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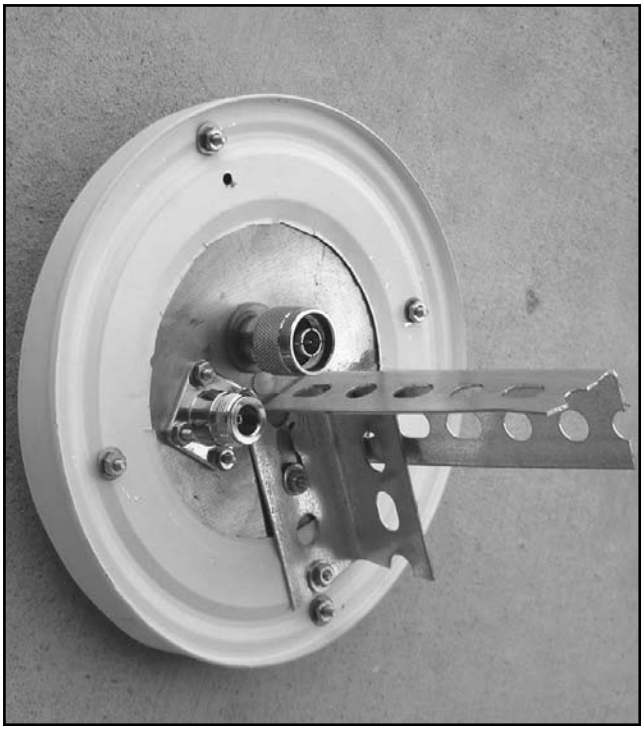

Fig 55—Rear of the completed feed. (K5OE photo; courtesy of *The AMSAT Journal*.)

Fig 56—The portable 435-MHz helix assembled and ready for operation. (*WØCY photo*.)

For additional information on constructing antennas, feeds and equipment techniques for use at microwave frequencies, see *The ARRL UHF/Microwave Experimenter's Manual* and *The ARRL UHF/Microwave Projects Manual*. Both of these books have a wealth of information for the experimenter.

antenna. The L band is noticeably improved over the helix predecessor. At low squint angles K5OE finds the L-band uplink to be about 1 S unit weaker than his U-band uplink. He later added a small plastic hat to extend over the top of the patches to keep the rain and bird droppings off—both detune the patches when built up between the patch and the reflector.

Though simple and effective, this is merely one way to construct a dual feed. Cookie-tin lids also make excellent supports. Tin snips are a good investment and much easier to use than a hacksaw. Use a flat file to remove burrs from the edges of the patches. Use stainless-steel hardware, most notably 3/8-inch 4-40 machine bolts and nuts for the antenna hardware and 1/2-inch 6-32 for the support-structure connections to the support arms (1/2-inch aluminum tubing). The copper sheet is much easier to solder to than aluminum. Once completed, the feed received a few coats of white enamel paint to protect the copper and to minimize the visual reflections.

This is not the only dual-band antenna on AO-40. There are many varied, innovative designs available, including G6LVB's simple and effective 1.2-meter homebrew stressed *chicken wire* dish with a dual-G3RUH helix feed. G3WDG has a 3-meter dish with L/S-band helices and a K-band (1.3-cm) feed horn, and WØLMD has developed some popular dual- and tri-band "round" patch feeds. (See the Notes and References, as well as the CD-ROM bundled with this book.)

PORTABLE HELIX FOR 435 MHZ

Helical antennas for 435 MHz are excellent uplinks for U-band satellite communications. The true circular polarization afforded by the helix minimizes signal *spin fading* that is so predominant in these applications. The antenna shown in **Fig 56** fills the need for an effective portable uplink antenna for OSCAR operation. Speedy assembly and disassembly and light weight are among the benefits of this array. This antenna was designed by Jim McKim, WØCY.

As mentioned previously, the helix is about the most tolerant of any antenna in terms of dimensions. The dimensions given here should be followed as closely as possible, however. Most of the materials specified are available in any well supplied do-it-yourself hardware or building supply store. The materials required to construct the portable helix are listed in **Table 1**.

The portable helix consists of eight turns of 1/4-inch soft-copper tubing spaced around a 1-inch fiberglass tube or maple dowel rod 4 feet, 7 inches long. Surplus aluminum jacket Hardline can be used instead of the copper tubing if necessary. The turns of the helix are supported by 5-inch lengths of 1/4-inch maple dowel mounted through the 1-inch rod in the center of the antenna. **Fig 57A** shows the overall dimensions of the antenna. Each of these support dowels has a V-shaped notch in the end to locate the tubing, as shown in Fig 57B.

The rod in the center of the antenna terminates at the feed-point end in a 4-foot piece of 1-inch ID galva-

Table 1
Parts List for the Portable 435-MHz Helix

Qty	*Item*
1	Type N female chassis mount connector
18 feet	1/4-in. soft copper tubing
4 feet	1-inch ID galvanized steel pipe
1	5 feet × 1-inch fiberglass tube or maple dowel
14	5-inch pieces of 1/4-inch maple dowel (6 feet total)
1	1/8-inch aluminum plate, 10 inches diameter
3	2 × 3/4-inch steel angle brackets
1	30 × 30-inch (round or square) aluminum screen or hardware cloth
8 feet	1/2 × 1/2 × 1/2-inch aluminum channel stock or old TV antenna element stock
3	Small scraps of Teflon or polystyrene rod (spacers for first half turn of helix)
1	1/8 × 5 × 5-inch aluminum plate (boom-to-mast plate)
4	1½-inch U bolts (boom-to-mast mounting)
3 feet	#22 bare copper wire (helix turns to maple spacers)

Assorted hardware for mounting connector, aluminum plate and screen, etc.

nized steel pipe. The pipe serves as a counterweight for the heavier end of the antenna. The 1-inch rod material inside the helix must be nonconductive. Near the point where the nonconductive rod and the steel pipe are joined, a piece of aluminum screen or hardware cloth is used as a reflector screen.

If you have trouble locating the 1/4-inch soft copper tubing, try a refrigeration supply house. The perforated aluminum screening can be cut easily with tin snips. This material is usually supplied in 30 × 30-inch sheets, making this size convenient for a reflector screen. Galvanized 1/4-inch hardware cloth or copper screen could also be used for the screen, but aluminum is easier to work with and is lighter.

A 1/8-inch-thick aluminum sheet is used as the support plate for the helix and the reflector screen. Surplus rack panels provide a good source of this material. **Fig 58** shows the layout of this plate.

Fig 59 shows how aluminum channel stock is used to support the reflector screen. (Aluminum tubing also works well for this. Discarded TV antennas provide plenty of this material if the channel stock is not available.) The screen is mounted on the bottom of the 10-inch aluminum center plate. The center plate, reflector screen and channel stock are connected together with plated hardware or pop rivets. This support structure is very sturdy. Fiberglass tubing is the best choice for the center rod material although maple dowel can be used.

Mount the type-N connector on the bottom of the center plate with appropriate hardware. The center pin should be exposed enough to allow a flattened end of the copper tubing to be soldered to it. Tin the end of the tubing after it is flattened so that no moisture can enter it. If the helix is to be removable from the ground-plane screen, do not solder the copper tubing to the connector. Instead, prepare a small block of brass, drilled and tapped at one side for a 6-32 screw. Drill another hole in the brass block to accept the center pin of the type-N connector, and solder this connection. Now the connection to the copper tubing helix can be made in the field with a 6-32 screw instead of with a soldering iron.

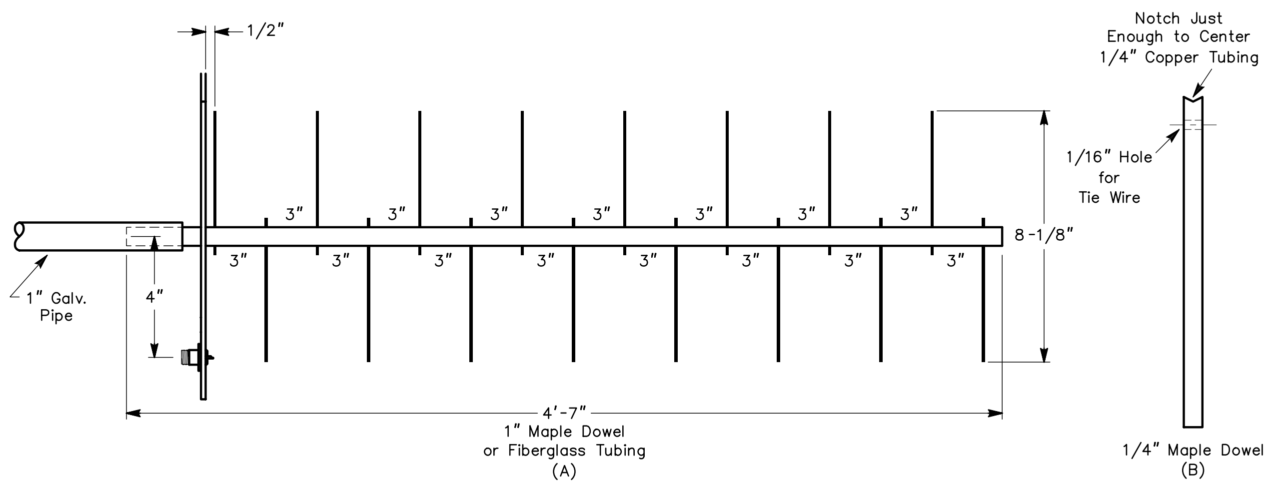

Fig 57—At A, the layout of the portable 435-MHz helix is shown. Spacing between the first 5-inch winding-support dowel and the ground plane is 1/2 inch; all other dowels are spaced 3 inches apart. At B, the detail of notching the winding-support dowels to accept the tubing is shown. As indicated, drill a 1/16-inch hole below the notch for a piece of small wire to hold the tubing in place.

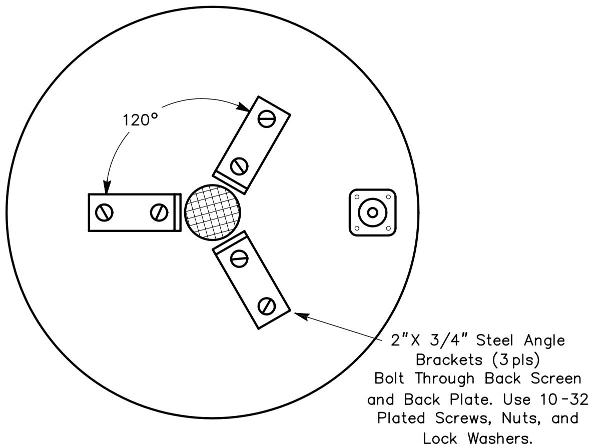

Fig 58—The ground plane and feed-point support assembly are shown. The circular piece is a 10-inch diameter, 1/8-inch thick piece of aluminum sheet. (A square plate may be used instead.) Three 2 × 3/4-inch angle brackets are bolted through this plate to the backside of the reflector screen to support the screen on the pipe. The type-N female chassis connector is mounted in the plate 4 inches from the 1-inch diameter center hole.

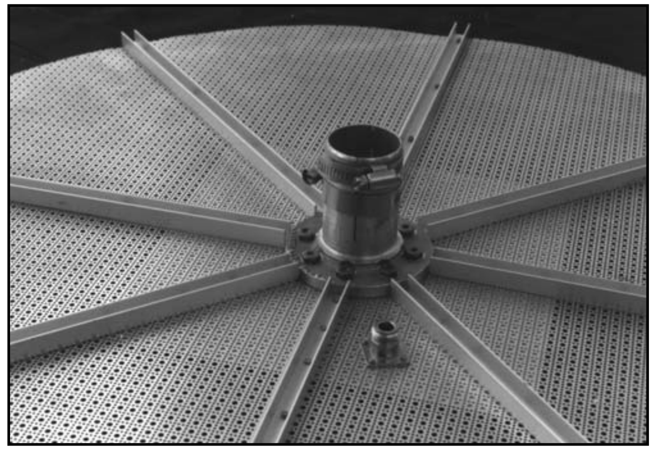

Fig 59—At top, the method of reinforcing the reflector screen with aluminum channel stock is shown. In this version of the antenna, the three angle brackets of Fig 58 have been replaced with a surplus aluminum flange assembly. (*WØCY photo.*) At bottom, this helix view shows the details of a 1/4-turn matching transformer, as discussed in the text. (*K9EK photo.*)

Refer to Fig 57A. Drill the fiberglass or maple rod at the positions indicated to accept the 5-inch lengths of 1/2-inch dowel. (If maple doweling is used, the wood must be weatherproofed as described below before drilling.) Drill a 1/16-inch hole near the notch of each 5-inch dowel to accept a piece of #22 bare copper wire. (The wire is used to keep the copper tubing in place in the notch.) Sand the ends of the 5-inch dowels so the glue will adhere properly, and epoxy them into the main support rod.

Begin winding the tubing in a clockwise direction from the reflector screen end. First drill a hole in the flattened end of the tubing to fit over the center pin of the type-N connector. Solder it to the connector, or put the screw into the brass block described earlier. Carefully proceed to bend the tubing in a circular winding from one support to the next.

See the earlier section entitled "50-Ω Helix Feed" and Figs 19 and 20 to see how the first half-turn of the helix tubing must be positioned close above the reflector assembly. **Fig 59B** shows also an excellent example by K9EK on matching his U-band helical antenna to a 52-Ω feed line. It is important to maintain this spacing, since extra capacitance between the tubing and ground is required for impedance-matching purposes.

Insert a piece of #22 copper wire in the hole in each support as you go. Twist the wire around the tubing and the support dowel. Solder the wire to the tubing and to itself to keep the tubing in the notches. Continue in this way until all eight turns have been wound. After winding the helix, pinch the far end of the tubing together and solder it closed.

Weatherproofing the Wood

A word about preparing the maple doweling is in order. Wood parts must be protected from the weather to ensure long service life. A good way to protect wood is to boil it in paraffin for about half an hour. Any holes to be drilled in the wooden parts should be drilled after the paraffin is applied, since epoxy does not adhere well to wood after it has been coated with paraffin. The small dowels can be boiled in a saucepan. Caution must be exercised here—the wood can be scorched if the paraffin is too hot. Paraffin is sold for canning purposes at most grocery stores. Wood parts can also be protected with three or four coats of spar varnish. Each coat must be allowed to dry fully before another coat is applied.

The fiberglass tube or wood dowel must fit snugly with the steel pipe. The dowel can be sanded or turned down to the appropriate diameter on a lathe. If fiberglass is used, it can be coupled to the pipe with a piece of wood dowel that fits snugly inside the pipe and the tubing. Epoxy the dowel splice into the pipe for a permanent connection.

Drill two holes through the pipe and dowel and bolt them together. The pipe provides a solid mount to the boom of the rotator, as well as most of the weight needed to counterbalance the antenna. More weight can be added to the pipe if the assembly is "front-heavy." (Cut off some of the pipe if the balance is off in the other direction.)

The helix has a nominal impedance of about 105 Ω in this configuration. By varying the spacing of the first half turn of tubing, a good match to 52-Ω coax should be obtainable. When the spacing has been established for the first half turn to provide a good match, add pieces of polystyrene or Teflon rod stock between the tubing and the reflector assembly to maintain the spacing. These can be held in place on the reflector assembly with silicone sealant. Be sure to seal the type-N connector with the same material.

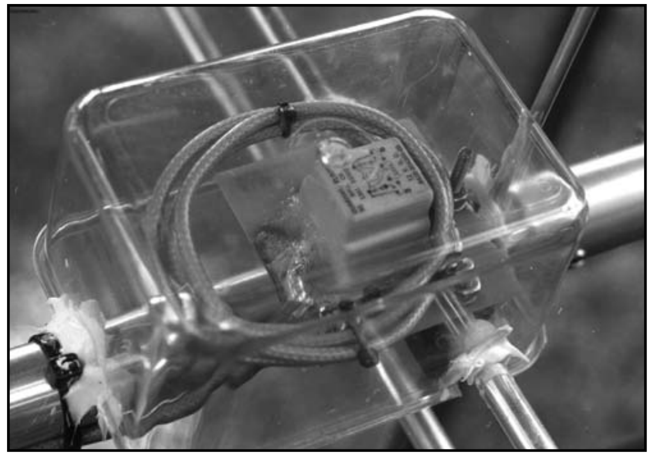

Fig 60—KLM 2M-22C antenna CP switching relay with relocated balun. The protective cover is needed for rain protection, be sure to use a polystyrene kitchen box, see text. (*WD4FAB photo.*)

Fig 61—A NEMA4 box is used to shelter the L-band electronics and power supply. The box flanges are convenient for mounting preamplifiers. The box is shown inverted since it is on a tilt-over tower. (*WD4FAB photo.*)

Exposed Antenna Relays and Preamplifiers

For stations using crossed Yagi antennas for CP operation, one feature that has been quite helpful for communicating through most of the LEO satellites, has been the ability to switch polarization from RHCP to LHCP. In some satellite operation this switchable CP ability has been essential. Operation through AO-40 has not shown a great need for such CP agility, since if the satellite is seriously off-pointed the signals are not particularly useable. When AO-40's squint angle is less than 25° the need for LHCP has not been observed. For those using helical antennas or helical-fed dish antennas, we just would not have the choice to switch CP unless an entirely new antenna is added to the cluster for that purpose. Not many of us have the luxury of that kind of space available on our towers.

For stations with switchable-circularity Yagi antennas, experience with exposed circularity switching relays and preamplifiers mounted on antennas have shown that they are prone to failure caused by an elusive mechanism known as *diurnal pumping*. Often these relays are covered with a plastic case, and the seam between the case and PC board is sealed with a silicone sealant. Preamps may also have a gasket seal for the cover, while the connectors can easily leak air. None of these methods create a true hermetic seal and as a result the day/night temperature swings pump air and moisture in and out of the relay or preamp case. Under the right conditions of temperature and moisture content, moisture from the air will condense inside the case when the outside air cools down. Condensed water builds up inside the case, promoting extensive corrosion and unwanted electrical conduction, seriously degrading component performance in a short time.

A solution for those antennas with "sealed" plastic relays, such as the KLM CX series; you can avoid problems by making the modifications shown in **Fig 60**. Relocate the 4:1 balun as shown and place a clear polystyrene plastic refrigerator container over the relay. Notch the container edges for the driven element and the boom so the container will sit down over the relay, sheltering it from the elements. Bond the container in place with a few dabs of RTV adhesive sealant. Position the antenna in an "X" orientation, so neither set of elements is parallel to the ground. The switcher board should now be canted at an angle, and one side of the relay case should be lower than the other. An example for the protective cover for an S-band preamp can be seen in the discussion on feeds for parabolic antennas.

For both the relay and preamp cases, carefully drill a 3/32-inch hole through the low side of the case to provide the needed vent. The added cover keeps rainwater off the relay and preamp, and the holes will prevent any buildup of condensation inside the relay case. Relays and preamplifiers so treated have remained clean and operational over periods of years without problems.

Another example for the protection of remotely, tower-mounted equipment is shown in Fig 50, illustrating the equipment box and mast-mounted preamplifiers at the top of WD4FAB's tower. The commercial NEMA4-rated equipment box, detailed in **Fig 61** (shown inverted), is used to protect the 23-cm power amplifier and its power supply, as well as a multitude of electrical connections. This steel box is very weather resistant, with an exceptionally good epoxy finish, but it is not sealed and so it will not trap moisture to be condensed with temperature changes. Be sure to use a box with at least a NEMA3 rating for rainwater and dust protection. The NEMA4 rating is just a little better protection than the NEMA3 rating. Using a well-rated equipment box is very well worth the expense of the box. As you can see, the box also provides some pretty good flanges to mount the mast-mounted preamplifiers for three bands. This box is an elegant solution for the simple need of rain shelter for your equipment. See **Fig 62**.

Elevation Control

Satellite antennas need to have elevation control to point up to the sky. This is the "El" part of Az-El control of satellite antennas. Generally, elevation booms for CP satellite antennas need to be non-conducting so that the boom does not affect the radiation pattern of the antenna. In the example shown next, the elevation boom center section is a piece of extra-heavy-wall $1^1/_2$-inch pipe (for greater strength) coupled with a tubular fiberglass-epoxy boom extension on the 70-cm end and a home-brew long extension on the 2-meter end. This uses large PVC pipe reinforced with four braces of Phillystran non-metallic guy cable. (PVC pipe is notoriously flexible, but the Phillystran cables make a quite stiff and strong boom of the PVC pipe.) For smaller installations, a continuous piece of fiberglass-epoxy boom can be placed directly through the elevation rotator.

Elevation boom motion needs to be powered, and one solution by WD4FAB, shown in **Fig 63**, uses a surplus jackscrew drive mechanism. I8CVS has also built his own robust elevation mechanism. See **Fig 64**. Note in each of these applications the methods used to provide bearings for the elevation mechanism. In WD4FAB's case, the elevation axis is a piece of heavy-duty $1^1/_2$-inch pipe,

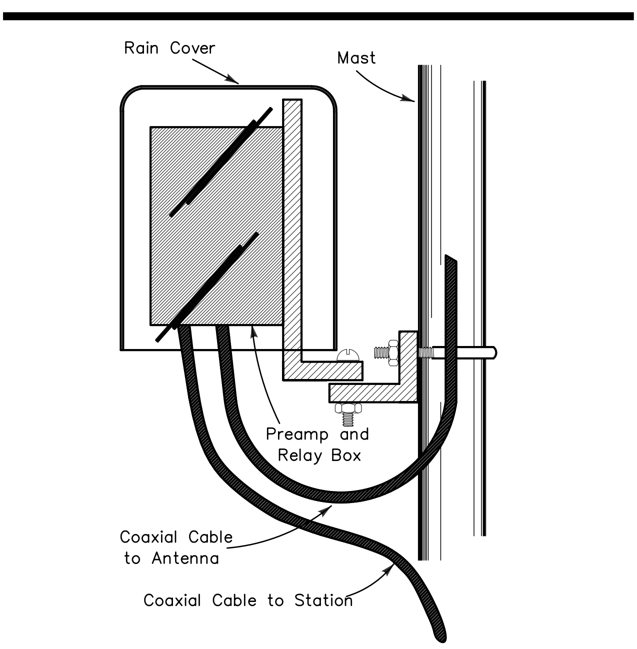

Fig 62—Protection for tower-mounted equipment need not be elaborate. Be sure to dress the cables as shown so that water drips off the cable jacket before it reaches the enclosure. One hazard for such open-bottom enclosures is that of animals liking the cable insulation as a delicacy. Flying insects also like to build their houses in these enclosures.

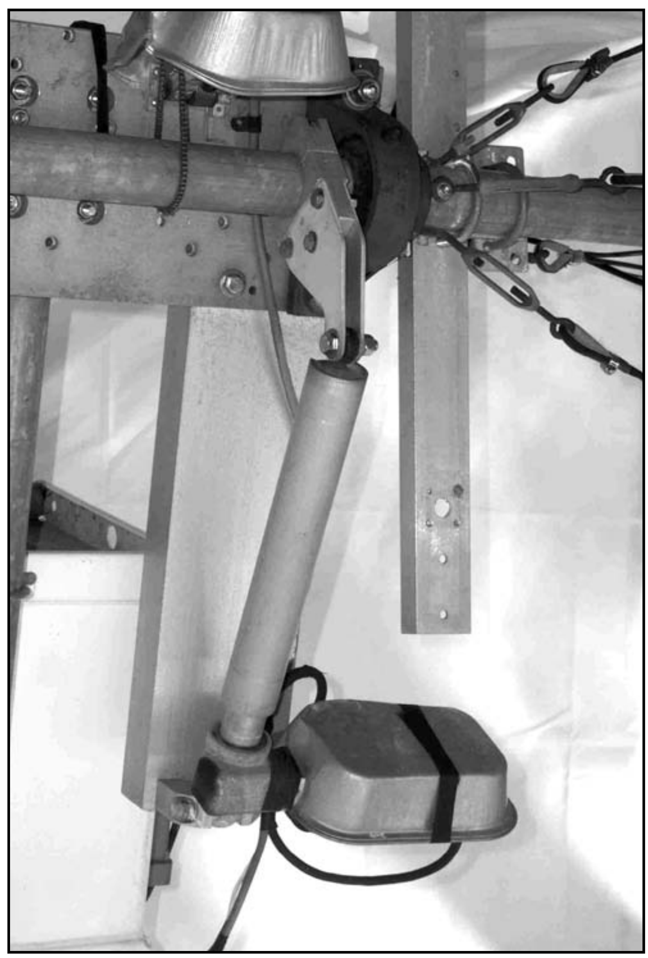

Fig 63—WD4FAB's homebrew elevation rotator drive using a surplus-store drive screw mechanism. Note also the large journal bearing supporting the elevation axis pipe shaft. (*WD4FAB photo*.)

($1^{15}/_{16}$-inch OD) and large 2 inch journal bearings are used for the motion. I8CVS uses a very large hinge to allow his motion.

Robust commercial solutions for Az-El rotators have given operators good service over the years. **See Fig 65**. Manufacturers such as Yaesu and M^2 are among these suppliers. One operator, VE5FP, found a solution for his Az-El needs by using two low-cost, lightweight TV rotators. See Fig 65B.

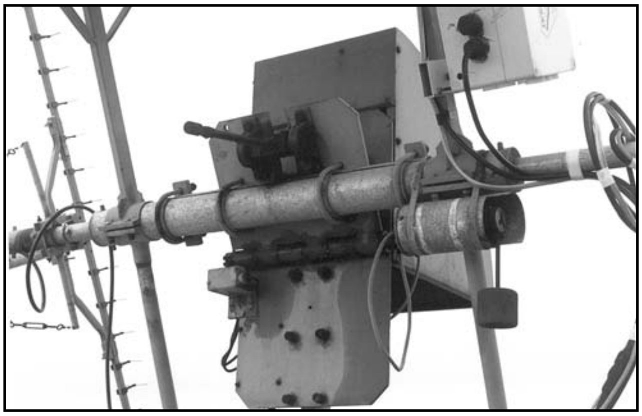

Fig 64—I8CVS's homebrew elevation mechanism using a very large, industrial hinge as the pivot and a jackscrew drive. (*I8CVS photo.*)

CONVERTED C-BAND TVRO DISHES

In working with larger, converted C-band TVRO dishes for AO-40, some operators have used only the polar mount with its jack-screw mechanism. See **Fig 66**. This dish is called *Big Ugly Dish* or just "BUD" by their users. Only using the polar mount mechanism limits the operator in the range of motion, as previously discussed. WØLMD provides for a greater degree of articulation of these dishes through several mechanisms. One of these is a sector-gear elevation drive, shown in **Fig 67**.

For the azimuth motion of our satellite antennas, most use motorized rotator drives, mainly the commercial sources previously mentioned. Most antennas are tower-mounted, allowing the placement of the rotator inside the tower. For the large wind loads of satellite antennas, these commercial rotators become rather expensive.

High loads are also prominent with the use of BUD

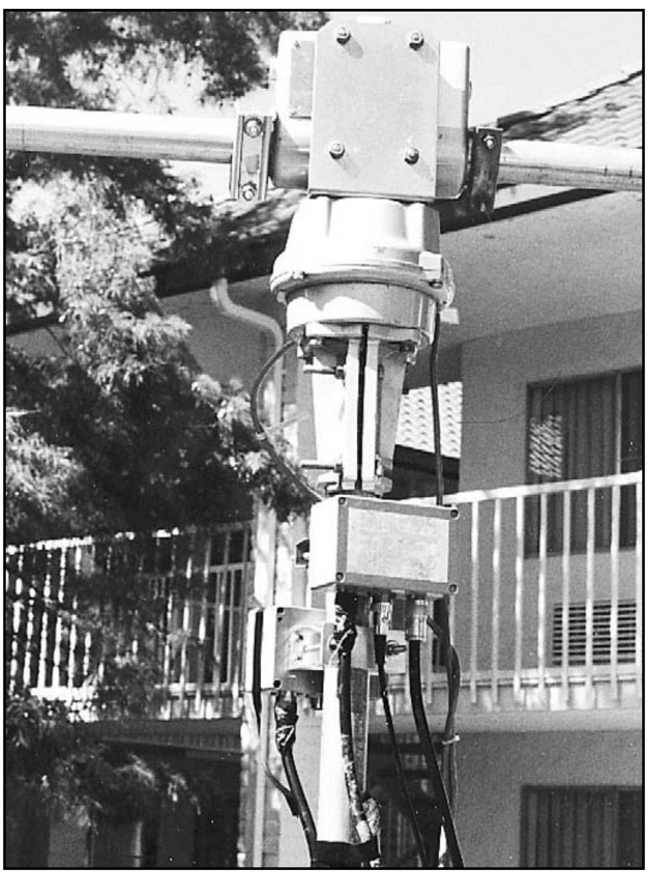

Fig 65—At left, Yaesu Az-El antenna-rotator mounting system is shown. Note that antenna loads must be more carefully balanced on this rotator than in the previously shown systems. At right, VE5FP has a solution for his Az-El rotators by bolting two of them together in his "An Inexpensive Az-El Rotator System", *QST*, December 1998.