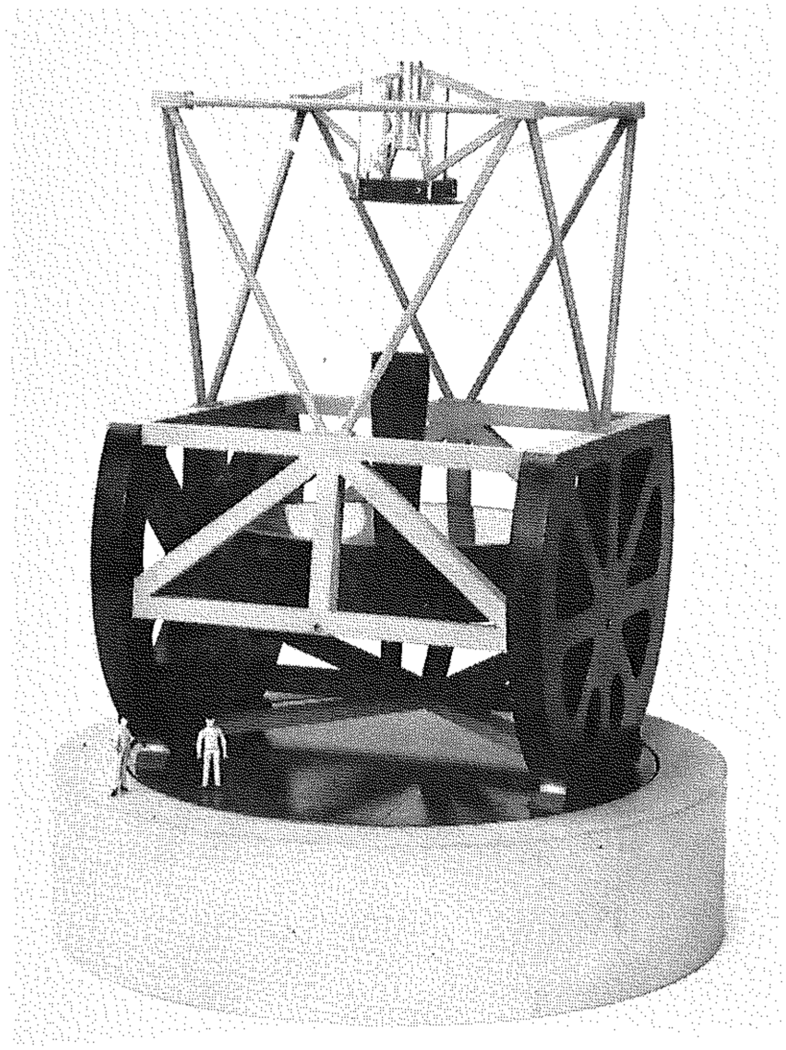
MAGELLAN PROJECT

University of Arizona | Carnegie Institution of Washington | The Johns Hopkins University



The Electrical Requirements of the 8-Meter Telescope

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The Observatories of the
Carnegie Institution of Washington
Pasadena, California

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1. INTRODUCTION

This report pertains principally to the 8-meter telescope building's electrical power distribution and grounding requirements for the Magellan Project.

In the past, most electrical motorized telescope equipment was tolerant of wide voltage variations and other power disturbances; the prospects of lower quality power did not cause great alarm. However, the recent quantum jump in computer technology means much more exacting requirements for electrical power throughout the telescope buildings. Mere compliance with codes will not meet these more exacting requirements, although it will provide a safe system.

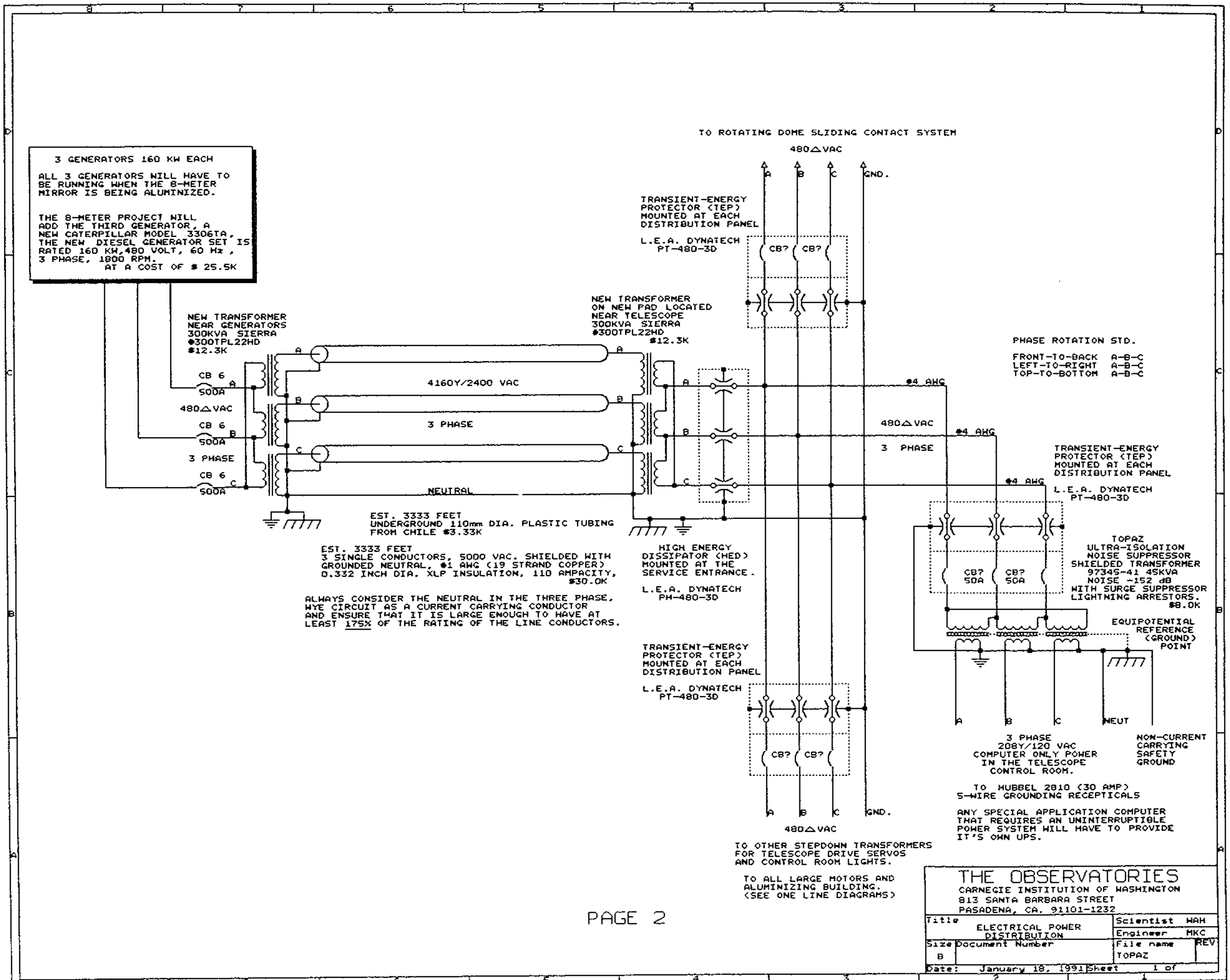
The National Electrical Code (NEC), published by the National Fire Protection Association, is the minimum level of practical safeguarding of persons and property. The NEC states that it is NOT intended as a design specification, although it is often erroneously used as such. The NEC in no way adequately covers or even considers the requirements of modern computer technology, which need oversize electrical feed wires to provide the necessary low impedance power feeds. The NEC minimum wire sizes and grounding specifications are based on electrical loads associated with major appliances and do not take into consideration the low impedances that are required when computer-based systems are switching at microsecond speeds.

The rapidly increasing sensitivity of electronic low-light level detectors used in astronomy is now placing increased demands on the integrity of the electrical ground systems.

What was adequate electrical power regulation and grounding requirements for telescopes 15 years ago at Las Campanas already needs to be upgraded. As we look into the future requirements of this 8-meter telescope, it is obvious that the very best low impedance, undisturbed power source and the very best grounding techniques must be used.

2. ELECTRICAL GENERATOR BUILDING

Fortunately, early Las Campanas Observatory planners thoughtfully provided for three generator pads in the generator building. When the 8-meter mirror is aluminized all three generators will need to be in operation for powering the 336 evaporation filaments at the same time. The planned simultaneous firing of the filaments is the peak load requirement to the telescope buildings. Two working generators now exist and a third will have to be added to provide the necessary capacity for the aluminizing load requirements.


3 GENERATORS 160 KW EACH
ALL 3 GENERATORS WILL HAVE TO BE RUNNING WHEN THE 8-METER MIRROR IS BEING ALUMINIZED.
THE 8-METER PROJECT WILL ADD THE THIRD GENERATOR, A NEW CATERPILLAR MODEL 3306TA, THE NEW DIESEL GENERATOR SET IS RATED 160 KW, 480 VOLT, 60 Hz, 3 PHASE, 1800 RPM. AT A COST OF $ 25.5K
NEW TRANSFORMER NEAR GENERATORS 300KVA SIERRA #300TPL22HD $12.3K
CB 6 500A
480△VAC
3 PHASE
4160Y/2400 VAC
3 PHASE
NEUTRAL
EST. 3333 FEET UNDERGROUND 110mm DIA. PLASTIC TUBING FROM CHILE $3.33K
EST. 3333 FEET 3 SINGLE CONDUCTORS, 5000 VAC. SHIELDED WITH GROUNDED NEUTRAL, #1 AWG (19 STRAND COPPER) 0.332 INCH DIA. XLP INSULATION, 110 AMPACITY, $30.0K
ALWAYS CONSIDER THE NEUTRAL IN THE THREE PHASE, WYE CIRCUIT AS A CURRENT CARRYING CONDUCTOR AND ENSURE THAT IT IS LARGE ENOUGH TO HAVE AT LEAST 175% OF THE RATING OF THE LINE CONDUCTORS.
NEW TRANSFORMER ON NEW PAD LOCATED NEAR TELESCOPE 300KVA SIERRA #300TPL22HD $12.3K
HIGH ENERGY DISSIPATOR (HED) MOUNTED AT THE SERVICE ENTRANCE.
L.E.A. DYNATECH PH-480-3D
TO ROTATING DOME SLIDING CONTACT SYSTEM
480△VAC
GND.
TRANSIENT-ENERGY PROTECTOR (TEP) MOUNTED AT EACH DISTRIBUTION PANEL
L.E.A. DYNATECH PT-480-3D
CB?
TO OTHER STEPDOWN TRANSFORMERS FOR TELESCOPE DRIVE SERVOS AND CONTROL ROOM LIGHTS.
TO ALL LARGE MOTORS AND ALUMINIZING BUILDING. (SEE ONE LINE DIAGRAMS)
PHASE ROTATION STD.
FRONT-TO-BACK A-B-C
LEFT-TO-RIGHT A-B-C
TOP-TO-BOTTOM A-B-C
#4 AWG
480△VAC
3 PHASE
CB? 50A
TOPAZ ULTRA-ISOLATION NOISE SUPPRESSOR SHIELDED TRANSFORMER 97345-41 45KVA NOISE -152 dB WITH SURGE SUPPRESSOR LIGHTNING ARRESTORS. $8.0K
EQUIPOTENTIAL REFERENCE (GROUND) POINT
NEUT
3 PHASE 208Y/120 VAC COMPUTER ONLY POWER IN THE TELESCOPE CONTROL ROOM.
NON-CURRENT CARRYING SAFETY GROUND
TO HUBBEL 2810 (30 AMP) 5-WIRE GROUNDING RECEPTICALS
ANY SPECIAL APPLICATION COMPUTER THAT REQUIRES AN UNINTERRUPTIBLE POWER SYSTEM WILL HAVE TO PROVIDE IT'S OWN UPS.
THE OBSERVATORIES
CARNEGIE INSTITUTION OF WASHINGTON
813 SANTA BARBARA STREET
PASADENA, CA. 91101-1232
Title ELECTRICAL POWER DISTRIBUTION
Scientist WAH
Engineer MKC
Size B
Document Number
File name TOPAZ
REV
Date: January 18, 1991
Sheet 1 of

A duplicate to the existing 300kVA transformer that presently feeds the entire mountain will have to be added at the generator building in order to feed the 8-meter telescope alone. A new transformer pad can be located next to the generator building.

The additional wiring and circuit breakers will need to be added to the generator switching bus inside the generator building.

4. UNDERGROUND ELECTRICAL POWER FEED TO THE 8-METER TELESCOPE

All the previously discussed generator building requirements and those of the electrical power feed to the 8-meter telescope are based on the worst case situation of the simultaneous firing of the filaments during the aluminizing of the 8-meter mirror.

This aluminizing forcing function turns out to be a real plus during night-to-night observing. The heavy gauge wires shown on the previous page from the generator building will provide an adequately "stiff" (low impedance) power feed to the 8-meter telescope when it is observing.

Another 300kVA transformer will be needed to step down the voltage to the telescope. This transformer will be located on a new transformer pad somewhere near the 8-meter telescope buildings. The layout of the grounds for the new telescope building step down transformer pad and its secondary 480 volt, three phase power feed to the telescope building can benefit from the use of techniques described in the Cadweld/Erico Products of Cleveland, Ohio, "Grounding and Bonding Applications in Electrical Substations", A4G05.

Las Campanas has now started the practice of running all new underground electrical power feeds through plastic pipe on the mountain. The plastic pipe protects the wires from the sharp rocks in the trench.

An additional advantage of the underground feature of the electrical power feed to the 8-meter telescope is that it also provides far greater lightning protection than an overhead power pole feed.

5. TELESCOPE CONTROL ROOM ISOLATION TRANSFORMER

The isolation transformer shown on the previous page, the Square D Company's Topaz #97345-41, will protect and isolate sensitive electronic equipment against electrical noise disturbances. These disturbances from such sources as lightning, utility generator switching and the operation of large electrical motors, are the most prevalent and troublesome of all AC power disturbances.

An oversimplified explanation of an isolation transformer is a transformer wound with shielded wire. This forms an excellent Faraday shield that enables the transformer to block all forms of high frequency electrical noise over a broad range of frequencies, without impeding the normal 60 Hz AC power. An isolation transformer can provide noise attenuation up to a ratio of 40 million to 1, (common-mode noise attenuation of 152 db) therefore the isolation transformer will reduce a 6000 Volt spike to an insignificant 0.00015 Volt.

This top-of-the-line Topaz (series 40) isolation transformer selected here is the only Square D isolation transformer series that features surge supressors and lightning arrestors. In the past we have found these features to be essential on similar isolation transformers used at the two solar tower telescopes at Mount Wilson.

The Square D Company's Topaz #97345-41 (45 kVA) isolation transformer is designed to be located inside a computer room close to the computers. This isolation transformer is designed to accommodate modern computer rooms with removable panel sub-flooring. The telescope signal cables that go to and from the telescope will achieve maximum separation from the noisy under-the-floor power distribution by being placed in overhead ladder-type cable trays in the computer room. See the National Electrical Code's "Standard for the Protection of Electronic Computer/Data Processing Equipment", NFPA 75-1976 (ANSI).

This isolation transformer is not a voltage regulating transformer, nor is it an Uninteruptable Power System (UPS). If any sensitive equipment requires these features they must be incorporated in that particular equipment.

The computer room air conditioning and any large exhaust fan motors will be three phase 480 Volt. No large motor loads like this will be on the 208/120 Volt secondary of this isolation transformer. The output of this isolation transformer should not feed any loads outside the computer room other than the telescope.

6. TELESCOPE CONTROL ROOM AIR CONDITIONING

Air conditioning is essential to the reliability of the computers in the telescope control rooms. Each kilowatt used by the computers releases 3412 Btu per hour of heat that must be removed from the rooms. Approximately 3 tons of additional refrigeration is needed for each 10 kW of computer equipment. Caution-most published guidelines are for comfort cooling and do NOT address the higher level of process cooling required here.

The air conditioning service equipment (compressors, fans, etc.) for the temperature control of the 8-Meter Telescope's control room (computer rooms) will be located at the far end of the telescope building.

The remaining telescope service equipment (24-hour refrigerated observing floor chillers, the cooling equipment for the electronics boxes on the telescope and the oil for the telescope hydraulic bearings) should also be located there. The object is to obtain as much physical separation as reasonable between the large, three-phase 480 Volt motors powering the service equipment and the sensitive computer rooms.

A semi-remote underground location for the heavy duty service equipment would also provide a thermal advantage by keeping all that heat as far as possible from the telescope.

Some of the air conditioning and heating equipment used in this location might also be of the new "High-Efficiency Heat Pump" type units with quiet and reliable scroll compressors. Heat pump type air conditioning equipment will help conserve electrical energy by 30% or more.

The National Electrical Code requires that a disconnecting means shall be provided to disconnect the electrical power to all electronic equipment in the computer room. This disconnecting means shall be controlled from a location readily accessible to the operator at the principal exit doors. There shall be a similar disconnecting means to disconnect the air-conditioning system serving this area. The air-conditioning disconnect would stop the fanning of any flames in the computer room in the case of fire. The NEC requires that if the ventilation or air conditioning system uses the under-floor area it must be restricted to that area only.

7. GROUNDING SYSTEMS

The National Electrical Code's primary concern is safety, that is, meeting the requirements for mandatory (safety) grounding and proper bonding as given in Article 250 of the NEC. This power system (safety) grounding ensures that all noncurrent-carrying metal parts will be at the same ground potential to prevent personnel shock hazards. It also provides a path to conduct fault currents back to the grounding electrode system, which facilitates operation of the circuit overcurrent protective device (circuit breaker or fuse).

The computer equipment manufactures primary concern is the proper operation of their computer and peripherals. In the past, many have insisted that their equipment ground should be isolated from the electrical power distribution system ground. This is based on the fact that computers and similar equipment are extremely susceptible to a variety of electrical disturbances typically found in commercial, industrial, and telescope power systems. While these various ground-isolation methods have been used with some measure of success in reducing data errors, system crashes, and other malfunctions, the methods of isolation typically employed violated NEC requirements and are potentially dangerous to personnel and equipment.

The 8-Meter telescope control room (computer rooms) needs a fully integrated, dual grounding system that addresses both the concerns of the NEC for safety and provides an equipotential grid to dissipate unwanted high-frequency electrical disturbances. This essentially calls for two separate, yet integrated grounding systems: one for safety and another for high-frequency disturbance protection. Because of inherent high-frequency limitations of the code-recognized equipment safety grounding conductors, a typical NEC power safety grounding wire system is not capable of providing an equipotential reference point (ground) for high-frequency disturbances.

The computer room removable panel sub-flooring is not only ideal for the previously discussed isolation transformer power distribution, but also these grounding connections as well.

8. SIGNAL REFERENCE GRID

The 8-Meter telescope needs, in addition to the required power equipment (safety) ground system, a high frequency, low-impedance, pre-fabricated Signal Reference Grid (SRG) within the computer rooms.

Transmission-line research has empirically determined that standing waves will not cause a significant voltage difference between the two ends of a conductor, if the length of the conductor is not more than 1/20 of a wavelength. At 30 Mhz, the wavelength is about 32 feet, and a 1/20 wavelength is just under two feet. If a number of conductors were connected in the form of a grid to create a multitude of low-impedance parallel paths, there should be a negligible difference of potential between any two points on the grid for all frequencies from 60 Hz up to the frequency where the length of one square represents about 1/20 wavelength. Therefore, a grid made up of 2-foot squares should provide an effective equipotential reference (ground) between any two points on the grid for signals up to 30 Mhz.

The Cadweld/Erico Products, Inc. manufactures a complete line of pre-engineered Signal Reference Grid (SRG) and ground connection products. The optimum arrangement for the 8-Meter telescope control room (computer rooms) application is to install the Cadweld/Erico pre-fabricated SRG, which uses 2-inch wide by 26 AWG thick copper strips on 2 foot centers conveniently mounted under the computer room sub-floor. All crossover connections of the copper strips are Cadwelded (an exothermic weld) to assure a "noise-free" bond (see Cadweld/Erico Products application notes; A4P02 and A-5K-02).

Note: The 2-inch wide by 26 AWG thick copper strips used in the above SRG have a lower impedance than a seven-strand, No. 4/0 AWG, round copper conductor.

All ground strap connections between the computer rack enclosures and the SRG are provided by 3/32 X 1/2 X 36-inch braided copper straps. A mechanical connection is used at the various computer rack enclosures, but a Cadweld (exothermic weld) is required to secure this braided ground strap to the SRG.

All metallic objects under the raised floor such as conduits, water piping, ducts and steel building columns, etc., are required to be bonded to the SRG using a short length of seven-strand, No. 4 AWG, bare round copper bonding conductor. Field-executed Cadweld connections are used at both ends.

Every third raised floor metallic pedestal will also be bonded to the SRG with the same No. 6 AWG type of bonding conductor. For convenience, the pedestals to be bonded can be prepared ahead of time on the work bench with about a 2-foot long pigtail Cadwelded to them.

The removable floor panels need to have a conducting floor covering material similar to that used in hospital operating rooms. The resistance between the center of a removable floor panel and the SRG must not exceed 10,000 Megohms during the lowest relative humidity conditions in the computer rooms. Floor polishes can make them unacceptable. It takes only a thin coating (half micron) of carnauba wax to create a serious problem in the dry desert air at Las Campanas.

A Transient Suppression Plate (TSP) is usually a 4 x 4 foot, No. 26 AWG sheet of copper. One TSP will be used under the isolation transformer and another under the input power junction box. The TSPs are used to prevent noise currents in the concrete slab reinforcing bars from being coupled into the power cables under the floor. The TSP provides a controlled bypass between the reinforcing steel and the electrical ground conductors at or near the point of power entry into the computer room.

The pre-fabricated SRG is shipped in rolls that are 12 feet wide and up to 100 feet long. Installation involves rolling the grid out onto the bare concrete floor starting flush against one perimeter wall and moving toward the other. As obstacles are encountered, such as steel building columns, the grid needs to be cut, fitted around the base of the columns, and cadwelded back together to form, as closely as possible, the desired 2 foot squares. In cases where the columns are larger than the 2 foot squares, the size of the square has to be expanded, but not more than absolutely necessary. The greater the deviation from the 1/20 wavelength (just under 2 feet), the greater the effect on the SRG's capacity to perform its desired function.

Where one roll is laid next to another, the outer edges of the rolls overlap to form a single strip and then are cadwelded together at one foot intervals.

After the installation of the individual computers and the computer support equipment, the braided equipment bonding straps will be installed and connected to the SRG. Equipment located on the outer edge of the grid should not be tied to the outer edge of the grid, but rather at least to the second row in from the outer edge, using the shortest possible length of bonding strap. The perimeter of the SRG is the source of most induced current because of its proximity to the outside of the building, but this voltage gradient diminishes as one moves toward the grid's center.

9. BUILDING GROUND

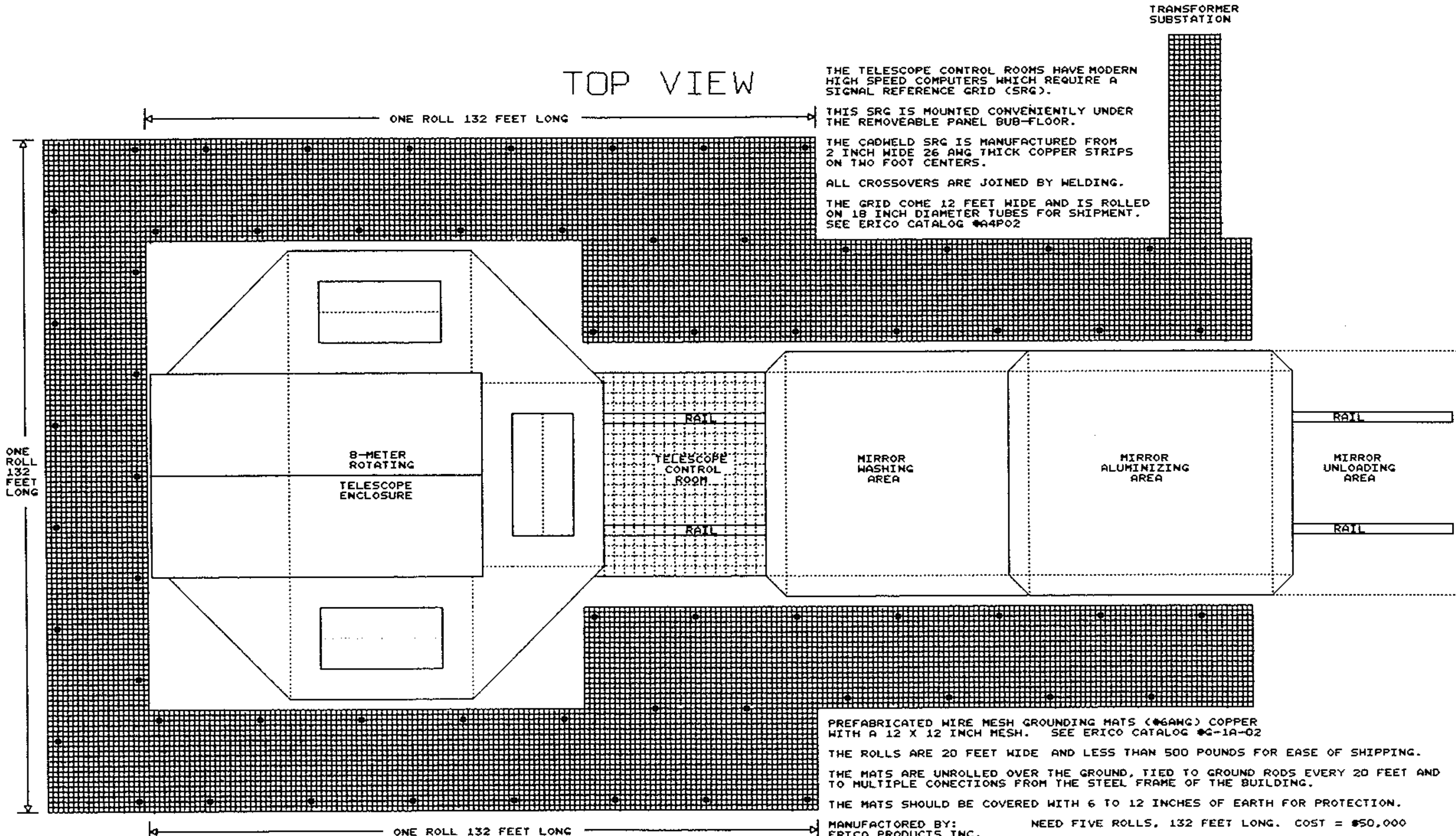
An area of deep concern in the dry desert environment at Las Campanas Observatory is the telescope and building ground. Cadweld/Erico Products pre-fabricates a wire mesh that is a convenient, efficient and economical means of providing a large area equipotential grounding system around the telescope buildings. The Erico grounding mats are made with No. 6 AWG solid copper wire with a 12 x 12 inch mesh. The longitudinal and crosswires of the Erico wire mesh are silver-brazed at their crossing points. This method provides joints with a high breaking strength, strong enough to resist separation during installation.

The area where the copper mesh mats are to be placed will first be covered with about a half-inch layer of water absorbing polymers. These polymers (little super sponges) retain the precious water that normally would percolate down through the rocks and be lost. Broadleaf P4 Water Storing Granules is the most widely available and comes in 55 pound bags. The pliable mats are simply unrolled over the layer of polymers, Cadwelded to the ground rods and interconnected where necessary (see Cadweld/Erico Products catalog A-1A, section 2). The mesh is joined by the Cadweld type PG connection which welds the wire ends from adjacent mats in a parallel, overlapped position. Because the connection requires overlapping the wires, the sides of the mesh have an extra two inches of length (see Erico Products bulletin G-1A-02).

The ground rods are staggered about every 20 feet and placed 2 feet in from the perimeter of the mesh. Each ground rod hole has two 50 pound bags of Grounding Augmentation Fill (GAF) in it. GAF is the lowest resistance fill available (0.8 ohms/meter), 1/3 that of bentonite. The mats will then be covered with about a 6 to 12 inch layer of top soil in the grass area or with gravel in the driveways for protection of the mesh.

The Cadweld process also provides the method of interconnecting the Cadweld/Erico wire mesh to the building steel and the reinforcement bar in the foundation. The nearby ground rods and the wire mesh are tied to the building in as many places as is convenient (see Erico Products catalog A-1A, sections 3 and 8).

TOP VIEW



THE TELESCOPE CONTROL ROOMS HAVE MODERN HIGH SPEED COMPUTERS WHICH REQUIRE A SIGNAL REFERENCE GRID (SRG).

THIS SRG IS MOUNTED CONVENIENTLY UNDER THE REMOVEABLE PANEL SUB-FLOOR.

THE CADWELD SRG IS MANUFACTURED FROM 2 INCH WIDE 26 AWG THICK COPPER STRIPS ON TWO FOOT CENTERS.

ALL CROSSOVERS ARE JOINED BY WELDING.

THE GRID COME 12 FEET WIDE AND IS ROLLED ON 18 INCH DIAMETER TUBES FOR SHIPMENT. SEE ERICO CATALOG #A4P02

PREFABRICATED WIRE MESH GROUNDING MATS (#6AWG) COPPER WITH A 12 X 12 INCH MESH. SEE ERICO CATALOG #G-1A-02

THE ROLLS ARE 20 FEET WIDE AND LESS THAN 500 POUNDS FOR EASE OF SHIPPING.

THE MATS ARE UNROLLED OVER THE GROUND, TIED TO GROUND RODS EVERY 20 FEET AND TO MULTIPLE CONECTIONS FROM THE STEEL FRAME OF THE BUILDING.

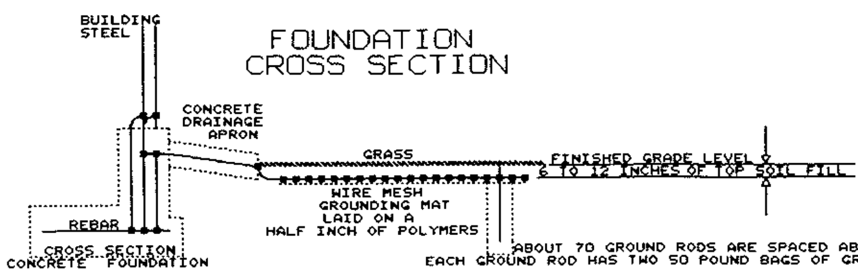
THE MATS SHOULD BE COVERED WITH 6 TO 12 INCHES OF EARTH FOR PROTECTION.

MANUFACTORED BY:
ERICO PRODUCTS INC.
34600 SOLON ROAD
CLEVELAND, OHIO 44139
(216) 248-0100

NEED FIVE ROLLS, 132 FEET LONG. COST = $50,000

REGIONAL MANAGER:
SAM BARNES
(213) 422-1343

FOUNDATION CROSS SECTION



NORTH

ABOUT 70 GROUND RODS ARE SPACED ABOUT 20 FEET APART AROUND THE PERIMETER. EACH GROUND ROD HAS TWO 50 POUND BAGS OF GROUND AUGMENTATION FILL (GAF) AROUND IT.

ALL REBAR IN BUILDING FOUNDATION TO BE CADWELDED TOGETHER AND CONNECTED THROUGH THE APRON REBAR TO THE GROUNDING MESH AT SEVERAL PLACES. SEE ERICO CATALOG #A-1A

PAGE 9

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

Title	TELESCOPE BUILDING GROUND PLANE	Scientist WAH	
		Engineer MKC	
Size B	Document Number	File name MATS	REV
Date:	January 17, 1991	Sheet 1 of	1

A wide area to the windward (northeast) side of the building needs to be planted with grass and drip watered with an underground system. Richard Rose has suggested that the waste gray water from the building could be used for this system. This watered grass area is needed to enhance the efficiency of the ground system.

Richard Rose's present layout puts all the traffic on the opposite (southwest) side of the building so this grass covered area would remain undisturbed. All the rain run-off (as little as it may be) from the entire building should be directed out to the grounding mats to also help the grounding efficiency. A fence around the grass may be needed to keep out wildlife, if it becomes a problem.

The top view drawing of the buildings on the previous page does not show any of the numerous electrical connections between the mats and the building for the sake of clarity.

All the steel structural members of the telescope buildings need to be bonded together with short seven strand No. 4 AWG bare copper conductors. All copper water pipes and all steel or cast iron pipe also needs to be bonded to the building steel at as many places as possible (see Cadweld/Erico Products catalog A-1A, section 3).

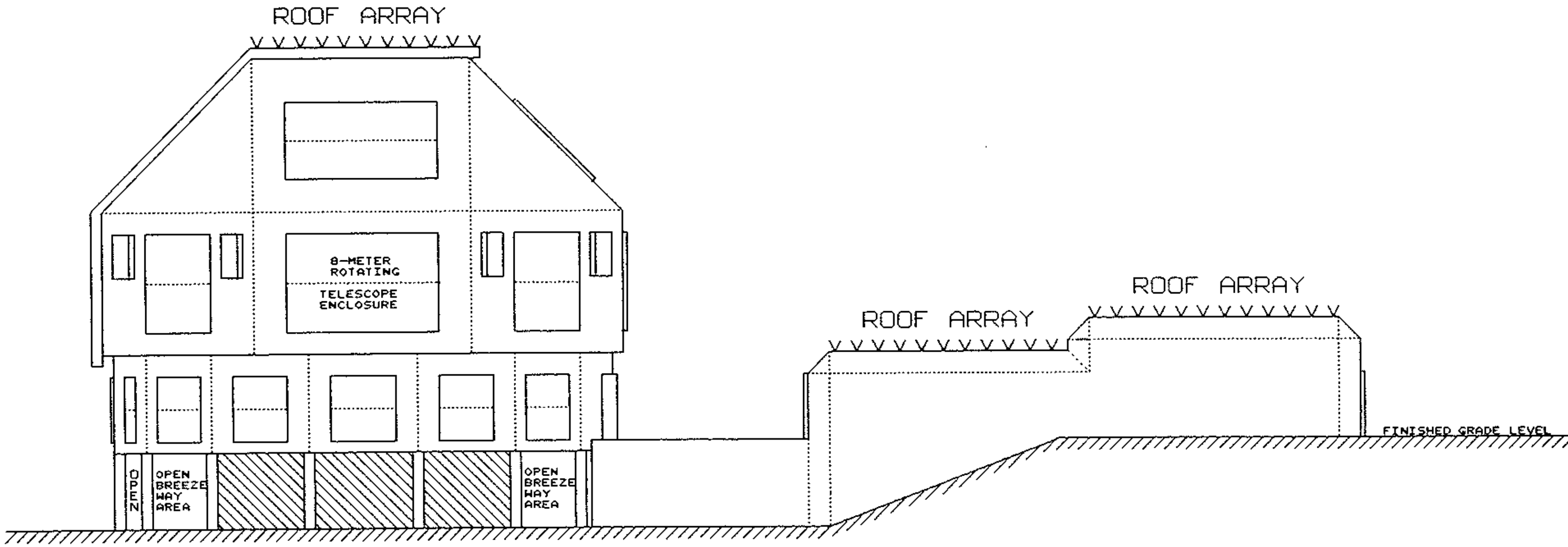
All of the reinforcement bars (rebar) in the foundation must be bonded together, then in turn to the structural steel and to the ground system before the concrete is poured (see Cadweld/Erico Products catalog A-1A, section 8).

Now, with the introduction of mobile radio transmitters, television repeaters and microwave communications links on the mountaintop at Las Campanas, more Radio Frequency Interference (RFI) protection is needed. Although the telescope control room (computer rooms) will be in a bonded all steel building with no windows, one wonders whether an inner shield should also be used. The insides of the ceilings and sides of the rooms could be completely covered with pre-fabricated shielding mesh (see Cadweld/Erico Products special applications bulletin A-4N).

11. LIGHTNING PROTECTION

Although Las Campanas Observatory does not experience thunderstorms very often, the 8-meter telescope will contain an abundance of modern sensitive electronic equipment susceptible to costly lightning damage. As with most typical optical observatories, it too is located on a mountaintop, higher than the surrounding terrain, which subjects it to a higher incidence of lightning.

The normal first line of protection should be to PREVENT a lightning stroke from striking the area of the telescope buildings.



SIDE VIEW

THE OBSERVATORIES CARNEGIE INSTITUTION OF WASHINGTON 813 SANTA BARBARA STREET PASADENA, CA. 91101-1232		
Title 8-METER TELESCOPE ROOF ARRAY	Scientist WAH Engineer MKC	
Size B	Document Number	File name ROOF	REV
Date: January 17, 1991	Sheet 1 of 1	

A single high tower located due north, topped with a hemispherical dissipation array (IONIZER) by Lightning Eliminators and Consultants of Boulder, Colorado would easily provide the preventative protection for both telescope buildings. However, because of sky interference this form of prevention will not be pursued.

When the slit doors are closed on the rotatable telescope enclosure it forms an almost square flat roof. As an alternative to the above tower, the perimeter of this roof should be lined with the "ROOF ARRAY" form of dissipation array. The roof array was designed to replace conventional lightning rods with lightning prevention, although it may hamper snow removal.

The bonded all metal buildings used here will act as Faraday cages to help protect the sensitive electronic equipment inside. An all metal building with bonded steel parallel columns is also a superior low impedance downconductor. All successful lightning protection systems depend on a good ground, which we will already have. The metal telescope buildings will be bonded to the existing ground plane mesh in numerous places all around their perimeter.

The rotatable telescope enclosure rolls on 16 or more large steel wheels. Steel wheels that are electrically bonded to the rotating steel enclosure, with each one making physical contact with the building's steel rail, which in turn is bonded to the building's steel structure, have proven in the past at the Sacramento Peak Observatory in New Mexico to make a surprisingly good grounding path for lightning.

Note: In the Magellan Project Report No.24 on the rotatable telescope enclosure the fourth Duct-O-Bar sliding contact is also a non-current carrying, electrical safety ground.

Once lightning associated transients enter the circuitry of an electrical installation, they must be diverted at each individual circuit locations with lightning arrestor devices. There are three basic category locations; the Equipment Receptacle (Category A), the Distribution Panel (Category B), and the Service Entrance (Category C).

At point "C" where the 480 volt, three phase, enters the telescope buildings (Service Entrance) a High Energy Dissipator (HED), such as the PH-480-3D by L.E.C. Dynatech, needs to be installed for lightning protection. At "B", just before each and every 480 volt power distribution panel, a Transient Energy Protector (TEP) such as the PT-480-3D by L.E.C. Dynatech is also needed.

13. ELECTRICAL STANDARDS

The Las Campanas Observatory uses the same electrical standards for voltage and frequency as Canada and the United States.

This facilitates the procurement and pretesting of all electrical equipment and electronic instrumentation in North America prior to shipment to Chile.

All electrical wiring devices and parts should be standard, readily available commercial units. No electrical parts shall be modified in any way to impede a quick replacement with an off-the-shelf part. This specifically means that no special drilling, filing a flat on a shaft, bending or disassembly of the part should be necessary at the time of installation or at the time of replacement!

The old, undesirable wild (high) leg delta transformer connections like those presently used at the Las Campanas Observatory telescopes must be avoided in the 8-meter telescope buildings. This unbalanced form of three-phase power source is not suitable for computer equipment which require three-phase power and which are disturbed by line voltage unbalance with unequal voltages to neutral and to ground. All integral horse power motors and even the larger fractional horse power motors should operate directly off the 480 volt 3 phase power. So, there will be no need to mix single phase 120 volt loads with 3 phase 240 volt motor loads through the use of wild (high) leg transformer connections.

In order to achieve the necessary power shielding, all of the electrical power wires in the telescope buildings will be run in oversized electrical metallic tubing (EMT) or metal conduit (no plastic conduit or outlet boxes will be used). All the metal conduit will be grounded to the building steel as often as possible.

All the metal conduits will use pulling elbows every other 90 degree bend. The conventional standard of using three 90 degree bends between pull boxes did require far too much effort to pull the wires by hand in the du Pont 100-inch telescope installation.

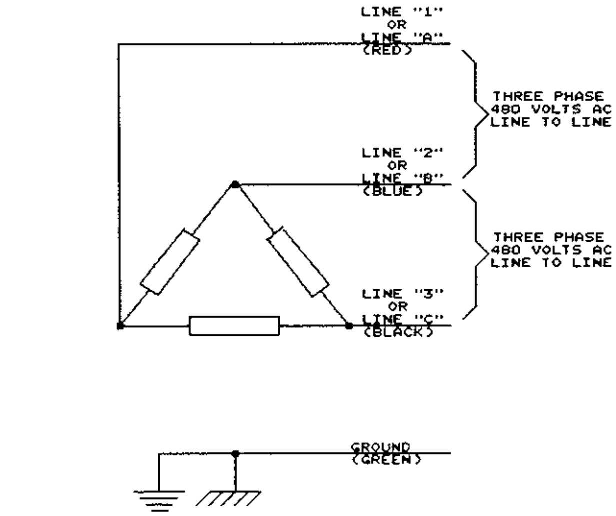
Electrical appliances are normally grounded through a conventional grounding receptacle which also mechanically connects its ground contact to the metal outlet box and then in turn to the metal conduit.

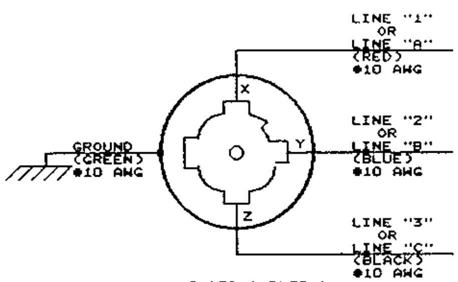
This is fine for the NEC required personnel safety ground. However, sensitive electronic equipment is often adversely affected by transient ground noise signals when using this conduit grounding system. The source of this noise problem is the multiple ground points often created as the metal conduit is secured in many places to the building structural steel, which is as it should be. The conduit's multiple ground points can lead to dreaded "Ground Loops" and common mode interference.

To avoid this problem with multiple ground points all of the telescope and telescope building's 120 volt electrical outlets will be of the Isolated Ground (IG) type that require a separate ground wire for safety ground.

PHASE ROTATION STANDARD:

FRONT-TO-BACK A-B-C
LEFT-TO-RIGHT A-B-C
TOP-TO-BOTTOM A-B-C





"WELDER OUTLET"

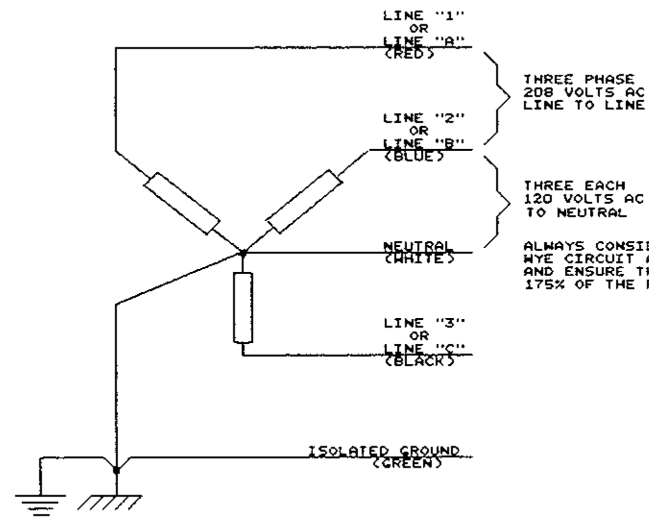
HUBBELLOCK 21420
3 POLE 4 WIRE
3 PHASE DELTA 480 VOLT AT 30 AMPERES

NOT ISOLATED GROUND BECAUSE
NO SENSITIVE ELECTRONIC EQUIPMENT
WILL BE USING THIS RECPTACLE.

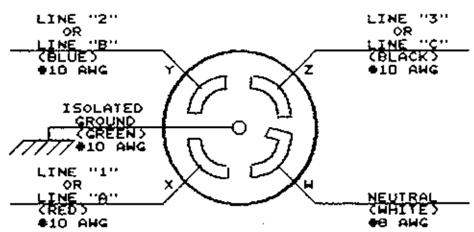
THIS IS ALSO THE STANDARD WELDER OUTLET
USED IN THE DU PONT 100-INCH TELESCOPE.

PHASE ROTATION STANDARD:

FRONT-TO-BACK A-B-C
LEFT-TO-RIGHT A-B-C
TOP-TO-BOTTOM A-B-C



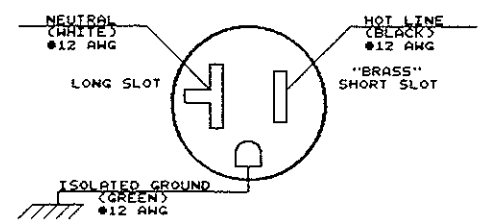
ALWAYS CONSIDER THE NEUTRAL IN THE THREE PHASE,
WYE CIRCUIT AS A CURRENT CARRYING CONDUCTOR
AND ENSURE THAT IT IS LARGE ENOUGH TO HAVE AT LEAST
175% OF THE RATING OF THE LINE CONDUCTORS.



HUBBELL IG-2810
SINGLE TWIST-LOCK RECEPTACLE

4 POLE 5 WIRE
3 PHASE Y WITH ISOLATED GROUND
120/208 VOLTS AT 30 AMPERES
NEMA L21-30R

THIS IS AN IDEAL RECPTACLE FOR
LARGE ELECTRONIC SYSTEMS AND COMPUTERS.



CATEGORY "A"
HUBBELL IG-8310-SP
SINGLE RECEPTACLE / SURGE PROTECTION
OR
"HOSPITAL GRADE"
HUBBELL IG-8300
DUPLEX RECEPTACLE

3 WIRE ISOLATED GROUND
120 VOLT AT 20 AMPERES
NEMA 5-20R

PAGE 14

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

Title: ELECTRICAL OUTLET STANDARDS		Scientist WAH	
		Engineer MKC	
Size B	Document Number	File name OUTLETS	REV
Date: February 6, 1991	Sheet 1 of 1		

The use of IG type receptacles establishes a separate non-current carrying safety ground path that has no electrical or mechanical connection with any conduit, box or fittings, only the ground contact in the receptacle. All of the 120 volt IG type outlets used will be connected with an independent green insulated ground wire which is the same size as the feed wires and is grounded only at the Load Center (circuit breaker box). The Load Center is the ONLY place where the Isolated Ground wires and the building's ground system electrically connect. This solution does comply with the safety code requirements. However, it does so in a manner which will also control or reduce potential noise problems.

The Las Campanas standard "welder outlet" shown on the left of page 15 is an exception. Although it needs and uses its safety ground, it does not need or have an ISOLATED ground. There will be no sensitive electronic equipment using this 480 volt single purpose outlet.

The Hubbell IG-2810 single twist-lock receptacle with its ISOLATED ground is an ideal receptacle to plug-in large electronic racks. The Observatories have used this receptacle in the past in combination with a three phase distribution panel in large racks to split the three phases out into three individual 120 volt outlet strips inside the rack. The distribution panels have two each three-phase circuit breakers, one for systems power and one for continuous power. The separate continuous power is often convenient for clocks and temperature stabilized equipment in the rack which should not be turned off with the system power.

All the 120 volt wall outlets used throughout the telescope building are the ISOLATED ground type. These outlets shown on the right of page 15 are the heavy duty 20 ampere type rather than the more common household 15 ampere type.

The new Hubbell IG-8310-SP single 20 ampere, 120 volt Equipment Receptacle (Category A) with its own built-in surge protection is an ideal choice for exclusive use with the computer room isolation transformer. This receptacle, with its unique color and shape, could be used to signal users that it was wired to the secondary of the isolation transformer.

We should consider putting in cheap wall outlets initially during the construction phase and replacing them with the heavy duty 20 ampere "hospital grade" later. Almost all of the original wall outlets used in the du Pont 100-inch telescope were no longer functional and had to be replaced after the construction crew finished and before the telescope went operational. Although the heavy duty 20 ampere wire must be installed from the beginning.

Again, the two most common computer problems associated with AC power are non-isolated grounds and when the conductor sizes are too small. These problems occur even when the grounding and wiring are done according to code.

15. REFERENCES

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