MICROWAVE ANTENNAS

HORN-REFLECTOR ORIENTATION USING 33A OR 43A TRANSDUCER AND WAVEGUIDE SYSTEM ALIGNMENT

CONTENTS PAGE

1. GENERAL

1.01 This section describes the orientation of the KS-15676 and the KS-21972 horn-reflector antennas using the 33A or 43A transducer (Fig. 1 and 2). It also includes waveguide axial ratio compensation adjustment methods and combining network alignment procedures. The orientation adjusts the antenna position for maximum received signal and minimum level of higher-order modes. This procedure can be used to align new antennas and to accurately adjust the cross-polarization discrimination of existing systems. Whenever an antenna is moved or the circular waveguide is broken for any reason, the cross-polarization discrimination should be checked and readjusted, if necessary.

1.02 This section is reissued to include the following information:

- The use of the 43A transducer for horn-reflector antenna orientation in the 11-GHz band

- The main beam technique for 11 GHz as an alternative to TM°_{01} method

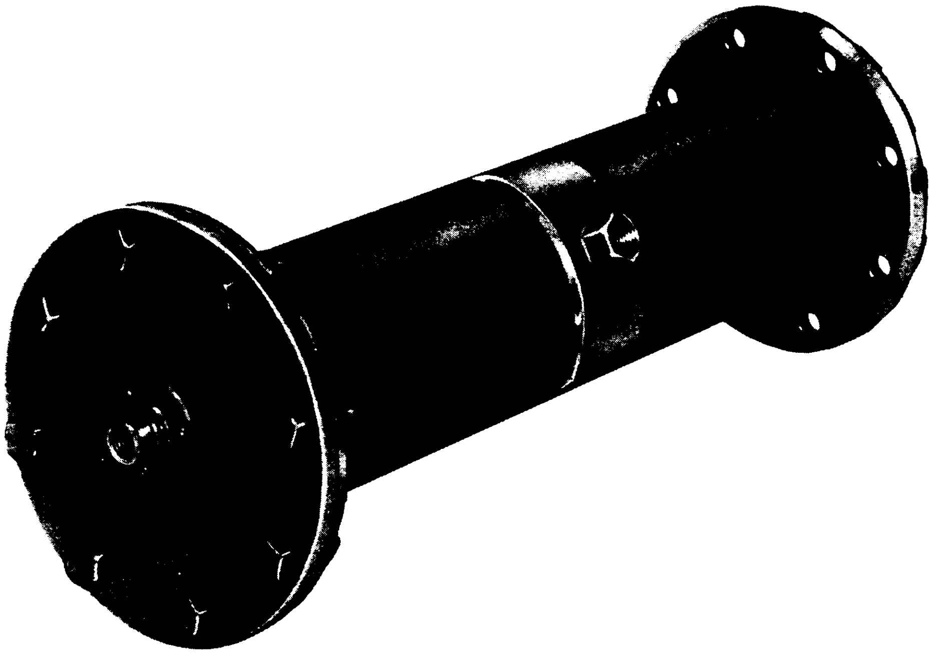

Fig. 1—33A Transducer

- The change in axial ratio compensation method for XPD which uses independent waveguide adjustment

- The systems combining network alignment tool.

Since this reissue is a general revision, no revision arrows have been used to emphasize significant changes.

1.03 The 33A transducer can be used for out-of-service TM°_{01} mode antenna orientation in either the 4- or 6-GHz band. For antenna orientation at 11 GHz, the 33A transducer is unsuitable because the on-axis null is not sufficiently narrow for precise antenna alignment. The 43A transducer is intended for out-of-service horn-reflector antenna orientation at installation locations where 11-GHz orientation is desired. The 33A and the 43A transducers may be used on any conical or pyramidal horn-reflector antenna whose in/out port is 2.81-inch circular waveguide. The transducers consist of a waveguide transition with a waveguide-to-coaxial probe on the end of the unit. The waveguide-to-coaxial probe is used to detect and couple the TM°_{01} mode to a coaxial connector.

1.04 When an incoming signal impinges on the horn-reflector antenna, most of its energy is coupled to the circular waveguide run in the dominant mode, TE°_{11}. This is the normal mode of transmission and the one to which the system combining networks (SCN) are designed to respond.

1.05 The radiation pattern of the transmitted TE°_{11} signal consists of one big lobe and small side lobes. In contrast, the radiation patterns of most higher-order modes (of which TM°_{01} is one) have a null along the axis of the main lobe of the TE°_{11} mode. The radiation patterns of the TE°_{11} and TM°_{01} modes and the configuration of each of these modes in the circular waveguide are shown in Fig. 3.

1.06 An improperly aimed antenna will cause unwanted higher-order modes, such as TM°_{01} to be generated in the throat of the feedhorn. The level of the TM°_{01} relative to the dominant mode is shown in Fig. 4 and depends on the amount of misaiming of the antenna in azimuth, elevation, and the frequency band. When a vertically polarized signal is received, misaiming the antenna vertically produces TM°_{01}; when a horizontally polarized signal is received, misaiming the antenna horizontally produces TM°_{01}. Conversely, when TM°_{01} signal is transmitted,

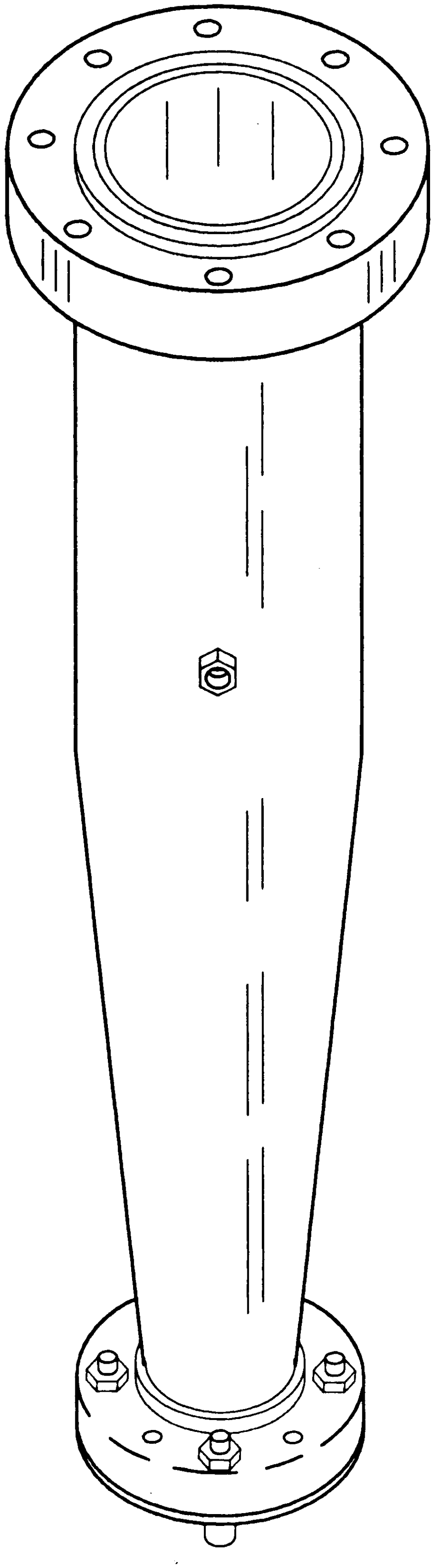

Fig. 2—43A Transducer

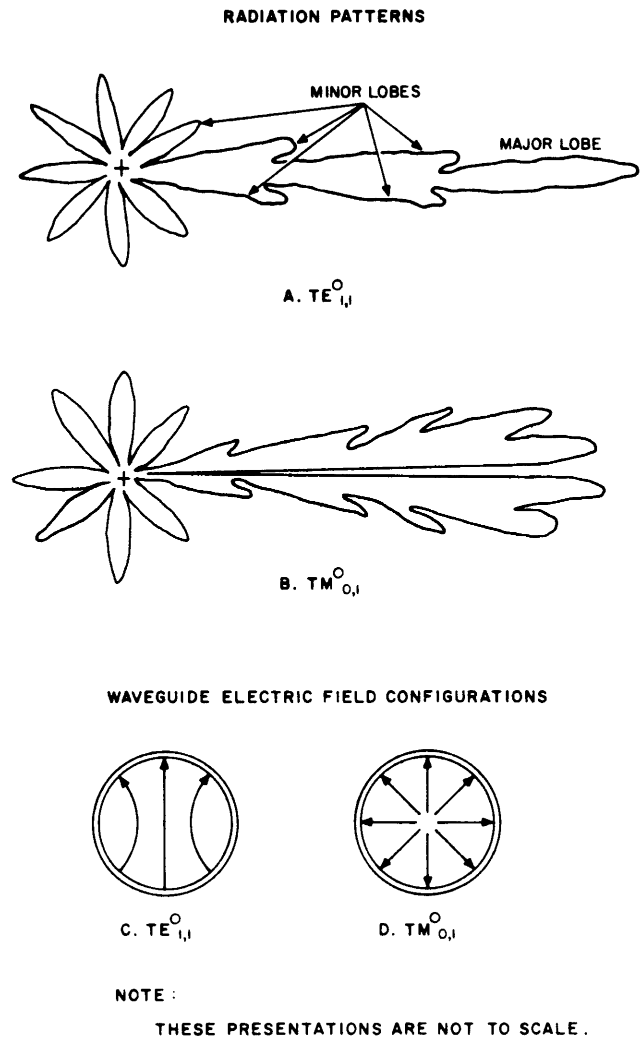

Fig. 3—Radiation Patterns and Circular Waveguide Field Configuration for TE°_{11} and TM°_{01} Modes

misaiming the transmit antenna vertically produces a vertically polarized signal at the receiving antenna; while misaiming the transmit antenna horizontally produces a horizontally polarized signal at the receiving antenna.

1.07 The antenna alignment procedures described in this section uses the null of the TM°_{01} pattern to aim the antenna accurately and uses the 33A or 43A transducer to detect the TM°_{01}. Correct antenna orientation is indicated by minimum TM°_{01}.

The null depth requirement (below the TE°$_{11}$ level) to achieve the accuracy of ±0.05 degree in antenna orientation is as follows:

FREQ BAND	TRANSDUCER	NULL DEPTH
4 GHz	33A	−30 dB
6 GHz	33A	−25 dB
11 GHz	43A	−19 dB

1.08 These procedures shall be followed regardless of what polarization is to be used when the system is placed in service.

1.09 In performing the antenna orientation and cross-polarization procedure, both horizontally polarized and vertically polarized transmission will be alternately required. Vertical polarization means that the electric field of the radiating wave is vertical, and horizontal polarization means that the electric field of the radiating wave is horizontal. Only one polarization can be transmitted with any rectangular waveguide. The electric field in rectangular waveguide is always parallel to the narrow edge of the rectangular waveguide cross-section. Circular waveguide can transmit both polarizations which is determined by systems combining networks.

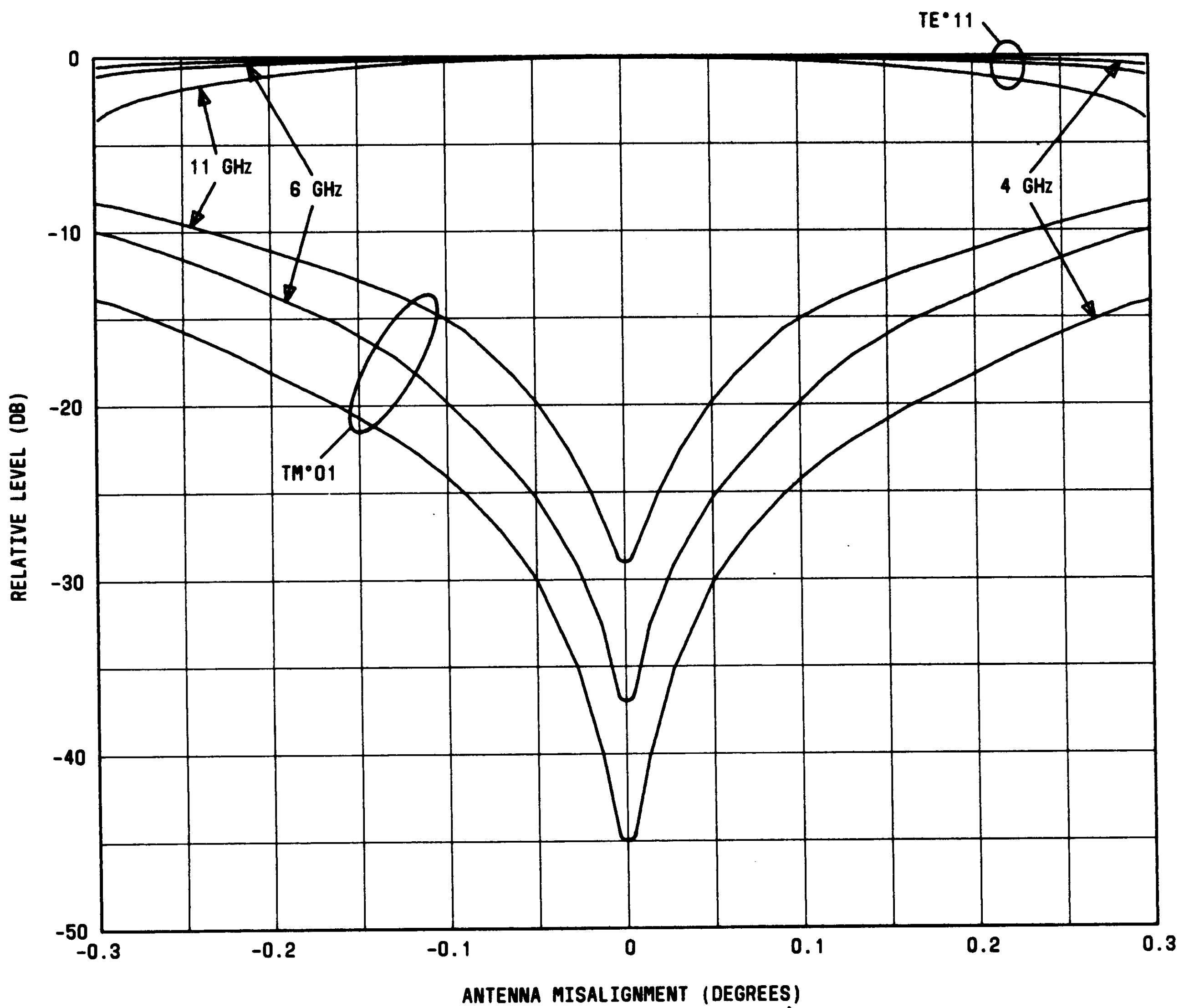

Fig. 4—TM°$_{01}$ and TE°$_{11}$ Levels Versus Antenna Position

1.10 Horizontal polarization is transmitted when the transducers and networks are arranged as shown in Fig. 5. The side arm of the 1406A, 1428A, or 1407A network is perpendicular to the transmission path. The long side of the rectangular port on the ED-59410-70, G1 transducer is parallel to the transmission path.

1.11 Vertical polarization is transmitted when the transducers and networks are arranged as shown in Fig. 6. The side arm of the 1406A, 1428A, or 1407A network is parallel to the transmission path. The long side of the rectangular port on the ED-59440-70, G1 transducer is perpendicular to the transmission path. Figure 7 shows the 1424A network arrangement for the horizontal and vertical polarizations.

1.12 All changes in the antenna position shall be made by the tower man under the direction of the person observing the received signal strength at the receiving end. Communication between station and tower personnel at each end of the hop is required.

1.13 The towers, antennas, and associated waveguide shall have been completely installed and inspected using suitable waveguide test sets before starting antenna orientation. Verify that all joints of the regular circular waveguide have been aligned with an AT-8390 waveguide alignment wrench or equivalent.

1.14 The antenna shall have been oriented by mechanical (survey) means with no access to RF signals, and clamped in place.

1.15 If it is necessary to suspend testing overnight, any transducers connected to the antenna feedhorn must be removed and the opening in the feedhorn should be covered overnight and during rainstorms to prevent water and condensation from collecting in the transducers. The transducers on the circular waveguide may be covered in place.

1.16 A fitting is provided in the 33A or 43A transducer for introducing air pressure into the antenna system to help stabilize the TM°_{01} signal level which is affected by the antenna weather cover position. Since high winds affect the weather cover

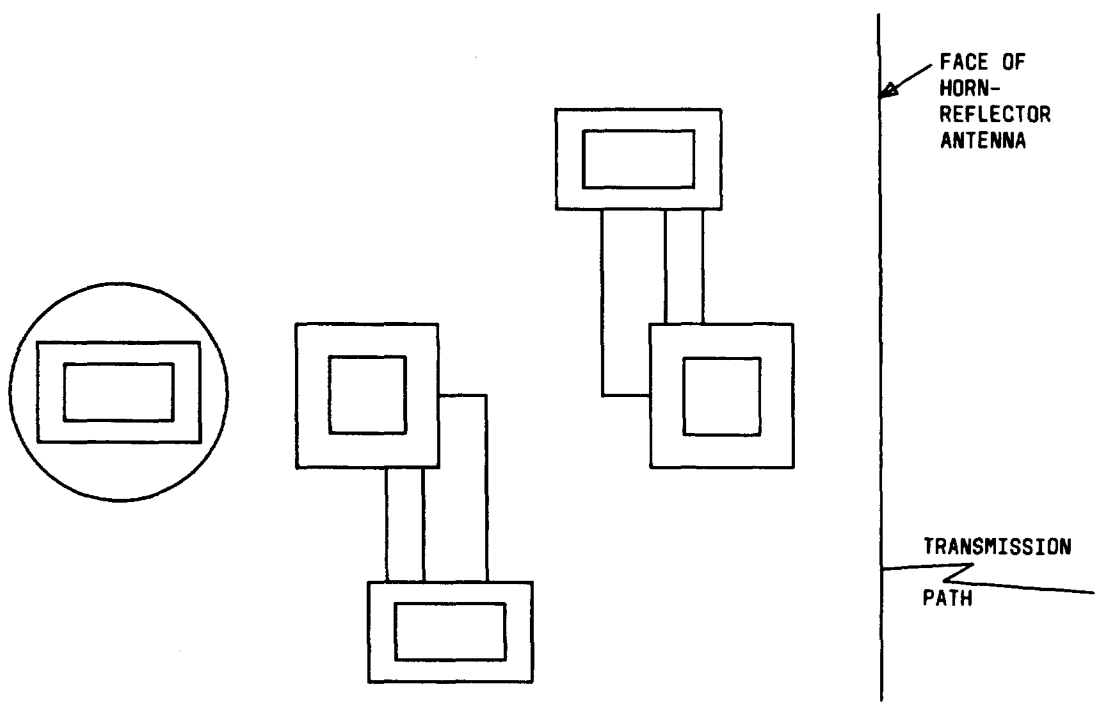

Fig. 5—Position of 1406A, 1428A, or 1407A Networks for Transmitting the Horizontal Polarization (View Looking Up the Tower)

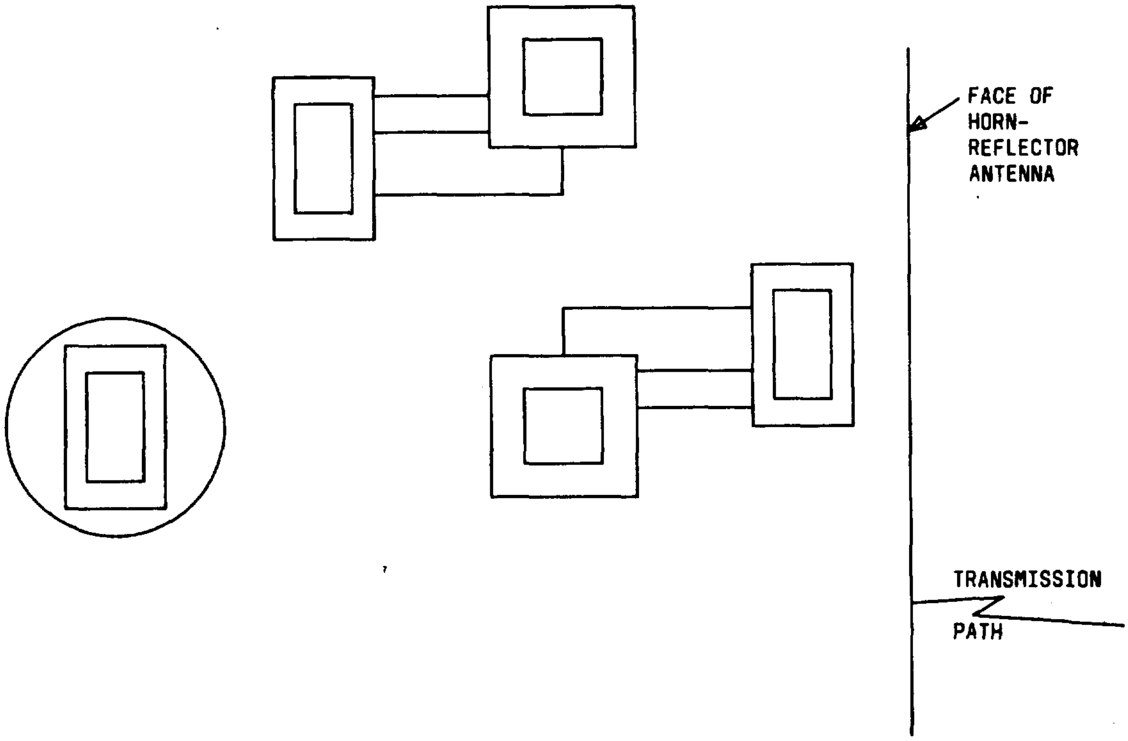

Fig. 6—Position of 1406A, 1428A, or 1407A Networks for Transmitting the Vertical Polarization (View Looking Up the Tower)

position, air pressure should be applied where these conditions exist.

1.17 If the antenna at one station is a parabolic antenna, begin orientation using that station as the transmitter.

1.18 If space diversity antennas are provided, the regular antennas at each station are oriented first using one for transmitting and the other for receiving the test signals. Then the diversity antenna at each station is oriented while using the regular antenna at the distant station for transmitting or receiving the test signal. The regular antenna must not be readjusted.

1.19 No attempt should be made to perform any of the operations in this section when the received signal level fluctuates more than 1 dB.

1.20 After the antennas at both ends of the hop are oriented, the system combining networks are adjusted. (When a parabolic antenna is used at one end, the rotation of the feed of the parabolic is equivalent to the rotation of the system combining network used with the horn antenna.) In performing this adjustment, the alignment of the networks or, in the case of a parabolic antenna, the rotation of the feed is done visually at one end and electrically at the other.

1.21 The orientation is performed at the highest frequency band equipped at 4, 6, or 11 GHz. The networks are aligned and the XPD adjustment begins at the lowest frequency band and progresses to the highest band.

1.22 The following tools and apparatus are required:

QUANTITY	DESCRIPTION
1	— Microwave Signal Receiver (Microtel 1900 or equivalent)
1	— Waveguide Test Set (Microtel 4350 or equivalent)
1	— 33A Transducer
1	— 43A Transducer

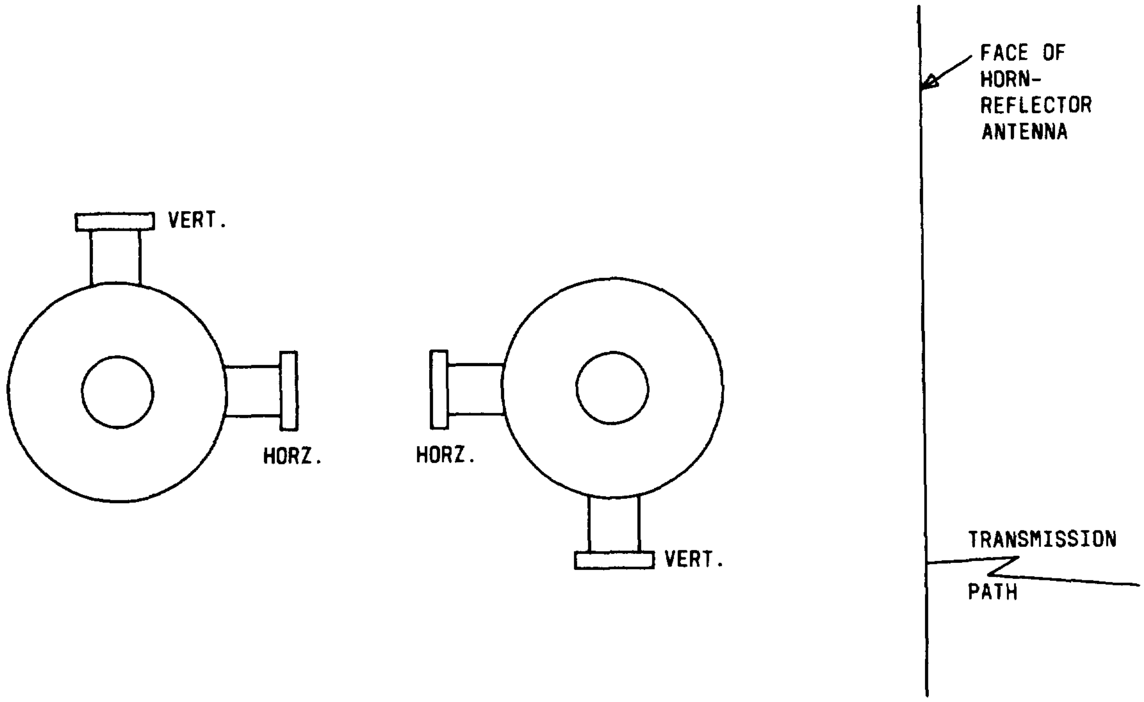

Fig. 7—Position of 1424A Network for Transmitting Horizontal and Vertical Polarization (View Looking Up the Tower)

QUANTITY	DESCRIPTION
6	— 24A Transducers (4 GHz)
1	— 29B Transducer
4	— ED-59410-70, G1 Transducers
4	— ED-63967-30, G1 Transducers (4 GHz)
2	— 90548 Waveline Transducers (6 GHz)
4	— WC-281 to WR-90 Transducers (11 GHz)
6	— W90 to Coaxial Transducers (11 GHz)
6	— 1A or 1B Transducers (6 GHz)
2	— KS-15676, L13 Tilt-Adjusting Tools
1	— KS-20073 Telescope
2	— KS-15676, L12 Azimuth Adjusting Screws
2	— KS-21972, L5 Elevation Adjusting Tools
2	— KS-21972, L4 Azimuth Adjusting Tools

QUANTITY	DESCRIPTION
1	— AT-8390 Circular Waveguide Wrench or equivalent
1	— System Combining Network Alignment Tool (Western Electric ERE-4956 or equivalent)
1	— ED-50498-50 Search Tool
3	— 6 Feet of RG-214 Coaxial Cable With N-Type Male Connector on both ends
5	— Sockets (1/4, 5/16, 3/8, 7/16, and 1/2-Inch) With 3/8-Inch Square Drive
1	— Adjustable Open-End Wrench With 3-Inch Capacity
2	— 12-Point Box Wrenches (1/2- and 7/16-Inch)
1	— Ratchet, Wrench (With 3/8-Inch Square Drive)
1	— 9/16-Inch Open/Box Wrench

QUANTITY	DESCRIPTION
1	— 1/2-Inch Open/Box Wrench
1	— 7/16-Inch Open/Box Wrench
20	— Regular SF Hexagonal-Head 1/4 - 20 Bolts 1-3/4 Inches Long for Rectangular Waveguide Flange
As Reqd	— Radiation Suits per Section 010-150-002
As Reqd	— 4A Clamp
As Reqd	— Tower Communication Terminal (Western Electric ETE-5479 or equivalent).

2. ANTENNA, WAVEGUIDE, AND ALIGNMENT DESCRIPTION

A. Tower Equipment

2.01 The KS-21972 and KS-15676 antennas are capable of simultaneous performance in both horizontal and vertical polarization in the 4-, 6-, and 11-GHz common carrier bands. A block diagram of antenna and associated waveguide is shown in Fig. 8.

2.02 The antenna feedhorn may be connected to the rigid circular waveguide using either a section of flexible waveguide or bent rigid waveguide. Both the flexible and bent rigid allow for slight misalignment of the feedhorn and the circular rigid waveguide run.

2.03 The rigid circular waveguide extends nearly the entire length of the tower. The circular cross-section permits simultaneous propagation of both polarizations in the 4-, 6-, and 11-GHz common carrier bands.

2.04 The adjustable axial ratio compensator (AARC) is used to increase the discrimination between the two polarizations of a common carrier band. It compensates for the out-of-roundness in the circular waveguide.

2.05 The systems combining networks are employed to connect microwave radio systems operating in any or all of the three common carrier bands to one common horn-reflector antenna.

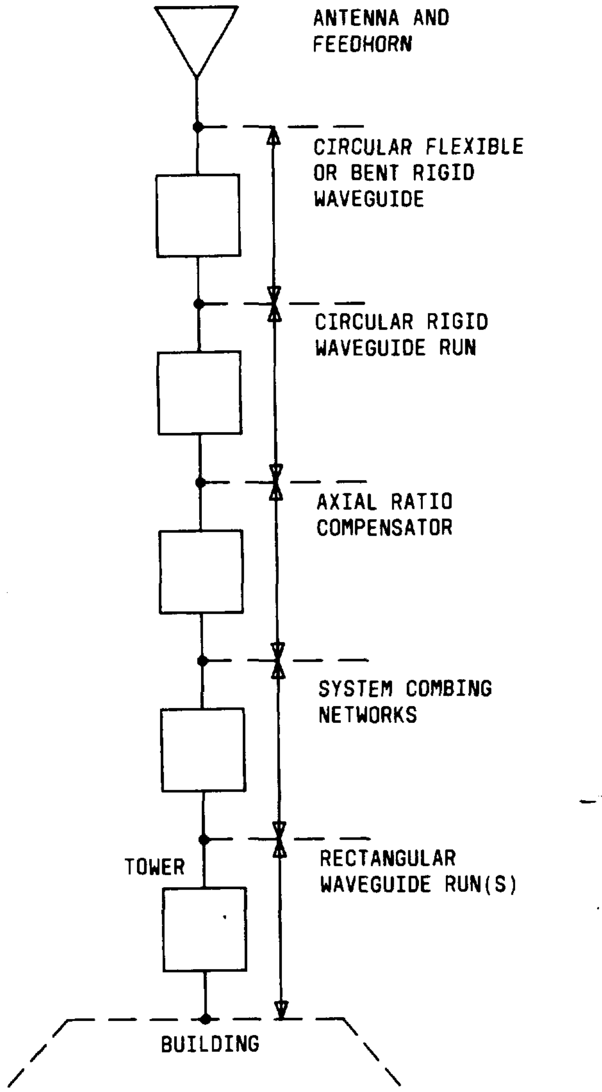

Fig. 8—Block Diagram of Antenna and Associated Waveguide

B. Antenna Coarse Alignment

2.06 The transmitting and receiving antennas are connected for horizontally polarized transmission. The transmitter is connected to the antenna waveguide at the transmitting station and the received signal strength is monitored with a receiver at the receiving station.

2.07 Both antennas are oriented horizontally (azimuth) and vertically (elevation) until they are both on their major lobes as indicated by maximum signal strength.

C. Antenna Fine Alignment

2.08 To adjust the antenna fine alignment proceed as follows:

(a) Connect the TM°_{01} transducer to the antenna feedhorn of the receiving antenna to be adjusted. Connect the output of the TM°_{01} transducer by coaxial cable to a rectangular-to-circular waveguide transducer and to a sensitive receiver through the waveguide system

(b) Arrange the transmitting antenna to send a horizontally polarized signal

(c) Perform the azimuth orientation of the receiving antenna by adjusting the antenna horizontally while observing for minimum signal strength at the receiver

(d) Arrange the transmitting antenna to send a vertically polarized signal

(e) Perform the elevation orientation of the receiving antenna by adjusting the antenna vertically while observing for minimum signal strength at the receiver

(f) Remove the TM°_{01} transducer from the receiving antenna and connect it at the transmitting antenna. Without transferring any of the test equipment, repeat the procedure for the other (transmitting) antenna.

Note: The TM°_{01} transducer is always connected to the transmitting or receiving antenna being aligned.

3. ALIGNMENT OF ANTENNA SYSTEMS WITH SHORT CIRCULAR WAVEGUIDE RUNS

3.01 A short waveguide run is one in which there is no waveguide section 4 feet long or longer on which to mount the adjustable axial ratio compensator (AARC).

3.02 The test arrangement of Charts 1 through 5 for stations with long circular waveguide runs which puts the signal transmitter and receiver at the inputs of the networks or in the building is principally for convenience of arranging and reading test equipment. For those few instances where there is little or no circular waveguide, the TM°_{01} and the circular-to-rectangular transducer may connect directly to the test equipment by coaxial cable. A number of arrangements of this type might be employed. It is necessary to observe polarities and to calculate the loss when comparing actual and calculated received signal strength.

3.03 For the case of a long waveguide run facing a short run, use the procedures of Charts 1 and 3 or 4. For XPD adjustment, where the transmitting station is the long run, the AARC may be attached to the transmitting waveguide. For the case of two short waveguide runs with insufficient circular waveguide at either end, use the procedure given in Chart 6. Where there is no long run of circular waveguide at either end, the system will probably meet the XPD requirement without special treatment. If such treatment is necessary because of failure to meet a requirement, and the received signal strength is sufficient, the slight antenna misalignment of Chart 6 should bring the XPD within the objective.

4. CHARTS

CHART 1

HORN-REFLECTOR ANTENNA ORIENTATION USING THE TM°_{01} NULL METHOD

APPARATUS:

As listed in Part 1.

STEP	PROCEDURE
	Note: Before removing the flexible or bent rigid waveguide, ensure that the transmitted signal is being received. If necessary, loosen the flanges at the waveguide and move the antennas one at a time in azimuth, to find the signal. Mark the antenna position prior to moving the antenna.
	A. Antenna Coarse Orientation
1	On both towers, remove the WC-281 waveguide section at the antenna feedhorn and install the transducers as shown in Fig. 9A (4 GHz), Fig. 10A (6 GHz) or Fig. 11A (11 GHz). Leave the rotatable waveguide flanges slightly loose at this time. Connect the waveguide test set and receiver as shown in Fig. 12.
	Note: For later checking of the signal level requirement, note that there is approximately an additional 2-dB loss in each antenna system with the transducers and cable installed at 4 or 6 GHz. At 11 GHz, 4-dB loss can be expected.
2	Rotate the bottom ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) on each tower so that the rectangular port is in the same position as the rectangular port of the SCN side arm connected to the generator or receiver.
3	On both towers, rotate the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) so that the transducer is oriented in the same direction (horizontal polarization) as shown in Fig. 5.
4	While observing the received signal strength on the receiver, rotate the bottom ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) on each tower one at a time for maximum signal. Tighten the bolts connecting the transducer to the waveguide run.
5	At the receiving end, rotate the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) for a maximum received signal strength (RSS). The transducer should be oriented in the same direction as shown on Fig. 5. If it does not, repeat Steps 3 and 4. Tighten the bolts connecting the transducer to the antenna feedhorn.
6	Swing the receiving antenna through a horizontal arc by means of the azimuth adjusting screw. Search several degrees in each direction from the starting point, while observing the receiver meter reading.

CHART 1 (Contd)

STEP	PROCEDURE
	Requirement: Ordinarily, the receiver meter should indicate at least three peak readings; one, centrally located, is higher than the other two. The highest reading indicates the major lobe and the lower readings indicate minor lobes (Fig. 3). It should be possible to positively identify the major lobe and at least one minor lobe. If only two equal peaks are found, it indicates that the antenna may be off in elevation. If the major and minor lobes are identified, position the antenna on the major lobe and proceed to Step 10. If only two peaks are found, proceed with Step 7.
7	Swing the antenna horizontally, mark the position of each of the two peaks, and position the antenna midway between these two marks.
8	Swing the antenna vertically to obtain a maximum receiver meter indication. There will sometimes be two peaks. If so, position the antenna on the higher of the two.
9	Swing the antenna horizontally. The meter readings should indicate three peaks; one, centrally located, is higher than the other two. Position the antenna on this major lobe.
10	Swing the receiving antenna through a vertical arc, by means of the tilt adjusting screw, sweeping several degrees in each direction from the starting point while observing the receiver meter reading. If there are three peaks, one centrally located and higher than the other two, position the antenna on the central or highest peak meter indication. There will sometimes be only two peaks; if this is the case, position the antenna on the peak with the highest meter indication.
11	When the receiving antenna has been aligned, repeat Steps 6 through 10, as necessary, to similarly adjust the transmitting antenna at the other end of the hop.
	Note: No turn-around of test equipment is necessary.
12	After completing Steps 1 through 11, observe and record the received signal strength (horizontal-to-horizontal polarization).
	Note: For a horn antenna, proceed to Step 17. If a parabolic antenna is used, continue with Step 13.
13	Swing the parabolic antenna in azimuth; then in elevation on the major lobe and adjust for maximum received signal strength.
14	Slowly move the antenna to one side until the received signal strength decreases 3 dB down from the maximum meter indication. Instruct the tower man to mark this mechanical position.
15	Slowly move the antenna in the opposite direction past the maximum level point until the received signal strength decreases 3 dB down from maximum meter indication. Instruct the tower man to mark this mechanical position.

CHART 1 (Contd)

STEP	PROCEDURE
16	Move the antenna to the center of the two marked mechanical positions. ***Note:*** If the major lobe is not symmetrical, the received signal strength may be less than the maximum reading.
17	On both towers, rotate the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) so that it is pointing 90 degrees from the antenna direction (vertical-to-vertical polarization). If the transmitting antenna is a parabolic type, it should be set up to transmit the vertical polarization. Observe and record the received signal strength.
18	Obtain the calculated received signal strength from the Transmission Engineer's Office records and compare the value with the value of the received signal strengths recorded in Steps 12 and 17. Be sure to take into account any differences in waveguide length and the loss of the transducers and cable arrangements used for orientation at each location. ***Requirement:*** The calculated and measured values should agree within 3 dB. If the requirement is not met, repeat Steps 1 through 17 to ensure that the orientation is valid before performing the procedures of Part 5.
	B. Antenna Fine Orientation
19	At the receiving tower, remove the top ED-59410-70, G1 transducer and install the 33A transducer (Fig. 9B, 4 GHz or Fig. 10B, 6 GHz) or remove the top WC-281 to WR-90 transducer and install the 43A transducer (Fig. 11B, 11 GHz).
20	At the transmitting end, rotate the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) so that it is oriented for horizontal polarization. If the transmitting antenna is a parabolic type, it should be set up to transmit the horizontal polarization.
21	Fasten the KS-20073 telescope to the receiving antenna (Fig. 13 or 14) and set vernier adjustments for midscale. ***Note:*** The telescope may be adjusted horizontally and vertically within its mounting frame by means of the vernier adjustments located on the telescope assembly. These controls are essentially the same except that the vertical vernier adjustment has a range of 3 degrees and the horizontal, 2 1/2 degrees. The degree indications are marked on the vernier shaft. Each degree is divided into four parts equal to 0.25 degrees. The vernier adjustable knob is divided into 25 units. One complete revolution of the knob will move the knob one unit (0.25 degrees) on the shaft, making each unit on the knob equal to 0.01 degree.
22	Choose, as a target, a convenient object about 2 to 4 miles from the tower, in the elevation and azimuth that the antenna is aimed. For example, a water tower or power line tower will provide a convenient edge for aligning the telescope sight.

CHART 1 (Contd)

STEP **PROCEDURE**

23 Loosen the locking screw and maneuver the telescope assembly to sight the target and keep the vernier adjustment on midscale. Tighten the locking screw.

24 While monitoring the received signal strength at the receiver, slowly turn the receiving antenna to the left until a maximum TM°_{01} received signal strength is obtained.

Note: Normally, the antenna will not have to be moved more than 1 degree. Positioning the telescope to a point 1 degree (100 small divisions) to the right of its midscale position and moving the antenna to the left until the telescope is back on target will ensure that the antenna has not moved more than 1 degree.

25 Bring the telescope back on target with the horizontal vernier control on the telescope. Record the TM°_{01} received signal strength and the telescope horizontal vernier indication.

26 Move the horizontal vernier in even 5-division increments (towards midscale position). At each increment, perform the following:

(a) Bring the sight back on target by moving the antenna in azimuth.

(b) Record the TM°_{01} received signal strength and the horizontal vernier position.

Note: Three-division increments are recommended near the null.

27 Continue this plot on through the null and back to the maximum value, plotting each point on regular 10 by 10 linear graph paper as shown in Fig. 15.

28 Using the azimuth adjusting screw, move the antenna for a null (minimum) meter indication as follows:

(a) Move the telescope horizontal vernier control to correspond to the second setting to the right of the null.

(b) Bring the telescope back on target by moving the antenna to the left (toward midscale position). Continue to move the antenna until it approaches the null.

Note: Since the exact position of the null is not known, the null location is found at the point where the received signal strength begins to increase again. In order to reverse the direction of turning when the null is passed, turn the screw another half turn and reverse the direction of screw turning.

29 Continue turning the azimuth adjusting screw on the antenna in the same direction until the minimum received signal strength is measured. If the point is missed, it may be necessary to repeat Steps 28 and 29.

CHART 1 (Contd)

STEP	PROCEDURE
	Note: Do not lock down the azimuth direction at this stage.
30	At the transmitting end, rotate the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) so that it is oriented for a vertically polarized signal for TM°_{01} plot of antenna elevation.
31	Perform the fine adjustment for antenna elevation following the procedure from Step 22 relating it to elevation adjustments to the antenna horn. The antenna elevation is changed by the use of the tilt adjusting tool. Telescope adjustments are performed using the vertical vernier control on the telescope. Plot the vertical-to-vertical TM°_{01} null as the horizontal-to-horizontal null was plotted in the procedure.
32	Return to horizontal polarization at the transmitter and verify the TM°_{01} null for the azimuth direction. While the minimum TM°_{01} signal is being observed, carefully lock down the antenna in azimuth without moving off the null. Record the TM°_{01} received signal strength, the horizontal vernier indication, and complete the plot. Keep for permanent record.
33	Return to vertical polarization at the transmitter and verify the TM°_{01} null for the elevation direction. While the minimum TM°_{01} signal is being observed, carefully lock down the antenna in elevation without moving off the null. Record the TM°_{01} received signal strength, the vertical vernier indication, and complete the plot. Keep for permanent record.
	Requirement: The received signal null for the TM°_{01} mode, azimuth and elevation, should be below that for the TE°_{11} horizontal-to-horizontal and vertical-to-vertical, respectively, as shown: null −30 dB at 4 GHz null −25 dB at 6 GHz null −19 dB at 11 GHz.
	If the requirement is not met, refer to corrective procedures given in Part 5.
34	If the receiving antenna system is equipped for receiving both polarities, remove the transducers and replace the waveguide. If the receiving antenna system is not equipped for receiving both polarities, remove the 33A or 43A transducer and reinstall the top ED-59410-70, G1 transducer or the WC-281 to WR-90 transducer. Remove the telescope.
35	At the transmitting antenna, install the KS-20073 telescope and replace the top ED-59410-70, G1 transducer with a 33A transducer or the top WC-281 to WR-90 transducer with a 43A transducer.
	Note: Although it is necessary to turn off the generator while working on the waveguide, no turn-around of equipment is necessary.

CHART 1 (Contd)

STEP	PROCEDURE
36	Repeat the steps of this chart from Step 21 to orient the transmitting antenna in TM°_{01} mode null. The generator will still be at antenna A and the receiver at antenna B with readings relayed to the A end by the communications system. As the orientations are changed at the transmitting antenna, no change will be necessary at the receiving antenna if it is equipped as noted in Step 34 with the exception of turning the top ED-59410-70, G1 transducer (4 GHz or 6 GHz) or the WC-281 to WR-90 transducer (11 GHz) used for single polarity systems.
37	When orientation is completed on both antennas, reassemble the antenna and waveguide as shown in the office drawings. Verify that the networks are properly positioned (see Fig. 5, 6, and 7). If the system is a single polarity system, rotate the network at the receiving end for maximum received signal strength and tighten all bolts. An alternate method would be to temporarily replace the transducer at the bottom of the network with a transducer arranged to receive the opposite polarity of the network, connect the receiver to this transducer, then adjust the network for minimum received signal strength. When this is completed, restore the original transducer and tighten all bolts. ***Note:*** Systems combining network tool should be used for rotation of networks.
38	Single polarity systems have now completed the section. Dual polarity systems proceed to Chart 3.

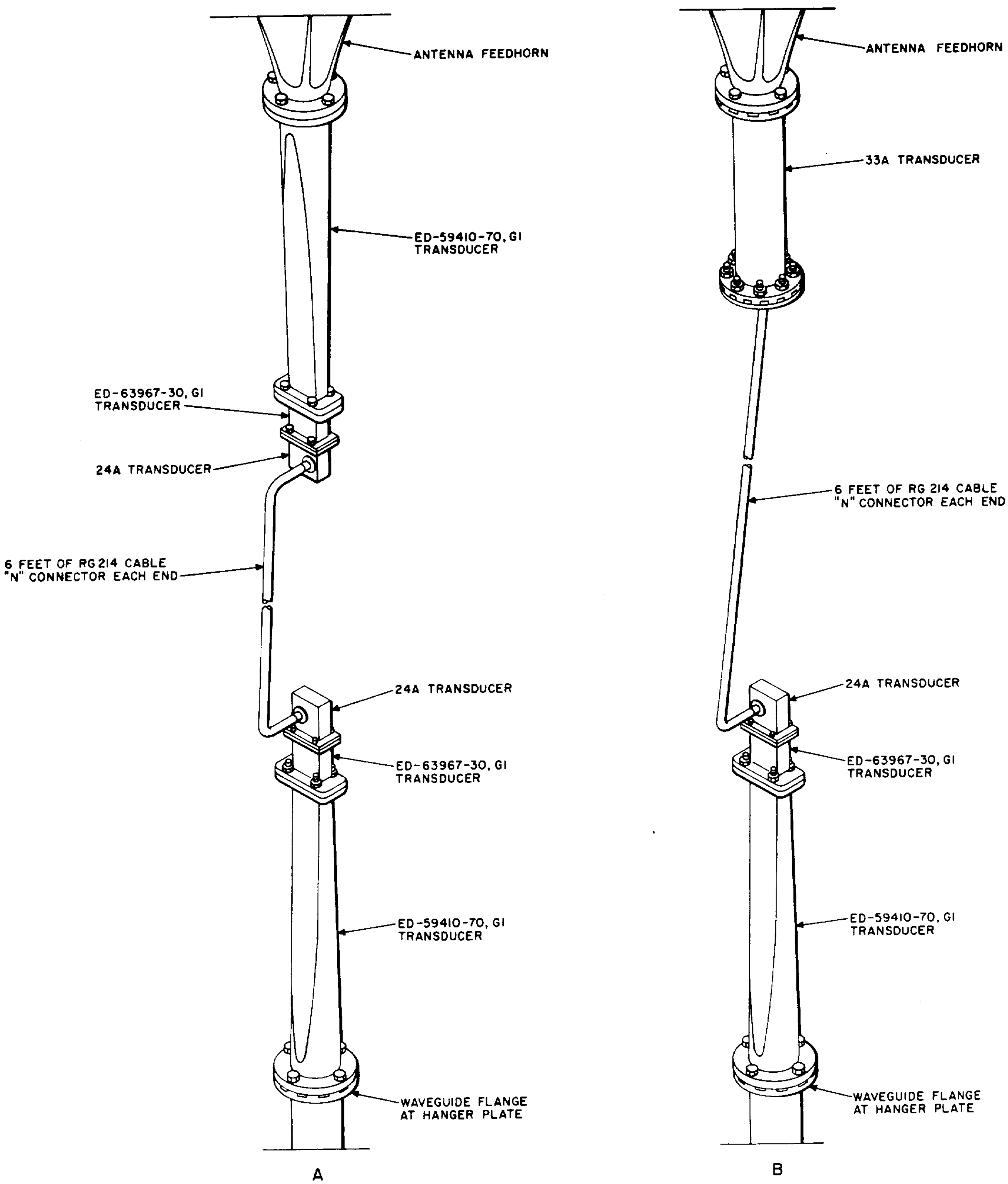

Fig. 9—Transducer Arrangement—4 GHz

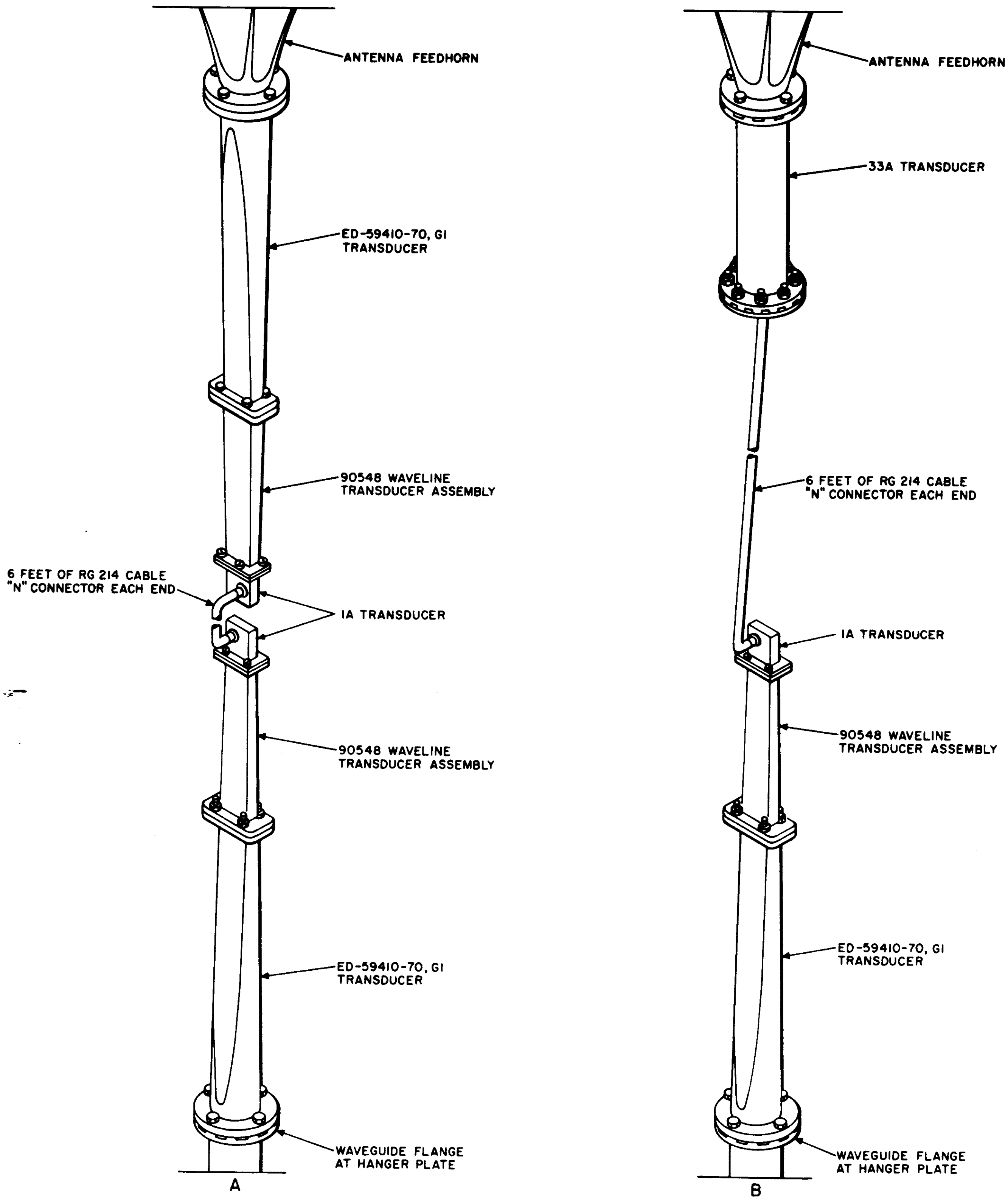

Fig. 10—Transducer Arrangement—6 GHz

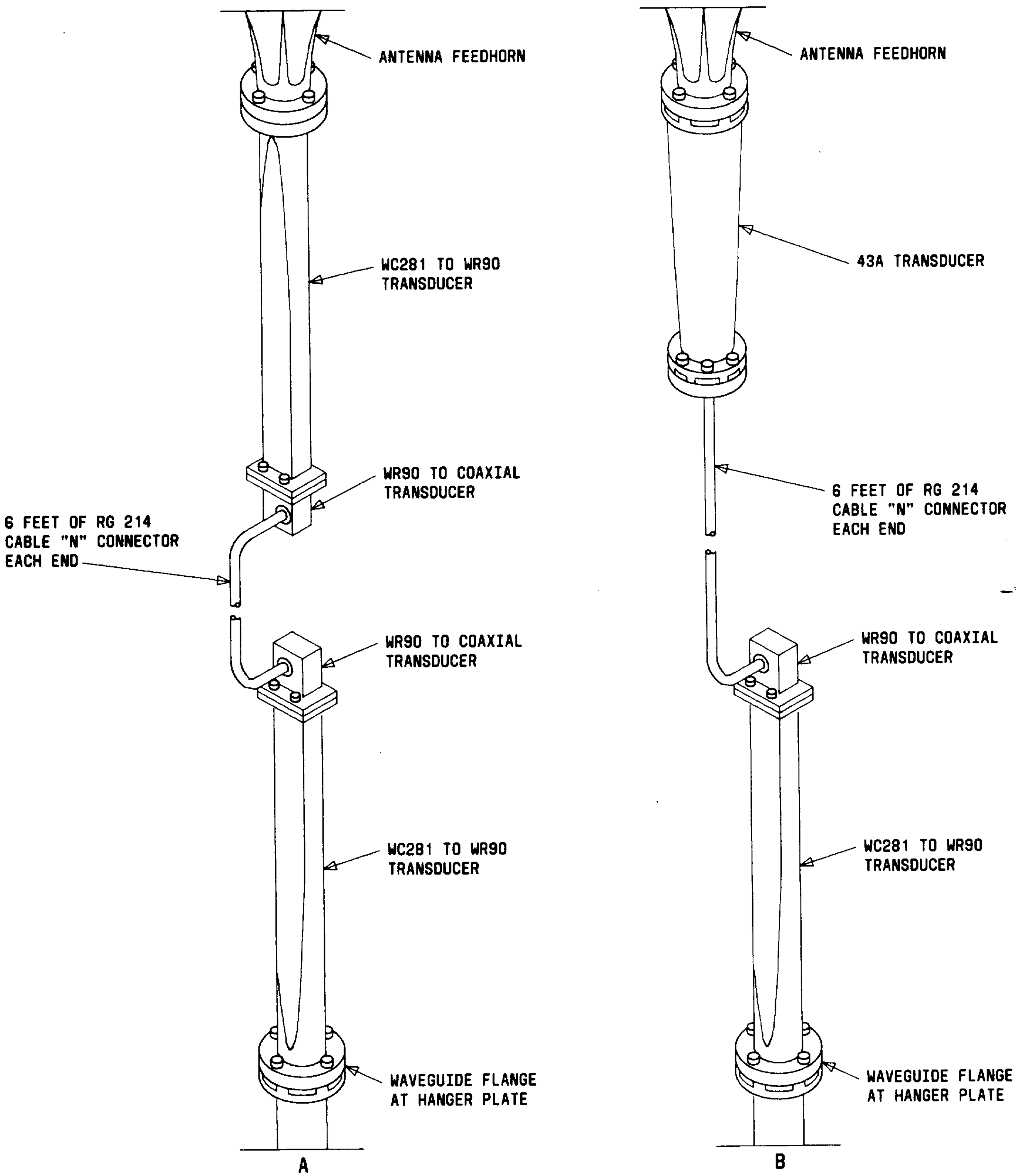

Fig. 11—Transducer Arrangement—11 GHz

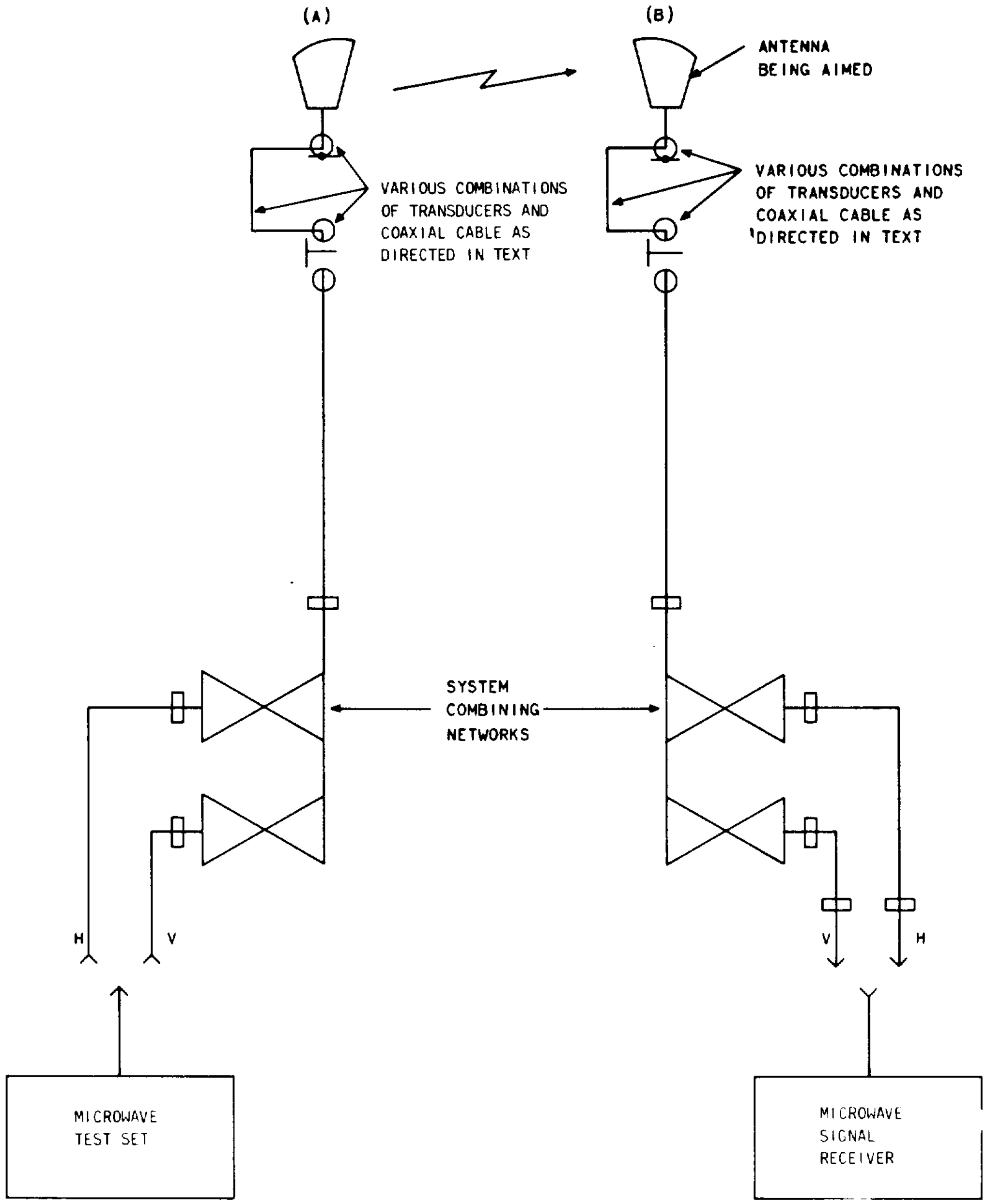

Fig. 12—Block Diagram of Test Arrangement—Antenna Systems

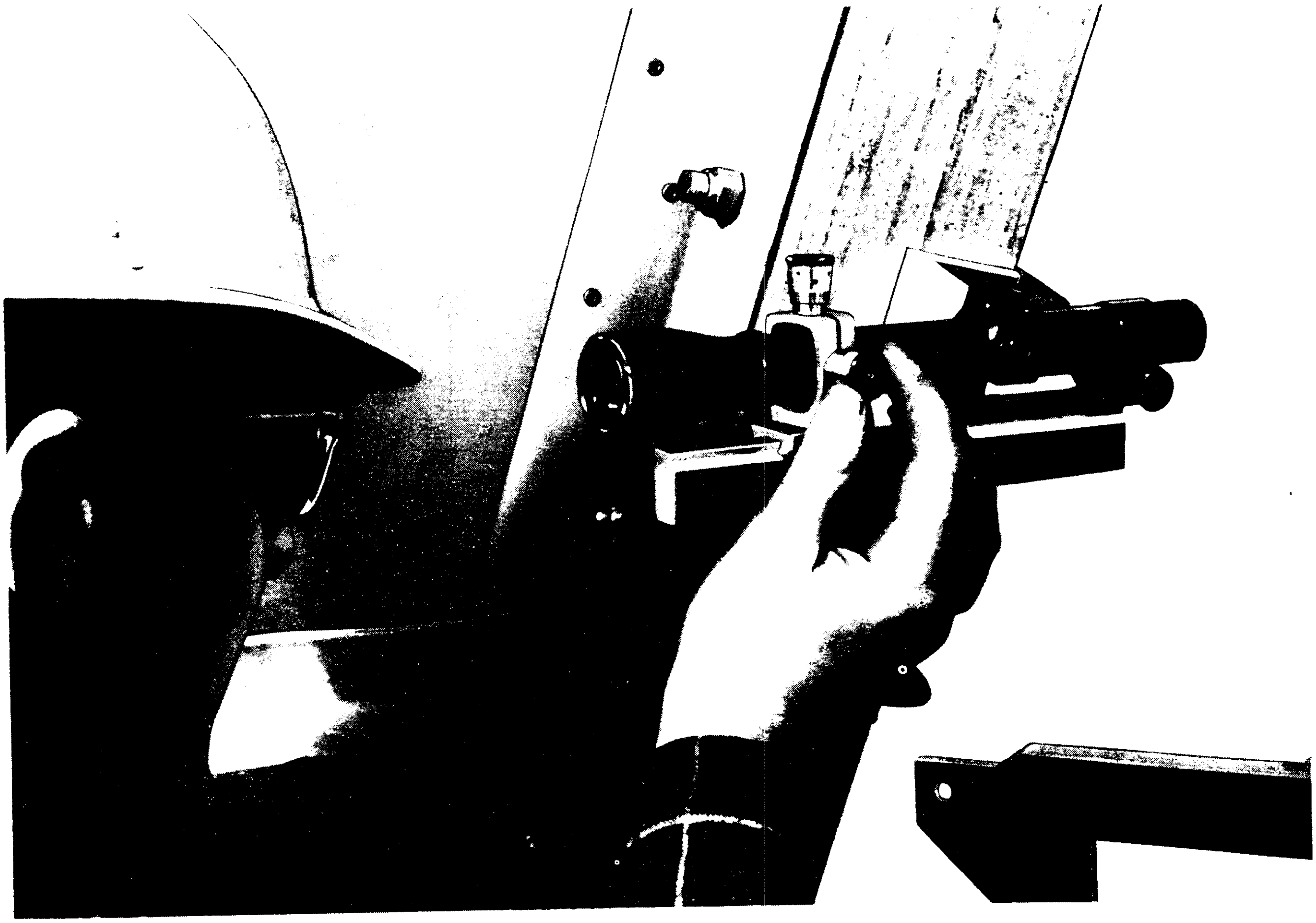

Fig. 13—KS-20073 Telescope Installed on KS-15676 Antenna

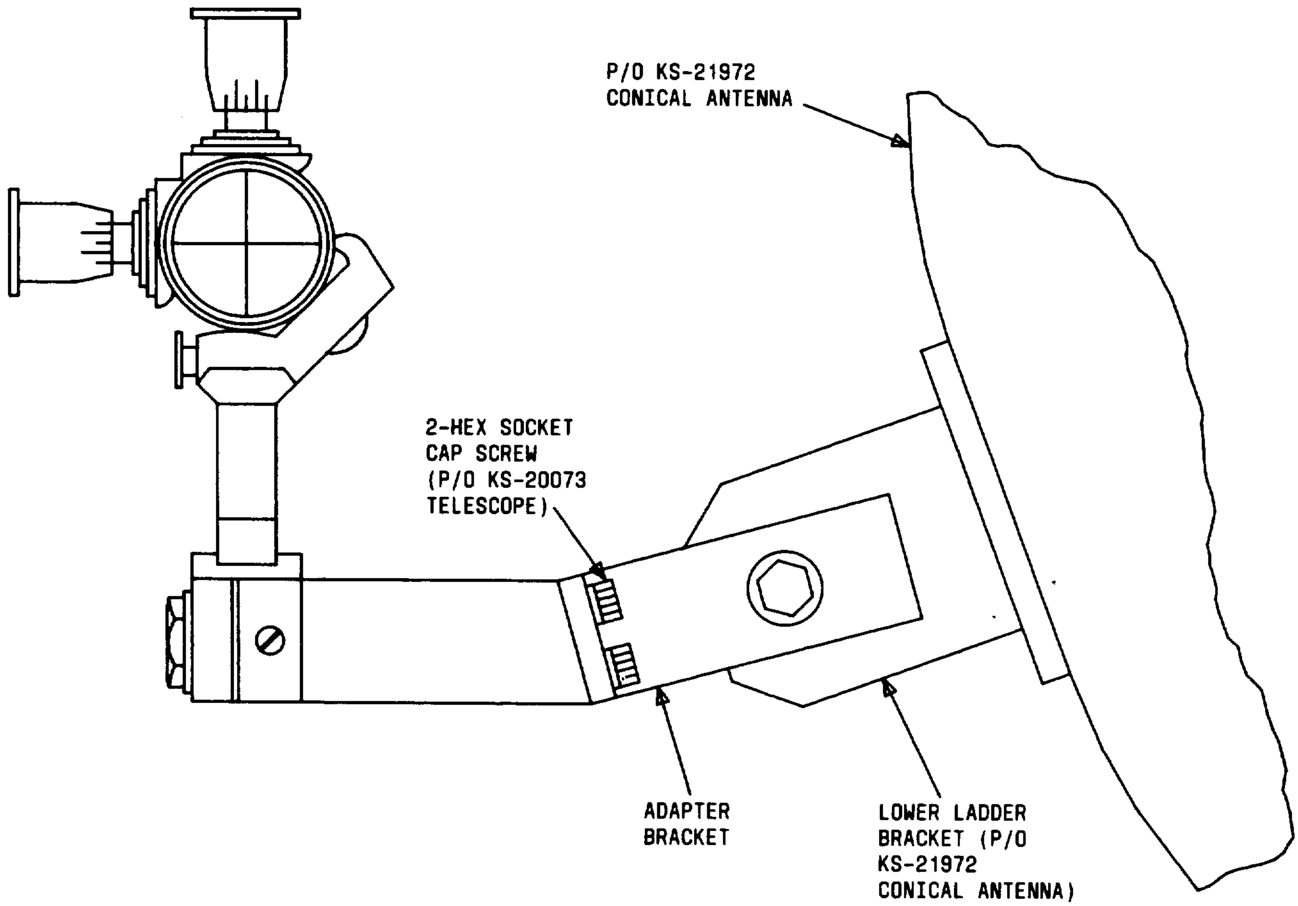

Fig. 14—KS-20073 Telescope Installed on KS-21972 Antenna

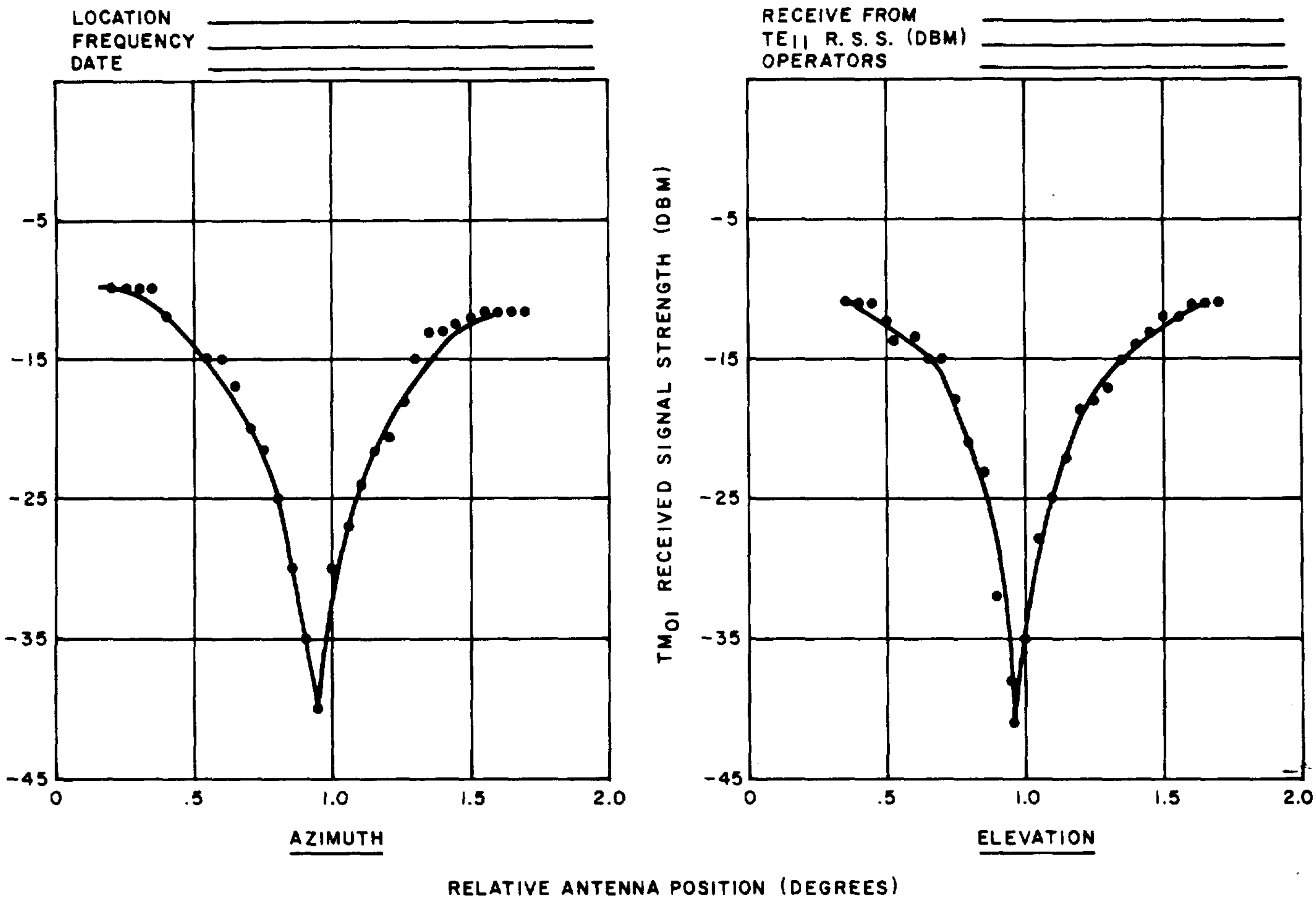

Fig. 15—Horn Antenna Orientation Plot of TM°$_{01}$ Signal

CHART 2

HORN-REFLECTOR ANTENNA ORIENTATION USING THE MAIN BEAM TECHNIQUE

This chart covers the procedure for orientation of the horn-reflector antenna using the main beam.

The main beam antenna orientation method is a less precise alternative which may be used if difficulty is encountered with the TM°$_{01}$ null method.

APPARATUS:

As listed in Part 1.

CHART 2 (Contd)

STEP	PROCEDURE
	Note: The procedure described in this chart should only be performed upon failure of the procedure in Chart 1, using the TM°_{01} null method, or if in-service antenna orientation is required and cannot be performed otherwise. Steps 1 through 18 (for coarse alignment) and Steps 21 through 23 (for telescope setup) in Chart 1 must be performed before proceeding with Step 1.
1	Adjust the microwave signal receiver (MSR) controls for a zero meter indication.
2	While monitoring the received signal strength, slowly turn the antenna to the left until the received power is reduced by 3 dB.
3	Bring the telescope (Fig. 13 or 14) back to target with the horizontal vernier control on the telescope. Record the received power and horizontal vernier setting.
4	Move the antenna to the right until the received power equals the value recorded in Step 3. Record received power and vernier setting.
	Requirement: As the antenna rotates, the received power should increase 3 dB to a peak and then decrease 3 dB to the value recorded in Step 3.
5	Determine the midvalue of the telescope readings recorded in Steps 3 and 4. Set the telescope reading and move the antenna to bring the telescope on target.
6	Lock down the antenna in azimuth.
	Requirement: The telescope should remain on target after lockdown. If the requirement is not met, the antenna should be loosened, reset, and relocked down.
	Antenna Elevation Adjustment
7	Repeat Steps 1 through 5 for antenna elevation adjustment.
	Note: The antenna is adjusted using the tilt adjusting tool. Telescope adjustments are made using the vertical vernier control on the telescope.
8	Lock down the antenna in elevation.
	Requirement: The telescope should remain on target after lockdown. If the requirement is not met, the antenna should be loosened, reset, and relocked down.
9	Adjust the antenna at the other end of the hop if required.

CHART 3

WC-281 CIRCULAR WAVEGUIDE AXIAL RATIO COMPENSATION ADJUSTMENT

This chart covers the procedure for adjusting the axial ratio compensator used on circular waveguide. This procedure applies only to initial installation and where each circular waveguide run is provided with an axial ratio compensator. The circular waveguide run must be equipped with networks which allow both polarizations to be used. This procedure is to be performed at both ends of the hop on each waveguide line.

The axial ratio compensator is adjusted using the lowest frequency band for which networks for both polarizations are provided, either 4, 6, or 11 GHz. For example, when both 4- and 6-GHz networks are provided, the axial ratio compensator is adjusted at 4 GHz and the compensator adjustment is repeated at 6 GHz using the 4A clamp, if necessary. After completing the adjustment of 4 and 6 GHz, the 11-GHz networks are visually aligned to the other networks and rotated (plus or minus 5 degrees) for best results as described in Chart 4.

Chart 5 is recommended for use when in-service cross-polarization adjustment is necessary, such as when an added frequency band is provided.

APPARATUS:

As listed in Part 1.

STEP	PROCEDURE
	Note: For proper adjustment of the axial ratio compensator, the system combining networks must be set very close to their final position. The antenna orientation procedure in Chart 1 or 2 must be completed before adjusting the axial ratio compensator. The networks will be slightly readjusted during the overall antenna and waveguide cross-polarization test. These readjustments require a very small rotation of the networks. If a relatively large readjustment of the networks is required, the cross-polarization test might have to be repeated to meet the requirements.
1	Place a waveguide short on the circular waveguide where it normally connects to the antenna at the top of the tower.
	Caution: The waveguide short must fit flush with the waveguide. It is possible to have the short cocked on an angle when the bolts are tightened. The short should lay flat on the guide. Do not fully tighten the bolts, but let the weight of the short and the associated flange hold the short in place with the guide.
2	Verify that the systems combining networks have been aligned and that the antenna orientation has been completed.

CHART 3 (Contd)

STEP	PROCEDURE
3	Set up the waveguide test set (WTS) for an operating frequency at the center of the operating band.
4	Connect the WTS as shown in Fig. 16, option A. Calibrate the WTS at any chosen midband frequency.
5	With the WTS calibrated, connect the unit as shown in Fig. 16, option B.
	***Caution:* The rectangular waveguide between the system combining network and the test set should not be less than 10 feet. If for any reason this minimum length is not used, the network leakage pulse will affect the axial ratio compensator adjustment.**
6	Install the adjustable axial ratio compensator (Fig. 17) on the first 4-foot long or longer section of the waveguide above the transducer. Mount the adjustable pressure bar of the compensator so that it is located 45 degrees with respect to an arm of a network.
7	While adjusting the axial ratio compensator, observe the pulse of interest and ignore all others. The pulse of interest is the one which occurs (on the oscillscope) at a distance approximately equal to the distance from the WTS to the short. Ignore any pulse that appears to be following the pulse of interest by a short time delay.
8	Tighten the axial ratio compensator slightly and note the change in the amplitude of the pulse of interest.
	Requirement 1: Usually the pulse will completely disappear. If the requirement is not met, loosen the axial ratio compensator and rotate it 90 degrees. Tighten slightly and normally the pulse will disappear.
	Requirement 2: The amplitude of any other pulses on the WTS display shall be at least −35 dB on the display.
9	Recalibrate the WTS at a low and high frequency within the band. Observe the pulse that may occur at the distance equivalent to the distance from the WTS to the short.
10	If a pulse appears, observe the amplitude of the pulse and adjust the axial ratio compensator to the requirements.
11	Repeat Steps 8 through 10 at low, middle, and high frequencies within the band for dual polarization 6-GHz networks, if equipped and if necessary.
	Note: For 6 GHz, the 4A clamp attaches diagonally to the corners of the 35A transducers corners (Fig. 18) in the center of the machined area. The small V notches of the clamp rests on the outside corners of the 35A transducers.

CHART 3 (Contd)

STEP	PROCEDURE
	Warning: Excessive clamping will cause permanent damage to the 35A transducers.
12	Apply a slight compression to the 35A transducers by carefully tightening the two cap screws on the clamp.
13	Observe the pulse amplitude. If the pulse amplitude increases, remove the 4A clamp and attach it to the other diagonal of the 35A transducer.
14	Repeat Step 12 and observe the pulse amplitude.
15	For those cases where clamping the 35A transducer diagonal does not provide a pulse −35 dB or lower, reverse the brass bars and attach the clamp to the sidewalls at approximately the center of the machined area.
16	Apply a slight compression to the 35A transducers by carefully tightening the two cap screws on the clamp.
17	Observe the pulse amplitude. If the pulse amplitude is not at least −35 dB, remove the 4A clamp, rotate it 90 degrees and attach it to the other sidewalls. Repeat Step 16.
	Caution: When restoring the waveguide to normal, it is important that no undue stress be applied to any waveguide section or flange. All flanges should mate and be tightened properly.
18	Restore all equipment to normal after the completion of the axial ratio compensator adjustment.

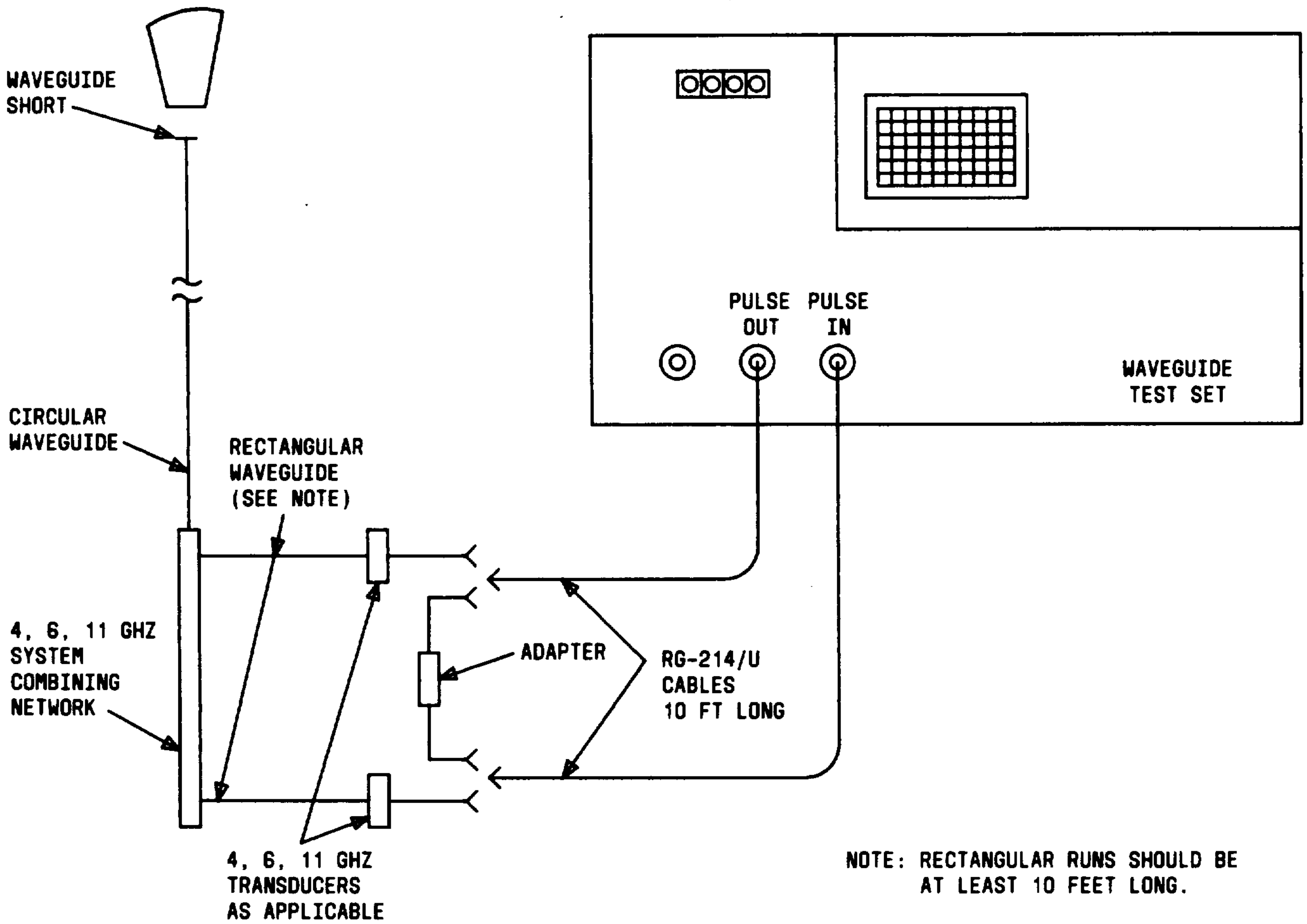

Fig. 16—Axial Ratio Compensator Adjustment Using the Waveguide Test Set

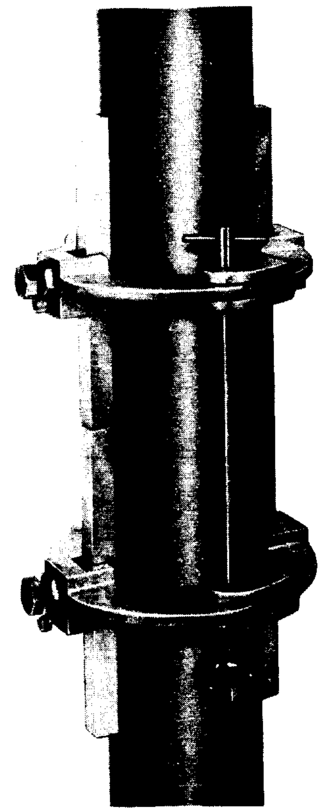

Fig. 17—Axial Ratio Compensator

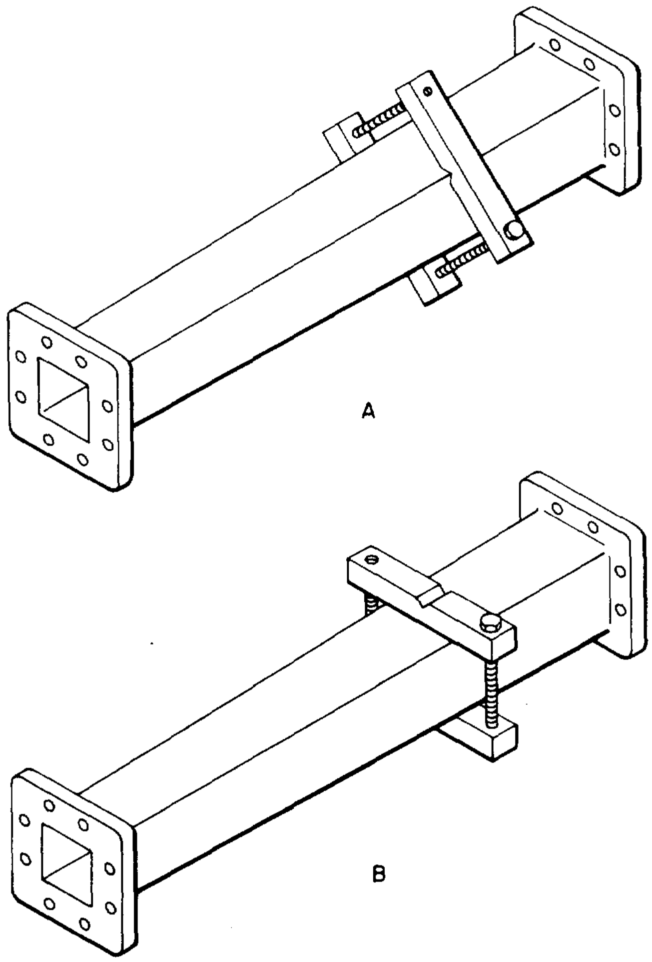

Fig. 18—4A Clamp Attached to Corners and Sidewalls of 35A Transducer

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CHART 4

SYSTEMS COMBINING NETWORK ADJUSTMENT AND CROSS-POLARIZATION DISCRIMINATION TEST

This procedure covers the adjustment of the system combining networks and the measurement of the cross-polarization discrimination of antenna and waveguide systems.

APPARATUS:

As listed in Part 1.

CHART 4 (Contd)

STEP	PROCEDURE
	Note 1: When the antenna is arranged for multiband operation, the system combining network for the lowest frequency band is adjusted first and its cross-polarization discrimination is measured.
	Note 2: The antenna orientation and axial ratio compensator adjustment of both ends of the hop must be performed prior to this procedure.
	A. Network Alignment
1	At the transmit end, arrange the waveguide test set (WTS) to transmit a horizontal polarized continuous wave (CW) signal.
	Note: Turn off the RF output of the WTS before making connections.
2	Connect the output of the WTS to the waveguide run which connects to the system combining network port used for the horizontal polarization.
3	Terminate the waveguide run connected to the other port by installing a waveguide to coaxial cable transducer and terminating the coaxial cable port with a coaxial termination.
4	At the receive end, connect the microwave signal receiver (MSR) to the waveguide run which connects to the system combining network port for horizontal polarization.
5	Terminate the other waveguide run using a waveguide-to-coaxial transducer and a coaxial termination.
6	Measure and record the received power on the horizontal polarization. Record on a form similar to that given in Table A.
7	Switch the connection of the MSR to the waveguide run used for the vertical polarization.
8	Terminate the other waveguide run as in Step 5.
9	Measure the received power on the vertical polarization. Record as in Step 6.
	Requirement: The received power shall be at least 15 dB below the power recorded on the horizontal polarization.
	If the requirement is not met, ascertain that the antenna orientation and the axial ratio compensator adjustment have been properly performed.
10	Rotate the system combining network for minimum received power using the system combining network alignment tool.

CHART 4 (Contd)

STEP	PROCEDURE

TABLE A

RECEIVING FREQUENCY IN THE 4-GHz 6-GHz, OR 11-GHz BAND	MEASURE (dB)				COMPUTED (dB)
	V OR H (1)		V OR H (2)		CROSS-POLARIZATION DISCRIMINATION (1) — (2)
	V	H	V	H	
Upper 100 MHz V: MHz	✓	—	—	✓	
H: MHz	—	✓	✓	—	
Middle 100 MHz V: MHz	✓	—	—	✓	
H: MHz	—	✓	✓	—	
Lower 100 MHz V: MHz	✓	—	—	✓	
H: MHz	—	✓	✓	—	

Note: V = vertical; H = horizontal.

Caution: Only a small rotation of the system combining network is required.

11 Measure and record the received power. Record for permanent record on a form similar to that given in Table B. This measurement is the XPD discrimination H-V.

Requirement: The received power measured shall be at least 30 dB (4 or 6 GHz) or 25 dB (11 GHz) below the power measured on the horizontal polarization. If the requirement is not met, repeat Steps 1 through 11.

12 While securing and fastening the system combining network, observe the received signal power to verify that the proper adjustment is maintained.

B. Cross-Polarization Discrimination (V to H) and (H to V)

Note 1: The cross-polarization discrimination shall be measured at the low, middle, or upper ends of the frequency band or at as many frequencies for which permission to radiate can be obtained.

Note 2: The cross-polarization (H to V) has been determined in Step 11 for whichever fre-

TABLE B

ANTENNA ALIGNMENT DATA SHEET

Levels and Elevations

Final azimuth TM°_{01} level	dBm
Final elevation TM°_{01} level	dBm
Final TE°_{11} level measured	dBm
TE°_{11} level calculated	dBm

Cross-Polarization Discrimination (XPD)

FREQUENCIES				XPD
Upper (4100 to 4200)	V H	H V	MHz MHz	dB dB
Middle (3900 to 4000)	V H	H V	MHz MHz	dB dB
Lower (3700 to 3800)	V H	H V	MHz MHz	dB dB
Upper (6300 to 6400)	V H	H V	MHz MHz	dB dB
Middle (6100 to 6200)	V H	H V	MHz MHz	dB dB
Lower (5900 to 6000)	V H	H V	MHz MHz	dB dB
Upper (11,600 to 11,700)	V H	H V	MHz	dB
Middle (11,100 to 11,200)	V H	H V	MHz MHz	dB dB
Lower (10,700 to 10,800)	V H	H V	MHz MHz	dB dB

Unusual Occurrences

Miscellaneous Notes for Record

CHART 4 (Contd)

STEP	PROCEDURE
	quency was used for network alignment. The XPD (V to H) must be measured at that frequency and also measured for (V to H) and (H to V) for all other frequencies.
	C. XPD (V to H)
13	At the transmit station, connect the CW output signal of the WTS to the waveguide run used for the vertical polarization. Terminate the waveguide run used for the horizontal polarization. When making the connections, the RF output of the WTS must be turned off.
14	At the receive location, measure the power received on both polarizations. This is done by connecting the MSR to one waveguide run and measuring and recording the received power. The MSR is then connected to the other waveguide run and the received power measured and recorded. The waveguide run to which the MSR is not connected must be terminated. The difference in dB between the measured received powers is the cross-polarization discrimination (V to H).
	D. XPD (H to V)
15	At the transmit station, connect the CW output signal of the WTS to the waveguide run used for the horizontal polarization. Terminate the waveguide run used for the vertical polarization. When making the connections, the RF output of the WTS must be turned off.
16	Repeat Step 14.
	Note: The measured cross-polarization discrimination shall be 30 dB or better at all frequencies within the 4- and 6-GHz band. In the 11-GHz band, the cross-polarization discrimination shall be 25 dB or better.

CHART 5

HORN-REFLECTOR ANTENNA SYSTEM CROSS-POLARIZATION ADJUSTMENT

This procedure covers the adjustment of the cross-polarization performance of a complete antenna and waveguide system. In-service systems may use this procedure to adjust the cross-polarization.

APPARATUS:

As listed in Part 1.

STEP	PROCEDURE
	Note 1: A dual polarity antenna system may be equipped with networks for 4 GHz, 6 GHz, and 11 GHz or singly for one frequency band. For systems equipped with networks for one frequency band, follow the procedure of Steps 1 through 16, using the correct generator and receiver combination for the frequency in use. For systems equipped with additional networks for dual polarity operation at other bands, continue from Step 17 as directed.
	Note 2: The axial ratio compensator on the WC-281 waveguide is adjusted using the lowest frequency band for which both polarizations are used. After the alignment of the axial ratio compensator at 4 GHz, the alignment is repeated at 6 GHz, using the 4A clamp instead of the axial ratio compensator. The 11-GHz networks are visually aligned to the other networks and then rotated plus or minus 5 degrees for best results.
1	At the transmitting end, connect the appropriate signal generator to the network for that frequency band which is associated with the horizontal polarization.
2	At the receiving end, connect the appropriate receiver to the network associated with the vertical polarization. Loosen the eight waveguide bolts that fasten the top flange (slip) of the 29B transducer to the bottom flange of the WC-281 circular waveguide run and rotate the networks using the systems combining network tool for minimum received signal strength. Tighten the eight waveguide bolts at completion.
3	Connect the receiver to the network associated with the horizontal polarization. Measure the received signal strength at three frequencies and record these horizontal-to-horizontal values for later calculation.
	Note: The three frequencies used for cross-polarization discrimination measurements must be selected in the upper, middle, and lower 100-MHz segments of the 4-, 6-, and 11-GHz bands. When these frequencies are selected, verify that the test frequency will not interfere with any service carrying channels in other systems.
4	Connect the transmitter and receiver to the networks associated with vertical transmission and reception. Repeat the measurements (vertical-to-vertical received signal strength) and record the readings.

CHART 5 (Contd)

STEP	PROCEDURE
5	At the receiving end, connect the receiver to the network associated with the horizontal polarization.
6	Install the ED-50498-50 search tool, shown in Fig. 19, on the first 4-foot long or longer section of the waveguide above the transducer on the normally receiving antenna. If no section is 4 feet long or longer, install the search tool on the transmitting antenna waveguide if sufficient length of waveguide is available there. If neither end has a 4-foot long or longer section, follow the procedure in Chart 6.
7	Tighten the bolt on the search tool fingertight; then tighten it approximately one additional turn.

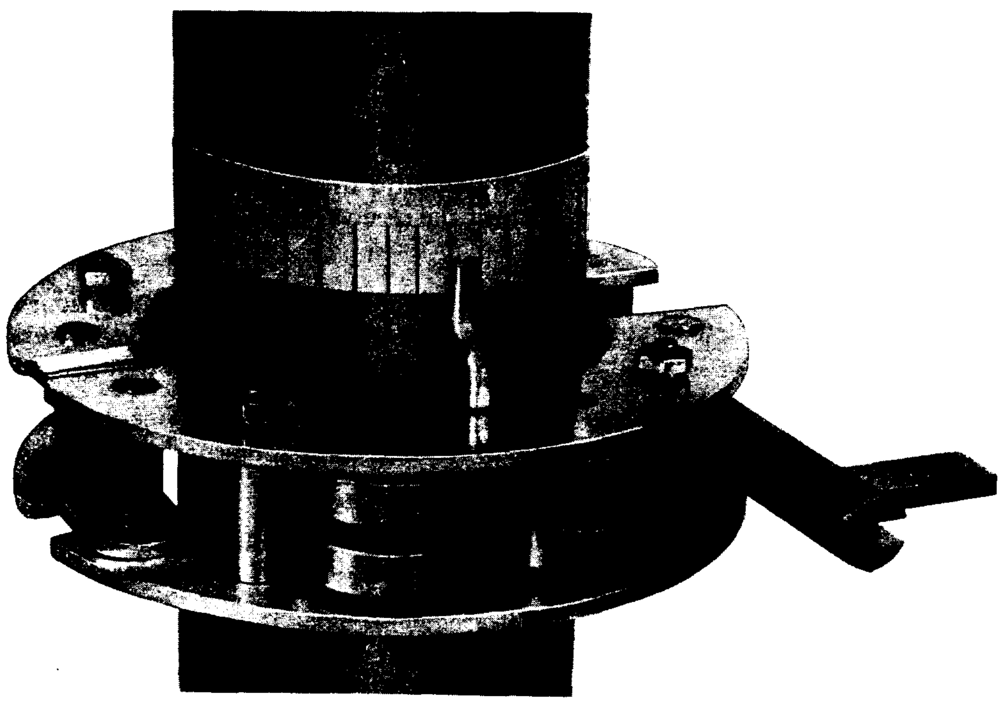

Fig. 19—ED-50498-50 Search Tool

CHART 5 (Contd)

STEP	PROCEDURE
8	Rotate the search tool while observing the received signal strength. There should be two dips in the signal strength for one full revolution. If there are more than two dips, the search tool is too tight. Loosen the bolt 1/4 turn and repeat the search for two dips.
9	Rotate the search tool to the minimum of each dip and mark the waveguide at the pointer indication for each.
10	At the transmitting end, connect the transmitter to the network associated with the horizontal polarization.
11	At the receiving end, connect the receiver to the network associated with the vertical polarization. Repeat Steps 8 and 9.
	Requirement: The two marks for each dip must be within 3/8 inch of each other. If they are not, one or both antennas are incorrectly aimed in azimuth.
12	Remove the search tool and install the ED-50499-50 adjustable axial ratio compensator on the waveguide section (Fig. 17). Locate the adjustable pressure bar of the compensator centrally on the two marks.
13	Tighten the compensator, adjusting the bolts equally, to obtain minimum horizontal-to-vertical received signal strength. Record this value.
14	At the transmitting end, connect the transmitter to the network associated with the vertical polarization. At the receiving end, connect the receiver to the network associated with the horizontal polarization.
15	Measure the vertical-to-horizontal received signal strength. Record this figure and the others previously taken on a form similar to that given in Table A and calculate the cross-polarization discrimination. Record for permanent record on a form similar to that given in Table B.
	Requirement: Cross-polarization discrimination (XPD) figures shall be 30 dB or greater for 4 and 6 GHz and 25 dB for 11 GHz. If not, readjust the compensator until the requirement is met.
	Note: Readjusting the compensator may degrade a very good cross-polarization figure. This is acceptable, provided that the requirement is finally met at all points.
16	If the system is equipped with only one frequency band, this completes Chart 5.
	When the requirement is met, remove the test apparatus and reassemble the system as shown on the office drawings. If additional frequency bands are used, proceed with Step 17.
17	Perform the measurements of XPD at each frequency band to determine if further corrective measures are indicated by failure to meet the requirement.

CHART 5 (Contd)

STEP	PROCEDURE
18	If the 6-GHz requirement is not met, additional XPD in the 6-GHz band may be acquired by use of the 4A clamp. Attach the 4A clamp to the 35A transducer corners (diagonally) in the center of the machined area near the 1407A network, with the small V notches of the clamp resting on the outside corners of the 35A transducer (Fig. 18A). ***Warning: Excessive clamping will cause permanent damage to the 35A transducer.***
19	Apply slight compression to the 35A by tightening the two cap screws on the clamp.
20	If the XPD decreases (increase in signal strength) remove the 4A clamp, attach it to the other diagonal of the 35A transducer, and repeat Step 19.
21	For those cases where the clamping of the diagonal does not increase XPD, reverse the brass bars and attach the clamp to the sidewalls of the transducer at the approximate center of the machined area (Fig. 18).
22	Apply slight compression to the 35A transducer with the 4A clamp. If the XPD decreases (increase in signal strength), remove the 4A clamp, rotate it 90 degrees, and attach it to the other sidewalls.
23	Apply compression to the 35A transducer with the 4A clamp for a minimum received signal strength (horizontal-to-vertical) and record the value.
24	At the transmitting end, connect the transmitter to the network associated with the vertical polarization. At the receiving end, connect the receiver to the network associated with the horizontal polarization and record the value of the received signal strength (vertical-to-horizontal).
25	When the −30 dB requirement is met, if there are no 11-GHz networks, reassemble the antenna system as shown in the office drawings. If 11-GHz networks are present, proceed with Step 26.
26	At the transmitting end, connect an 11-GHz transmitter to the network associated with the horizontal polarization. At the receiving end, connect an 11-GHz receiver to the network associated with the vertical polarization.
27	At the receiving tower, loosen the eight waveguide bolts which fasten the network to the bottom flange (slip) of the 34A transducer.
28	Rotate the networks for a minimum received signal strength. Measure and record the value (horizontal-to-vertical) at the three selected frequencies.
29	At the receiving end, connect the receiver to the network associated with horizontal polarization. Measure and record the received signal strength (horizontal-to-horizontal).

CHART 5 (Contd)

STEP	PROCEDURE
30	At the transmitting end, connect the transmitter to the network associated with the vertical polarization. At the receiving end, measure and record the received signal strength (vertical-to-horizontal).
31	At the receiving end, connect the receiver to the network associated with the vertical polarization. Measure and record the received signal strength (vertical-to-vertical).
32	At the conclusion of measurements, reassemble the antenna and waveguide systems as shown on the office drawings. ***Note:*** The requirement for XPD at 11 GHz is 25 dB.

CHART 6

CROSS-POLARIZATION ADJUSTMENT FOR HORN-REFLECTOR ANTENNA WITH SHORT WAVEGUIDE RUNS

APPARATUS:

As listed in Part 1.

STEP	PROCEDURE
1	Aim the antenna by following the procedure given in Chart 1. Connect the 33A or 43A transducer to the feedhorn and arrange the test apparatus for the TM$^{\circ}_{01}$ adjustment as the situation dictates.
2	Perform the procedure in Chart 3 and return to Step 3 of this chart if the requirements are not met.
3	Move one of the antennas slightly in azimuth and remeasure. Repeat until the XPD requirement is met, but do not move either antenna more than 0.1 degree.

CHART 7

SYSTEMS COMBINING NETWORK ALIGNMENT TOOL INSTALLATION

This chart covers the procedure for installing the systems combining network alignment tool which provides a means of obtaining precise alignment of networks. This tool eliminates damage to networks through possible abuse in orientation, and provides the best cross-polarization discrimination if precisely aligned.

The systems combining network alignment tool clamps to the tower slot angles and a flange joint in the main vertical network array. A hex turnbuckle (Fig. 20) is situated between the clamps to permit small rotational adjustment of the networks. The bottom flange joint of a 29B transducer is used for 4- and/or 6-GHz systems. For 11-GHz systems, the bottom flange joint of the 34A transducer is used. These flange joints are directly below the slip flange of the transducers which may be observed during alignment of the networks. The hex turnbuckle will permit the adjustment range of approximately four inches or 54 degrees.

APPARATUS:

As listed in Part 1.

STEP	PROCEDURE
1	Loosen the slip joint of the transducer and all network restrainers to permit free rotation of the networks. On the 29B transducer, the circular wave restrainer must be moved out of the way. Return the restrainer tube to cover the slip joint once it is loosened for lateral restraints during alignment of networks.
2	Align the networks to the approximate polarization by hand rotation of the flange joint in the main vertical array nearest the slip flange.
3	For 4- and/or 6-GHz systems, install the square clamp adjustment arm assembly on the bottom flange joint of the 29B transducer. For an 11-GHz system, install the circular clamp adjustment arm assembly on the bottom flange joint of the 34A transducer.
	Note: The arm of these assemblies should be to the right and between the open and closed positions.
	Warning:* *Excessive tightening of the hardware with tools will damage the waveguide.
4	Tighten the hardware evenly until the clamp is firmly secured to the flange joint.
5	Install the clamp assembly to the tower slot angle on the right side, at approximately the same level as the clamp adjustment arm assembly installed in Step 3. The bracket on the clamp assembly has three sets of holes to fit slot angles with 1-1/2, 3, or 3-1/2 inch legs.

CHART 7 (Contd)

STEP	PROCEDURE
6	Adjust the clamp assembly so that the bolts are flush with the slot angles. Ascertain that the hole in the horizontal arm of the bracket is 2 inches toward the center of the tower from the face of the slot angle. Securely tighten the clamping bolts.
7	Assemble the two eyebolts (Fig. 20) and the hex turnbuckle together.
8	Attach the hex turnbuckle assembly to the clamp assembly with the hardware furnished.
9	Adjust the length of the hex turnbuckle assembly until the eyebolt hole and the adjustment arm hole are aligned. Securely attach with the hardware.
10	Adjust the hex turnbuckle for optimum orientation. ***Note:*** Do not remove the systems combining network alignment tool until the slip joint of the transducer and all network restrainers are properly secured.

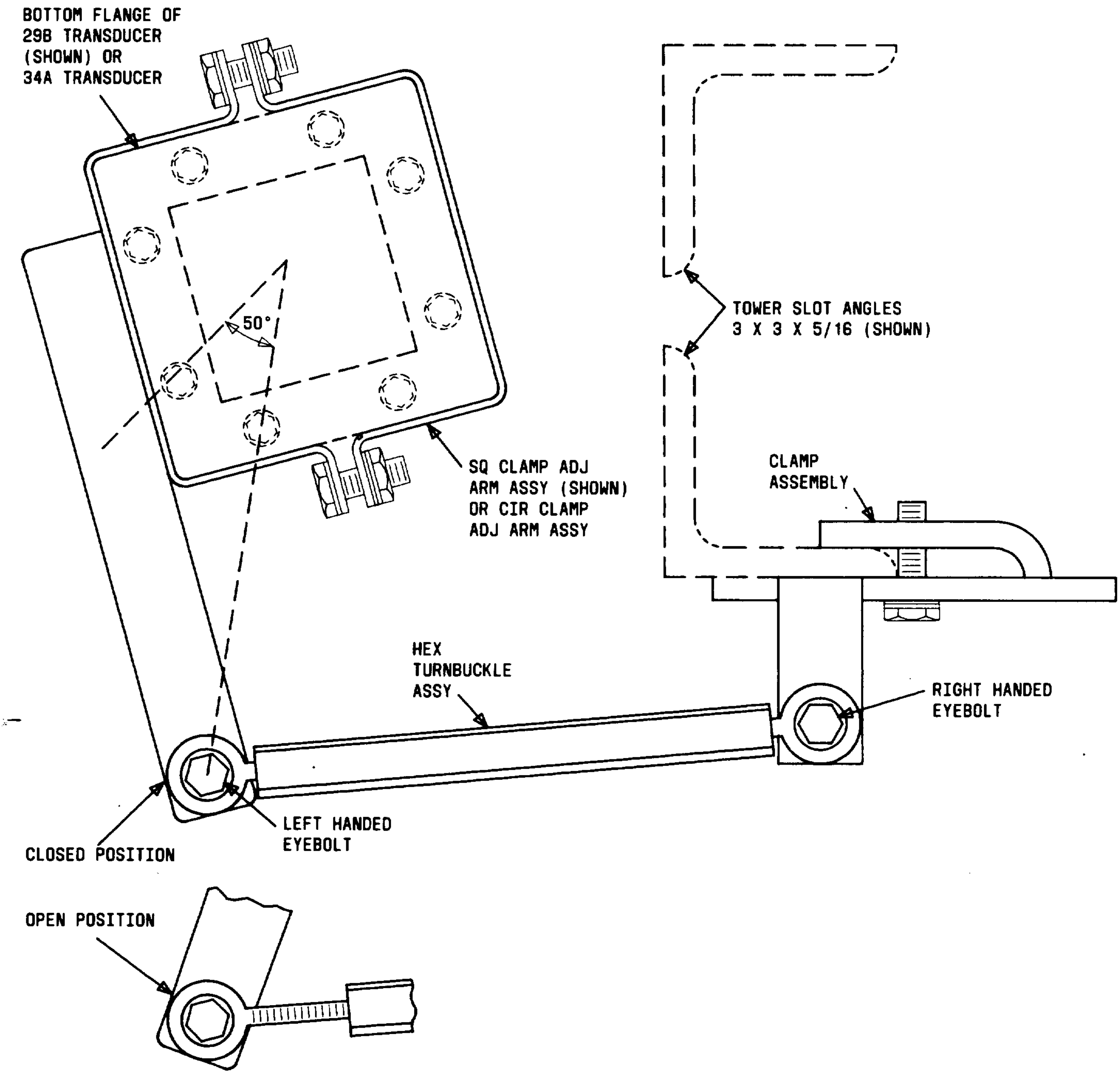

Fig. 20—Systems Combining Network Alignment Tool

5. CORRECTIVE PROCEDURES FOR TROUBLE INDICATIONS

A. Filling in of TM°_{01} Received Signal

5.01 If the TM°_{01} null is less than the requirement, a reflective path may be at fault. For this case, an increase in the null level may be introduced by rotation of the 33A or 43A transducers. This change is caused by waveguide misalignment which causes a conversion from TE°_{11} to TM°_{01}. The null depth variation does not have a significant influence on the position of the null. As such, its influence on antenna orientation accuracy is negligible. A change in frequency with the resulting phase change can also alter the resultant TM°_{01} level and may permit the null to develop. If all above attempts have failed, the less precise main beam antenna orientation method may be used.

B. Reflective Path

5.02 A reflection on the path results in two signals being received by the receiving antenna: one direct from the transmitting antenna and one from the direction of the reflecting surface. Typical reflecting surfaces are the earth, ponds, rooftops; etc., each of which will result in a signal arriving at an elevation angle different from that of the line of sight signal. With a vertically polarized transmitted signal, the main signal and the reflections will produce some TM°_{01} in the receiving antenna. The strength of each TM°_{01} component depends upon the strength of the received signal and the angle of arrival of each component with respect to the axis of the receiving antenna. If the antenna is aimed at the line-of-sight signal, the reflected signal will generate TM°_{01}. If the antenna is aimed at the reflection, the line-of-sight will produce TM°_{01}. If the antenna is aimed between the two, each produces TM°_{01} and the 33A or 43A transducer will respond to the sum of the two components. In extreme cases, no vertical null at all can be found; i.e., there is high TM°_{01} level no matter where an antenna is aimed. With a horizontally polarized signal on the other hand, the TM°_{01} produced by each component depends upon the azimuth component of its angle of arrival with respect to the axis of the receiving antenna. All reflections from the typical reflecting surfaces noted above arrive at the same azimuth position, resulting in an azimuth null of normal depth. Thus, a reflection on the path may result in a shallow vertical null and a normal horizontal null. (In a small minority of cases, a reflection in the horizontal plane may be present, caused by the wall of a building, a canyon or other large obstruction. This would tend to fill in a horizontal null and not affect a vertical null.)

5.03 The record of the path test, performed on the hop before the route was built, is a good source of information on the presence of reflections on the hop. Any reflection stronger than 20 dB down and more than 1/4 degree off the line-of-sight signal is suspect.

C. TE°_{11} Level Incorrect

5.04 If the measured TE°_{11} is more than 3 dB down from the calculated value, one or more antennas may not be aimed on the main TE°_{11} lobe. Reaim each antenna by scanning a wider section. If the TE°_{11} level does not increase to within 3 dB of the calculated value, the trouble is probably in the waveguide. Check for physical damage to the waveguide or flanges, or for water or ice in the waveguide. If the cause is not obvious, return-loss tests performed in accordance with Section 402-400-501 or 402-400-502 may locate a faulty waveguide section.

D. Insufficient Cross-Polarization Discrimination (XPD)

5.05 Cross-polarization discrimination is affected by literally everything that the signals encounter in their journey from the transmitting networks to the receiving networks. Some of the major causes of poor XPD are listed below, not necessarily in the order of importance.

(a) An antenna misaimed in azimuth will couple together vertically and horizontally polarized signals. If an axial ratio compensator (ARC) is applied to an antenna system to correct the vertical-to-horizontal coupling due to a misaimed antenna, the horizontal-to-vertical coupling will get worse, and vice versa; i.e., an ARC cannot compensate for the cross-polarization coupling due to a misaimed antenna. (This is the reason for the requirement in Step 11 of Chart 5.)

(b) Some pieces of circular flexible waveguide have a rather poor axial ratio; i.e., they are quite elliptical. The effect of the axial ratio of such a piece can be minimized by aligning it axially so that the axes of the ellipse coincide with those of the signal polarizations. This is accomplished in practice by rotating the flexible waveguide axially, with the flanges loose, for maximum XPD. The axial ratio of circular flexible waveguide can be sensitive to its configuration (i.e., bends) and the sensitivity varies from piece to piece. Out-of-limits XPD readings can often be improved markedly by moving the flexible waveguide slightly; if this occurs, the flexible waveguide should be replaced, because it cannot be expected to remain in the optimum configuration under the influence of the wind and the other environmental factors. The position of the end of the circular flexible waveguide within its flange clamp can also influence XPD.

Note: The KS-20104 flexible waveguide has been replaced by the bent rigid in new installations, where conditions permit it to be used.

(c) The alignment of the system combining networks is very critical, and it is very difficult to maintain while locking the networks into position. Good XPD cannot be obtained unless all networks are properly aligned, using the system combining network alignment tool.

(d) Damage to waveguide and foreign matter in the waveguide can result in poor XPD. Return-loss tests in accordance with Section 402-400-501 or 402-400-502 may indicate such causes.