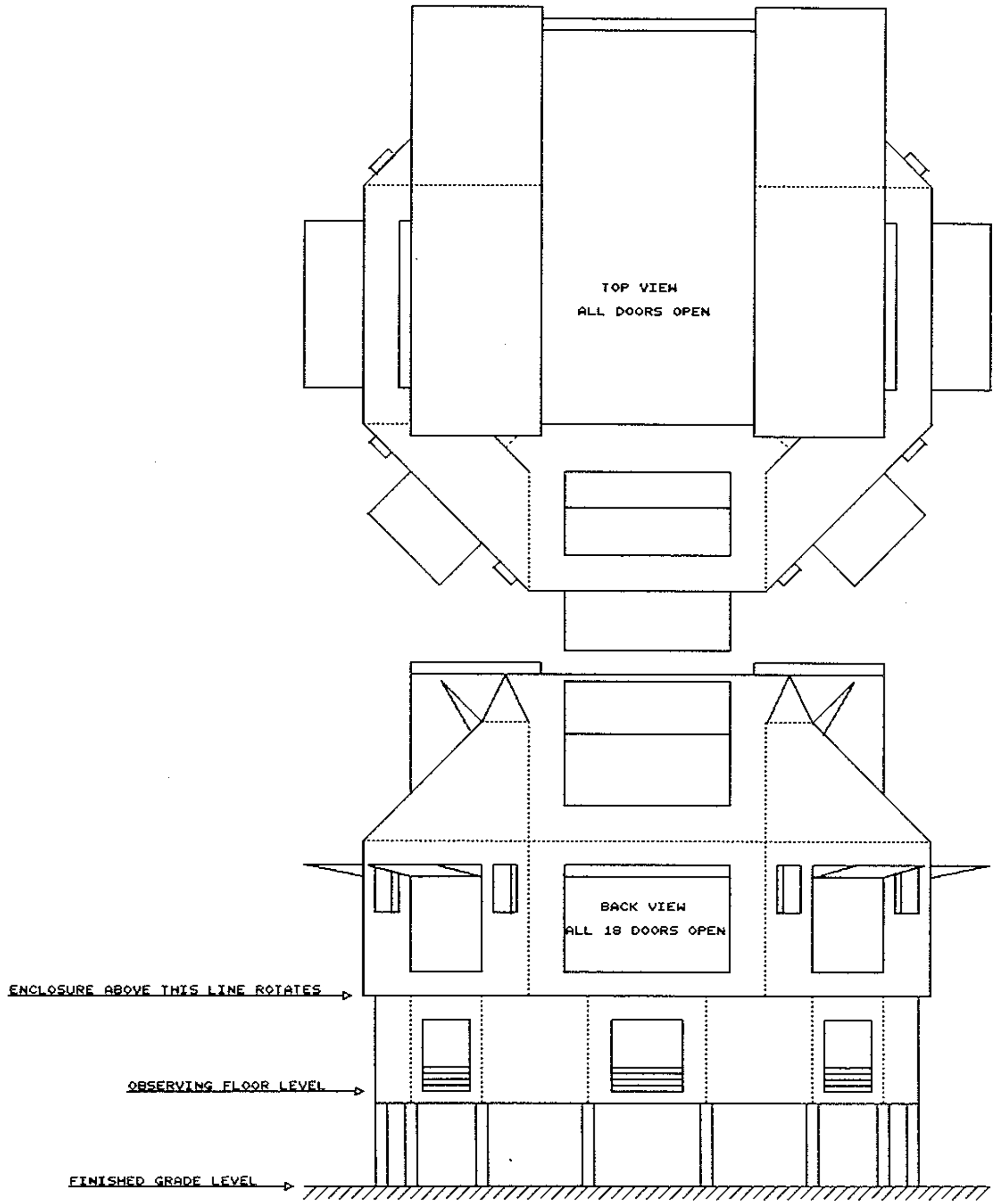

FIGURE 6: PASSIVE NIGHT-TIME VENTILATION DOORS

THE OBSERVATORIES CARNEGIE INSTITUTION OF WASHINGTON 813 SANTA BARBARA STREET PASADENA, CA. 91101-1232		
Title VENTILATION DOORS	Scientist WHH Engineer MKC	
Size B	Document Number ROTATING ENCLOSURE	File name OPEN	REV
Date: September 13, 1990	Sheet of	

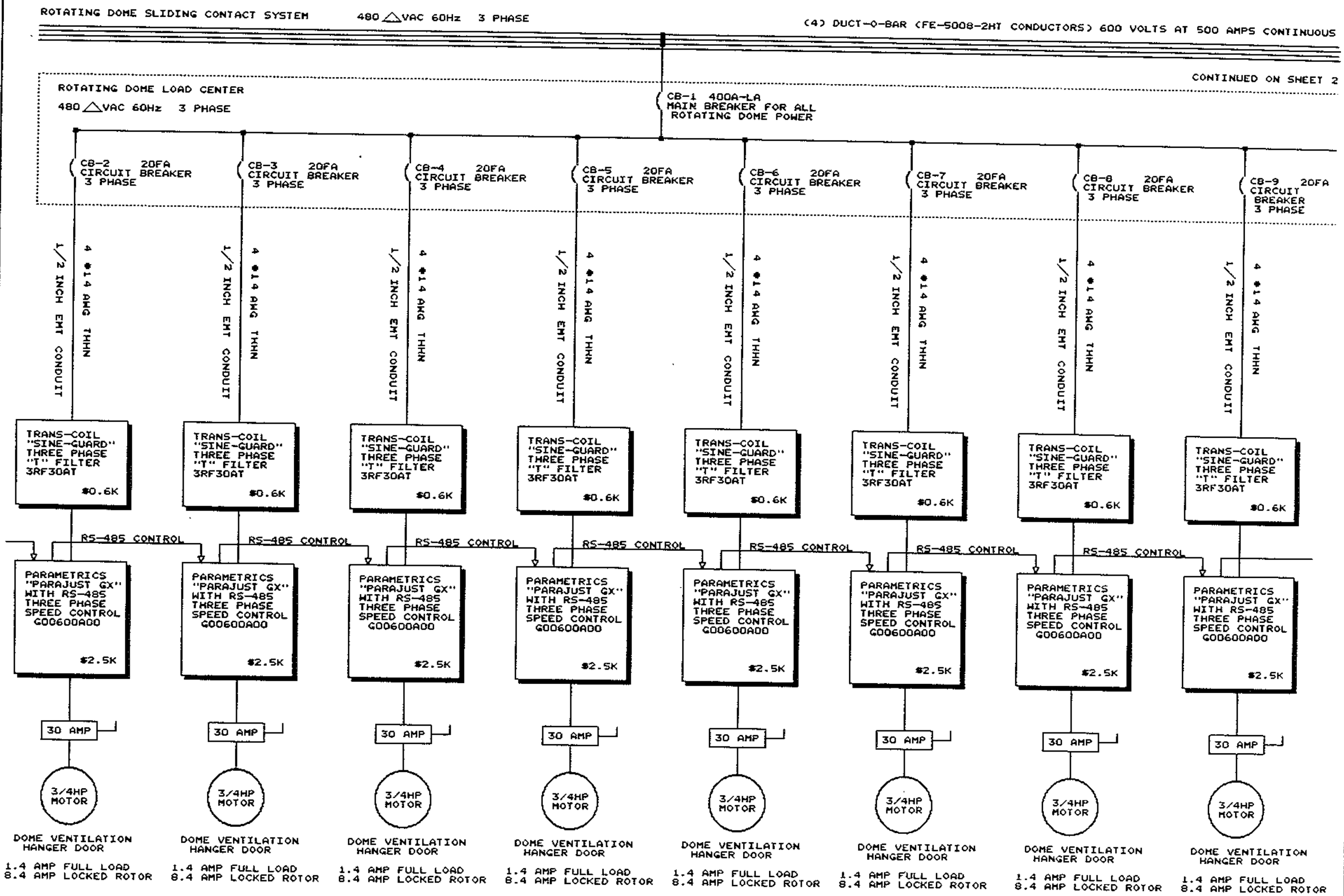

FIGURE 7: PASSIVE NIGHT-TIME VENTILATION SYSTEM

MAGELLAN 8-METER PROJECT CARNEGIE INSTITUTION OF WASHINGTON 813 SANTA BARBARA STREET PASADENA, CA. 91101-1232	
Title: ONE LINE DIAGRAM	Scientist: WAH
	Engineer: MKC
Size: B / Document Number: ROTATING DOME	File name: E4 / REV
Date: August 19, 1990	Sheet 1 of 4

7. Daytime Enclosure Temperature Controls

If the enclosure were perfectly insulated, all ten doors had perfect seals and no lights were left on there would be no need to air condition the enclosure during the day.

The 24-hour refrigerated observing floor is not part of the rotatable enclosure, the subject of this discussion. The refrigerated floor does influence the daytime cooling of the dome.

The new telescope Tripod Disk mount has an even larger azimuth disk, about 50 feet in diameter. The larger disk dictates the need for cooling its rotating portion of the observing floor. Refrigerant line will have to go up over the maypole wrap-up anyway since the electronics boxes need to be cooled.

The fixed portion of the load bearing observing floor which is less than a 20 feet wide strip around the telescope azimuth disk will also have to be refrigerated.

Horror stories have circulated regarding the long term degrading of copper tubing embedded in concrete floors. The refrigerated rotating azimuth disk design (with no concrete in it) might be used as an example for the fixed portion of the observing floor. The coolant tubes would be thermally bonded to the underside of the steel floor plates, with the necessary amount of insulation below them. If the insulation panels were removable, it would aid in servicing the coolant tubes from below. Massive concrete floors have high thermal inertia which makes it difficult to control their temperature to the required accuracy.

The most economical method of cooling the enclosure during the day would be to mount eight modular wall air conditioners in each corner of the octagon shaped rotating dome. The flat vertical sides of the octagon shape provide a convenient mounting location for the modular wall air conditioners. The air conditioners are mounted high on the vertical flat sides of the rotating dome. This location is about mid way up in the telescope chamber. With this mid height location and a unit in every corner total coverage of the telescope chamber is provided. When the dome is closed in the morning the modular air conditioners would turn on only their indoor blowers to maintain a uniform temperature throughout the dome.

The air conditioning codes for office buildings require that a percentage of outside air be blended in with the recirculated air. There seems little need to do this because the enclosure air gets completely changed every night when the telescope is in use.

The recommended Bard 49WA-C15N modular air conditioners do have a manually adjustable outside air damper assembly as standard equipment. The factory does recommend using their blank-off plate in place of the above damper assembly for maximum energy conservation.

All eight of the modular air conditioners do not come with RS-485 interfaces, but the factory will wire the units to the customers configuration. We would then have to add our standard 8752 serial controller to each unit.

With all eight of the air conditioners running at the same time, the air conditioners total output easily exceed the estimated total cooling load compiled by Eric Melsheimer in his interoffice memorandum of 6 November 1989. This has also been confirmed by Ed Snoddy's calculations.

The computer would select the optimum number of compressors to be turned on at any one time during the daytime hours. This gives the computer a choice of eight levels of cooling throughout the daytime hours.

The inside daytime temperature of the closed chamber varies only a couple of degrees during the day when no cooling is provided. The air conditioner compressors will only be operated for a relatively short time in the heat of the afternoon, from 11:00 to 19:00 hours at the most.

All of the Bard modular air conditioners have provision for built-in electrical heaters. The heaters have no application regarding astronomical observations, but would be most helpful during extended winter engineering runs.

In addition to the refrigerated observing floor and the eight modular air conditioners, two exhaust fans with weatherproof motor driven shutters can be mounted in the top of the dome. These two exhaust fans would be useful in removing any hot air trapped in the top of the dome. These two exhaust fans would also be individually controlled by the computer.

8. Overhead Engineering Lights

Telescope engineering functions need the enclosure illuminated to a high level. Twelve 250 Watt mercury vapor flood lights are proposed. The 12 flood lights are split into four groups of three. Each quadrant of three will have individual switching capability.

There will be 16 low level incandescent lights on the fixed part of the building. These lights will illuminate the observing floor and the Cassegrain instrument area. These 16 lights may be on a dimmer so the astronomer has full control of the desired light level.

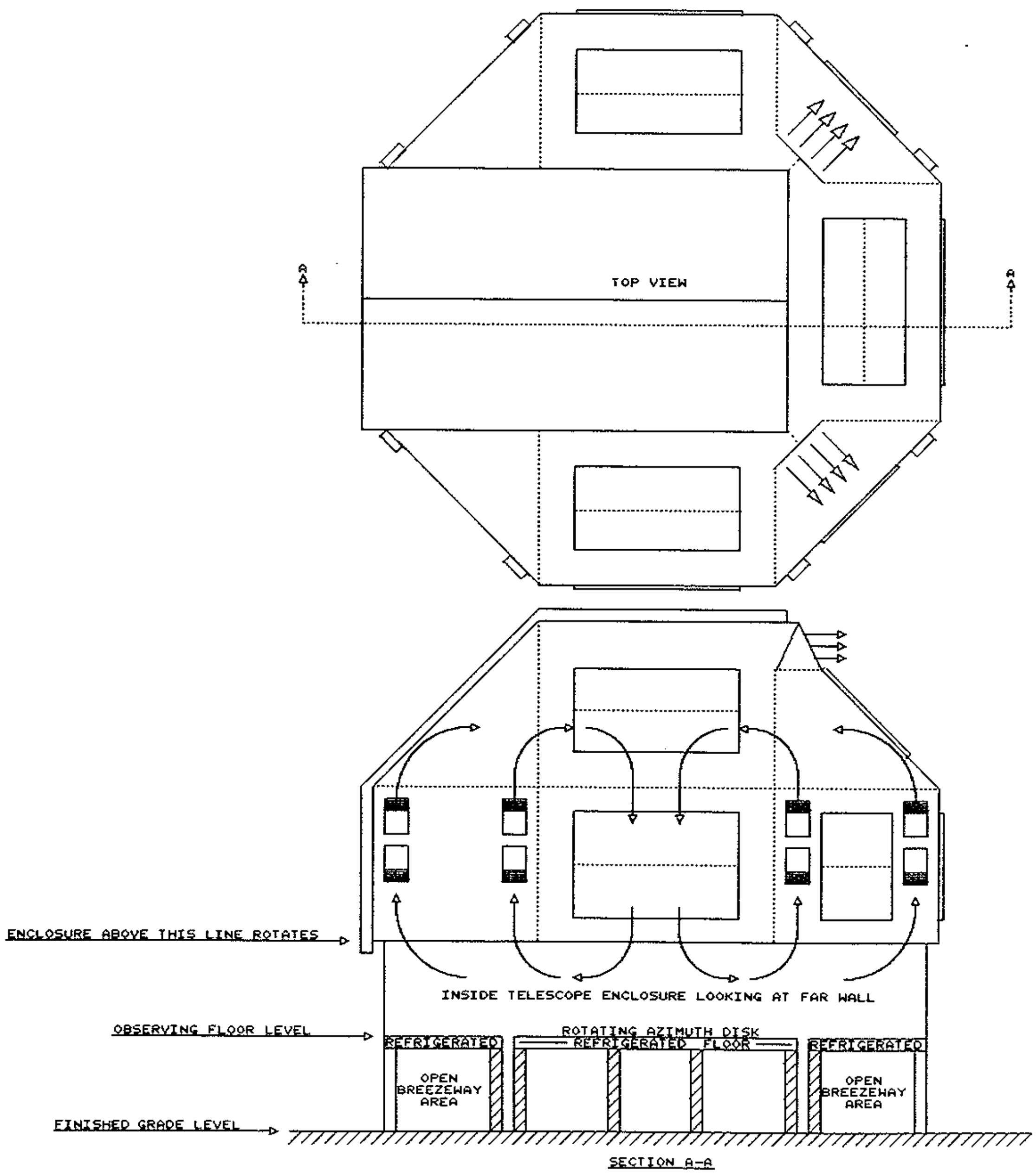

FIGURE 8: DAY-TIME TEMPERATURE CONTROLS

THE OBSERVATORIES CARNEGIE INSTITUTION OF WASHINGTON 813 SANTA BARBARA STREET PASADENA, CA. 91101-1232			
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Size B	Document Number ROTATING ENCLOSURE	File name AIR	REV
Date: September 13, 1990		Sheet	of

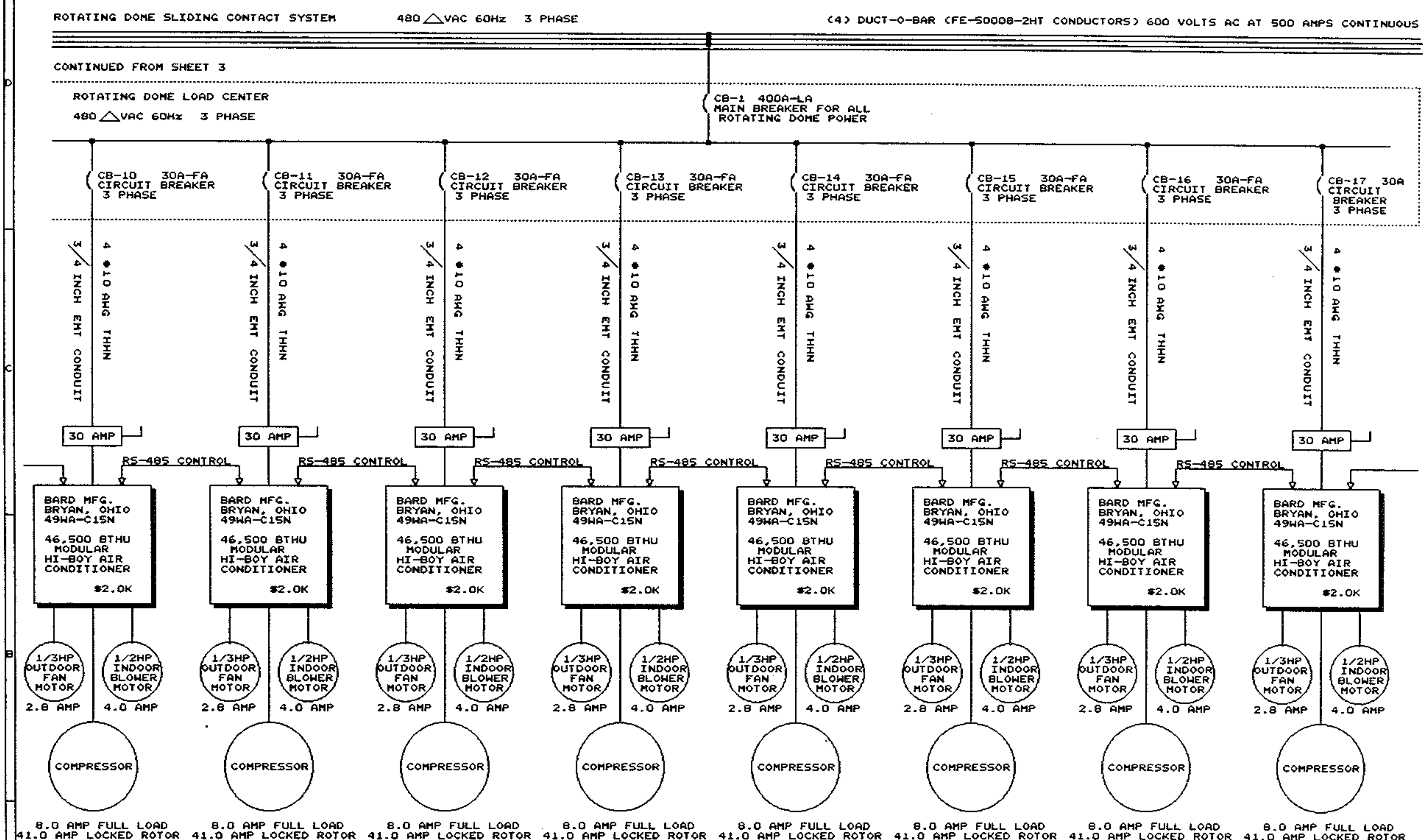
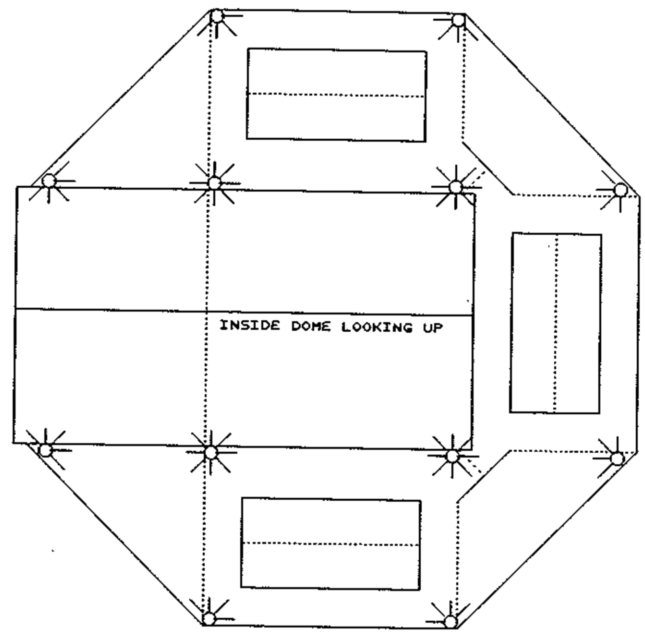


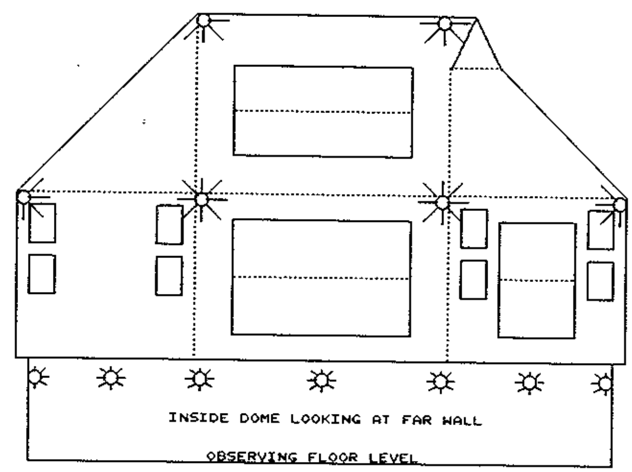
FIGURE 9: DAY-TIME AIR CONDITIONING SYSTEM

MAGELLAN 8-METER PROJECT
CARNEGIE INSTITUTION OF WASHINGTON
813 SANTA BARBARA STREET
PASADENA, CA. 91101-1232

Title ONE LINE DIAGRAM OF AIR CONDITIONING UNITS		Scientist	WAH
		Engineer	MKC
Size B	Document Number ROTATING DOME	File name E4D P	REV
Date: August 23, 1990		Sheet 4 of 4	



THESE 12 MERCURY VAPOR FLOODLIGHTS ARE FOR TELESCOPE MAINTENANCE.



THERE WILL BE 16 LOW LEVEL INCANDESCENT LIGHTS ON THE FIXED PART OF THE BUILDING. THESE LIGHTS WILL ILLUMINATE THE OBSERVING FLOOR AND THE CASSEGRAIN INSTRUMENT AREA AS THE ASTRONOMER CHOOSES.

FIGURE 10: OVERHEAD ENGINEERING LIGHTS

THE OBSERVATORIES
CARNEGIE INSTITUTION OF WASHINGTON
813 SANTA BARBARA STREET
PASADENA, CA. 91101-1232

Title MERCURY VAPOR ENGINEERING LIGHTS		Scientist WAH
		Engineer MKC
Size 8	Document Number ROTATING DOME	File name LIGHTS — REV
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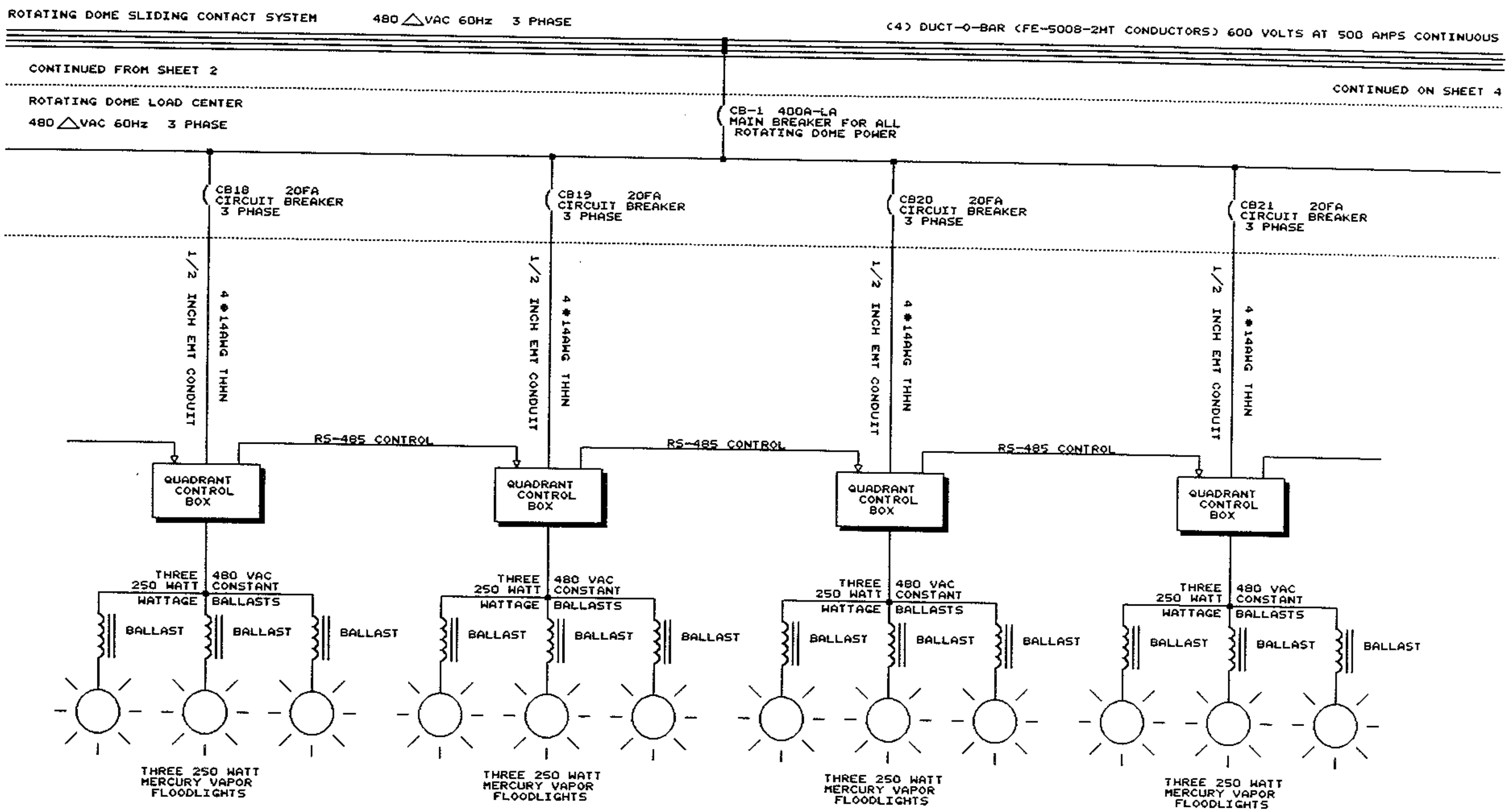

FIGURE 11: ENGINEERING LIGHTS

MAGELLAN 8-METER PROJECT CARNEGIE INSTITUTION OF WASHINGTON 813 SANTA BARBARA STREET PASADENA, CA. 91101-1232	
Title: ONE LINE DIAGRAM	Scientist WAH Engineer MKC
Size B, Document Number: ROTATING DOME	File name E4C, REV
Date: August 19, 1990	Sheet 3 of 4

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2. D. M. Carr, E. R. Koch "8752 Controller System", Magellan Project Report No. 23, June 1990.

3. E. Melsheimer, "Dome Cooling Load", Interoffice Memorandum, November 1989.