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Assembly Instructions for PRO-DOME Observatory HD15

S/N _____

Congratulations.

You have purchased an HD15® observatory, which will serve you well in the years to come. We are sure your new dome will increase your enjoyment of observing, and help you be a more active astronomer.

Even though you will be constructing the equivalent of a small building, the HD15 dome is easy to assemble. However, it is essential that you read these instructions because the assembly involves the handling of fairly large structural pieces, use of power tools, and the need to perform mechanical assembly. Assembly should be an enjoyable experience, so take your time and be careful.

We hope and believe that you will be happy with this product. We ask that you let us know of any suggestions or criticisms of our products. We have incorporated many ideas from customers into these instructions, and into the HD15 design. We thank all who contributed (and you are the beneficiary!) If, at any time, you have questions, please feel free to give us a call so we can help you. Our aim is for you to be satisfied!

JERRY SMITH
Technical Innovations

CAUTION

Handling fiberglass improperly can result in skin injury, while failure to perform several easy, but crucial, steps in the HD15 assembly can cause the HD15 dome not to operate properly. In addition, failure to follow recommended assembly may result in injury during or after construction. Please at least scan all parts of these instructions, even those parts covering skills you already have.

Technical Innovations is not responsible and assumes no liability for any damage or injury arising from assembly or use of this product. While the instructions include cautions and warnings, it is ultimately the customer who must exercise good judgment and care in the assembly and while the observatory is in use to avoid damage to materials or persons, and it is the customer who assumes all risk and liability.

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PARTS LIST HD15

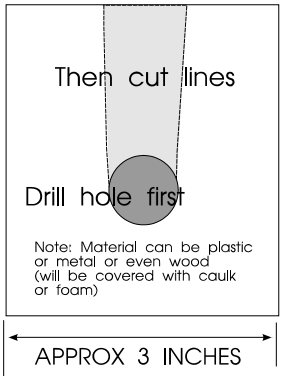
Fiberglass Pieces
Front Quadrants, one each Left & Right
Rear Quadrants (with notch in slot edge), one each Left & Right
Dome Support Ring Sections (4 pcs)
Rear Cover (1)
Top Shutter (1)
Front Shutter (1)
Base Ring Sections (5)

Fittings and hardware
Stainless Steel Carriage Bolts
Stainless Steel Flat Head Bolts
Nuts, washers
Front Latch (40 in long)
Rear Latch (27 in. long)
Shutter Catcher Brackets (2)
Wind Restraint
Wheels (51) and Side Rollers (24)
Handles (2)
Shutter Restraint System (cables, bolts, etc.)
Shutter bearing strips (5 pcs) & surface cleaner
Front Shutter Edge Molding
Rear Opening Cover (Soffit)
Splice Plate
Electric Dome Drive (4 motor plates, hardware, cable)
Electric Shutter (drive motor, cables, pulleys)
Power supply (PS-2) w/ hardware
Caulk
Instructions

Tools Required by Purchaser (not included with HD15)
3/8 in electric drill, multiple bits
(two drills are even more efficient)
Countersink (82 deg. preferred)
File or rasp
Metal rule (25 ft. or longer)
Carpenter level or water level
Hand tools: clamps, screw drivers, socket wrench set, etc.
Large metal square & straight edge
Duct tape
Caulking gun
Gloves, Eye Protection

Stepladders (6 ft., 12 ft.)
Worktable - Sawhorses & plywood OK
Extension cords
Foundation bolts, fender washers
Shims & spacers for leveling**

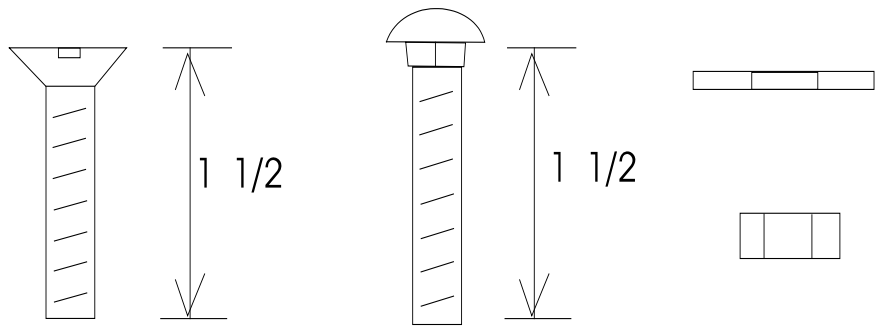
** Shims – have several thicknesses available (such as 1/8", ¼"). The design shown here is useful because you can slide it in under the fiberglass and around a bolt without having to remove everything.



BOLT COUNT FOR BASIC HD15

BOLT LOCATION	Flat 1½"	Flat 2 ¼	Carr 1¼"	Flat 1"	Carr 1"	Flat 3/4"	NUTS	WASHERS	Special
Greenwich Flange			20				20	20	
Base Ring				5	5		10	10	
DSR safety					4		4	4	
Equatorial Flange						40	40	40	
Rear Cover	20						20	20	
Shutter Latches					9		9	9	
Shutter Catchers					6		6	6	
Shutter Stop			2				2	2	
Handles					4		4	4	
Rollers		51					52	104	
Side Rollers									20 self tap
TOTALS	69		22	5	28	40	168	15	
Wall Ring (Opt)					32		32	32	

Notes: 1. Non-1/4-20 hardware for Semidoor, latches, etc. not shown
2. Extra bolts, nuts, etc. are provided



FLAT HEAD SCREW/BOLT CARRIAGE BOLT NUT & WASHER

SCREW LESSON

The outer diameter of small screws is a number such as #6, or #8. #8 is bigger than #6. In larger sizes, the diameter is in fractions of an inch (e.g., 1/4 inch). The second number (e.g., 6-32, 1/4-20) is the number of threads per inch. The third number (e.g., 6-32x1/2) is the length in inches.

1. INTRODUCTION TO INSTRUCTIONS

The assembly of the HOME-DOME involves several steps. These include:

* obtaining necessary permits
* building the foundation
* assembling the wall (if any)
* assuring that the top of the wall is level
* installing the base ring and rollers
* assembling the dome
* installing the shutters
* installing the fittings and hardware

Building Permits

In some areas, building permits are needed for the installation of the HD15, although there are sometimes exemptions for small accessory structures. If you need a permit, you will need to apply for it, and include a sketch of the proposed location, and a sketch of the proposed installation. If the dome is to be installed on a school or house or other inhabited building, special fire or other codes may apply in addition to structural integrity requirements. Check with the local officials: it is much easier to handle the questions before you build, than to find out later you are in violation of the local law.

Foundation

The HD15 must rest on a secure foundation if it is on the ground, or framing support if it is to be installed on a deck or other structure. The major purpose of the foundation is not to support the weight, since the HD15 only weighs about 650 pounds. Rather, its purpose is to provide stable support under all environmental conditions.

The foundation must support the observatory so that the walls and dome do not twist as the ground freezes or thaws or becomes dry vs. wet (this could cause the dome to become hard to turn).

FIG 4,5,6

The foundation must hold the HD15 down in the case of severe wind. Depending on the area of the country, hurricane or other winds 80 mph (or more!) can occur, so building codes require that buildings and their foundations resist such winds. (An 80 mph wind on the HD15 can generate a force of over 1500 lb.!). In addition, in most cases, the foundation system must provide some means of leveling the observatory.

The foundation may be part of a building or house, a deck, a ring foundation, piers into the ground, or a concrete pad (often with wood or carpet covering). If you want suggestions, please contact us for more information on constructing foundations.

Foundation bolts

Selecting the appropriate foundation bolts to hold the bottom ring to your surface is your responsibility. The most common bolts are lag bolts into anchors in a concrete pad, or carriage bolts through a wood deck. In all cases, it is absolutely necessary to use washers at least 1 1/2 inch diameter under the bolt heads. In general, we recommend using 3/8 inch diameter bolts spaced about 16-18 inches apart along the bottom flange. Lag bolts should penetrate the pad or deck at least two inches. Be sure to allow enough length in case you need to use shims under the wall or base.

Installation Practices

Many of the installation steps take longer to read than to do. While no complex carpentry or other skills are needed, you will need to perform some measurements, locate and drill holes, and install bolts. Sometimes edges of fiberglass may need to be sanded or trimmed. However, no experience is needed in working with fiberglass, and no application of fiberglass needs to be done. None of the pieces weigh more than about 75 pounds, so even though they are bulky, they are relatively easy to handle.

We would strongly urge that you have several workers to help you assemble the HD-15. This allows you to check on each other, and will help avoid mistakes. A second person can help a great deal in holding items in place while the first drills holes and installs bolts. Certain steps in the HD15 assembly normally require four or more persons working in concert.

Before beginning construction, all workers should read through the directions and study the pictures. Note especially the terminology that we use for the various parts. We urge that you **not** try to build the dome in an order different from that in the instructions: some of the short cuts that look attractive have traps in them (we know - we've gotten stuck!)

Finally, if you make a mistake, don't panic. In most cases you can just take the components apart, drill new holes, and do it over. If you want to, you can always go back later and patch any mistakes with resin (that is one of the virtues of fiberglass!) And if you get really stuck, give us a call and we will try to help.

2. SAFETY PRECAUTIONS

Constructing an HD15 requires you to follow several safety precautions and use common sense, since the activity does include mechanical and manual operations. Care is needed in the use of tools and you should follow the precautions provided by the manufacturers of any tools you may use. Since you will be constructing a small building, you will need to use step ladders: be careful. While the fiberglass parts are not very heavy, they are bulky: use care in handling them so that neither you nor the parts are injured. Carefully read all the instructions, and think through your activities before you commence. Make liberal use of props, tape, clamps, or other aids in the construction.

CAUTION

If the dome is to be installed on any support or wall more than three feet above the ground, or in a location with difficult outside access, we **STRONGLY** recommend that you pre-assemble the base ring, dome, shutters, and all fittings on the ground. You can then assemble the dome in a convenient and safe situation. Once pre-assembled, it only takes an hour or two to disassemble the parts. You can then reassemble in place, knowing how the parts fit together, and with direct experience in handling the pieces.

Fiberglass

Fiberglass is really a misnomer: the material is fiberglass reinforced plastic (FRP). In our case, the plastic is polyester resin (not epoxy). In its "raw" state, polyester resin is a syrupy liquid, After mixing about 15 drops of catalyst per ounce of resin, it hardens in about an hour. Because the hardened resin is somewhat brittle, it is reinforced with fiberglass for strength, and to prevent the propagation of cracks. The fiberglass can be in the form of woven material which has the resin spread onto and into it, or long fiberglass strands which are chopped into 2 inch pieces, then mixed with resin that is sprayed into a mold.

Fiberglass has many virtues, but also two potential problems:

FIBERGLASS IS FLAMMABLE
FIBERGLASS CAN IRRITATE THE SKIN

Yes, fiberglass will burn, or rather, the plastic in it will burn. Once started, it does burn very hot (you might want to try a 1 square inch piece in a fireplace to see). Therefore, use common sense as you would with wood or any other flammable construction material. Keep fire and open flame away from all parts of your PRO-DOME. Also, do not let fiberglass dust or trimmings accumulate. Be especially careful about this where there is any risk of flame or fire.

The fiberglass within the FRP is glass, and it can cut or abrade the skin. Sharp edges of the dome pieces can cut, so be careful. Whenever handling FRP pieces, always wear

gloves to be on the safe side. Of course, the surfaces of the FRP are smooth, because they have been coated with a layer of resin (called Gel-coat) that covers the glass.

Fiberglass dust can irritate the eyes and skin. When cutting or trimming or filing or drilling -- in short, whenever doing something to the FRP that makes dust -- always use gloves and eye protection. Also, wear a long sleeved shirt and long pants. In addition, be sure to change your clothes and wash thoroughly when you are done the dusty part. If there is lots of dust, change how you are doing things to reduce the dust exposure! Reasonable care is all that is needed; however, failure to follow reasonable care could lead to eyes or skin that itches for a day or so. Hand lotion can help relieve itchy skin. If itching persists, see your physician.

Construction and Operation Cautions

During construction and operation, there are specific cautions that must be followed. The HD15 observatory is not a toy, so be sure that children (and adults) do not climb upon it. Since the observatory does contain moving parts, users must be careful to avoid injury. Keep your fingers away from the moving parts where they might become caught.

The shutters CAN BE DANGEROUS. Each shutter weighs about 50 lb., and slides on the slot edges. They are normally interlocked, and under control of the user. However, if they should not latch properly, or if they are separated for maintenance work, the shutters (especially the front shutter) can begin sliding with little warning. It is ESSENTIAL that care be used never to let the top or front shutter rest by itself at the top of the dome without proper anchoring (if the two are latched together as they normally are, there is no risk). To help prevent injury, you should consider installing a safety device on the front of the dome to limit unexpected downward movement of the front shutter.

To prevent high winds from damaging the dome, it is **essential** that the shutters be fully latched and the front shutter fastened when the dome is not in use.

3. SPECIAL ASSEMBLY INSTRUCTIONS

This section contains special instructions that apply to several parts of the assembly. We have written these for the relatively unskilled assembler. However, even those who are skilled in carpentry or other mechanical assembly SHOULD read and follow these instructions, especially concerning leveling the structure.

FIG 13

Nomenclature

Parts of the PRO-DOME observatory have special names. These include the following.

- **Reverse Flange** - This is the curved topmost flange that is a part of the top flange of the base ring or wall. The purpose is to hold the dome down in case of wind, and also to provide a drain for any water that might enter the dome.
- **Equatorial Flange** - This is the internal flange at the "base" of the dome quads where the equator would be on the earth.
- **Front of Dome** - The dome is that portion of the observatory that rotates. The front of the dome is the location of the front shutter.
- **Front of Observatory** - The observatory wall (or observatory building) is stationary and does not rotate. Usually, we define the closed front shutter to be the "front" of the observatory when “parked” in the home position. The home position is where the contact sliders are resting on the contact plates so that power can be transferred to the shutter motor assembly to oen or close the shutter. These considerations are important when you install the dome for appearances and wind tolerance.
- **Home Position -** When the contact plates and contact slides are making contact, the dome is in the HOME position.
- **Base Ring** – the ring that has the rotation rollers.
- **Foundation Ring** – the bottom most ring of the wall that bolts to your foundation. It will normally be the base ring (when you are not using extra HD15 wall rings).

See later chapters for details.

Locating Holes

In assembling the HD15, you will need to drill holes and insert bolts to hold the various pieces together. But how will you find where the holes are to be and what is the hole drilling procedure?

To assure as few mistakes as possible we have created a “Bolt Hole Drilling Guide” (attached to this manual) as well as describing the hole locations in each of the assembly sections in the manual. These holes are to be drilled before assembly. During assembly, if some of the holes do not quite line up, and if you are SURE no assembly mistake has been made, you can use your drill to "open up" the holes to accommodate a bolt. Hole sizes will be given in the instructions (most will be 1/4", 9/32", 3/8" or 5/16").

Drilling and Bolting

FIG 1

Many HD15 parts are held together with carriage bolts or flat head bolts, 3/4 or 1 inch long. Carriage bolts have round tops, with a square shank that catches in the hole, preventing turning of the bolt. Flat head bolts are installed in a countersunk hole. We provide stainless steel carriage and flat head bolts, washers, and nuts to minimize corrosion.

In most cases, bolt holes are drilled before pieces are assembled. Drilling in fiberglass requires use of eye and skin protection, but otherwise presents no problems except that bits become dull after 50-100 holes. If a flat head bolt is to be used, you will also need to use a "countersink" to create the sloping hole to accommodate the screw head. If available, use an 82 degree countersink, and cut the material just enough to recess the flat head.

Once the holes are drilled, assemble the pieces by installing the carriage bolt or screw in the proper direction (the instructions will tell you in each case). Be sure the bolt head is snug into the hole. Install a 1/4 inch washer and nut, and tighten. If the nut will not turn, check for fiberglass dust in the threads -- clean the nut and bolt and try again. Do not force the nut! A drop of oil may help as well.

If you drill a hole in the wrong location, either re-drill a new hole in the correct location, or, for small errors, enlarge the hole on the "nut end" piece, and install one or more large washers, or metal or wood plates, before installing the nut.

Here are some additional tips for drilling holes in fiberglass, or cutting it:

- Drill a pilot hole smaller than the final hole to keep the drill from wandering during the final drilling.
- A common twist drill will produce a triangular hole. In some cases, this can cause a problem. To prevent this, simply drill a hole a few 64ths smaller than the final hole, then finish drill with the desired size.
- Drilling fiberglass produces fine glass dust. If you leave it in the hole, the dust will get into screw threads and make nuts hard to turn. Clean the holes (rag on a screwdriver) and use a bit of oil on the screw to reduce the problem.
- A drilled hole will usually have a ragged edge. In most places, this is not a problem; however, you may want to know several tricks to prevent this. These include predrilling undersize holes, back up the fiberglass with a piece of scrap wood while drilling, drill partway through on one side, then do the other side. You can also lightly countersink every hole after drilling.
- We often call for use of a countersink (makes a conical hole). If you don’t have one, you can use a large bit (eg 1/2 inch bit on a 1/4 inch hole) to make the cut. However, be careful not to go too deep. Also, note that the

angle of the cone may not match very well the bolt that will go in it (usually 82 deg).

- Sometimes the gelcoat will chip when drilling or sawing. If this is a problem, there are tricks to use. These include putting masking tape on the gelcoat before drilling/cutting, use high speed cutting with low pressure, using fine toothed cutting blades, and drilling preliminary undersize holes.

Leveling the Foundation, Wall, and Base Rings

The more level the foundation is, the easier your overall installation will be. In any case, the top of your base ring or wall must be level (or at least planar). If the base ring is not level, the dome will not be supported uniformly on its rollers. This can cause a variety of problems not only with turning the dome, but also with the shutter operation as the shutter opening may be distorted. At least 1/4 inch accuracy in leveling is needed; however, 1/8 inch is even better.

While the "bottom line" is to achieve a level base ring, any wall built below the base ring should also be level and/or provide a means of leveling the base ring. Leveling techniques using shims or adjusting bolts are discussed below in the foundation section.

There are many ways to perform the leveling. Here are details on several of the best.

* If you have a **transit or theodolite**, you can use it.
* If you have a **split image transit** or **eye held level**, don't bother. It is not accurate enough and/or is too hard to use for this application.
* **String levels** are not sensitive enough.
* The **human eye** can see out-of-plane errors in the ring; however, it is very confusing to identify which portion is too high or low, and hard to estimate the amount. It is also hard to keep track of errors in the portions of the ring crossways to the line of sight, versus those more parallel.
* **Carpenter levels**, if sensitive, can be used, but will not do the job if simply moved around the circumference. See below.
* **Water levels** are far and away the easiest and best way to level the base ring or wall. They can be made or bought (about $15), and are described below. (We once spent two frustrating hours with a carpenter level and split image transit and could not do better than 1/2 inch, but a water level did the job to 1/8 inch in ten minutes!)

Leveling with Carpenter Level

FIG 2

The two to four foot carpenter level can serve to level the structure. However, you will find that if you simply move it along the circumference, it is impossible to level the ring accurately. The problem is the subtle shifts of the bubble as you move around the ring.

A much better method is to set up a support at the center of the dome, at a height equal to the top of the wall ring or the item to be leveled. Use a bar from this center to the outer ring, and place the level on the bar. Now as you swing the bar around, you can track which parts of the ring are high or low relative to the center. It is easy then to adjust the wall ring to a level condition.

Leveling with Water Level

FIG 3

This is the best! A water level is made of two see-through containers, connected by a flexible, long tube, filled with colored water. (Hint - Use food coloring.) After adjusting the water levels, one container is set on a reference point (e.g., one spot on the ring) while the second one is moved to different points around the ring and the difference in elevation measured. The water level in the moveable container will rise (or fall) with the fall (or rise) of the level of the point you are measuring when compared to the reference point.

Commercial water levels read directly in inches, so it is easy to make accurate leveling corrections. Homemade water levels will work fine, so long as they don't leak. Water levels are tough to use in freezing weather!

Making the Observatory Circular, and maybe Centered

While only the base ring **MUST** be accurately circular, it is highly desirable that all portions of the dome, including the foundation and walls (if any), be circular. On the other hand, while aesthetically desirable, it is not necessary that the observatory be centered on some "magic" point, with all parts concentric (note that the telescope pier need not be at the center of the dome).

Identify the center of the observatory and mark it with a a screw driven firmly into the foundation, or a small post sunk solidly into the ground. Mark the exact center of the screw or the post with a small nail driven into it but projecting 1/4 inch. You can now use this as the center for marking the foundation, your foundation bolt circle, etc.

The easiest way to start is to draw inner and outer diameters for your wall or base ring directly on the foundation. You will match the inner edge of the foundation ring bottom flange to the inner diameter that you drew. The outer diameter is there as a reference too, but use the inner mark because it is easier to keep in view.

FIG 2

To check the "centeredness" of successive (higher) wall rings, you will want a "center point" that is at the height of your wall. We will describe one easy method of providing this center.

As you build the observatory higher, you can use a plumb bob from beneath a tripod (surveyor or camera tripod) to establish a center at any height you want. If you have no tripod, nail a box together, or stack cinder blocks so that you can hang a plumb bob over

your center point. With a little care, you should be able to perform the centering to about 1/8 inch. In either case, you can then use a tape measure to measure the radius to each point around the wall, so as to show that the wall is both circular and centered.

Several dimensions will be used later in the assembly of your dome. We put them in a table below, for your reference.

ITEM	OUTER DIAMETER AVERAGE (IN.)	CIRCUMFERENCE (IN.)
Base Ring	179.00	562.35
DSR	180.57	567.00*
Dome	180.00 (nom)	565.00

* Measured 1 in. below upper flange of DSR

4. FOUNDATION

The HD15 must rest on a secure foundation if it is on the ground, or framing support if it is to be installed on a deck or other structure. The major purpose of the foundation is not to support the weight, since the HD15 only weighs about 650 pounds. Rather, its purpose is to provide a stable support under all environmental conditions.

The foundation must support the observatory so that the walls and dome do not twist as the ground freezes or thaws or becomes dry vs. wet (this could cause the dome to become hard to turn).

The foundation must hold the HD15 down in the case of severe wind. Depending on the area of the country, hurricane or other winds up to 80 mph can occur, so building codes require that buildings and their foundations resist such winds. (An 80 mph wind on the HD15 can generate a force of over 1500 lb.!). In addition, in most cases, the foundation system must provide some means of leveling the observatory (usually using shims).

The simplest foundation fastening technique is to drill 5/8 in. holes in the foundation, install anchors, and use 3/8 lag bolts (with washers), and shims as necessary for leveling. An alternative is to use studs (threaded rod or bolts) cast into the foundation with adjusting nuts. Both schemes are shown in figures below. In any case, the foundation should be built to be as level as possible, so that height adjustments to level the walls are minimal and easy to do.

Technical Innovations has supplied several sample foundation and anchoring designs, but any support or foundation design **must be approved** by your local building code officials. We make no warranty that the designs will be legal or function in your particular circumstances. These can be "mixed and matched" to meet your needs. All these designs are suitable for do-it-yourself construction; however, if you are not comfortable with such a project, check your local library for books on foundations and concrete construction.

FIG 4

Ring Foundation

An excellent foundation is a concrete ring. The thickness and depth of the ring depend on local law and weather conditions, but typically might be five inches in radial thickness and two feet deep. The top of the foundation should be several inches above the ground, and sloped very slightly outward for drainage. Lag bolts with anchors or foundation bolts cast into the foundation are both feasible. Then, if using wall rings, holes are drilled in the lower wall ring flange to match the bolt locations.

When building a ring foundation, don't forget to allow some holes through the foundation for power or other cables! You may also want steps or a ramp cast at the same time, depending on how you wish to enter the dome.

Pier Foundation

FIG 6

Instead of a continuous ring, you may want to install piers. We recommend twenty piers -- these may be pressure treated posts, concrete, or other material. Again, your building code official must approve any design.

One advantage of wood piers is that it is easy to locate and drill holes for the foundation bolts. Also, wood piers may be easier to install at remote locations. A disadvantage may be that digging twelve holes is a lot of work in some soils!

Concrete Pad

FIG 7

Another alternative is to pour a concrete pad that will serve both as a floor and as the foundation. This is perfectly feasible, but may be more costly than other alternatives. You may find the floor to be uncomfortably hard and cold; however, outdoor carpet or a wood floor will correct that. If you use a concrete pad, install your pier before pouring the floor, or at least leave a hole so you can have a separate pier or post for the telescope. You will also want access for cables from the outside to the dome walls and to the central pier. Depending on your local laws, you may need separate footings for the pad. In most areas, the pad should be about 4 in. thick, should have heavy reinforcing wire in it, and should have some gravel drainage beneath it. Be sure to install a sheet of plastic under the concrete to keep out moisture.

Wood Deck

Another type of foundation is to construct the observatory on a wood deck. This is perfectly feasible; however, it is obviously important that the deck be well constructed to withstand wind forces. It is also vital that the wood be treated to prevent rot. Such an installation will normally have a hole near the center of the observatory for a separate pier extending down to the ground. If the deck is more than a few feet above the ground, be sure to provide strong railings. The interior floor of the deck can be left as is, or additional flooring (eg., plywood and outdoor carpet) can be added.

5. WALL AND BASE RING ASSEMBLY

Now we are ready to build the observatory! Most HD15 installations do not include a wall (other than the base ring), but we have included material on wall rings because sometimes extra height is called for. Wall ring and base ring assembly are very similar.

CAUTION

If the dome is to be installed on any support or wall more than three feet above the ground, or in a location with difficult outside access, we **STRONGLY** recommend that you pre-assemble the wall rings (if any), base ring, dome, shutters, and all fittings on the ground so that you can assemble the dome in a convenient and safe situation. Once pre-assembled, it only takes a few hours to disassemble the parts. You can then reassemble in the final location, knowing how the parts fit together, and with direct experience in handling the pieces.

The assembled HD15 weighs about 700 lb, including shutters, but not including any wall rings. Although the pieces can be moved by hand and assembled in place (after preassembly), you may find it easier and safer to assemble and test the observatory at ground level, then rent a crane to lift the entire assembly into position. This will require the help of persons with professional rigging experience.

The wall may be constructed using your own plans or using wall rings supplied by Technical Innovations (or both). Any wall must be able to handle wind loads, prevent twisting as the dome is turned, be water tight and resistant to the weather, look good, and, last but not least, provide a solid, level support for the lower flange of the observatory base ring.

If you are constructing a wall of your own design, you may want to send a copy of your proposed wall design to Technical Innovations. We can review it, and may have suggestions or cautions that will make the wall easier to build, or otherwise help assure a successful installation.

Wall/Base Ring Assembly Instructions **FIG 9, 9B**

Constructing all or part of a wall with HD15 wall rings is very easy because sections form a ring of the right size which can then stacked and bolted to the desired height. The optional wall rings are the same design as the base ring, so the same assembly for each is followed. The base ring is different from the wall ring by having a reverse upper flange, an access hole for aid in assembly, and holes cut into the upper flange for the rollers and motor drives.

The HD15 base ring (and wall ring) is divided into five equal length sections of the circle. Each of the sections are single piece, full length, 72 degree sections.

In general, assembly is one ring at a time. After pre-drilling (below), you will slide the five full length sections together, clamp the joints as necessary, and check the circumference and roundness before final drilling and bolting one section to the adjacent ring section. You will then build the next ring similarly, finishing with the base ring.

Several holes can be “pre-drilled” on a bench (or other comfortable work area) and working with each section rather then the ring as a hole. This includes both the wheels and side rollers on the reverse flangs of the base ring sections.

FIG 9B

First Ring Assembly

To assemble your **first** (lowest) ring, (in most cases the base ring), select the five full length sections in the proper order (for the base ring – wall ring sections are identical).. Attachment 9B shows the section order that will result in the proper placement of the ED15 rotation drive motors. You will notice that one end of each section is "stepped" inward (the "male" end) and this fits into the plain "female" end of the next section. The male end will aim to the RIGHT as seen from the outside of the section. The female end of each section should now be “pre-drilled” with the two guide holes which will be the locations for the joint bolts. [*Bolt Hole Drilling Guide #1*] The lower flange of each full length section of the wall/base ring can now also be “pre-drilled” at the five measured locations for the bolts used to fasten the ring to a lower ring (only if wall rings have been added).

Roller Mounting

There are two types of rollers: the 3 in. diameter hard rubber wheels that **support** the dome, and the white 2 in. dia HDPE side rollers that keep the dome **centered** on the base ring. First install the support wheels.

The **support** wheels project through the base ring upper flange. Some of the holes are 3in. long for the rollers, while four of them are about 7in. long for the dome drive the dome drive motors. There is also a hole for the azimuth sensor (used if you are installing automation equipment.) Do not put a wheel in this hole.

Hold a wheel in place in each hole to check that the roller will turn freely in the hole (the outer edge of each wheel hole must be smooth and flush with the inside of the base ring web). If it is not, use a file or rasp and smooth the fiberglass until it is flush. Use sandpaper to smooth the edges. Wear gloves and eye protection when drilling, cutting, or filing the fiberglass.

A template has been provided to use as a guide for drilling pilot roller holes. If the plastic template is misplaced, you can transfer the template design in Fig. 11 to metal or cardboard, or use the dimensions in the figure to locate the roller axle locations. Drill a

5/16” hole and countersink the outside for mounting each wheel. Install a 2 1/4 inch flat head bolt from the outside through the roller. Install a washer on each side of the wheel and nut on the inside. Check that the wheel turns freely. If it does not, remove the wheel and find and remove the interfering material. [*Bolt Hole Drilling Guide #2*]

The **centering** or **side** rollers are mounted on the base ring upper flange. Using Fig. 9C as a guide, hold each roller in place projecting out 1/8-3/16 in. (use a 1/8 in. thick piece of material as a guide), and drill a 13/64 hole for the axle. Use a 1/4-20 thread cutting screw and drive it straight into the hole. Drive the screw in until it just touches the roller: the roller must turn freely. To keep the screw from becoming loose, place the lock nut on the underside and tighten. **Note: The side roller must still spin freely after adding the lock nut.** [*Bolt Hole Drilling Guide #3*]

After the pre-drilling you will now fit the sections together, and check the circumference and roundness before drilling and bolting the final joint. [*Bolt Hole Drilling Guide #4*] The first ring is a little tricky, because you have to fit the pieces together to make the ring, while fitting it to the foundation, as well. In most cases this first ring is the base ring, which also means it is the final ring. It is particularly important that the base ring be circular and level.

Measure and pre-marked the holes to locate foundation bolts, (don't drill them yet). Do this for each piece.

Now assemble the five sections on a reasonably level surface, with male ends pointing right. Insert each male end tightly into its corresponding female end. You will now check the circumference and roundness before drilling the final holes and bolting the sections together. Clamps can be very useful to hold individual joints in place while working with other joints.

Measure the circumference (i.e., the distance around the ring about one inch down from the top) with a metal tape rule. Your goal is a circumference of 562.35 inches (+/- 1/2 in.), corresponding to an average diameter of 179 inches. If the circumference is too small, pull the sections apart as necessary. If too large, push the last joint closer together (cut some of the female end if necessary).

Note that while your wall ring has an **average** diameter of 179 inches, it is likely not to be an exact circle. That is, across one diameter it may be 178 while another may be 180 inches. Wall rings can easily be "nudged" two inches out of circular shape (and conversely, are easy to nudge INTO circular shape). To gain a bit of experience, take a few minutes with the wall ring on a level surface, and measure -AND WRITE DOWN THE RESULTS- the diameter for at least six different "diameters" (directions) across the ring.

The easiest way to take diameter measurements is use a steel tape from the inside (blue) surface to the opposite blue side of the ring. If you swing the tape measure a few inches left and right, you will note the spot with the longest measurement, which is the diameter.

Try adjusting the ring to become circular to within about 1/2 in. maximum range (e.g., 178 3/4 to 179 1/4). This is an easy task, but only if you keep track of your work with a drawing!

Using the previously drilled holes as a guide, drill holes in through the male end. Install 1 in. carriage bolts, washers, and nuts in the joint from the outside in. Do all five joints. Be sure that both the upper and lower parts of each joint are fully seated: often the second joint needs to be pushed together to avoid a conical shape to the wall.

Installing Base (or First Wall) Ring on Foundation

Now the job is to put the first completed wall ring on the foundation. You will need to provide at least 20 3/8 or 1/2 in. bolts or anchors into the foundation to hold the observatory in place during high winds.

The challenge is to mount the ring onto the foundation, while assuring that it is circular, and getting holes in the lower flange to line up with your foundation bolts or anchors! Some foundation surfaces are not flat, and require some shimming to produce a level wall.

Lag Bolts and Anchors. If you are going to use lag bolts and anchors, you will already have marked the holes on the inside of the lower flange (but don't drill them yet). You can't simply drill holes in the flange, mark the concrete, and drill the concrete because when you drill into concrete the hole will wander away from the mark as the bit hits stones in the concrete. [*Bolt Hole Drilling Guide #5*] Proceed as follows.

FIG 7

- Place the ring on the foundation, and adjust it to be circular to within about 1/4 in. or better.
- Use a magic marker and draw the inner and outer outline of the base flange onto the foundation. Mark the azimuth locations around the ring on the foundation for the foundation holes. After marking the ring so that you can reinstall it in the same position, remove it.
- Mark and drill your anchor holes with a masonry bit. Install the anchors.
- You will likely find that the drill bit will have wandered, but not to worry. Draw a pair of 12 in. guidelines to the actual location of each anchor on the foundation.
- Reinstall and re circularize (ugh, what a word) the ring. Using the guidelines and a straightedge, you can easily mark the wall ring flange for the exact hole locations to match the anchors in the foundation.

FIG 5

• Remove the ring and drill your foundation bolt holes in the lower ring. Once the holes are drilled, again make sure the ring is circular, and install the bolts and washers into your anchors.

Cast Foundation Bolts. If you are using foundation bolts already cast into the foundation, proceed as follows.
• Set the ring lightly on top of the foundation bolts. Make the ring circular, then mark the bolt locations on the underside of the wall ring flange.
• Drill your foundation bolt holes in the lower flange of the wall ring
• Install the wall ring on the foundation bolts as shown on the sketch.

Whichever fastening method is used, you will want at least 20 bolts to fasten the lowest ring to the foundation. You must install washers under the bolt heads or nuts as shown, so that the wind and other forces will be spread out on the flanges. Use steel washers at of at least 1 in. diameter.

Using your level, adjust the foundation nuts or insert shims to level the wall ring to an accuracy of at least 1/4 inch (preferably 1/8 in). You might also use upside down DSR sections to help guide leveling the wall. Tighten all bolts.

You now have the first wall ring bolted to the foundation.
hinge to the right hand stub.

Completing the wall

This section will suggest how to assemble the additional wall rings and final base ring. Normally, the leveling does not need to be repeated with successive wall ring (until you get to the base ring) unless you want to do it. Proceed as follows.
• Select the wall ring sections for your next ring.
• Pre-drill the holes in the lower flange of the wall ring that will join the new ring to the old ring (if not completed during ring preperation above).
• Assemble on a flat surface, check the circumference, and complete the joint bolting as you did for the first ring.
• Place the new ring over the old ring, with the vertical joints aligned. Work your way around the ring, and use a straight edge to assure that the new ring is circular, and exactly over the first ring. If the first ring was not properly circular, you can go ahead and make the new ring circular, thus leading to slight overhang or setback from the first ring. This is perfectly OK.
• Drill 5/16 holes through the previously drilled lower flange holes of the new wall ring into the upper flange of the previously installed wall ring. Then install 1 in. bolts, nuts, and washers and tighten the bolts. Bolt heads should be on top for a neat job.

Assemble the base ring just as you did the wall rings, except that the base ring sections are NOT interchangeable (because of the dome drive motor spacings). You must use the proper layout. Because the base ring is the final ring, it is particularly important that it be

FIG 9, 9C,11

circular and level. When your top wall ring (the base ring) is in place, check again to assure it is level, and close to circular (equal diameters around the ring). If not, correct the difference by adjusting the foundation bolts or shims. Repeat with all the wall rings to be used.

Dome Drive Preparation

The dome drive motor holes are the longer ones (about 7 in.). Refer to Fig. 53 for locations of the motor drive plate pivot and spring support. Install those items now in the four locations.

FIG 9C

You should now have assembled the Base Ring so that the sections are in the correct order, as shown in Fig. 9C. This will assure that the motor drive holes are equally spaced around the wall. (Again, be sure that the resulting base ring is accurately circular).

You will long since have noted that one of the base ring sections has a circular hole in the reverse and upper flanges! This is the **access hole** that allows you to get at the top of the dome equatorial flange, and the underside of the DSR so that you can install the dome bolts. This hole will usually be located in the right rear portion of the dome, as seen from the front.

Later you will install the Electric Dome Drive motors. Some ED hardware (pivot and hook) is fastened to the base ring, so you may want to install it now.

6. DOME PRE-CONSTRUCTION

With the base (and wall rings if used) done it is time to prepare and pre-assemble portions of the shutters and dome. The next chapter covers the actual assembly of the dome. Because a partially assembled dome is at the mercy of the weather, it is **very** desirable to complete all preliminary work so that the actual dome assembly can be done in 4-6 hours.

FIG 10,10B

Assembling the HD15 does not require cranes or other special equipment (although they can be used, if desired). Instead, judicious use of multiple workers will allow the dome to be completed quickly and safely, **IF** proper precautions are followed. It is very desirable that at least some of the work team have experience in construction beyond the "homeowner" level. It is essential that work be carefully thought through and coordinated. Far better to take a few extra hours, than risk injury or damage to the dome!

Most of the pre assembly work can be done by one or two persons. However, bolting the quads together takes at least three people, while a five workers plus a supervisor is necessary for the actual dome assembly.

- The directions are written assuming the availability of four reasonably strong people to move quadrant pairs.
- Be sure to follow the sequence of assembly given here. Failure to do so may allow construction errors to accumulate, and cause operation problems later.
- Do not attempt dome or quad assembly on a windy day: fiberglass quadrants make great sails. They will not look pretty flying into something or someone. Check the weather forecast for your area before beginning.
- At various times during assembly, you may have quadrants resting without bolts on the dome support ring. We urge that you use jigs, clamps, or duct tape or other means to prevent a quadrant falling off the wall and becoming damaged.
- As noted above, if the dome is to be installed on a wall more than two feet high, or in an place with difficult outside access, you MUST pre-assemble the dome and wall on the ground. You can then partially disassemble it, and then reassemble the dome in the final location, knowing how the parts fit together, and with direct experience with handling the pieces.
- We recommend that you **fully** prepare all the pieces of the shutters and dome (as described in this chapter) **before** you assemble them into a dome. Using this procedure, you can take all the time you wish to drill bolt holes, install shutter hardware and so on, and then be assured that the actual dome assembly can be accomplished in a few hours.
- If you do not complete assembly of the dome so that it can be properly closed, you may be exposing the partially completed dome to damage if high winds occur. If you find yourself in this position, consider temporarily disassembling the dome or at least adding braces, clamps, or other devices to assure safety of the dome. A short time spent in disassembly and reassembly may save your dome!

Dome Support Ring (DSR)

FIG 12

Since the HD15 does not have a door and a DSR Swing-out, an HD15 Splice-Plate needs to be installed. Because the reverse flange covers the DSR, which in tern covers the base ring upper flange, it is desirable to have a way to access the base ring upper flange (wheels and side rollers). It is not essential to install, but in the future if you do need access to the upper base ring the dome will need to be disassembled. To install, two cuts are made in the front section of the DSR. **Note: The DSR will be cut but <u>NOT</u> the Splice-Plate.** The Splice-Plate is then bolted across these cuts. The plate provides continuous support across this cutout both for rolling, and yo maintain the proper slot edge spacing and dome circumference. However, if you need to access the top of the base ring you can remove the second bolt from each end, loosen the two end bolts (one is in a slot), then swing the DSR cut out section out away from the base ring. The two center bolts remain tightened at all times. Make sure Splice-Plate is closed and bolted before rotating dome again.

- Select the DSR section that will be at the front of the dome (all are the same). Center the Splice-Plate on the DSR front horizontal flange, and transfer the hole locations and the flange cut lines to the DSR section. Note whether the cut at the pivot end is curved (if so, the radius is from the pivot bolt). Use a square to extend the cut lines down the front of the DSR skirt. Set the Splice-Plate aside.
- Drill 17/64 inch holes in the DSR as marked. Countersink on the blue side for the ¾ inch flat head bolts. [*Bolt Hole Drilling Guide #6*].
- Use a saber saw or hack saw to cut the DSR section. Use a fine blade to reduce chipping. Use gloves and eye protection.
- Assemble the Splice-Plate onto the DSR using the bolts wachers and nuts provided.
- You may need to bevel the vertical cut at the pivot end to allow easy swing of the Splice Plate.
- When installation is complete, clean the guide lines off the splice-plate.

Select the DSR sections to use for the front (where the DSR Splice-Plate is installed), rear, and sides and place them on the base ring rollers. If some of the DSR section ends (on the horizontal flange) are not cut on the dome radius, trim them at this time. If needed, use a file (wear gloves) to bevel the insides of the ends of the skirts and the flanges so that the DSR will ride over any projections on the base ring (see drawing). This is also a good time to brush off any excess grit on the underside of the DSR.

Using masking tape or duct tape on the outside of each DSR joint, tape the DSR sections end to end so that the ends of the horizontal flanges are butted together with minimal, but equal gaps. Use ¼ in. shims every 18 in. between the skirt and base ring wall to make sure there is about ¼ in. between the blue side of the DSR and the white side of the base ring all the way round. Once adjusted, drill a single hole through each DSR overlap lip and install any convenient small screw or bolt to join the DSR sections together (don't let

the screw go through and scratch the base ring). The screws can be removed later, or left in if they are stainless. Check the DSR circumference against the table value in Ch. 3 [*Bolt Hole Drilling Guide #7*]

Check that the DSR sections ride around the dome without binding.

Note that the DSR sections are coated with an organic abrasive material on the underside to provide traction for the dome drive motors. Some of this will drop off, especially early in use.

Rear Cover Preparation

FIG 16B, 14, 32

The rear cover is the narrowest of the three and has a downward lip at the top (front) end. The rear cover fills in the circle at the rear of the dome, and stabilizes the two quadrant pairs near the zenith.

Referring to the drawing, check that the front (horizontal and vertical) edges of the rear cover are beveled on the outside to allow the front shutter to ride up and over. If not, use a file or rasp to bevel the edges as necessary. Sand the remaining edges if necessary. Check that the latch hole on the rear cover is properly beveled: at the front of the hole the bevel is vertical (but with rounded edges), and an the rear of the hole the bevel is on the outside.

Measure and mark hole locations on the shutter flanges of the rear cover. [*Bolt Hole Drilling Guide #14*]. Drill 5/16 in holes along the **center** of the flange.

While you have the rear cover off the dome, place the electric shutter on the rear cover as shown in Fig.32. Drill and countersink the mounting holes (do not mount the motor yet). Note that the multi-sheave pulleys are on the centerline of the rear cover (ie., the ES15 drive is off center, overall). Predrilling will make motor installation easier later. [*Bolt Hole Drilling Guide #12*].

Front Shutter Preparation

FIG 16B

Select the front shutter (the middle width shutter). Referring to the drawing, check that the rear top corners are beveled on the inside to ride up over the rear cover. Check that the latch receiving hole edges are beveled properly (flat on the front side of the hole, and beveled on the inside on the rear of the hole. Sand any sharp edges of the shutter (since your hand may touch these at some time).

Install a pair of handles with centerline 6 1/4 inches from the lower/front edge of the shutter. Space the handles so that the central bolts are about 3 in. from one another. Use 3/4 in. carriage bolts from the outside. [*Bolt Hole Drilling Guide #10*].

FIG 19

Because the underside of the front shutter slides on the slot edges, low friction strips are provided for the front and top shutters. You will install them now.

To assure good adhesion for double back tape on back of the strips, you will need to clean the underside of the shutter adjacent to the flanges. Use GOOF-OFF, Fiberglass dewaxer, or other solvent or paint remover, preferably containing methylene chloride. You will put two strips pieces end to end adjacent to each flange of the shutter, with the pre-bent ends around the ends of the shutter. Because the shutter is more than eight feet long, one piece is used at nearly full length, the second is cut to fit with a minimal gap with the joint between the two being cut on a diagonal (save the pieces: you will use them on the top shutter.) Remove about 10 in. of wax paper from the double back adhesive tape at a time and press the strips firmly into place.

DANGER: A non-anchored shutter installed on the dome will slide easily and can cause injury. Be sure the shutter is always latched or otherwise prevented from unexpected movement.

Drill two 1/4holes 7.5 inches from the front edge, 2 inches inside each side flange (measured on the outside of the shutter). These holes are for bolts connecting to the electric shutter cables. Later, when you install the shutter cable connector, you will cut away a section of the glide strip around these bolts. [*Bolt Hole Drilling Guide #11*]

Finally, install the vinyl "grommet" to provide a softer leading edge for the end of the front shutter. Push on, or use light hammer blows, as needed. If your head bumps the edge of the partially open shutter, you will appreciate this (we did, the second time).

Top Shutter Preparation, Latch, Wind Restraint **FIG 16B, 24**

You will now install the latches on the top shutter. The short latch will go on the rear of the shutter and engage the hole in the rear cover, while the longer latch is on the front of the top shutter and engages the hole in the front shutter. The installation of each latch follows the same steps: we will describe the front latch installation.

Install the latches as shown in the figure. Mark a line across each end of the shutter, 9 1/4 in. from the end of the shutter. Center a latch on the shutter, with the latch holes on the line. Mark the hole locations on the shutter (five for the front, and four for the rear latch). Drill 5/16 holes and install each latch with 1 in. stainless steel carriage bolts. The "points" of both latches should aim toward the center of the shutter. Note the countersunk holes for the nuts and washers. [*Bolt Hole Drilling Guide #9*]

Install the two low friction strips (left over from the front shutter) on underside of the top shutter adjacent to the flanges. Start about five inches behind the front latch and continue as far as possible toward the rear of the shutter. Cut a length from your fifth piece of strip and install on the midline of the shutter between the two latches. You will have a pre-bent end piece left over.

The wind restraint system uses cables to hold the top shutter in place, and most of the installation is described in Chapter 11. However, one part of the installation is to install J-guides (J shaped plastic guides through which the cables move) onto the flanges of the top shutter. You should do that now.

The HD15 top shutter requires 6 equally spaced J-guides on each flange. Fig. 20 shows how these are arranged. Holding each J-guide in place, drill 3/16 holes through the flange. Countersink on the inside, and install a 10-32x3/4 flat head screw outwards with locknut in each hole. [*Bolt Hole Drilling Guide #8*]

Dome Quadrants Sub-Assembly **FIG 13**

Caution: DO NOT attempt to assemble the quads outdoors on a windy day. Also, we strongly recommend that at least three, and preferably four people work together to do this task. The dome pieces are bulky, and heavy, so you will need extra pairs of hands for lifting and balancing.

The dome is made of two slightly different dome quadrants. We refer to these as the right and left, as viewed from the front of the dome. The right front quadrant is the same design as the left rear (and vice versa) **except** that the rear quadrants have a notch cut into their slot edges which accommodates the rear cover.
Pick the right front and right rear (notched) quad. Refer to the drawing to identify what we call the DSR Equatorial (lower) flange, the slot edge, and the Greenwich flange (inner flange joining the two quadrants). Measure and mark the hole locations on the DSR Equatorial flanges, [*Bolt Hole Drilling Guide #15 and #19*]. Drill 5/16 holes at these marked locations. On the front right quad measure and mark the hole locations on its Greenwich flange, [*Bolt Hole Drilling Guide #17*]. Predrill 5/16 in. holes at these ten marked locations.

The goal now is to bolt the Greenwich flanges together so that the joints on the slot edge where the shutter rides, and the outside surface are smooth, and so the outside surfaces of the dome quadrants match closely.

Place the front and rear quadrants together on a reasonably level surface (not yet on the DSR!). Provide 4 in. of so of support under the equatorial flanges so that the slot edge tabs are not damaged. Adjust the positions of the quadrants so that the equatorial and slot edges are aligned, and the outer dome surfaces meet as smoothly as possible outside the Greenwich flange. You will want to use C-clamps and short lengths of wood to facilitate alignment of the slot edges and equatorial flange. Once clamped together, use the

previously drilled holes in the Greenwich flange as a guides in drilling holes into the second quad, [*Bolt Hole Drilling Guide #26*. Install 1 1/4 in. carriage bolts through the two Greenwich flanges and tighten. Once bolted together, the two quadrants will stand together without support.

Caution: Do not get under the quads with only C-clamps holding them-they may slip. Always have C-clamps, PLUS a prop or a person holding the quad pair.

Now assemble the second pair (left) of quads in the same manner. [*Bolt Hole Drilling Guide #16,20,18,22*]

Shutter Cable Pulley Installation

FIG 31, 32

At this point, you will have both quad pairs assembled, each with its equatorial holes drilled. Choose one set for the LEFT quad pair (as viewed from the front) and one for the RIGHT pair. Label the front and rear of each with masking tape to avoid confusion.

We will now install the shutter cable pulleys. Although this work can be done after the dome is assembled, it is much easier to do it now, and the later electric shutter installation will go much faster.

Figure 32 shows the RIGHT quad pair, with the shutter cable pulleys mounted on the inside face of the slot edge. The pulleys are numbered from the front to the back. #1 is a plain 1 1/4 in. diameter pulley with fender washer. Mount the #1 pulley directly onto the slot edge tab, 2 in. from the lower edge of the tab with a 1/4-20x1 in. carriage bolt pointed inside. Place a 2 in. large washer under the nut.

Pulleys #2-#11 are plastic pulley assemblies, each containing two pulley rollers. To locate these pulleys, measure ten 18 in. intervals along the slot edge starting from the front pulley. For pulleys #2 to #10, drill a 5/16 mounting hole 2 1/4 in. from the slot edge. Mount them with 1 1/2 in. carriage bolts. The angled tab should be about 1/4 inch below the slot edge. Do not mount #11 — it will be installed after dome assembly. But you will drill the hole for #11 pulley now, using the dimension in Figure 32 (the bolt hole is **2 ½ in.** from the notched slot edge of the rear quad.)

Similarly, mount the pulleys on the left dome quad pair. [*Bolt Hole Drilling Guide #23 & #24*]

You have now completed the preparation work. The assembly of the dome will now go quickly (in about four hours)!

Caution: if the quad pairs and other parts will be left outside overnight, be sure to secure them against unexpected wind gusts.

Wind Restraint cable posts

The two assembled quad pairs (marked left and right for the Shutter Cable Pulley installation) can now be drilled for the wind restraint system Spring Posts and Cable Guide Posts. Although this work can be done after the dome is assembled, it is much easier to do it now while the dome halves are "on the ground". The final "Finish Work" steps will go much fatser with the holes all drilled for the wind restraint system.

The steps will be the same for both dome halves. [*Bolt Hole Drilling Guide #25 & 26*]

Start at seam of dome quadrants (top, middle); measure **BACK** 4 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 22 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 24 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 24 inches; go out from the shutter flange 3.5 inches and drill ¼" cable spring post hole.
Start at the rear of dome half; measure forward (up) 26 inches from bottom of shutter flange tab; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 26 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 26 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole. This hole should be approximately 21 inches from the very first hole drilled above.

7. DOME ASSEMBLY AND SHUTTER INSTALLATION

Now comes the Big Assembly Event! Recheck the cautions at the beginning of the previous chapter, making sure that you are fully prepared for the steps ahead. **Note: This assembly should not be done in winds exceeding 5 mph.**

Before proceeding, all workers should thoroughly review what is to be done. Each quadrant pair (i.e., half a dome) weighs about 250 lb. and is awkward to handle. Four or five persons (the "workers") of average strength can handle them, with an additional person (the "supervisor") providing supervision and bolting services.

If you have doubts about safely handling the pieces, or if you do not have sufficient workers available, **DO NOT** proceed. Please call Technical Innovations, and we can make suggestions for use of jigs, braces, and other construction aids that will fit your situation.

Check that the DSR is ready to receive the quadrants, that the front “home” location has been identified and that the DSR is rotated such that the Splice-Plate is positioned to be in the approximate center for the front shutter opening

.

Make two wood spacers to hold the slot opening to the correct width while you work on the dome. Cut two 2x4s of the correct length to set the **outside** of the slot edges to 50 in. (2x4s will be about 49.5 in. long).

Using one of the wood spaces just made, lay across the Splice-Plate to find the approximate “front edge” of each dome half and make a mark on the DSR top surface. This will be your rough reference point when lifting the dome halves up onto the DSR and minimize the amount of adjusting required later on when you begin dome assembly.

When you put the quad pair (now a dome ‘half”) on the DSR, you will find that the quad pair seems longer front to back than the dome wall, and that the quad pair wants to fall off the DSR (one of the jobs of the workers is to keep it on). You need to control the quad pair by preparing a 1/4 in. rope or strap to connect from the front slot edge across the interior of the dome to the rear slot edge. We found that what works best are inexpensive “cargo straps” with ratchet tigheners. The front strap can be held with a clamp or “vice grip” tool, while the rear can be attached using the lower wind restraint cable post hole drilled earlier. As soon as the quad pair is put on the DSR (as described below), you can pull the ends together so the quad pair does not spread front to back.

FIG 15

We will assume that the first quad pair will fit on the LEFT side of the dome (as seen from the front). Have the workers lift the quad pair onto the DSR, sliding it under the reverse flange. The left front of the equator flange should almost touch the mark made by using one of the wood spacers. The strap (or rope) connected between the front and rear edges should not be tightened to the point that both the rear and the front dome aedes are

flusg with the DSR skirt. With the workers holding the quadrant pair on the DSR, the supervisor should tape the quad pair and DSR together. Two workers should remain with the left dome half to assure that it stays up on the DSR and the right side is fitted and in case a breeze comes up (remember these dome halves will be like giant sails and can move in very minor winds)

With the workers walking outside the dome while holding the dome onto the DSR, rotate the DSR and quad pair so that the right quadrant pair can be lifted up into place.

You will notice that the outer surface of the dome at the Greenwich flange may be inward from the DSR and inch or so, and that the equatorial flange may rub against the inner edge of the reverse flange. This is normal: this will be adjusted after you install the rear cover and when you install the remaining equatorial flange bolts.

Now install the right pair of quadrants in the same way and place it on the DSR.

With both dome halves resting on the DSR install one of the 49.5 inch longwood spacers between the two dome halves, in the front about 12 in. above the base ring. Use 2 in. drywall screws through small holes drilled in the slot edge, about 1.5 in in from the slot edge (do NOT use short screws as later assembly forces may pull them out). This will require some "adjusting" of the dome halves to get the correct spacing. The holes drilled through the shutter flanges will be later covered b the shutters. Install the second higher up, about two feet in front of the Greenwich flange. After installing the spacers, the front will be stabilized and les prone to light wind worries.

Rear Cover Installation

FIG 14

Using two people outside and one inside, install the rear cover so that it straddles the rear slot edges, with the lower edge of the rear cover approximately even with the lowest part of the slot edge. The rear cover should fit into the recess cut in the slot edge of the rear dome quadrants, so that the transition from slot edge onto the rear cover is reasonably smooth.

Make sure the right and left sides are equal, and that the rear cover is square (even) with the slot edge toward the front. You may want to use a prop or C-clamps to hold it in position. Using the previously drilled holes in the rear cover as guides, drill 1/4 in. holes into the slot edge at the bottom rear of the rear cover and install 1 1/4 in. flat head bolts, washers, and nuts. [*Bolt Hole Drilling Guide #27&27*]

You will now drill and bolt your way down the rear cover, starting from the front. If the slot edges are not snug against the inside front of the rear cover, use 2x4s or other means to force the slot edges outward. If the rear cover flanges have bumps or excessive thickness, this is the time to remove the rear cover and grind/sand them off. With the parts fitted together, start at the top of the rear cover and drill both left and right holes, and install 1 1/4 in. flat head bolts, washers, and nuts. After the first pair, remove the bottom rear pair installed earlier so the shutter can move as you install bolts. Then work

downwards, doing the next pair of left and right holes, and so on. The inside worker may need to push the slot edges **out**ward against the insides of the rear cover flanges. Be sure the rear cover is fully seated against the slot edge, and is not "outward", especially at its front edge toward the top of the dome. When installing the rear cover, you may need to remove the rear equatorial bolts installed when you first put the quads on the DSR.

You may notice that as you install the rear cover, the forces you exert will modify the shape of the quad pairs already installed. This is normal.

When the rear cover is bolted on, you have the two dome halves joined together, resting on the DSR. The dome is held in place with the spacers and the rear cover. Tape the DSR to the base ring so that the dome cannot rotate.

Dome Inspection

You should now examine the dome as assembled so far.

Because the dome is not yet bolted down, its shape will not yet be correct. However, you should adjust the dome on the DSR so that it is symmetrically located left/right and front/back.

Adjust the front slot opening so that it is equally spaced left/right relative to the DSR Splice-Plate. Mark the DSR with a pencil as a future guide.

Recheck that the DSR sections are joined together properly

FIG 15

Final Dome Bolting

Now you will install the remaining bolts in the equatorial flanges, with the front first.

Remove the tape from the DSR/Base Ring and rotate the dome so that the 1R location is at the access hole. While keeping the slot opening centered on the DSR Splice-Plate, push in on the dome so that the rear of the slot edge is within 1/4 in. of the DSR. Using the previously drilled hole in the equatorial flange as a guide for drilling 5/16 hole down through the DSR, drill a 1R hole in the DSR. Countersink from beneath, and install 3/4 in. flat head bolt upwards. Rotate to the 1L position and repeat. This bolts the front of the dome in its final position to the DSR.

Now rotate the dome to the 20R position over the access hole. Again, push in on the dome so that the slot edge is within 1/4 in. of the DSR, while assuring that the dome is centered Left/Right at the Greenwich location on the DSR. Install the 20R and 20L bolts as before.

Stand back and recheck your work. If you have a substantial error, fix it at this time. If OK, now go ahead and do the remainder of the equatorial bolts. Although a bit more work, you will get the most circular dome result if you alternate left and right sides, and

do about every fourth bolt in your first pass. Then go back and do all the in between bolts.

Remove any wood blocks, spacer shims, and tape or DSR lip bolts, and turn the dome! If you assembled the dome correctly, it will turn with about 35-40 pounds of force. But don't panic if it doesn't. See Sec. 10 for how to investigate and fix any problems. Note: except for completing installation of the shutters (for weather protection of the dome), you should fix any rotation problems BEFORE completing installation. And don't caulk the wall rings, base ring, or dome equatorial flange until you have a smoothly operating dome.

FIG 14

Shutter Catchers

Install the two shutter "catcher" brackets at this time (see drawing). Locate the catchers flush with the bottom of the rear cover, and placed all the way to the edges with the wind restraint tabs extending past the rear cover. Drill 5/16 holes in the rear cover and install the catchers with 1 in. bolts. [*Bolt Hole Drilling Guide #13*]

Shutter Installation

The instructions below tell you how to install the shutters and operate them manually with ropes. You should do this before attaching the electric shutter (described in the next chapter) to assure that the shutter operates safely and smoothly.

WARNING: When the low friction strips are in place on the shutter, the front shutter will move very easily. As noted in Section 2, uncontrolled motion of the shutters can result in damage to the shutters or in serious personal injury. Always have the shutters under full front **and** rear control when moving them. **NEVER** rest the front shutter alone at the top of the dome arc since it can begin sliding with no warning and slam down on the front or on a person. This is not normally an issue, because the front and top shutter are normally safely latched except when they are toward the rear of the dome, and the front shutter is controlled by cables. You can install the shutter safety device described in Fig 18 or a similar device to limit uncontrolled shutter movement.

Place the front shutter on the **rear** of the dome with the handle up and toward the front, and the flanges straddling the rear cover. The shutter will not rest on the shutter catchers, because the handles rest against the rear cover lip.

Also on the rear, install the top shutter so that it rests in the shutter catchers, and straddles the front shutter. The longer (front) latch should be toward the front of the dome, and the short latch toward the rear.

Together, the shutters weigh about 140 lb. This weight can be dangerous. The shutters are designed to be under control BOTH when opening and when closing, as the weight moves from the front to the back of the dome. You MUST NOT pull (or push) the

shutters from only one side of the dome UNLESS you also have a means of restraining the shutters as they move over the top of the dome. For test purposes, you may use lengths of 1/4 in. ropes connected to the handles, one rope going to the front to be controlled by a person there, and one to be controlled by a person at the rear of the dome.

Initial Manual Shutter Operation

Starting with both shutters on the back of the dome, pull the front shutter toward the front (i.e., up and over). It should slide easily, though the weight will make it hard to move. With the rear cover in place, workers may have to help lift the front shutter to get it started. As it moves past the top of the dome, the front latch of the top shutter will drop into the hole in the front shutter, so that you will begin moving both front and top shutters together. As the front latch and hole become visible on the underside of the front shutter, visually check that the latch is fully seated. Assuming that it is, and **while restraining the shutters from the rear**, continue pulling forward and down. The rear latch on the top cover will engage the hole in the rear cover, and the shutters will lock into the closed position.

Note: if the front latch does not fully engage, restore the shutters to the back of the dome, and retry. If the latch does not seat properly on the second try, **DO NOT** attempt to use the shutters until you have found and corrected the problem (See Chapter 12).

To open the shutters manually, again use persons stationed in front and rear of the dome. The person in the rear will pull on the rope, sliding the front shutter up and back. **Both** the top and front shutter should move back. If **both** shutters do not move together (e.g., if the front shutter delatches and begins moving under the top shutter), **immediately** return the shutters to the closed position and use the information in Chapter 12 to identify the problem).

Assuming proper operation, as the front latch rides over the rear cover lip, it will partially unlatch, completing unlatching when the top shutter rests on the shutter catcher. Continue moving the front shutter back until it is seated. DO NOT let go the front shutter until it is fully opened and resting at the top edge of the rear cover, as it will slide uncontrolled to the back where it may be damaged.

Shutter Latch Check

Your last step is to check that the latches fully seat when the dome is closed and front shutter locked down (so that the wind cannot lift either shutter). Go inside the dome, and have the workers controlling the ropes pull the shutters closed. Check that both latches not only dropped into their receiving holes, but that they *fully* lock the rear cover and front shutter. If not (for example, if inside hardware is preventing full closure), be sure to correct the problem before continuing.

The HD15 is designed so that the closed and latched dome can be secured simply by locking only one item: the front (lower) edge of the front shutter. Whether or not security

is an issue for you, you MUST use some kind of securing device (lynch pins, bolts or padlocks) to prevent wind from lifting the front shutter when the observatory is closed. That is, both flanges of the front shutter must be held to the slot edge. Ropes, bungee cords, and the like will not protect the dome from wind!

The HD15 is supplied with two Shutter Lynch pins that engage both slot edges, and the installation is given in a later section. If you defer installation of this system, you must immediately install some alternative means of making the shutters secure. The simplest system is to drill a hole in each shutter flange through the slot edge and insert spare 1/4 or larger bolts. Almost as simple is to install a small hasp on each front lower inside of the slot edge. Install the staple on the inside of the front shutter. Use hooks or padlocks, if desired. Hasps can also be installed on the outside of the dome, with the staple on the outside of the front shutter flange. Or you can install a hasp on the DSR, and put a single staple on the lower center of the front shutter. Fancier locks or latches can be used, either exposed or tucked up under the front shutter.

Failure to immediately install and use a locking device of some type may result in damage to your dome in event of a severe wind storm.

8. ELECTRIC SHUTTER INSTALLATION

Introduction

Installation of the electric shutter for the HD15 as the next step is desirable though not absolutely necessary. Although manual operation of the HD-15 shutter is possible, the weight of the shutters makes manual operation difficult and potentially dangerous. As discussed above, the shutters must be controlled by ropes or other means from **both** front and rear of the dome as the shutter moves from front to back, or vice versa. In addition, substantial strength is needed to produce more than 100 lb. of force needed for the movement.

We recommend that the electric shutter be installed so that the shutters can be operated conveniently and safely. Note that emergency manual operation of the shutter is provided, as discussed below.

Electric Shutter Theory **FIG 31, 32**

The HD15 shutters are operated by moving only the front of the front shutter in the direction desired. The top shutter will automatically move, latch, and unlatch from the front shutter.

The electric shutter has two cable loops, one on each side (i.e., on the right and left) of the shutter, and both loops are driven in the same direction, at the same rate. Each cable loop travels on pulleys already installed on the slot edge. Each cable loop connects to the front of the front shutter. As the cable loops are driven in one direction, the shutter opens, and vice versa. Because the loop is connected in both the open and close directions from the attachment point, the cables limit the shutter movement under all conditions. For example, when opening, the cable lifts up the front shutter uphill along the slot edge, but also controls (i.e., restrains) the shutter as it moves downhill on the rear of the dome.

The cable is 3/32 inch diameter, stainless steel wire rope. The cable is driven by special multi-sheave pulleys driven by a pair of low voltage electric motors. The motors receive current from the 16 V power supply (supplied) via contact plates and rollers that transfer power from the dome base to the rotating dome when the dome is in the HOME position.

The two motors each have a slip clutch on a common shaft. The motor shaft is connected to the primary pulley shaft by a chain drive via a speed reducer "jack shaft". The primary pulley shaft is connected to the secondary pulley shaft by a chain. Thus, the motors in effect drive both the primary and secondary pulleys.

Each pulley contains approximately 20 sheeves, or grooves, for the cables (the pulley grooves look like a single spiral groove or screw thread but a closer look will show they separate grooves). Each cable loop passes over the two pulleys approximately eight times, moving from one groove to the next. Thus, the pulleys have the traction of eight

turns of cable around a shaft without the characteristic of moving along the shaft as the shaft turns.

Installation of the electric shutter includes
* installing the Power Supply
* installing the cable pulleys
* installing the motor drive on the rear cover
* installing the cables for proper operation.
* installing the contact plate/slider to get power to the motors
* connecting the motor drive to the power supply
* adjusting the cables for proper operation.

Power Supply Installation

The power supply will serve both the electric shutter and electric dome rotation systems. The power supply has a front mounted switch for the shutter, and a top mounted switch for the dome drive. Electric terminals are located inside the power supply, and are accessible by removing the rear cover. The power to the motors is a low 16 VDC; however, 120 VAC is present in the power supply whenever it is plugged in. **Always remove the plug from the power outlet when removing the back of the power supply.**

FIG 42

The power supply may be mounted in two ways, depending on how you will enter the dome. If you enter from inside (up through a floor) or through a door in your own wall, simply mount the power supply wherever convenient (usually on the inside wall next to the door) with the front switch facing into the dome. If you enter from outside through the semidoor (requiring shutter operation), you will need to operate the shutter from outside with the front switch facing outward. You should mount the power supply on an inside wall, to the immediate right of the semidoor (as seen from outside). Place the power supply where desired, and mark where the key switch and front toggle switch hit the wall. Drill and/or file 1 in. diameter holes in the wall. Install the power supply in accord with Fig. 42.

You can then operate the key switch and the electric shutter from the outside.

Cable Pulley Installation

The shutter cables are carried in pulley assemblies mounted to the slot edge. You will already have mounted all but two pulleys on each slot edge when you prepared the dome quadrant pairs. You will now install the remaining pulley assemblies.

You will have drilled a mounting hole for the rearmost plastic pulley assembly (#11) when you prepared the dome quad pairs. Mount the pulley assembly with a 1 1/2 in. carriage bolt installed from the outside.

Drive Motor Installation **FIG 31,32**

The motor has drive cables pre-installed at the factory. **DO NOT** move the cables on the pulleys or operate the motor until you have completed the installation steps below.

To install the drive motor, place the drive motor on the rear cover, so that it will be 24 in. down from the rear cover lip, and with the multi-sheeve pulleys on the center line of the rear cover. Mark the four mounting hole locations on the rear cover and drill 1/4 holes, then countnersink them. With an outside person assisting, install the motor with 1/4-20x1 in. flat head bolts. The bolt heads should be smooth on the outer surface.

Now you will install the #12 rearmost pulley as shown in Fig. 31 and 32. The goal is to install the pulleys so that the cables from the shutter drive enter the pulleys with minimum angles.

To mount the right hand (RH) #12 pulley, first unroll the RH cables, but DO NOT loosen them on the drive pulleys. Now thread the RH cables through the pulleys as shown in Fig. 31. Place the pulley against the slot edge so that the cables are as close as possible to horizontal, and enter pulley with minimum angle. Mark the hole locations on the slot edge, and drill and bolt (1 in. carriage bolts) the pulley to the slot edge. Some of these holes will penetrate the rear cover , as well as the slot edge. Mount the left hand pulley similarly.

Cable Installation **FIG 32**

You previously drilled two holes in the front cover for the shutter cable connection. Install the plastic Slot Edge Guide part of the Shutter-To-Cable-Connector-Assembly (SCCA) provided. Use a razor knife to remove the glide strip where the SCCA will be mounted, then use a 1 1/4 in. carriage bolt and nut. In a few minutes, you will connect the cables to the SCCS, and then attach the SCCA to the carriage bolt with a locknut.

Reinstall the shutters on the rear of the dome, with the front shutter handles resting on the lip of the rear cover.

Right OPEN - thread the SHORT cable through the UPPER rear pulley on the right side (facing the rear cover from the inside), then over the upper pulley #11 to the shutter connector. Loop the cable through the SCCA and tighten the screws.
Right CLOSE - Thread the LONG cable through the LOWER rear pulley on the right, down over the LOWER pulleys, around the OUTSIDE of the lower pulley back over the UPPER pulleys and up to the forward end of the same SCCA. Pull the cable snugly tight and clamp as before.

Left OPEN - thread the SHORT cable through the UPPER rear pulley on the right side (facing the dome from the inside), then over the upper pulley #11 to the shutter connector. Connect as above.

Left CLOSE - Thread the LONG cable through the LOWER rear pulley on the right, down over the LOWER pulleys, around the OUTSIDE of the lower pulley back over the UPPER pulleys and up to the same SCCA as above.

Install each SCCA with cables onto its carriage bolt. The nut already holding the Slot Edge Guide will provide a spacer behind the SCCA. Install a lock nut (NOT aa regular nut) onto the carriage bolt. With all four cables installed, equalize the tension in each by pulling the cable tight on the SCCAs.

You may now remove the cable clamps on the drive motor multi-sheave pulley. The cable tensions will decrease, so re tighten the cable tensions.

Note: With the SCCA attached to the front shutter, you cannot now move the shutter by hand. If you ever need to move the shutter manually, you may leave the cables attached to the SCCA and remove the SCCAs from their bolts, releasing the shutter. If you do so, BE CAREFUL that you have a person to hold the shutter so that it does not move suddenly.

Contact Plate Installation

Refer to Fig. 32 for the installation arrangement. Be sure to place the dome in the home position (normally with the DSR swingout hinge centered above the door hinge). The contact sliders will be mounted on brackets attached to the inner surface of the dome, and the contact plates will be mounted on the reverse flange. Be sure that the location of the plates and the contact sliders is correct and will not interfere with other parts of the dome as it turns. Mount the contact plates about 4 in. apart using their adhesive backing, with the terminal screws toward the center of the dome. Center the sliders on each contact plate, and mount the slider brackets with the bolts provided. Adjust the slider brackets for moderate force of the sliders on the contact plates.

Motor Drive Wiring

FIG 41

Be sure to remove the power supply plug from the outlet before opening the back of the power supply!

The motors on the drive unit are pre-wired with black to red and red to black to make the both motors drive the primary shaft in the same direction.

- Use the ten foot length of wire, and connect the contact rollers to the motor terminal strip overhead.
- Connect the 20 ft. wire to the contact plates and to the FRONT SWITCH terminals inside the power supply.

Cable Adjustment

Initial operation of the shutter motor will change the tensions in the cables. The tensions on each side of the shutter must be adjusted to avoid either excessive tension (that

unnecessarily loads the motor drive) or slack tension (that may prevent operation of the drive pulleys and/or lead to cables jumping out of the cable pulleys).

Recheck that all installation steps have been taken, that bolts are tight, and that cable clamps are properly fixed.

Final Step before operation: Remove any remaining clamps or tape on the cables on the drive pulleys on the motor drive. Save the clamps for use as spares.

Plug in and turn on the power supply. Press DOWN and quickly release the front switch. The motor and pulleys should have turned, and the shutter should have moved down (toward the front of the dome). If it moved up (or if the cables tightened above the front shutter), reverse the electric wires to the shutter drive motor at the contact plates (the goal is to make DOWN on the switch correspond to CLOSE the shutter).

Check the cables. Tighten loose cables by adjusting the cables on the shutter connectors.

Again operate the power supply switch briefly. As you operate the switch for longer durations first in one direction and then the other, constantly check the cables, pulleys, and connections to assure proper tension and operation. It is normal for the cables to change in tension during operation. However, the cables should never be so slack that they sag or make loops. As you gain assurance that the system is operating properly, use the electric motor to fully open and close the dome.

If you encounter a situation where the shutter is blocked (i.e., stops suddenly) during opening or closing, you must stop the motor at once. Before doing anything else, draw a diagram of where the shutters are in relation to the slot edge and in relation to each other. Also, make a sketch of where the shutters are in relation to each other on the outside o the dome. This will help you understand what might be hitting or causing the blockage. The leading edge of one of the moving shutters is likely hitting something “head on” or perhaps scraping on a bolt head beneath the fiberglass part. Or the wind restrain cables may be too tight (check the tension while you are outside the dome).

See Chapter 12, Problem Solving, for more suggestions; if you cannot diagnose the situation on you own, you may call or email to us.

Finally, operate the shutter to the fully closed position, and check inside that the shutter latches are fully seated in the holes. Mark the position of the shutter to assure proper closure. If you have not already done so, you may wish to drill 1/4 in. holes thorough the shutter flange and slot edge to accept lynch (locking) pins. If you use locking pins, be sure to remove them before operating the shutter motor!

When the cable adjustments are complete, with both cables doing roughly equal work, you may want to trim the ends of the cables. The stainless cable is hard to cut--one of the

most convenient tools is a 7WR Vise Grip brand pliers with a built-in wire cutter. Be careful that the ends of the cables do not strike you or another person in the eye. We recommend keeping at least a foot of extra cable ends on each shutter connector. You may wrap the slack end around the cable and tape it. Do not leave loops, clamps, or other arrangements or hardware that can hook onto the slot edge pulleys.

Operation

The electric shutter motor operates whenever the switch is operated. That is, the motor does NOT stop automatically when the shutter reaches its end point. Be careful not to operate the shutter past the proper open or closed point. On the other hand, be careful to close the shutter fully with the latches fully engaged.

We recommend that when closing the shutter, release the switch when the shutter is still 3-4 in. above fully closed. The shutter will coast down into approximate lock position. You can then jog the shutter switch to place the shutter at the desired position.

Electric Shutter Maintenance

The electric shutter requires little maintenance once it is properly adjusted. DO NOT oil the cable or cable drive motor multi-sheave pulleys. Every six months apply oil *sparingly* to the roller pulley ball bearings (not to the pulley cable surfaces). Occasionally check that the cable tensions are reasonable.

In normal operation, the tension end of each cable winds tightly onto the multi-sheave pulley, but the slack end unwinds loosely. Therefore, when you look at each winding, you will usually see one end of the winding tight and the other end loose. If the tension is correct, the slack turns will bow out from the multi-sheave pulley by about 3/8 in for several turns. This slack is very important, for it allows automatically for variations and cable stretching in the drive system. If the tension is too loose, the slack turns can become too large, and may become snarled or overlapped. This can cause slow shutter operation, and obvious heavy loading of the shutter drive motors. You can check for this by visual inspection of the windings.

If the windings have become snarled, you can easily straighten it out using your fingers. You may wish to have an assistant hold the shutter to reduce cable tension not properly adjusted, or you can remove the shutter connector for the cable affected, Note that the cable cannot become knotted in this condition, therefore it is not necessary to remove the cable from the pulley to rewind it.

If you should ever need to rewind the pulley, be sure the shutter is safe as discussed above. If one cable is still attached, let it continue to hold the shutter. Connect one end of the cable to the shutter connector, thread the cable through the slot edge pulleys, and wind it onto the multi-sheave pulleys as shown in Fig. 31. Each winding should have 8 full turns around the two multi-sheave pulleys.

If you need to rewind both cables, we recommend that you put the shutters in the open position. Then wind the cable onto the multi-sheave pulleys with about 7-8 ft free to go over each of the upper pulleys (Fig. 31).

If you find that the motors turn, but the shutter does not move, you need to identify where in the power train the slippage is occurring. If the motors turn, but the main drive shaft does not (Fig. 31), try tightening the motor clutch adjustable clamps. If the multi-sheave pulleys turn, but the cable does not move, the tension may be very slack or there may be oil on the cable. Finally, check that nothing is binding or otherwise blocking the shutter movement. Remember that this drive system has tremendous reserve driving capacity, and that the tension and other adjustments are not critical. Be careful when testing the drives to avoid injury.

Manual Operation

There are two ways to operate the shutter manually. The first way is to remove the connectors from the front shutter. **Caution: Never remove the cables or connectors unless the shutters are fully open or fully closed. Half-open shutters can move without warning and can cause injury.** You can then move the shutters manually, using ropes front and rear as discussed above. Use great caution when using this method.

The second method is useful if the shutter electric motor is not operative, but the drive chains and cables are still operable. Disconnect the power supply at the contact plate or drive motor. Use a screwdriver to fully loosen the clutch clamps on both motors (let them flop around). You may now use a vise-grip pliers or other method to turn the motor shaft to raise or lower the shutter (slow but safe).

Emergency Entry

If the shutter is closed and fails to open, first check:

* Did you remove the cable clamps on the motor?
* Did you forget to remove your padlock that is preventing the dome from opening?
* Is 120/230V power being supplied to the observatory?
* Is the led lamp lit on the power supply?
* Is the dome in the home position (you may want to move the dome back and forth to see if the problem is a poor or dirty contact)
* Is some part binding, so that if you help, the motor can open the dome?
* Is the key switch turned on?

9. ELECTRIC DOME DRIVE INSTALLATION

Introduction

The electric dome drive consists of four drive plates equally spaced around the base ring. Each drive plate has a low voltage DC motor that drives 3 in. rollers via a cog belt. The rollers in turn press against the abrasive traction coating on the underside of the dome support ring, thus turning the dome.

Installation consists of

* installing the drive plates
* wiring the drive plates

Drive Plate Installation **FIG 51,53**

Each motor drive plate moves up and down on a pivot bearing, and is held against the DSR by a spring loaded arm. The pivot bearing and spring bolts should have been installed when the base ring was installed. If they were not, refer to Ch. 5 for instructions. With the DSR installed, you will turn the dome, then open the DSR splice-plate to gain access to the outer part of the base ring. If you do this, remember NEVER NEVER turn the dome with the splice-plate open--the dome slot can open up and the dome can fall off the wall! **ALWAYS** close and bolt the splice-plate, even if turning the dome only a few inches.

See Fig. 51 &53 for the dome drive plate hole locations. On Fig. 53, the lower right hole is for the lift arm pivot. To locate its vertical position, slide the drive plate onto the pivot bearing. The drive plate should slide smoothly up and down on the pivot, and the rollers should easily contact the underside of the DSR. Then while holding the drive plate against the DSR, swing the lift arm to a horizontal position with the connecting arm vertical, and mark the lift arm pivot hole, drill, and install the bolt as shown. Reinstall the drive plate, but leave it in the lowered position.

Drive Plate Wiring **FIG 52**

Refer to Fig. 52 Use the 7 ft. wire to connect from the TOP SWITCH terminals to the first drive motor. Then use the 17 ft. wires to connect to each successive motor. Be sure each is wired with the same polarity. Remove power supply from outlet while connecting to internal terminals. **On the HD15 motors the red and black terminals will be wired**, ignore the terminals with the red wires

Turn on the power supply. With the motors down (not in contact with the bottom of the DSR), operate the top switch briefly to the right while watching the drive rollers on each drive plate. Verify that each one turns clockwise so as to turn the dome clockwise (viewed from above). If all motors turn counter clockwise, switch the wires inside the power supply terminals. If one motor turn opposite of the other motors, the wires coming

into that motor must be swapped. Once you confirm that all motors are rotating in the proper direction, they should be mounted up against the DSR. Push the motor assembly up, with the drive plate slot straddling the bushing, tightly against the DSR. Stretch the tension spring with as much force as possible by hand and slip onto the hook. The HD15 dome is so heavy that is not possible to have too much force. Try attaching the spring without using the small chain.

Once the motors are all in place try running the dome in a clockwise direction. If you encounter a situation where the rotation is blocked (i.e., stops suddenly), you must stop the motors at once. Before doing anything else, draw a diagram of where the slot opening is in relation to the door or some other reference point on the base ring. Also, make a similar sketch of the dome as seen on the outside. This may help you understand what might be hitting or causing the blockage. The dome support ring is likely hitting something "head on" or perhaps scraping on a bolt head beneath it, or perhaps a bolt on the dome equator flange is hitting the underside of the reverse flanage.

See Chapter 12, Problem Solving, for more suggestions; if you cannot diagnose the situation on you own, you may call or email to us.

Dome Drive Operation

Caution: The dome drive units are very powerful and can cause injury or damage. Always be sure that they are clear of any wires, that no one is in contact with the units, that hair, clothing, and fingers cannot be caught in the motors. Each drive plate can exert as much as forty (40) lb. of traction, so exercise care.

If ever the rotation is blocked, do not keep running the motors to try to overcome it. You will succeed in damaging the motors (ruining the drive belt and flattening the rubber tires.) Instead, stop the motors and make the sketches as described above so you can proceed with a logical analysis.

Caution: The HD15 is designed to be rotated ONLY when the DSR Splice-Plate is FULLY closed and BOLTED into place. Always check that the DSR Splice-Plate is closed before operating the drive motors. Operating the dome with the DSR Splice-Plate unbolted could cause the dome slot to expand, and the dome to fall off the wall.

To prepare the drives for operation, raise each drive plate so that it is in spring loaded contact with the DSR. Check that the DSR Swingout and Semi-door are CLOSED and latched. The power supply switch should now operate to turn the dome in the desired direction.

10. SHUTTER LOCKDOWN INSTALLATION

Installation – Shutter Linch Pins

If it is determined that the Observatory will be idle (not used) for an extended period, or a serious storm (hurricane) is predicted, the Shitter Lockdown system (utilizing quick release linch pins) should be installed. With the shutter completely closed (two latch bars firmly locked into place), drill a 3/8 inch hole on each side through the shutter flange and front shutter flange. The holes can be at any convienent location that does not interfer with the ES cable system.

Caution: With the electric shutter installed, you **MUST** remove the Linch Pins before operating the shutter or damage may result.

Notice: Our warranty for this lockdown system does NOT include consequential damages for damage arising from failure to clear the linch pins prior to operating the dome.

11. FINISH WORK & ACCESSORIES

You have finished the big work: building the dome. However, there are a number of additional items to install that will increase the safety and convenience of your dome. These include:

- Shutter Restraint System
- Soffit
- Caulking

Shutter Restraint System

FIG 24

The Shutter Restraint System is a cable and spring system that applies a calibrated radially-inward force to the top shutter to prevent wind from lifting the top shutter or the adjacent end of the front shutter. This system allows the observatory to be operated under higher wind conditions because it assures the engagement of the top shutter latches when closing the shutter. Of course, it also prevents the wind from blowing the shutter off the dome when the shutter is open. If this system is not installed, the Home-Dome/Pro-Dome should NOT be operated if the wind is more than about 15 mph, a very light breeze. With the system installed, the dome is safe to operate to about 30 mph, a very stiff wind. Note that this system does not affect the wind strength of the properly closed observatory--that is a function of the strength and design of the fiberglass, latches, and front shutter hold-down. However, it will improve the resistance to shutter lift off if the shutters are not fully and properly latched.

Description of Operation. With reference to the figure, each flange of the top shutter has J-shaped guides through which passes a 1/16 in. stainless steel cable. The cable is anchored at the rear of the dome, and in the front connects to a special spring that is mounted on a post.

When the shutter is closed, the spring and cable at are **very** low tension, virtually zero. When the shutter is to be opened, the front and top shutter move back, and the rear latch of the top shutter leaves its latch receiving hole. This raises the rear of the top shutter, putting tension on the spring and cable. This tension remains essentially constant as the shutters move to the rear, but increases again when the front latch of the top shutter disengages from the front shutter. When the shutters are in the rear, there is thus a controlled force inward on the top shutter, so that the wind cannot lift it away from the dome. The spring is designed so that it has only a limited travel, so even a high wind cannot do more than lift the shutter an inch or so. When the shutter is to be closed, the inward force then assures that the latches properly engage the receiving holes.

Where the cable is outside the top shutter J-guides, small cable posts mounted on the dome keep the cable from sliding across the dome surface.

You have already installed the J-guides on the Top Shutter. You will now install the remaining items.

Spring Post. The Spring Post Assembly is mounted using the forward most hole drilled during the dome preparation steps. [*Bolt Hole Drilling Guide #30 & 31*]

Rear Cable Bracket. The rear cable bracket is part of the shutter catcher (already mounted), and is a lip with two small holes that will project out from under the fully opened top shutter.

Cable Installation. One end of the cable attaches to the spring, the other end to the rear bracket. One end of the cable has a permanent termination loop, the other end is bare where you will use a split bolt as a cable clamp. Assuming a rear cable clamp, to install the cable, feed the free end of the cable through the spring bracket and through the loop. With the top shutter back in the shutter catcher, feed the free end of the cable through the J-guides and attach the end to the cable bracket with the cable clamp. Pull the cable to remove any slack then put about 1/4 inch of space between the cable bracket and the split bolt clamp (you will readjust and/or tighten it later).

Cable Guide Post. The twelve cable posts prevent the cable from sliding across the dome (this is primarily an aesthetic issue). They are mounted in the remaining holes drilled during the dome preparation steps [*Bolt Hole Drilling Guide #30 & 31*]

Cable Tension Adjustment. With the shutters **closed**, adjust the cable tensions so that the cables are LIMP, ie., NO tension. Tighten the cable clamps tightly and test the system by operating the shutter. You should see a slight spring tension as the shutter opens and the latches leave the receiving holes. You should notice only a slight increase in the force required to operate the shutters compared to no wind restraints. If you do see a significant increase in shutter force, relieve the tensions slightly and retry.

Soffit.

The soffit (fabricated from dark blue PVC) covers the opening between the rear cover and DSR. Installing the soffit is optional: many persons choose to leave the opening to maintain more ventilation in the dome.

FIG 17

Safety Device.

We recommend that you install a safety device to prevent the front shutter from an uncontrolled sliding to the front of the dome. This situation should not normally occur, since the shutter should always either be open, or closed, latched to the top shutter, or under control of the user: it can only happen if the front shutter is left by itself at the top of the dome. The figure shows one simple device (an alternative is a stop bolt installed in the slot edge whenever the front shutter is raised). Install the device that is convenient to your style of observatory use.

FIG 18

Anti-rotation Linch Pins.

Although optional, anti-rotation lynch pins may be desirable for preventing rotation when you are NOT observing and for doubly assuring that severe wind storms do not damage the dome. You should drill two holes down through the equatorial flange, DSR, **and** base ring. You can then insert the lynch pins bolts to prevent rotation when your dome is not in use. If you are aware of a severe wind storm is coming, (a hurricane for example) it is desirable that you replace these pins with long bolts, place nuts on these bolts and tighten them to make sure the wind cannot lift the dome off the base ring and vibrate it against the reverse flange.

Caulking.

If you are satisfied with the dome assembly and operation, it is time to caulk the joints.

If the dome has been exposed to rain, it almost certainly has water between some of the flanges: it can stay there for weeks! Before caulking, the water should be removed or else the caulk will not make a good bond. You can wait, and verify dryness by looking into the joints or inserting a paper strip. But an easier way to get the water out is to use compressed air or similar means to blow out the water.

If it is too cold or wet to caulk, you may use vinyl tape from a department or hardware store and apply it to the joints. Do not use duct or electrical tape, since these leave sticky residues that are difficult to clean. Tape should be removed as soon as the weather improves. Use tape or *low* quality caulk if you plan to disassemble the dome in a short time (good caulk is hard to remove!).

Our experience is that simply injecting caulk into the exterior seams from the outside forms a completely effective seal. We provide clear silicon caulk (the clear looks better than the white after it is dry). With the seams clean and dry, simply inject a smooth bead. We recommend that you not try to smooth the bead with your finger or other tool because then the silicon caulk tends not to form a smooth surface. Extend the caulk down along the skirt side joints on the DSR. Check that you have applied caulk on the joints between the quadrants (Greenwich Flange), including the joint as it extends up and under the shutter flanges at the top of the dome.

If you do want to inject caulk into the seams, you can do so by loosening the flange bolts and installing small wedges. Inject caulk into the opening, being careful not to overdo it at the points where the DSR sections abut. You do not want caulk to ooze down into the roller area. Remove the wedges, and tighten the bolts.

If you have not already caulked the wall ring and base ring joints, now is the time. Again, you can choose to apply caulk only to the outside of the joint, or you may partially disassemble the parts to inject caulk into the joints.

If there is a gap between the bottom of the wall and the foundation, now is the time to fill it. We recommend expanding foam, which you can inject into the gap. It will ooze out inside and out, but after it hardens, you can cut off the ooze with a sharp knife. Paint the outside with latex paint so the sun won't cause deterioration.

12. PROBLEM SOLVING

This section describes some problems that may occur and how to solve them. Most problems are easily solved with a careful, step by step approach.

The first thing to do is stop and make notes of what you were doing when the problem occurred, including making sketches of the dome. Exactly how were things positioned in relation to each other when you observed the problem? Usually the difficulty involves moving parts. When you stop to record exactly where things are, you'll find it easier to be more methodical than if you just keep taking action at random.

In the event that some parts need to be modified, or if portions of the dome must be disassembled and then reassembled, don't despair: these activities are easy to carry out. You will find that fiberglass is very forgiving of errors, and that fixing problems is usually very easy, once the problem is understood. If you find that you need to, call Technical Innovations and we will try to help.

Dome Rotation Problems

One possible problem at this point is that the dome does not turn easily, i.e., it turns easily at some points of the circle, and not at others, or it may turn in one direction and not the other. A systematic look will generally locate the problem.

First, check that all the blocks are removed, and that there is no foreign material (tape, wood scraps, etc.) between the DSR and the base ring. A bolt or nut under the DSR can make horrible noises at particular rotation points, and also resist rotation. Check that the DSR lip screws have been removed (or are not touching the base ring). Check that the rollers are all clean. Check that nothing is catching on a sharp edge (this will normally show up as a sudden stoppage of the rotation). If this is the case, find the offending spot and bevel or modify it. If you think the problem is under the DSR (e.g. a lost bolt), see the section "**Base Ring Service**" below for how to inspect that area safely.

If nothing is catching on an edge, i.e., the dome simply is much harder to turn at some points, the problem is likely to be binding of the DSR against the base ring. This can have several causes:

FIG 21

- the Base Ring was made too large
- the DSR was made too small
- Base Ring and DSR are out of round.

Check your base ring and DSR circumference measurements. (Compare to the chart in Chapter 3.) The DSR circumference should be at least 2.5 in. greater than the Base Ring, giving a DSR diameter at least 0.8 in. greater than the base ring. If the DSR to Base ring diameter difference is too large, (Case 3 in figure), binding will not occur but you will have substantial side to side movement as you turn the dome. If the DSR to base ring diameter is too small (Case 4), binding will occur.

Case 1 shows correct circumferences, with the dome centered on the base ring. As you turn the dome, you can push the dome off center (Case 2), given the DSR-base ring gap. This is normal.

Now, suppose the circumferences are OK, but the base ring and/or DSR are out of round. If centered, Case 5 shows that the gap may be uniform around the dome. But if you turn the dome 90 deg. (Case 6), you will see a different pattern of gap measurements. If you suspect this case, carefully take several sets of measurements, pushing the dome in both directions, and compare the results to determine exactly what is happening.

The most common cause of the problem was that the base ring was not circular during initial assembly (e.g., was forced onto improperly located foundation bolts). If the base ring was out of round, this would then cause the DSR to assume an out of round shape when bolted to the dome quadrants.

In either case, examine the situation carefully, make careful measurements, and think out carefully what is happening before making changes. If necessary, set up a good center point so that you can measure the "radius" of the Base Ring and DSR at different points on the circumference, and plot the results. Proceed step by step, rather than "just trying things". Try loosening the bolts holding the item (e.g. one of the DSR sections) to its improper shape, modify the shape (use people power, twisted ropes, duct tape, clamps, or other means), drill new holes, and install and tighten new bolts. Don't worry about making extra holes in the DSR or other parts (the extra holes won't show, and the parts are all sufficiently strong to accommodate the extra holes).

Shutter Engagement Problems **FIG 16B**

Shutter or latch engaging problems are nearly always caused by the edge of one item catching the edge of another. To solve, simply examine closely the location of each shutter as you have the problem, and identify the offending points. Fix it by beveling or adjusting the interfering edge properly. If the problem is a cavity (rather than a projection), fill the cavity with epoxy or polyester resin (or BONDO from an Auto store) and file to obtain the desired shape.

If the latches of the shutters do not properly engage, do NOT use the dome until the problem is corrected.

Shutter Dis-engagement Problems

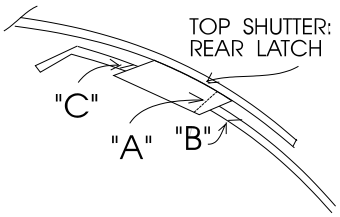
When the shutter is opened the first few times after the observatory is constructed, you should make several observations as the shutter moves up the first foot:

- watch that the top shutter moves back as the front shutter is slid upward
- look up inside to check that the rear latch has disengaged
- look up inside to check that the front latch is still partially engaged (i.e., still in the hole)

When opening, if the front latch disengages while the rear latch remains engaged (the opposite of what should happen), then when the rear of the front shutter reaches the latch it will force a disengagement. The top shutter will then slide to the back OUT OF CONTROL and will usually break the shutter catchers. This can damage the shutter, and is dangerous and must be corrected.

The cause of this behavior may be one or both of the following:

- some condition at the rear latch or hole prevents easy disengagement of the rear latch
- some condition allows the front latch to disengage too easily.



The top shutter rear latch should disengage very easily as the top shutter is pushed back. Difficulty can be caused by:

- The rear latch may be excessively rounded at the ends of the rear face with a perpendicular bevel ("A" in figure). Because the rear edge of the hole is triangular, the ends of the latch will initially contact the rear of the hole, and a perpendicular face will not slide up out over the edge. Correction is to cut off the ends, or modify the bevel from perpendicular to sloped (as is the remainder of the rear face)
- The rear of the rear latch hole may be beveled too sharply ("B" in drawing). This can cause grooves or cuts in the rear face of the latch which worsen the problem. Correction is to sand the face to under 45 deg with smooth edges. If the rear face of the latch is grooved, sand or shave it smooth.
- The front of the hole may be beveled too sharply, causing the latch to jam in place ("C" in drawing). Sand the front of the hole to a more vertical face, and smooth the edges.

The front latch should NOT disengage until the front latch passes over the down lip of the rear cover and the rear of the top shutter has reached the shutter catchers. Too easy disengagement can be caused by lack of vertical bevel on front face of latch. Correction is to create a bevel about 1/4 in. high (sand, plane, or cut).

Note, sometimes there may be excessive force required to disengage the front latch even when they are back in the correct position. This may be caused by warped shutters, a front shutter glide that has come loose, excessive electric shutter tension, or other problems that lift the front of the top shutter and/or the rear of the front shutter away from the dome. The cure may be to reduce an excessive front latch vertical bevel, or to make vertical the front edge of the front hole.

Shutter Blow-off

With the shutter restraint system in place, it is virtually impossible for the shutters to blow off. If the top and/or front shutter should blow off your dome, it is almost always that the latches were not fully engaged holding the top shutter to the rear cover and front shutter, or that the front shutter was not fastened to the front slot edges. Please review the shutter installation instructions, and recheck your latches and locking system. Never use

ropes or bungee cords to hold the shutters in place: they allow too much movement of the shutter.

Base Ring Service

If you identify a problem that requires you to work under the DSR, you can do this WITHOUT disassembling the dome from the DSR. Simply turn the dome to the position needed, and open the DSR Splice-Plate, thus allowing access to the base ring beneath. However, remember, UNDER NO CIRCUMSTANCES should you turn the dome even a few inches unless the DSR Splice-Plate is closed and bolted. Failure to follow this rule may cause the dome to fall off the wall.

13. USE AND CARE OF YOUR HD15 DOME

Your HD15 dome should give you many years of faithful service. Feel free to modify it, drill holes in it, and generally add your own personal touches to it. The walls are strong. You can use any fastening means (including fiberglass) to add desks, benches, etc.

Use the dome, but exercise reasonable care: it is NOT a toy. Don't let adults or children on top of the dome. And keep open flames away: remember, fiberglass is flammable. If you use a heater, be careful to keep it away from contact with the fiberglass.

Your closed and locked observatory is designed to withstand the full range of normal adverse weather conditions, including extremely high winds. However, it is not designed for occupied use under high wind conditions. It is not possible to place a specific limit on the wind velocity that is acceptable, although most users find that winds above about 30 mph are not comfortable. If you wish to use the dome under higher wind velocities, you should contact us for suggested changes to improve shutter operation under high wind conditions.

Although your dome is very weather tight, be sure to cover your telescope with a sheet of plastic when not in use. If the air temperature drops so that the dew point is below the dome temperature, condensation can form, and drip from the top of the dome. This is rarely a problem except for domes attached to a house or other source of water vapor (in that case, you **must** have double doors or other means of keeping the water vapor out of the dome). If condensation is a problem, try a dehumidifier or a small heater or 100-200 watt lamp near the center of the dome and call us for additional help.

Your HD15 requires very little care. Overall, the care of the dome is similar to that of a fiberglass boat, although since the dome is not in a marine environment, it will require less maintenance (and there is little chance for barnacles to grow!).

If you wish to keep it looking as new as possible for as long as possible, wash it with mild detergent (no abrasives) every 6-12 months to remove dirt and grime. You may want to apply rubbing compound and wax to the outer surface to help it remain "clean looking" longer, and help protect the finish. If the appearance is important to you, this should be done as soon as you build your dome if it is located close to trees, or if you have lots of dirt in the rain in your area. With occasional waxing the surface should last for many decades, though it may become slightly yellowish. You may wish to talk with auto or marine or boat supply stores for advice or materials for fiberglass maintenance and repair.

Three brands of fiberglass treatment that we have tried and like are

- 3M Marine Fiberglass Restorer and Wax (combines rubbing compound and wax in one application)
- IOSSO Fiberglass Reconditioner (restores color, removes oxidation and chalking, toll free number 1-888-747-4332)
- Meguiar's Cleaner and Wax (excellent cleaning and shine, easy to use)

It is possible that the surface of the fiberglass may become chipped or damaged during assembly. Or, after many years, it may develop some surface crazing or blisters. Normally, these chips or discolorations will cause no functional problems. That is, while they may affect appearance, they do not significantly affect the strength of fiberglass beneath. However, if you do wish to repair the surface, you can use epoxy or polyester resin to cover the area for a functional fix, and add gel-coat for an aesthetic fix. Contact an auto or any marine or boat supply (see the Yellow Pages) for a fiberglass repair kit containing white Gel-coat (i.e., resin with white pigment) which can be applied easily.

If major damage to the dome occurs (e.g., you forgot and left the dome open during a major windstorm), virtually any damage can be functionally repaired using a fiberglass repair kit. You'll find a kit for this purpose in an auto parts shop or marine supply. If you wish, you may contact Technical Innovations for advice and/or replacement parts.

After 15-25 years, the surface may begin showing its age, usually by a dulling or chalking of the finish. (But then, so will we all!) Unless the surface is damaged, the only care really needed is wax. However, if you wish to repair the surface, you may reapply gel coat, or you may paint the dome using a high grade epoxy paint. In either case, you will need to prepare the surface properly by cleaning and some abrasion. Again, give us a call, or check with your local marine or auto supply stores for advice and materials.

APPENDIX 1 LIST OF ILLUSTRATIONS

Figure Numer	**Title**	File
1,2,3	Bolt detail, Carpenter Level, Water Level	HD101
4,5,6	Foundation optons, Foundation bolts & leveling	HD102
7	Concerete Pad Detail, Pad with Bolts & Shims	PD103
8	none	
9	PD15 Wall/base ring cross section	HD105g
9B	PD1 First ring installation	PD1514
9C	PD15 Wall/Base ring identification	PD1516b
10	Front view Pro Dome	PD106c
11,12,13	Roller hole, DSR bevels, Quadrant flanges	HD120b
14,15	Rear cover installation, Quadrant Bolt ID	HD118b
16B	Shutter operation	PD109B
17,18	Soffit, shutter safety device	PD110
19	Shutter anti-friction strip	PD111
20	none	
21	Rotation tests	PD112
22	Wall with Semi-door	PD113C
23	PD15 Locking system	LOCK1D
24	Shutter restraint system	PD117
31	ES15 Model 2	Es1501E
32	Electric shutter installation	ES1502d
41	Power Supply schematic	PS1C
42	Power supply layout	PS2c
51	Dome Drive Plate	ED1
52	Drive Motor wiring	ED9
53	Drive mounting holes	ED2

Bolt Hole Drilling Guide
HD15

Introduction and Terminology

When the dome has not been preassembled, there are a number of holes that need to be drilled in order to attach one fiberglass section to another or install miscellaneous add-on parts.
Throughout the process, it is extremely important to maintain roundness and levelness, while keeping a pleasing "cosmetic" appearance at the different "seams". Most times there will be a hole going through two pieces of fiberglass, which will then be bolted tightly together. Even though the sections must be moved around until the final position meets the specifications, (especially base and wall rings), we know closely enough where the holes will be located to be able to drill one of the holes ("Guide") then use that hole as a guide when we drill through the second piece ("Final"). The drilled identified as "Final" will, in most cases, be immediately followed by bolting the part or adjacent fiberglass section, together.
Base ring sections join together end-to-end ("Overlap").
The reference "Right" or "Left" has the orientation of standing outside the front shutter opening location (or "Home" position), facing the dome and looking in.

Construction Overview

The construction step sequence (detailed in the manual), is as follows:

1. Installation Preparation – Foundation, leveling, tools, organization and planning
2. Pre-drilling
3. Base ring prep and install
4. Mounting base ring to foundation
5. Rotation system install (wheels and side rollers)
6. Prep and install DSR
7. Prep dome quadrants
8. Install rear shutter panel
9. Install dome halves to DSR
10. Prep front and top shutter sections
11. Install shutter
12. Finish items

Bolt Hole Drilling Guide

1. Base Ring sections, Overlap, Guide

The 90 degree wall sections each have one end "stepped in" ("female") and the other end a "flat" ("male"), continuation of the wall. All of the initial "Guide" holes for base and wall ring sections are made at the "flat" end, and all sections con be drilled at this time. Two holes are drilled (9/32 inch bit) on the "flat" (male) end of the section. Their locations are, 2 inches down from the top and 2 inches up from the bottom - with both 1 1/8 inch in from the end edge.

2. Wheels, Final

Locate the wheel cutouts in each base ring section (on the underside of the reverse flange). Find the center of each cutout and measure down the outside wall of the base ring 7/8" (or use the template provided with the dome hardware). Drill a 1/8" guide hole first, then drill out hole (5/16 inch bit) and then countersink the outside of the hole to a depth that results in the head of the 2 ¼ " Flat Head bolt to be flush with the outside wall surface.

3. Side Rollers, Final

There are 24 side rollers that get distributed approximately equal distance apart around the top surface of the base ring (under the reverse flange). (See **Figure 9C** in the manual for placement). The side roller is mounted horizontally on the top surface so that it extends between 1/8 and 3/16 inch out from the base ring wall surface. Measure ¾ inch inward (or use template) and mark for the Side Roller mounting hole. Drill 1/8" guide hole, then drill out these holes using a 13/64 drill bit.

4. Base Ring, Overlap, Final

The 90 degree wall sections each have one end "stepped in" ("female"), that slide in behind the "flat" end of the adjoining sections and/or stub sections. The bottom ring is fitted together in this fashion until a continuous circle is formed on top of the pad or mounting surface. Using clamps, this ring is adjusted until it is circular and meets the circumference measurement tolerances. All of the initial "Guide" holes for these ring sections are on the outside of each joint and are used as guides to drill the Final overlap holes (9/32 inch bit). The sections are bolted at this point to form the solid bottom ring.

5. Base Ring, Mounting Flange, Final

With the bottom ring of correct circumference, circular, and placed on the mounting surface at the desired location, the anchor holes can be drilled. Anchor holes will be made through the bottom flange of this ring approximately every 15-18 inches around the circumference. Using a small (1/8 inch) bit, drill "Guide" hole through the flange and into the mounting surface below. Depending upon material the ring may need to be moved and holes for bolt anchors drilled out. The ring is moved back into place and the mounting holes in the fiberglass flange drilled out to match the anchor bolt size decided upon (normally 3/8 inch bolt).

6. DSR Splice-Plate, Final

The DSR on an HD15 will be made up of four solid (no door) sections to make up the ring. One of the sections (which will become the "front" section as the splice-plate must be centered in the front shutter opening) needs to have the splice-plate centered. Using the splice plate as a template, the six holes (9/32 inch bit) are drilled.

7. DSR overlaps, Final

With the wall/base rings of correct circumference, circular, and bolted together, the DSR sections are set into place with each end overlapping the adjacent. Once adjustments are made to obtain the correct DSR circumference, a 6/32 hole is drilled in the center of each overlap section.

8. Top Shutter, J-Guides, Final

Six J-Guides (2 holes each - 3/16 inch bit) are mounted onto each of the side flanges of the top shutter panel. One of the J-Guides should be used as a template for the pair of holes, and positioned such that loop section only extends past the flange edge. The first pair holes are drilled 5 inches in from one end of the shutter panel and the second pair 5 inches in from the other end. The remaining 4 are evenly spaced between the first two (approximately 18.5 inches between each. All 20 holes (both sides) will be counter-sunk on the inside of the flanges to prepare for the 10-32 flathead machine screws.

9. Top Shutter, Latch Bars, Final

The shutter latch bars (long – 5 holes and short – 4 holes) are mounted near the ends of the top shutter. The long is near the front edge and the short near the rear edge. In both cases a centerline is used 9.25 inches in from each shutter edge. The latch bars are each centered on the shutter with the latch holes centered on that line. NOTE: there are “marks” in the white fiberglass surface to locate these latch bars. Place the latch bar over the marks to make sure that they match up. Mark the bolt hole locations and drill 9/32 inch holes at each point (total of 9 holes). Start at one end after recheck the latch bar alignment after each hole is drilled.

10. Front Shutter, Handles, Final

The shutter handles (two, mounted side by side) are attached on the outside of the Front shutter section, near the front. The handles will be mounted on a centerline which is 6.25 inches in from the front edge of the front shutter section. Space the handles such that the inside bolt of each is 1.5 inches out from the shutter section center line. Mark the bolt hole locations then drill the four 9/32 inch holes.

11. Front Shutter, ES15 SCCA Assembly, Final

The two shutter motor cable holders (SCCA assembly) are mounted on the inside of the Front shutter section, near the front and close to the shutter section side flanges. **NOTE: The Shutter Glide Strips must be installed on the front shutter before completing this step**. The holes will be drilled through the attached glide strip, and part of that strip will need to be cut away in order to mount the SCCA assembly on each side. The hole for each of the SCCA assemblies is 7.5 inches up from the front edge of the front shutter section (same centerline for the deadbolt system) and 2 inches in from the side flange.

12. Rear Shutter, ES15 Motor Assembly, Final

The ES15 shutter motor assembly is mounted onto the top area of the rear shutter panel. The motor assembly is positioned so that it is centered along a shutter centerline. The top edge of the motor assembly case (the white plastic three sided frame) is located 14 ½ inches down from the center of the rear shutter panel top cut out slot. Mark the four hole locations in the back of the motor assembly, remove the assembly, and drill four 9/32 holes at the marked locations. Countersink the outside (white surface) of these holes so that the flat head bolts used are flush.

13. Rear Shutter, Shutter Catchers, Final

The pair of shutter catchers (which are mounted on the outside at the bottom of the rear shutter panel) have a right and a left unit. They are positioned such that they are flush with the bottom and side (each outside bottom corner of rear shutter panel), and the "arm" with wind restraint cable hole, extends out from panel. Mark and drill four 9/32 holes (two for each shutter catcher).

14. Rear Shutter, Side Flanges, Guide

Twenty holes (9/32 inch bit) are centered and drilled (10 on each side) through the side flanges of the rear shutter panel. From the top end (next to large latch slot and tapered edge), the first hole is drilled 1 inch down from the bottom tab, followed by a second hole 2 inches further down, then the third hole 11.25 inches down from the second. The fourth hole is measured from the bottom of the shutter panel, 3 inches up from bottom of the tab edge. The remaining eight holes are then evenly spaced, each approximately 13.25" apart. All twenty holes will be countersunk on the outside of the shutter panel flange

15. Front Right Dome Quadrant, DSR Flange, Guide

Ten holes (9/32 inch bit) are drilled into the bottom horizontal, DSR, flange of the front right dome quadrant. The first hole is drilled 5 inches from the front edge followed by the next nine, each approximately 12 inches apart. The tenth bolt will be 3 inches from the Greenwich Flange.

16. Front Left Dome Quadrant, DSR Flange, Guide

Ten holes (9/32 inch bit) are drilled into the bottom horizontal, DSR, flange of the front left dome quadrant. The first hole is drilled 5 inches from the front edge followed by the next nine, each approximately 12 inches apart. The tenth bolt will be 3 inches from the Greenwich Flange.

17. Front Right Dome Quadrant, Greenwich Flange, Guide

Ten holes (9/32 inch bit) are drilled into the center, Greenwich flange of the front right dome quadrant. The first hole is drilled 3 inches up from the bottom edge (next to DSR flange), followed by the next nine, each approximately 12 inches apart. This will result in the last bolt hole approximately 5 inches from the top f the flange

18. Front Left Dome Quadrant, Greenwich Flange, Guide

Ten holes (9/32 inch bit) are drilled into the center, Greenwich flange of the front left dome quadrant. The first hole is drilled 4 inches up from the bottom edge (next to DSR flange), followed by a second 8" up from the first. The next eight are each approximately 12 inches apart. This will result in the last bolt hole approximately 3 inches from the top f the flange

19. Rear Right Dome Quadrant, DSR Flange, Guide

Ten holes (9/32 inch bit) are drilled into the bottom horizontal, DSR, flange of the rear right dome quadrant. The first hole is drilled 5 inches from the front edge followed by the next nine, each approximately 12 inches apart. The tenth bolt will be 3 inches from the Greenwich Flange.

20. Rear left Dome Quadrant, DSR Flange, Guide

Ten holes (9/32 inch bit) are drilled into the bottom horizontal DSR flange of the rear left dome quadrant. The first hole is drilled 5 inches from the front edge followed by the next nine, each approximately 12 inches apart. The tenth bolt will be 3 inches from the Greenwich Flange.

21. Rear Right Dome Quadrant, Greenwich Flange, Final

The Rear Right and Front Right dome quadrants are joined together at the Greenwich Flange to form the Right Dome Half. Bring and clamp the two quadrants together, making sure that the seams line up on the outside and that the bottoms are flat/horizontal. Using the guide holes drilled in the Front Right Dome Quadrant, drill 9/32 inch holes through the Rear quadrant Greenwich Flange.

22. Rear Left Dome Quadrant, Greenwich Flange, Final

The Rear Left and Front Left dome quadrants are joined together at the Greenwich Flange to form the Left Dome Half. Bring and clamp the two quadrants together, making sure that the seams line up on the outside and that the bottoms are flat/horizontal. Using the guide holes drilled in the Front Left Dome Quadrant, drill 9/32 inch holes through the Rear quadrant Greenwich Flange.

23. Right Dome Half, ES Pulleys

The ES15 electric shutter system uses a pulley system made up of twelve units on each side of the dome shutter flange – a single “loop return” pulley, ten over/under double guide pulley in plastic holders, and a double “side-by-side” pulley assembly on an aluminum bracket.
The hole for the first single “loop return” pulley is drilled in the center of the Greenwich flange tab (at the front of the dome half), 2 inches up from the bottom of the flange tab.
The next ten pulleys (the over/under double guide), are spaced 18 inches apart, starting from the single “loop return” pulley. There is one hole for each plastic holder and is located 2 ¾ inch down from the top edge of the dome shutter flange (this will result in approximately ¾ inch overhang at the bottom and provide top clearance for the SCCA as it travels back and forth with the shutter). Make sure that the tenth (and last of the over/under) ends up 2.5 inches below the start of the notched-out section for the rear shutter panel.
The double pulley assembly (drilled after rear shutter panel and ES15 motor assembly are installed), will use the shutter cables as guides. Position the aluminum bracket in a way that allows the cables to be as close as possible to horizontal and that they enter the pulley at minimal angle. Mark the hole locations then drill the two 9/32 holes on each side.

24. Left Dome Half, ES Pulleys

NOTE: Left Dome Half exactly the same as Right Dome Half
The ES15 electric shutter system uses a pulley system made up of twelve units on each side of the dome shutter flange – a single “loop return” pulley, ten over/under double guide pulley in plastic holders, and a double “side-by-side” pulley assembly on an aluminum bracket.
The hole for the first single “loop return” pulley is drilled in the center of the Greenwich flange tab (at the front of the dome half), 2 inches up from the bottom of the flange tab.
The next ten pulleys (the over/under double guide), are spaced 18 inches apart, starting from the single “loop return” pulley. There is one hole for each plastic holder and is located 2 ¾ inch down from the top edge of the dome shutter flange (this will result in approximately ¾ inch overhang at the bottom and provide top clearance for the SCCA as it travels back and forth with the shutter). Make sure that the tenth (and last of the over/under) ends up 2.5 inches below the start of the notched-out section for the rear shutter panel.
The double pulley assembly (drilled after rear shutter panel and ES15 motor assembly are installed), will use the shutter cables as guides. Position the aluminum bracket in a way that allows the cables to be as close as possible to horizontal and that they enter the pulley at minimal angle. Mark the hole locations then drill the two 9/32 holes on each side

25. Right Dome Half, Wind Restraint, Final

Start at seam of dome quadrants (top, middle); measure **BACK** 4 inches; go out from the shutter flange 3.5 inches and drill ¼” cable post hole.
Measure **FORWARD** 22 inches; go out from the shutter flange 3.5 inches and drill ¼” cable post hole.
Measure **FORWARD** 24 inches; go out from the shutter flange 3.5 inches and drill ¼” cable post hole.

Measure **FORWARD** 24 inches; go out from the shutter flange 3 inches and drill ¼" cable spring post hole.
Start at the rear of dome half; measure forward (up) 26 inches from bottom of shutter flange tab; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 27 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 27 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole. This hole should be approximately 26 inches from the very first hole drilled above.

26. Left Dome Half, Wind Restraint, Final

NOTE: Left Dome Half, Wind Restraint Final is exactly the same as Right Dome Half
Start at seam of dome quadrants (top, middle); measure **BACK** 4 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 22 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 24 inches; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 24 inches; go out from the shutter flange 3 inches and drill ¼" cable spring post hole.
Start at the rear of dome half; measure forward (up) 26 inches from bottom of shutter flange tab; go out from the shutter flange 3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 27 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole.
Measure **FORWARD** 27 inches; go out from the shutter flange3.5 inches and drill ¼" cable post hole. This hole should be approximately 26 inches from the very first hole drilled above.

27. Rear Right Dome Quadrant, Shutter Flange, Final

The rear shutter panel is placed so that it straddles the shutter flanges at the rear of the two dome halves and is positioned such that the top of the rear shutter panel fits into the start of the notched out area and the bottom is approximately equal with the bottom of the shutter flange rear bottom edge. Using the guide holes drilled into the rear shutter panel, drill 9/32 inch holes through the rear right dome quadrant shutter flange.

28. Rear Left Dome Quadrant, Shutter Flange, Final

The rear shutter panel is placed so that it straddles the shutter flanges at the rear of the two dome halves and is positioned such that the top of the rear shutter panel fits into the start of the notched out area and the bottom is approximately equal with the bottom of the shutter flange rear bottom edge. Using the guide holes drilled into the rear shutter panel, drill 9/32 inch holes through the rear left dome quadrant shutter flange.

29. DSR, Final

The two dome halves are properly positioned on the DSR and the guide holes in the dome half DSR flange are used to drill 9/32 inch holes through the DSR. These holes are then countersunk on the bottom side of the DSR for flathead machine screws

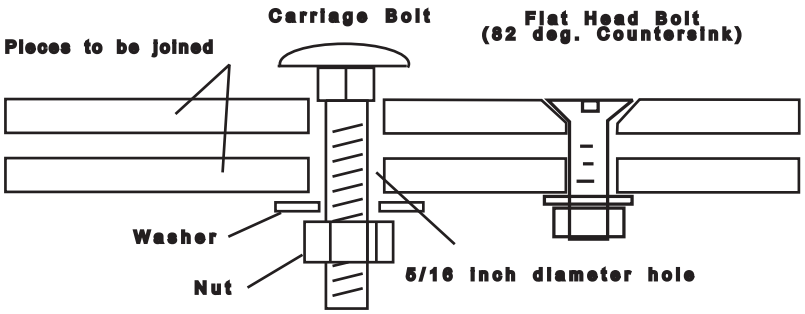


Figure 1
Bolt Detail

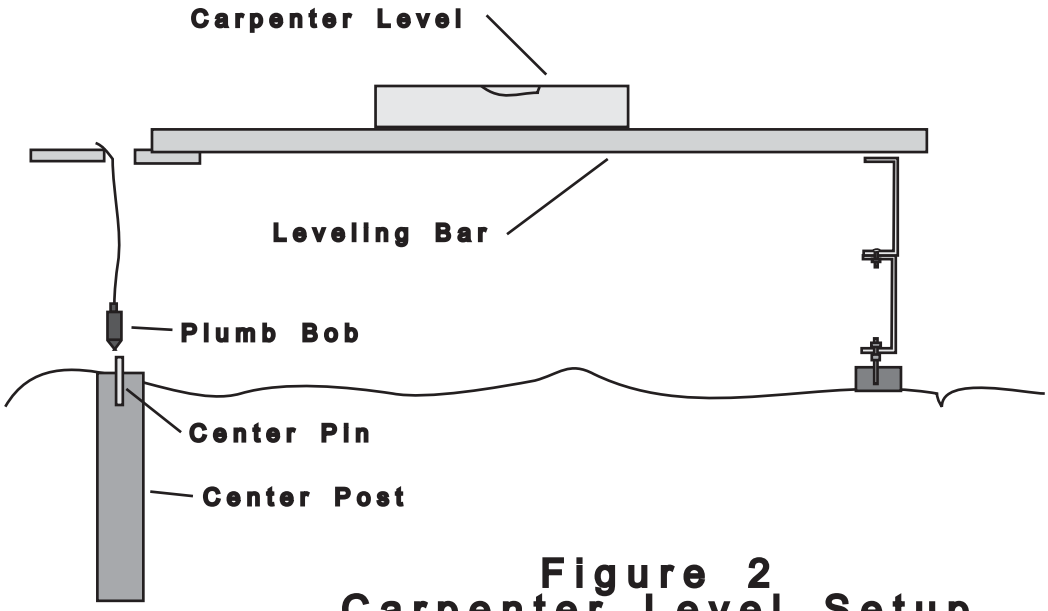


Figure 2
Carpenter Level Setup

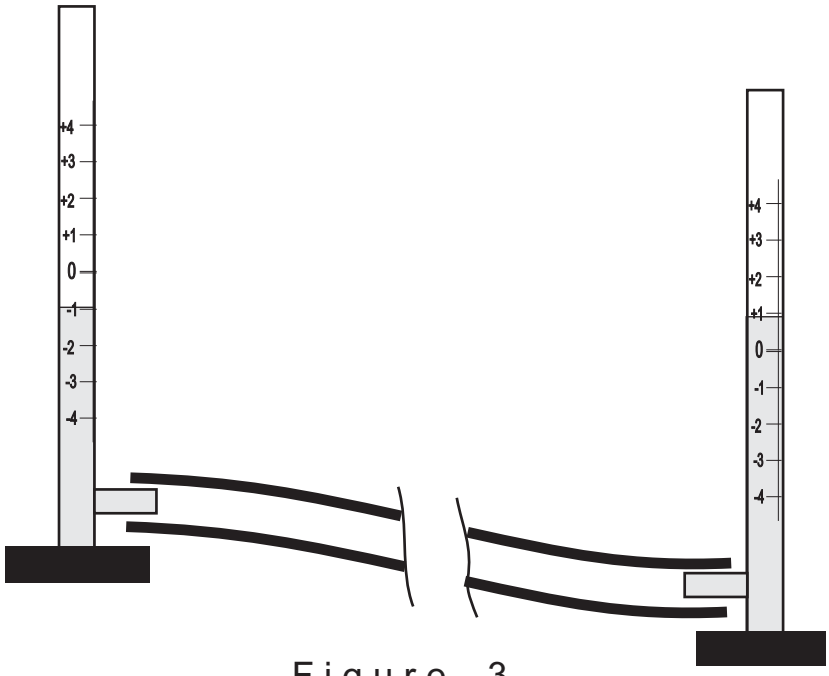


Figure 3
Water Level

HD101

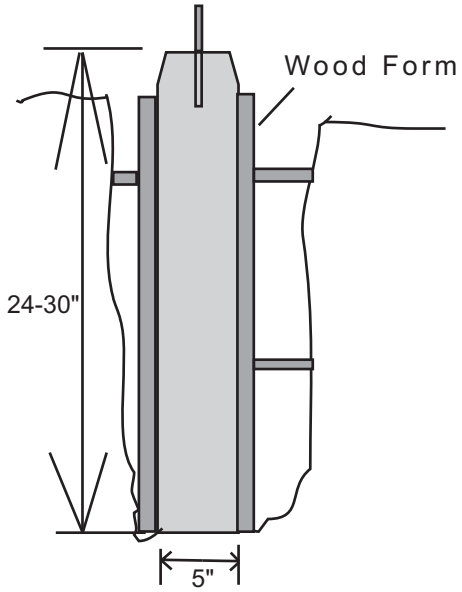


Figure 4
Ring Foundation Cross-section
(Poured Concrete)

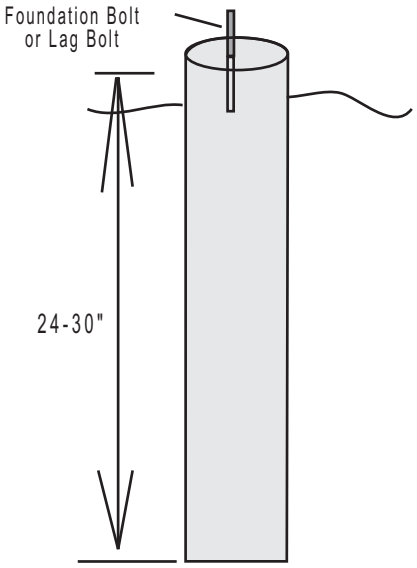


Figure 6
Wood Pier Foundation
(Post in Ground)

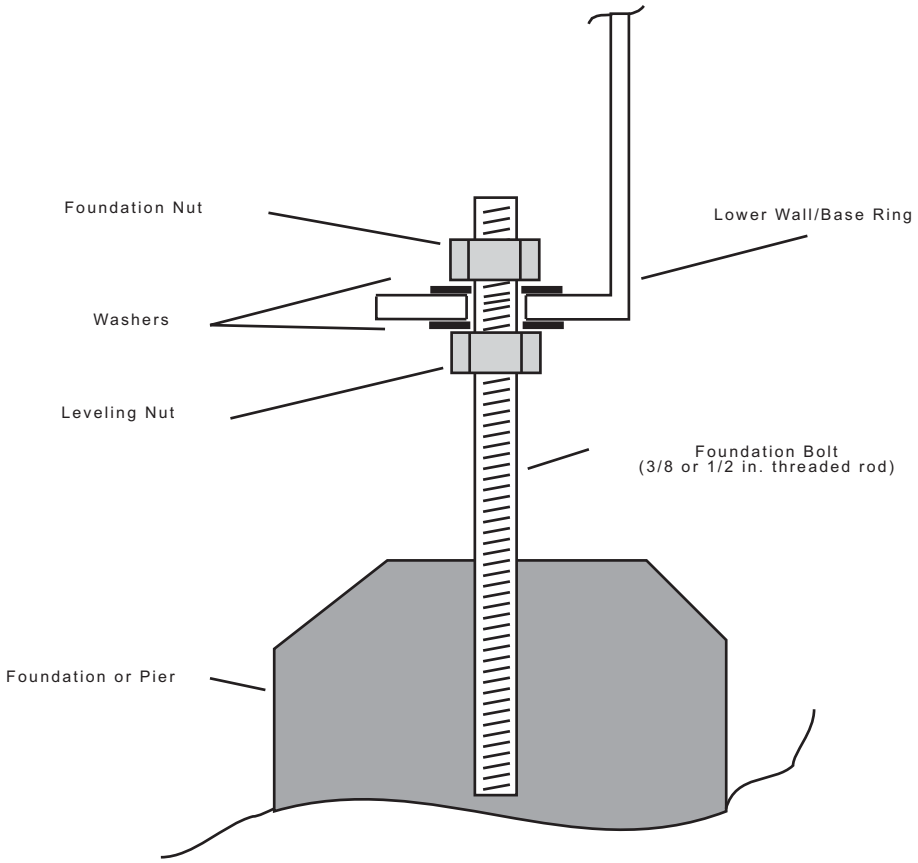
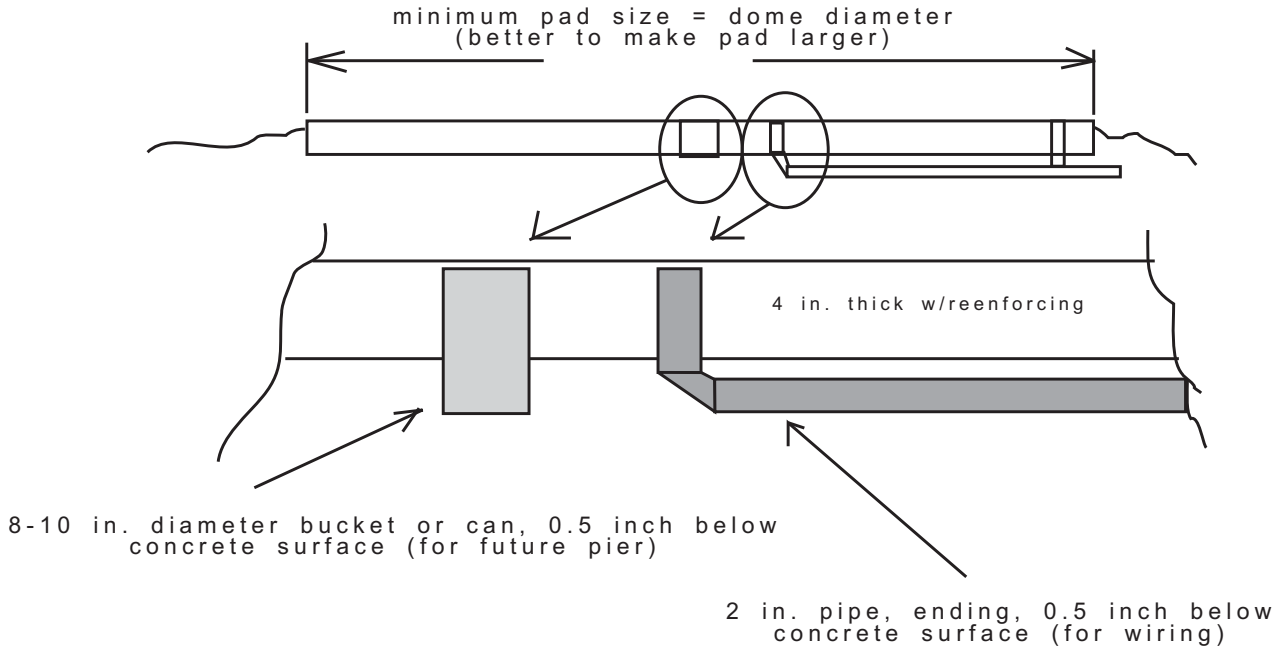
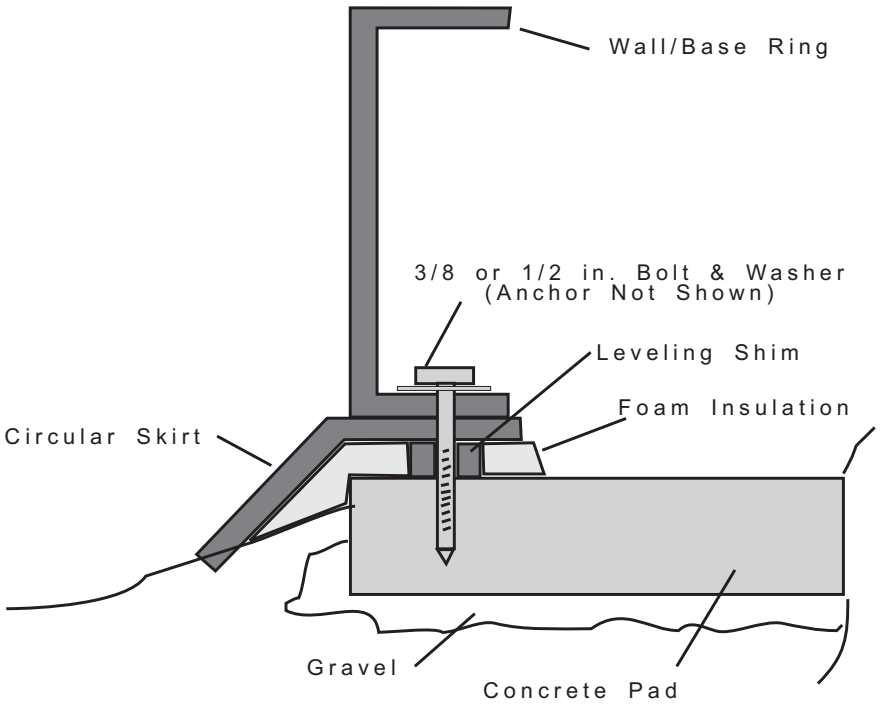


Figure 5
Foundation Bolts & Leveling



CONCRETE PAD DETAIL



FOUNDATION MOUNTING AND
SKIRT DETAIL

Pad with Bolts & Shims Figure 7

DRAWINGS NOT TO SCALE

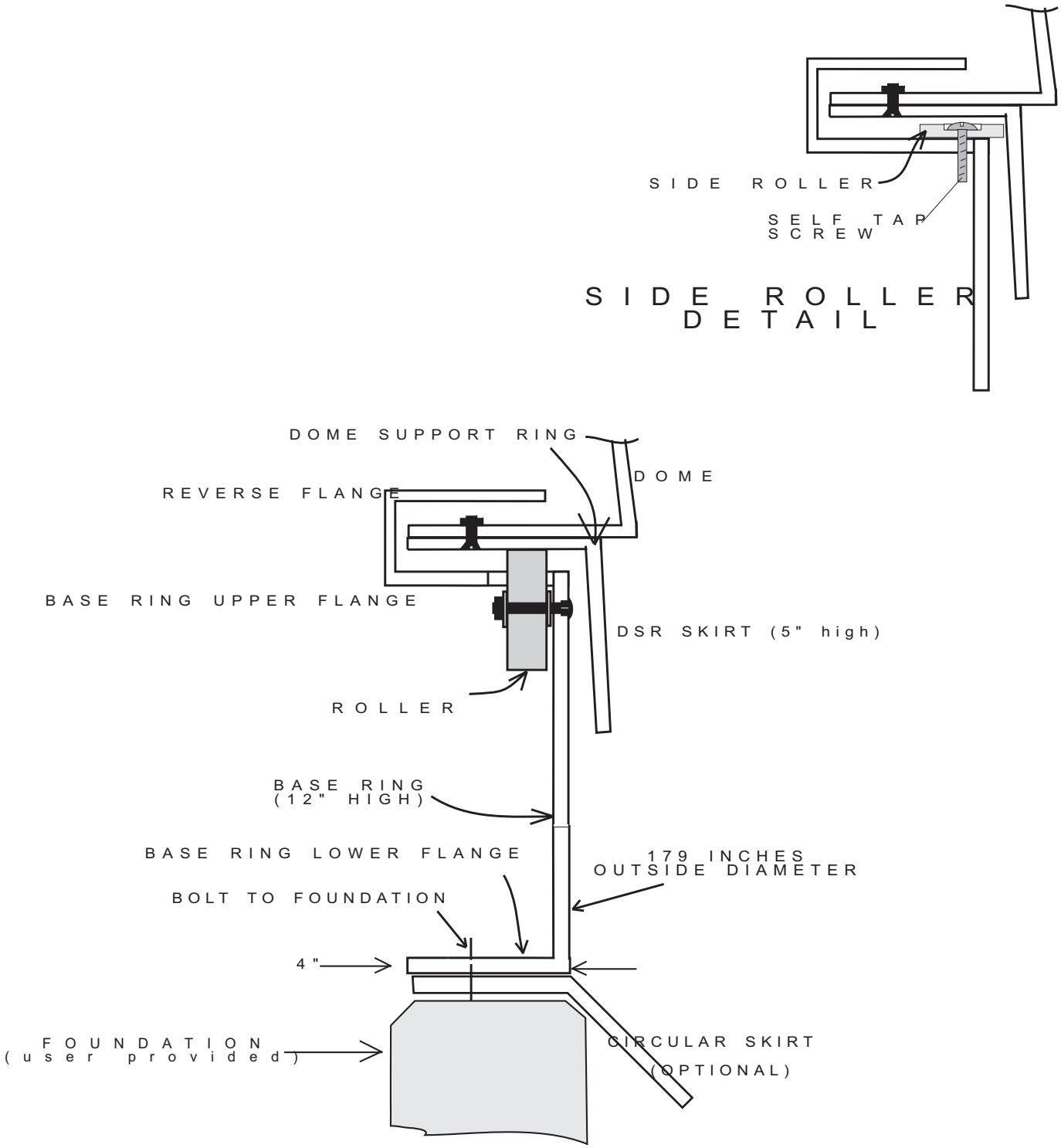
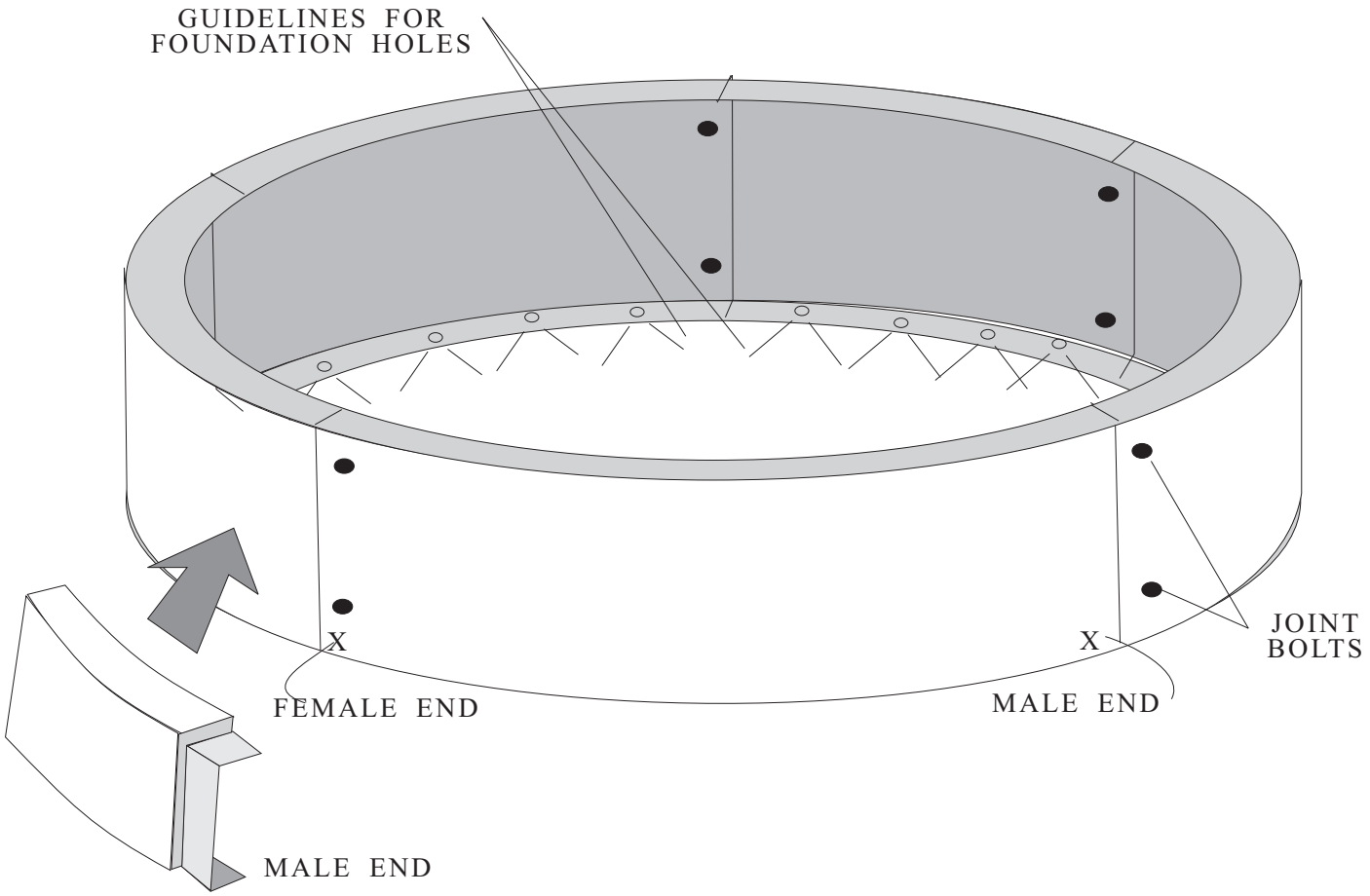


FIG. 9 - HD15 Base Ring

(NOT TO SCALE)

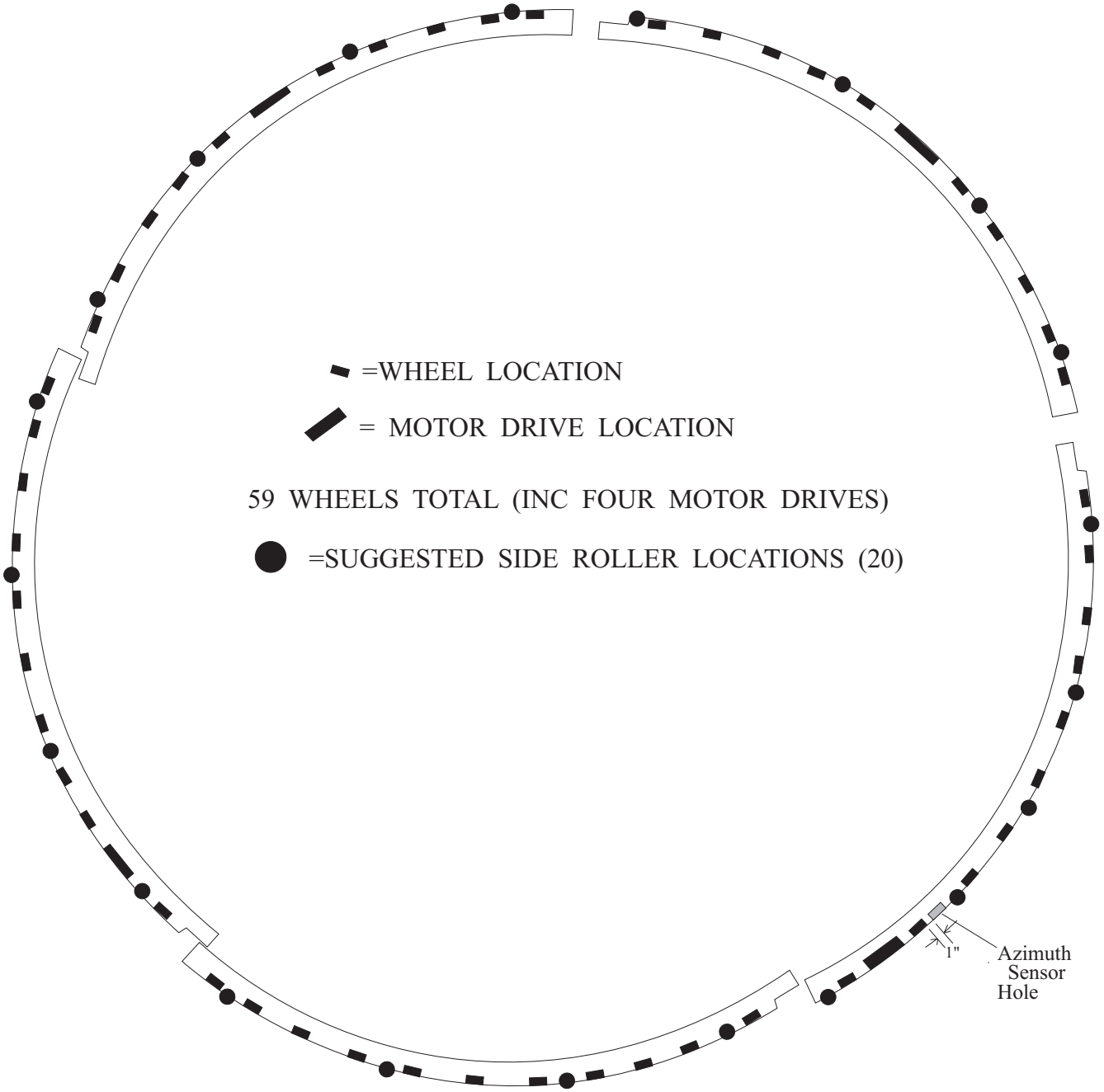


Note: Complete ring is made of five equal segments.
First ring is normally the Base Ring, but some Hd15
are order with one or more wall rings for height.

HD-15, FIRST RING INSTALLATION
FIGURE 9B

HD1514

110898

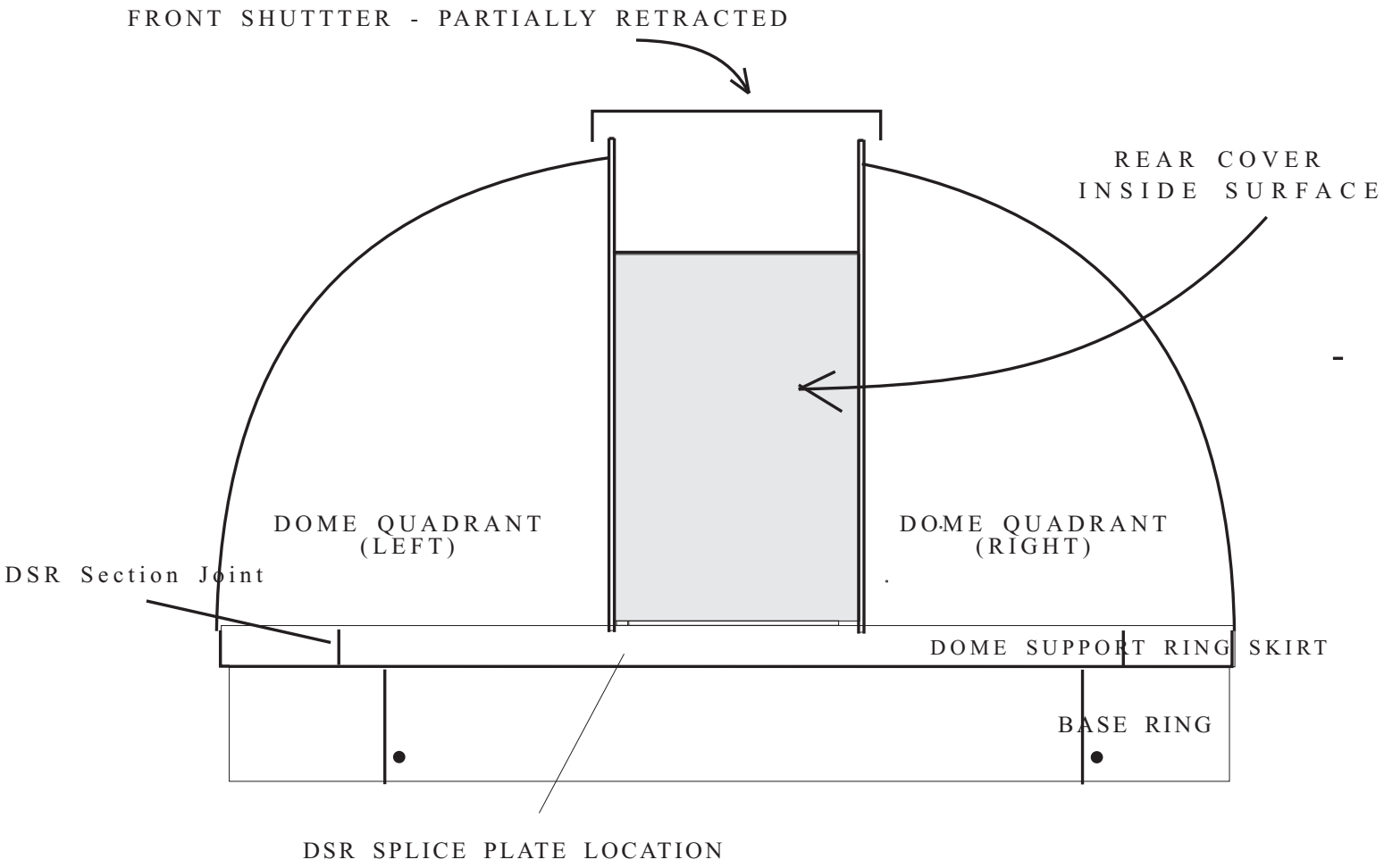


HD-15 Base Ring Identification
(4 motor installation)

FIG 9C

hd1516b

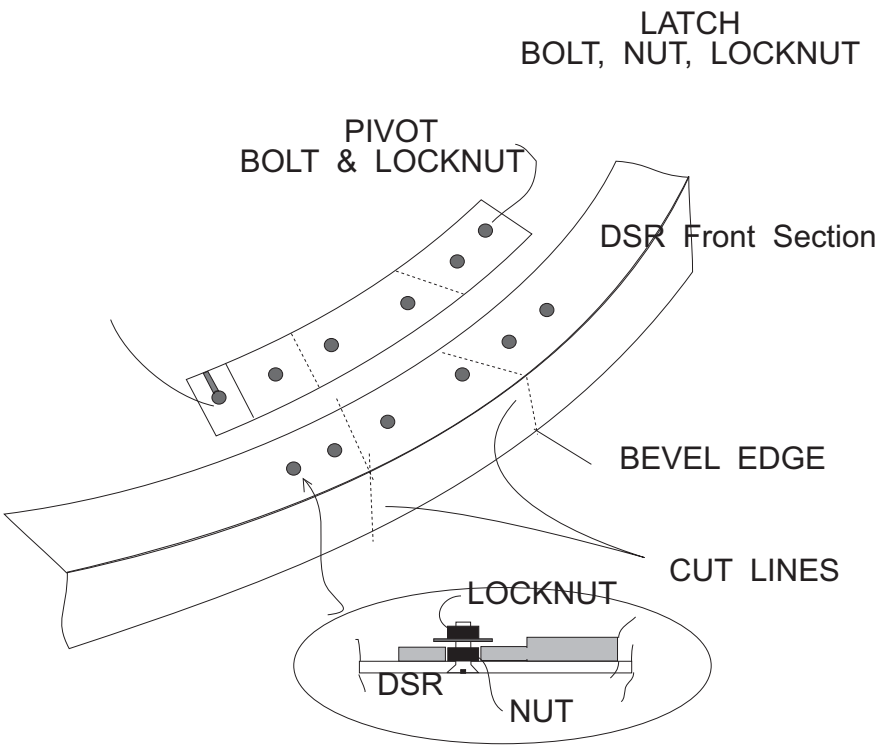
040409



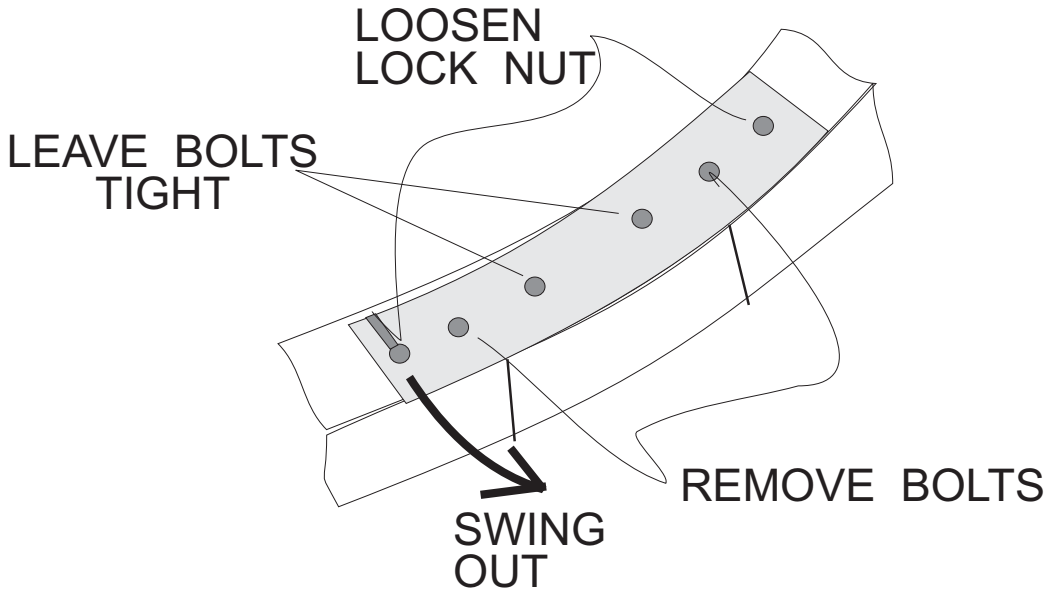
Front View HOME-DOME Figure 10

HDI06C

TO INSTALL SPLICE PLATE

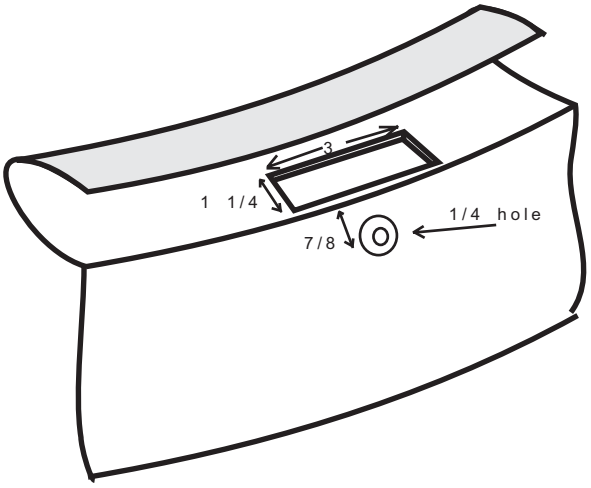


TO USE SPLICE PLATE

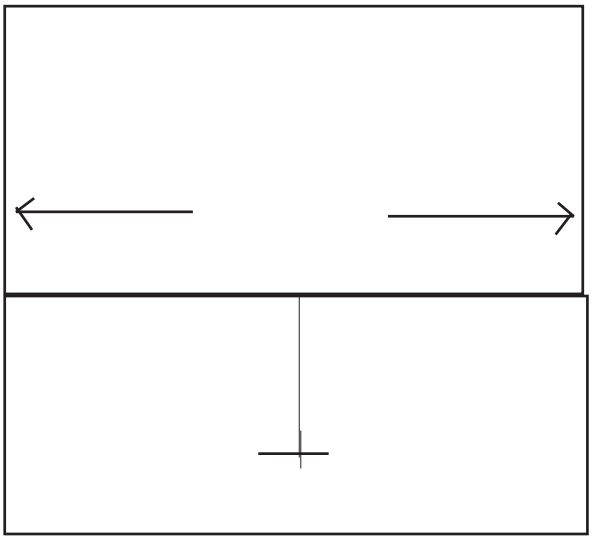


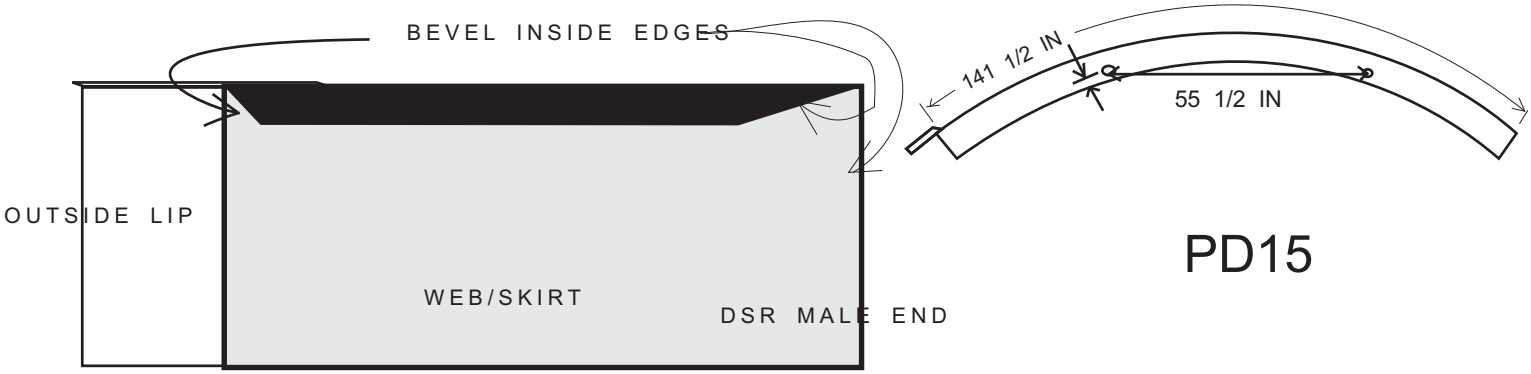
DSR SPLICE PLATE

FIG 12

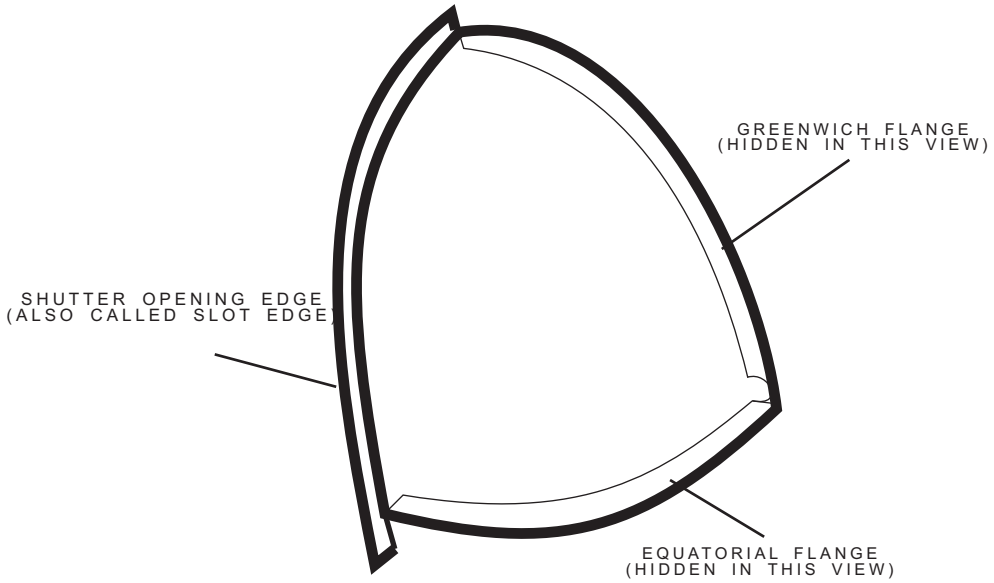


BASE RING - ROLLER HOLE
Figure 11



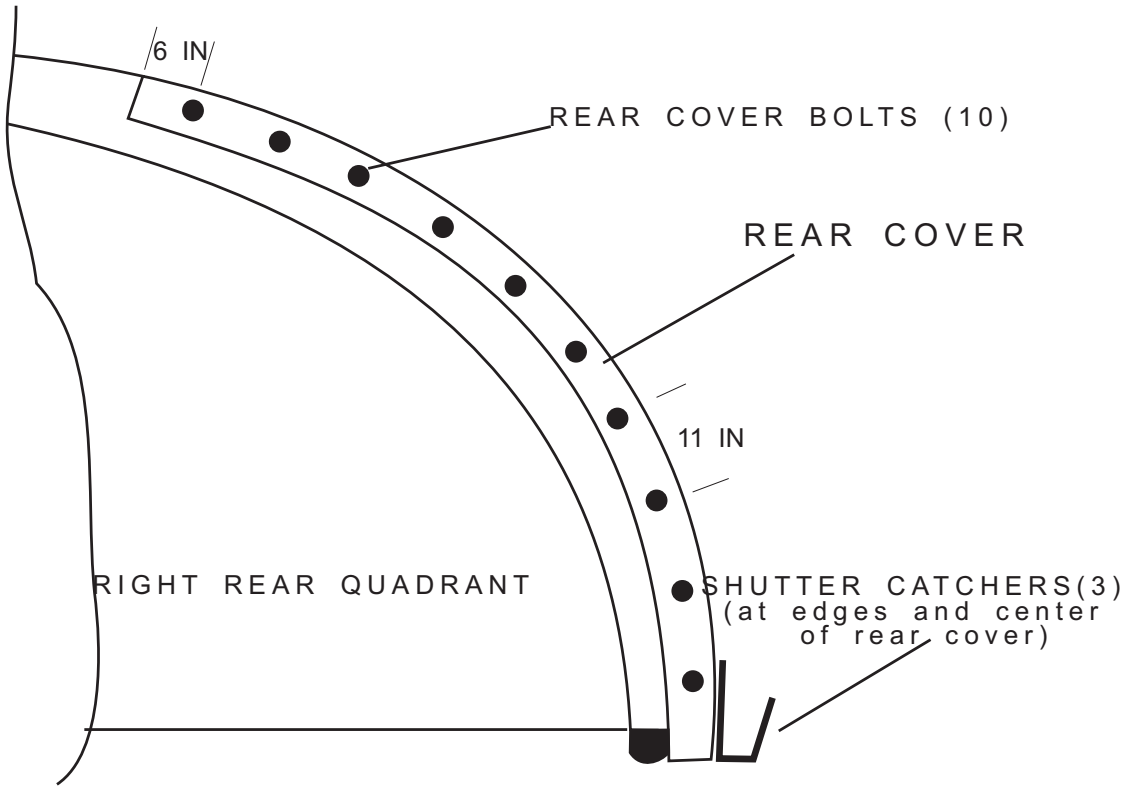


DSR - CROSSECTION SHOWING BEVEL
Figure 12

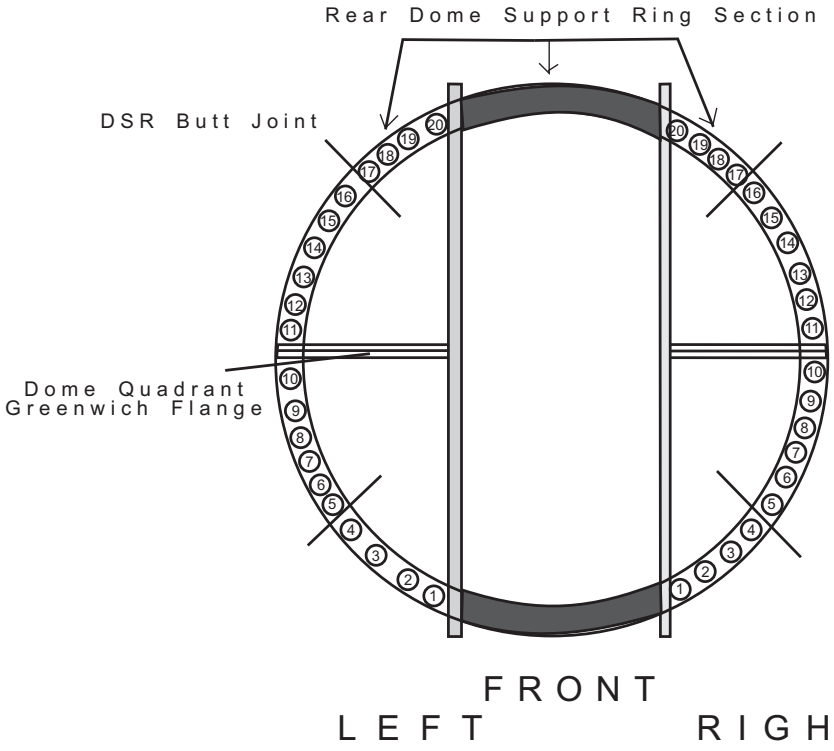


RIGHT FRONT QUADRANT - FLANGE NOMENCLATURE
Figure 13

hd120b



REAR COVER INSTALLATION
Figure 14



Quadrant: Bolt Identification
Figure 15

hd118b

PD15

110898

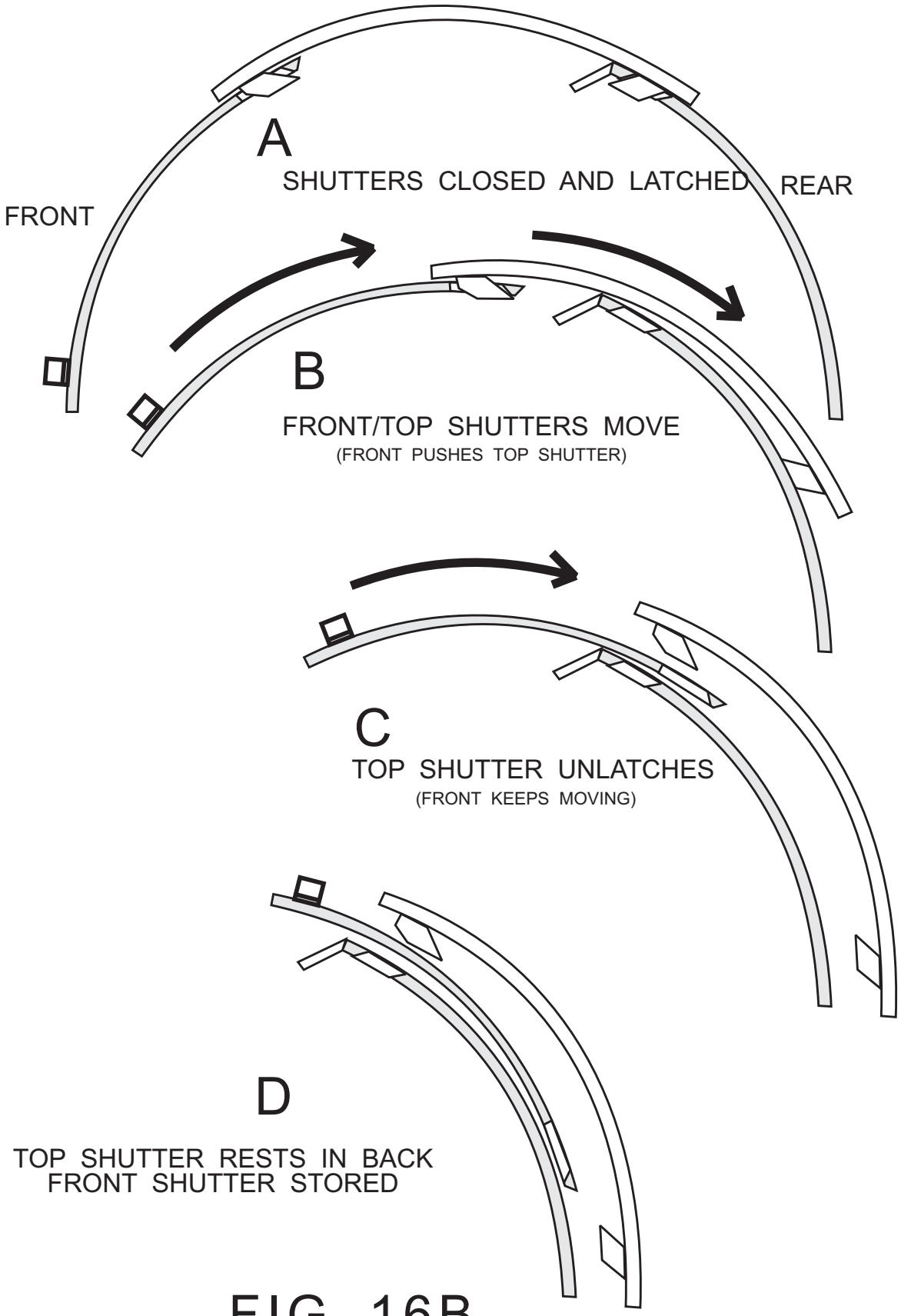
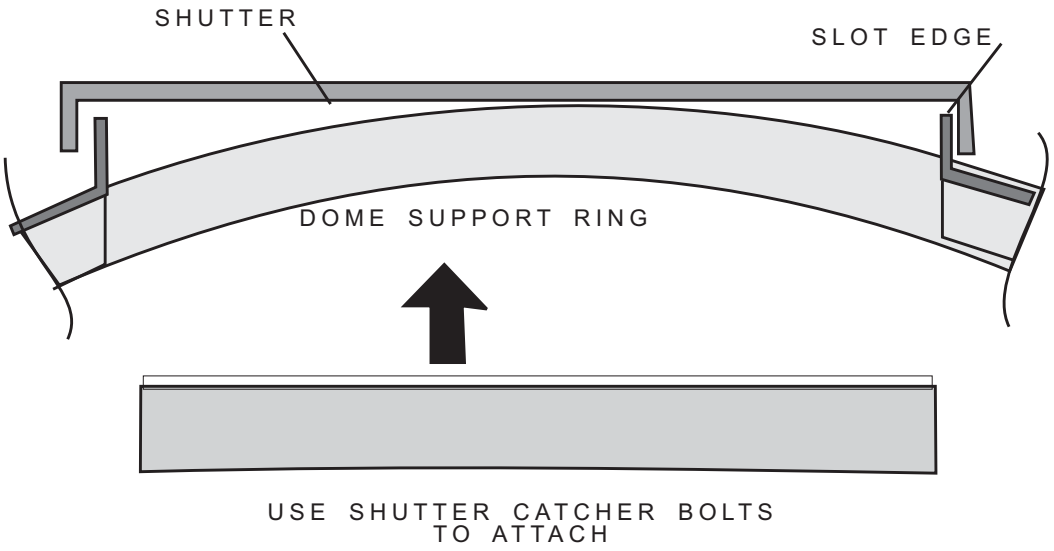


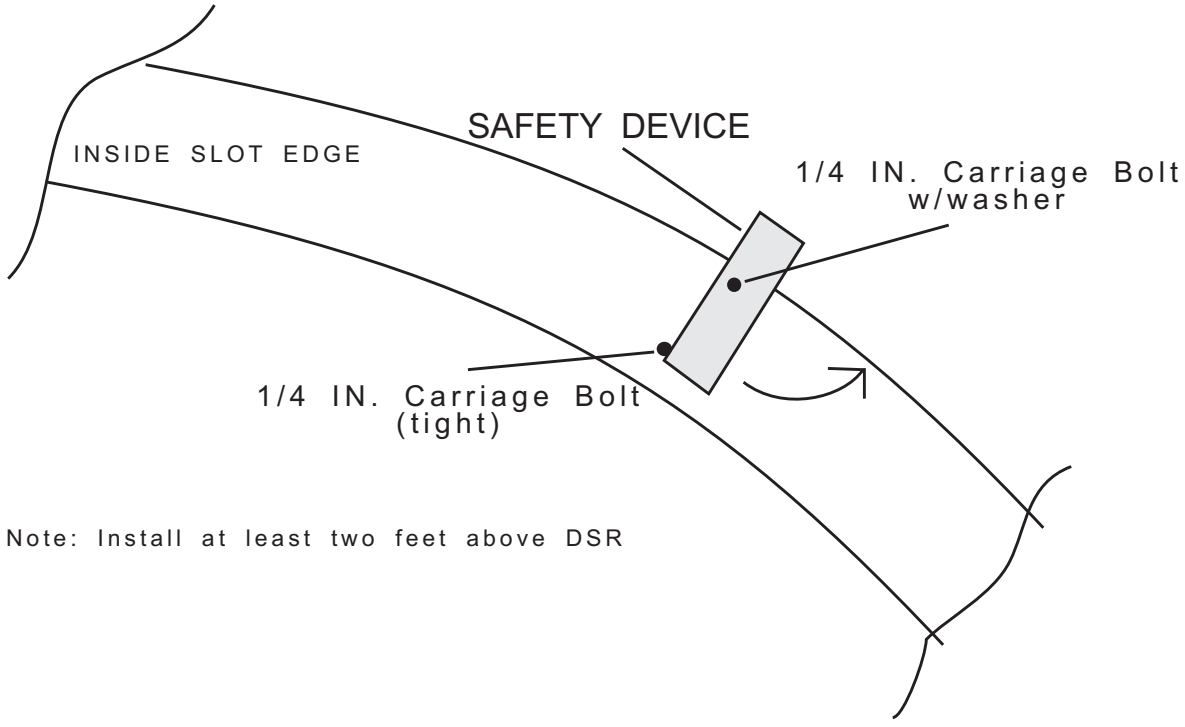
FIG 16B
SHUTTER OPERATION

NOT TO SCALE

PD109B



SOFFIT (PRO-DOME ONLY)
Figure 17



SHUTTER SAFETY DEVICE
Figure 18

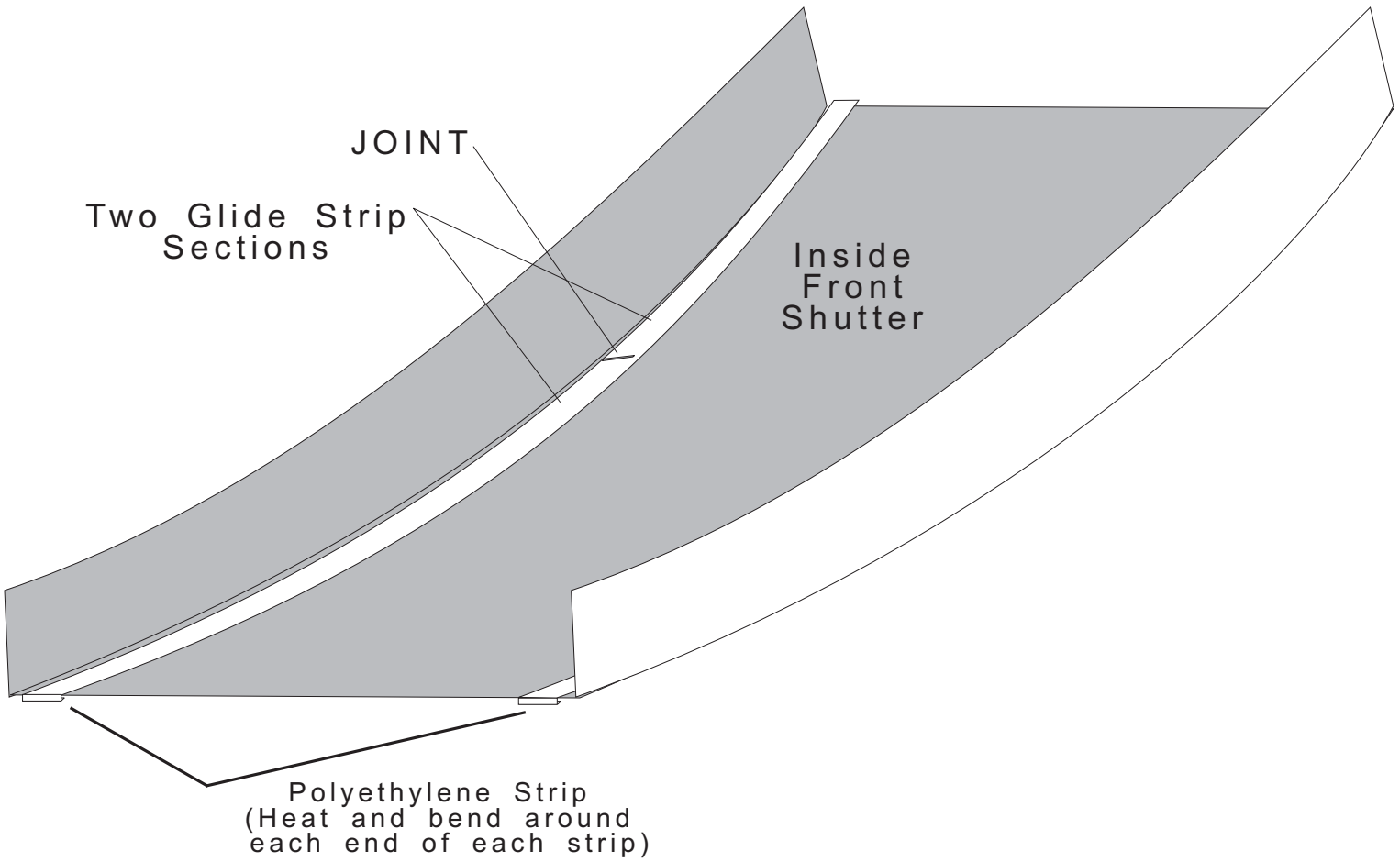


FIG 19 SHUTTER ANTIFRICTION STRIP

PD111
110898

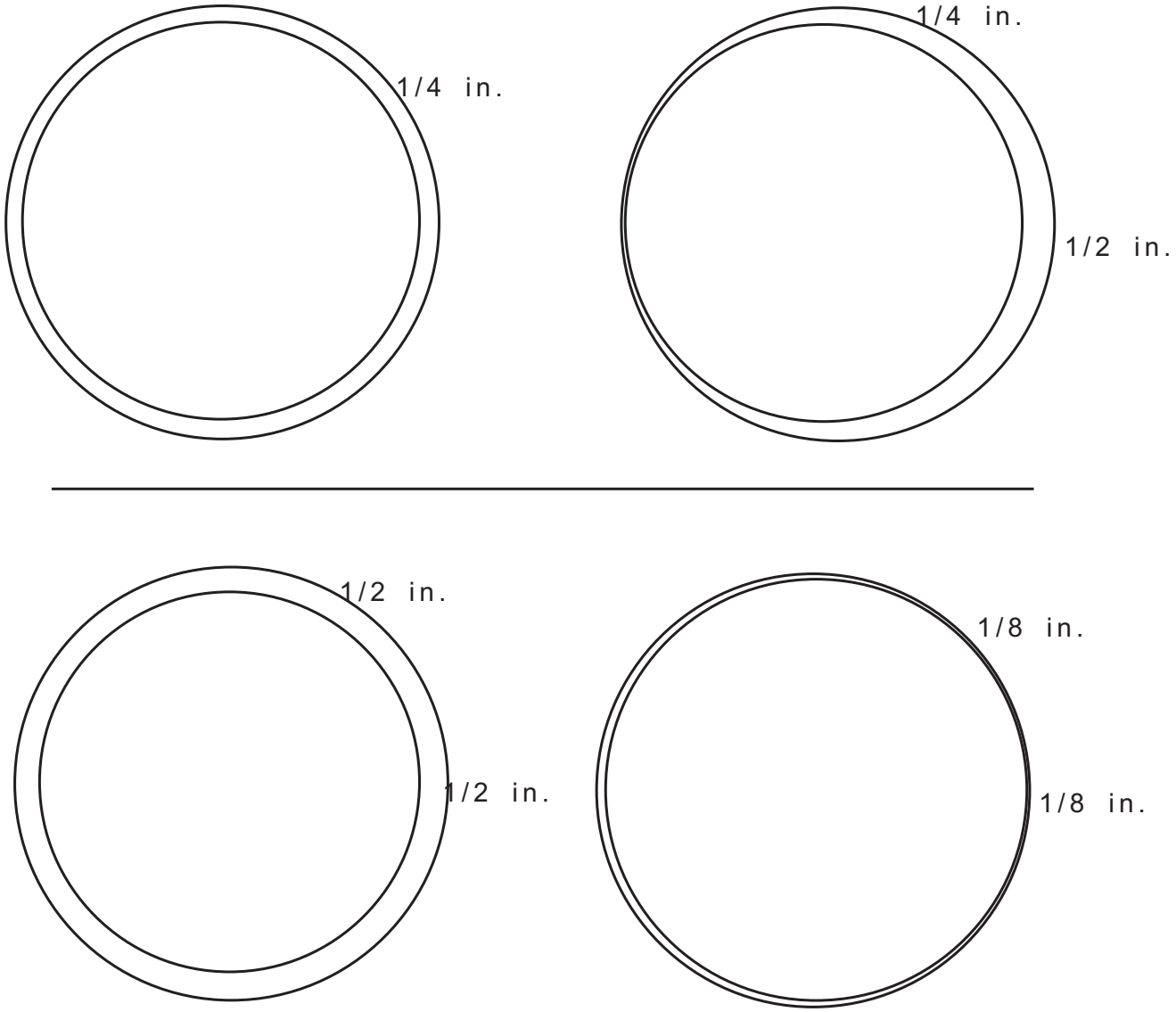
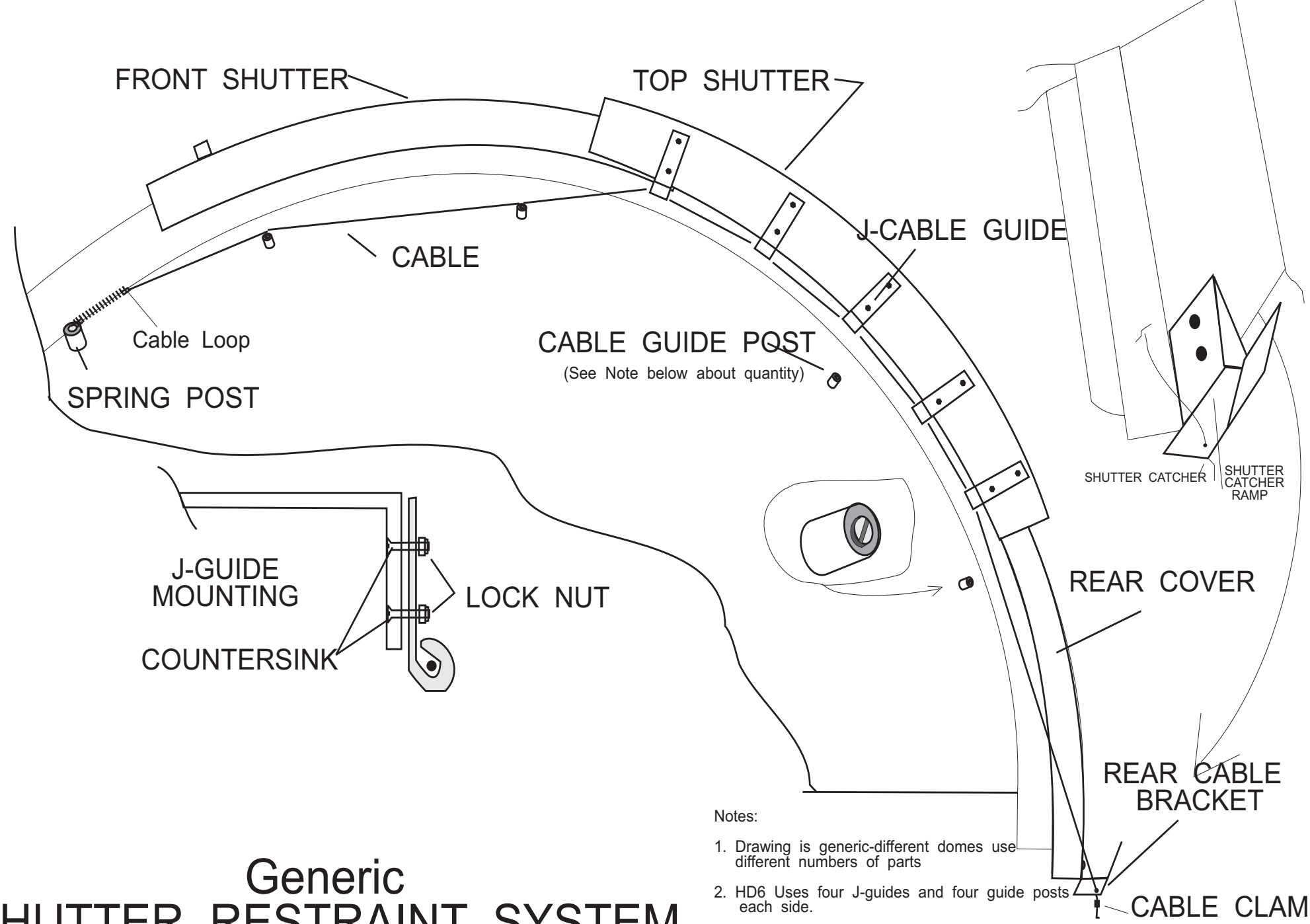


FIG 21 - ROTATION TESTS

PD112



Notes:

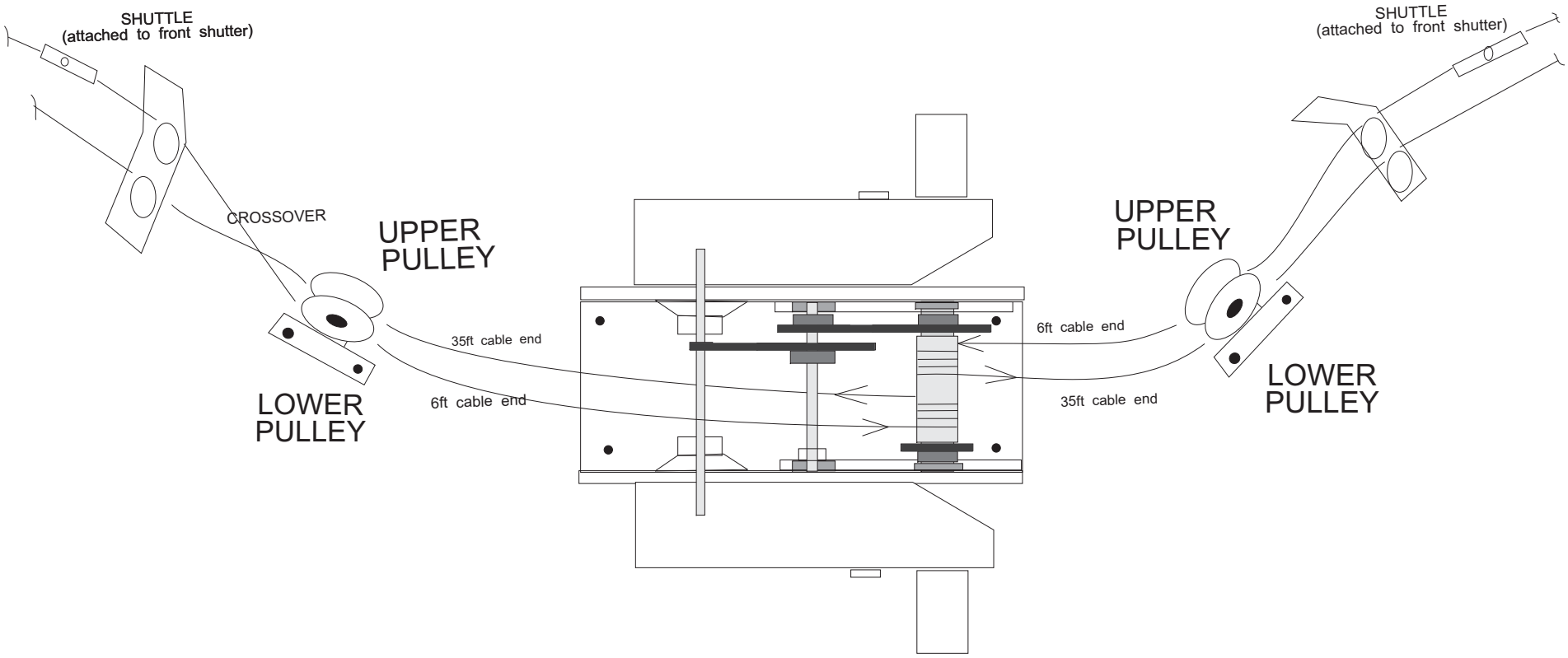
1. Drawing is generic-different domes use different numbers of parts
2. HD6 Uses four J-guides and four guide posts each side.
3. HD10/PD10 uses five J-guides and four guide posts each side
4. PD15 uses six J-guides and six guide posts each side
5. Space J-guides equally starting about 4" from the ends of the shutter

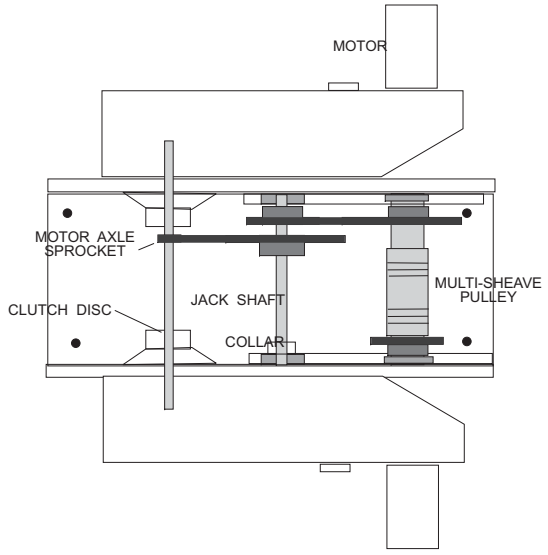
Note: Cable clamp and spring may be switched end for end. Use rear (Outward) hole

Generic
SHUTTER RESTRAINT SYSTEM

FIG 24

PD117
082101





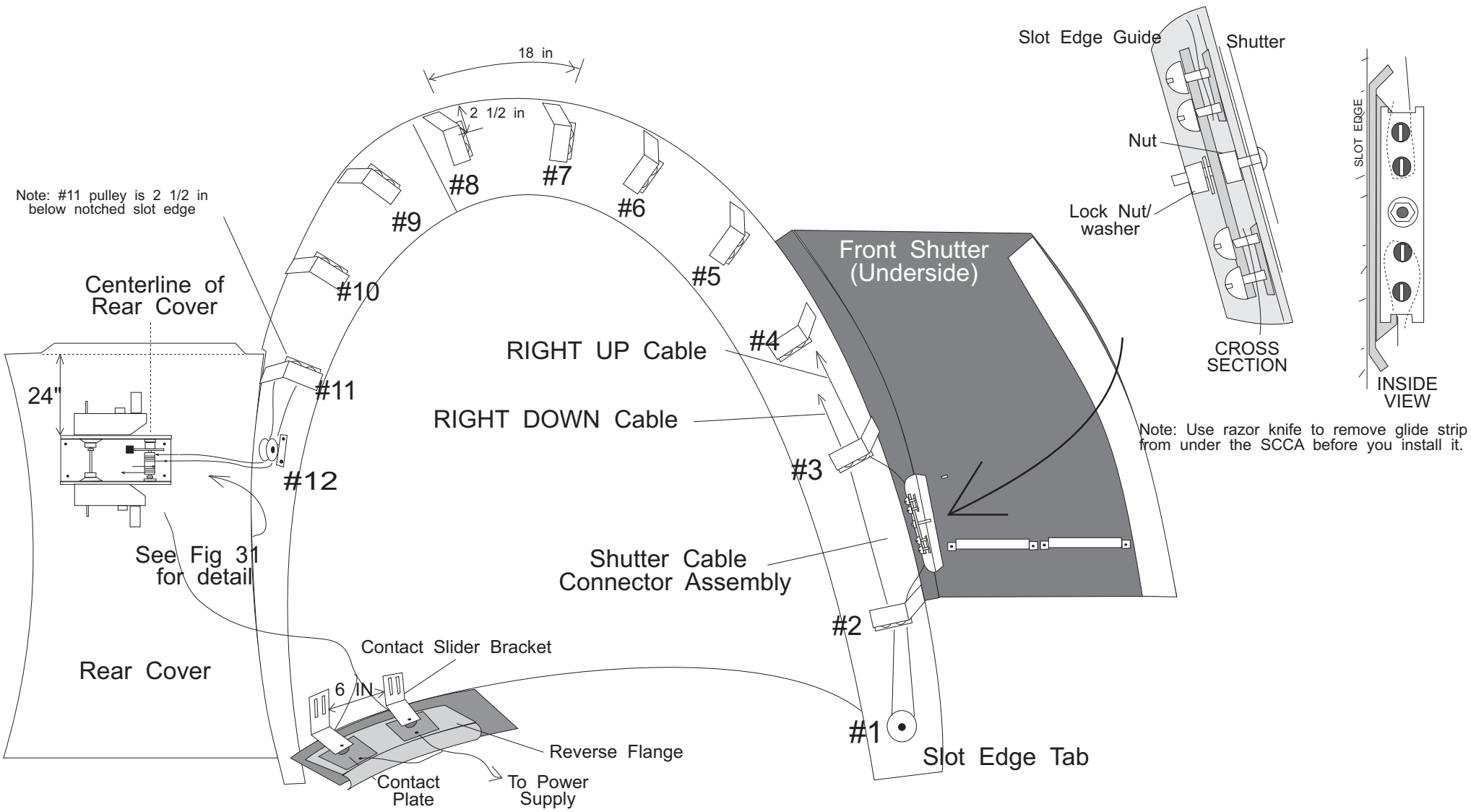
ARROWS SHOW OPENING (RAISING) SHUTTER. EACH WINDING HAS ABOUT 6-8 TURNS (4 ARE SHOWN)

Cables are 3/32 in SS
50 ft. long

ES15 MODEL 2

FIG 31

ES1501E
110898

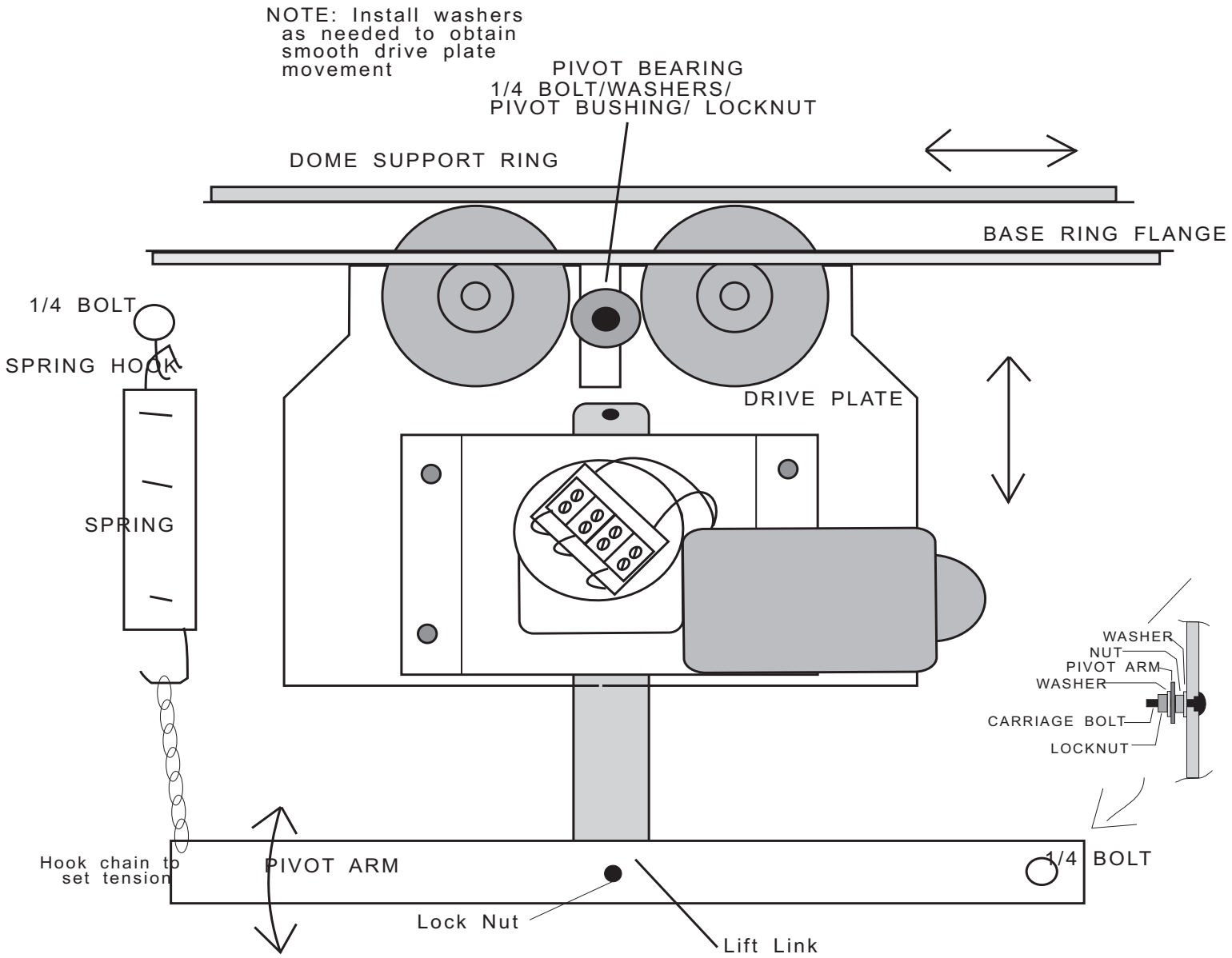


Electric Shutter Installation

Note-Schematic to show general design
(not to scale, partial construction only)

Fig. 32

ES1502d
032201
092401 pulleys in 1/4



NOTE: DRIVE BELT AND BELT IDLER ARMS DELETED FOR CLARITY

NOTE: You may switch pivot arm left-right if desired.

NOTE: Motor for HD6S is horizontal

FIG. 51
DOME DRIVE PLATE

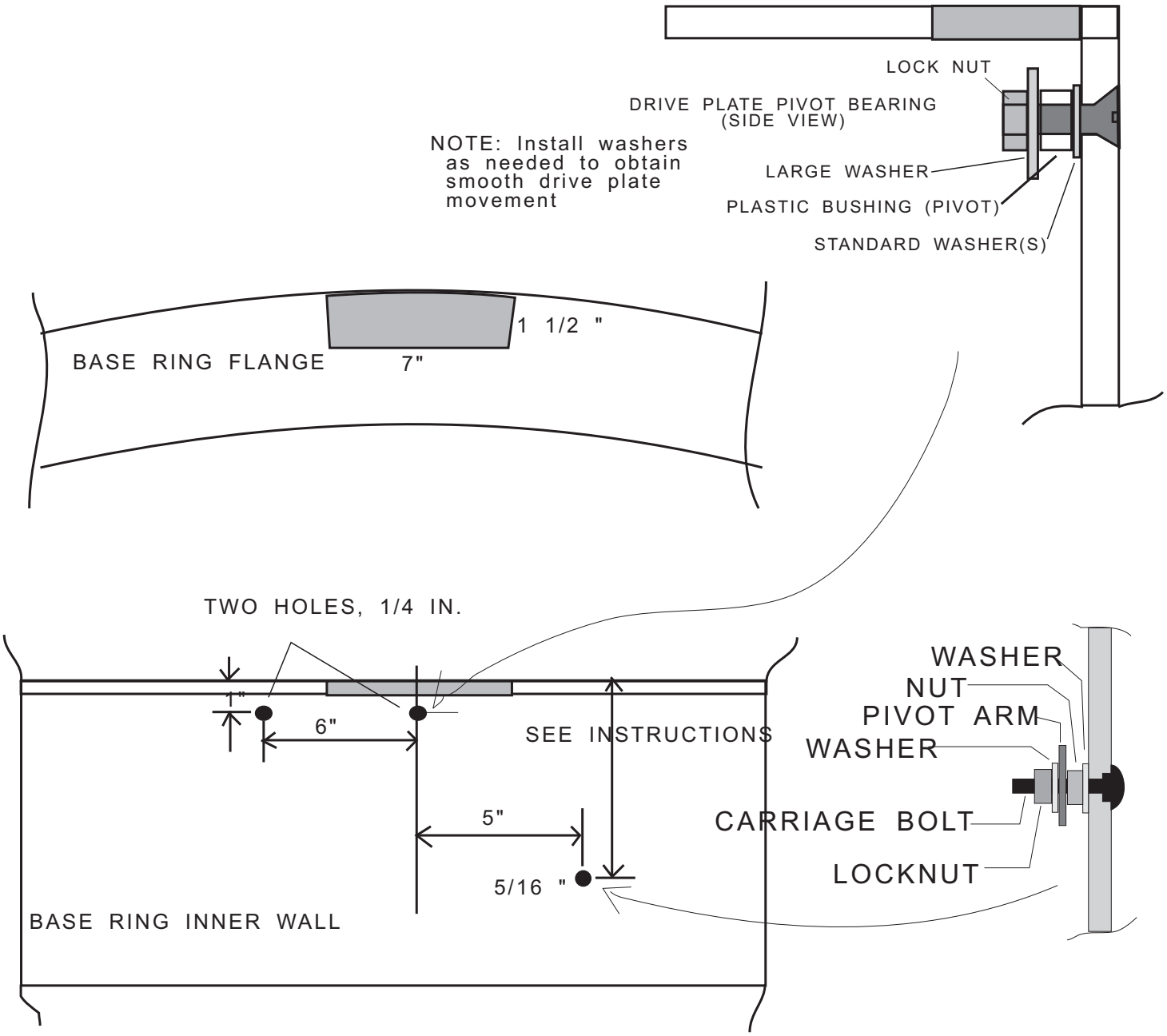


FIG 53 - DRIVE MOUNTING HOLES

ED2

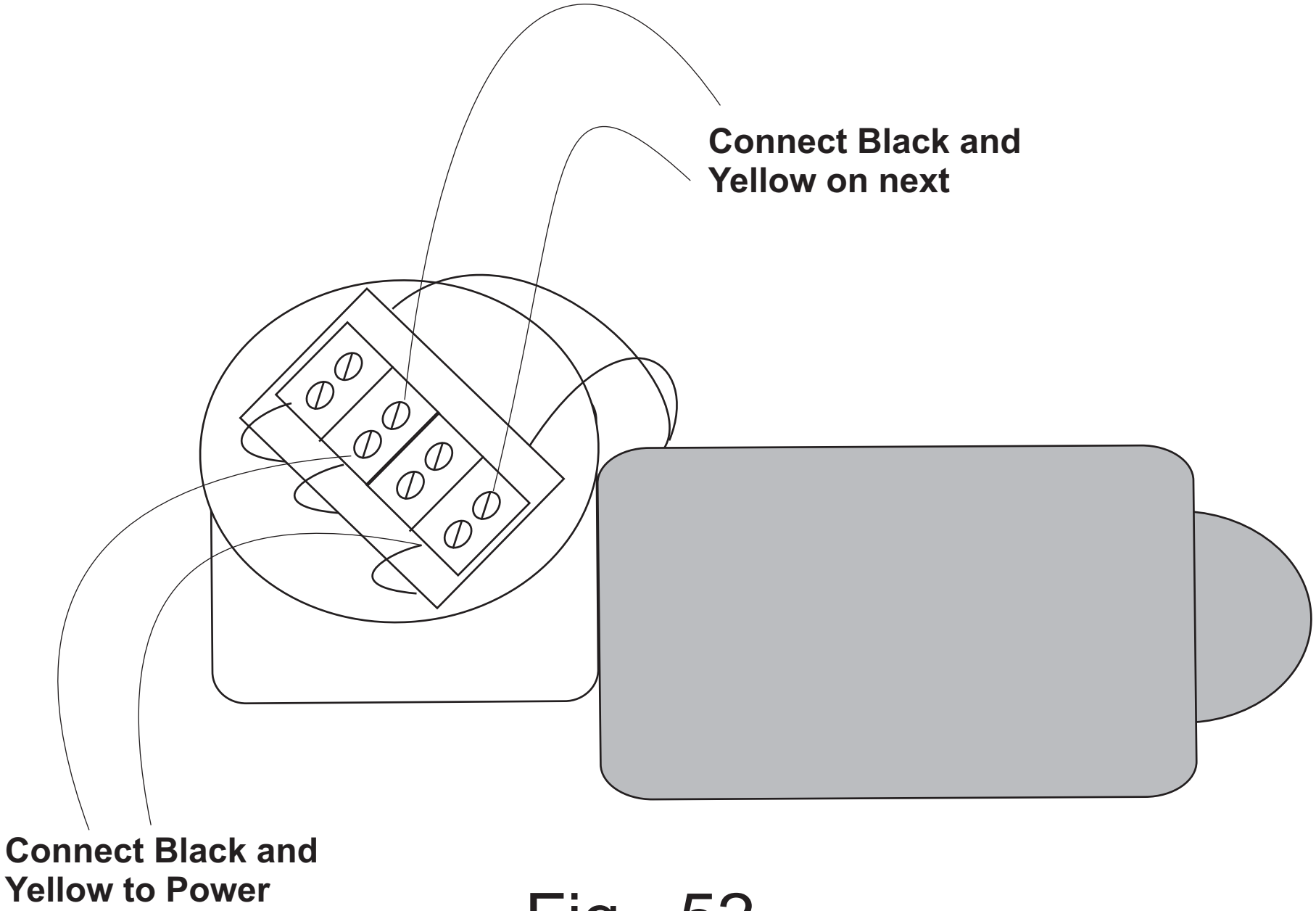


Fig. 52
Drive Motor Wiring