

**TL-1 MICROWAVE RADIO
SYSTEM TESTS
GENERAL**

	CONTENTS	PAGE
1.	GENERAL	1
2.	INITIAL INSTALLATION	1
3.	NONDIVERSITY SYSTEMS	4
4.	DIVERSITY SYSTEMS	4
5.	USE OF TEST EQUIPMENT	4
6.	SUGGESTIONS FOR EASIER ALIGNMENT	4
7.	RECEIVED RF SIGNAL LEVEL	6
8.	CHART	6
	1—Procedures for Removing and Restoring Service	6

Since this is a general revision, arrows ordinarily used to indicate changes have been omitted. This reissue affects the Equipment Test List.

1.03 The J99296AA, List 1 modulator-preamplifier has been redesigned. The latest unit is designated J99296AA, List 3. The List 3 units may be installed without requiring any overall adjustments. The J99296AA, List 2 unit is rated "Manufacture Discontinued (MD)."

1.04 Tests and adjustments should be made at the time of initial installation and at the suggested test intervals shown in Section 409-001-011. If routine tests reveal trouble which cannot be cleared on the site, plug-in units can be replaced and faulty units may be sent to the Western Electric Company for alignment and adjustment.

1.05 Test equipment required is as follows:

2—J99262AA TL Test Sets

1—KS-14510 Volt-Ohm-Milliammeter (VOM)

1. GENERAL

1.01 This section and Section 409-303-501 describe the methods of making overall system tests and adjustments on TL-1 radio systems. These tests can be performed at the radio stations using portable test equipment normally available to TL-1 routes.

1.02 This section is reissued to include information for TL-1 systems that may now be equipped with either of the following:

- (a) The J99296AA-1, List 3 modulator-preamplifier unit with the J99296G-2 receiver IF and baseband unit
- (b) The J99296AA-1, List 3 modulator-preamplifier unit with the J99351E-1 IF amplifier unit and the J99351J-1 FM receiver unit.

2. INITIAL INSTALLATION

Caution: *Do not change the factory adjustment of the receiver beat-oscillator (BO) klystron tuning at this stage of the lineup in an attempt to increase the apparent signal strength. If both the BO tuning and antenna position become misaligned, it is extremely difficult to complete the lineup procedure. If the BO at one end of the hop should become misaligned, use transmission in the other direction to make an initial contact before attempting to readjust it.*

2.01 The TL-1 system consists of a number of equipment units which have been tested separately prior to an overall system lineup. Initial system lineup is accomplished by performing the following preliminary tests.

SECTION 409-303-500

(a) The towers and antennas, together with their associated waveguide runs to the radio equipment, are installed and inspected. Tower guy tensions should be correct prior to any antenna system alignment. Antennas and reflectors should be optically oriented to their computed azimuths and elevations.

(b) The transmitter-receiver bays and cabinets shall be tested as independent units with no waveguide or antenna connections as described in the section covering transmitter-receiver—performance requirements (801-415-180).

(c) The order-wire and alarm entrance link is adjusted in accordance with Section 409-310-502, omitting the following subsections:

- (1) Interrogation frequency adjustment
- (2) Alarm indicating circuit check
- (3) Alignment of the return VF transmission path.

2.02 The radio-frequency transmission for each hop in the system is adjusted and measured and the order-wire transmission is verified as follows.

(a) Maximize the received signal level for each hop by refining the antenna orientation adjustments at each end of the hop. Refer to the automatic gain control (AGC) meter to measure the received signal level. This will require good communication between the personnel on the tower adjusting the antenna or reflector and the personnel on the ground observing the AGC meter. Alignment procedures should be planned so that antenna orientation is first done at one end of the hop and then at the other end; simultaneous adjusting at both ends cannot be done without excessive confusion. If the optical alignment has been good, a received signal level sufficient for order-wire communications will frequently be obtained immediately, and the order wire can be used for coordinating operations at the two ends. If the optical alignment does not result in an initial received signal sufficient for order-wire communication, obtaining initial contact can be aided by modulating the distant transmitter with a 1000-Hz tone at -10 dBm into the transmitter IN jack and placing a 2B or 3A noise meter at the receiver output and listening

with the monitoring earphone. The high gain of the noise meter, its selectivity, and the selectivity of the human ear in detecting 1000-Hz permit detecting a received signal much lower than is indicated on the AGC meter. The antenna can then be oriented to obtain the clear 1000-Hz tone. To do this, it is necessary to disable the squelch circuit temporarily by turning the SQUELCH control fully counterclockwise. (This affects the AGC meter calibration; therefore, the squelch should be readjusted to its proper level after the initial antenna orientation has resulted in contact between the two stations.) After contact has been established with the aid of the 1000-Hz tone, it should be removed so that the order wire can be used; the AGC meter should then be used for indication of the received signal level.

(b) Having established initial radio contacts, the antenna orientation at each end in turn should be refined by swinging the antenna or reflector in azimuth on several elevations differing by approximately one 3-dB beam width in angle so that it will be clear that the orientation finally selected is the major lobe. Before the final adjustment of the antenna or reflector is made, a check should be made to determine that the peak chosen is on the major lobe. When the point of making final refinements on the antenna adjustment is reached, the peak of the received signal, as indicated on the AGC meter, may be broad. The peak gain antenna setting can be selected by counting turns on the antenna-adjusting mechanism between points where the AGC indication is down 30 (600 scale) for maximum; then setting the antenna-adjusting mechanism midway between these extremes. A final trimming technique which may be used on cross-polarized radio hops is described as follows. After maximizing the received signal level in the manner given above, connect one receiver to the waveguide run of opposite polarization. Make small adjustments of the antenna and/or reflector alignment to obtain a minimum or dip in the received signal. Finally, reconnect the receiver to the proper waveguide run to verify that the received signal is unchanged from the maximum obtained previously.

(c) Each antenna position is optimized, using one of the above procedures, by reference to received signal only. For an east-west pair, east antenna is adjusted by reference to signal

from west after which west antenna is adjusted by reference to signal from east, etc., until the maximum signal is attained. When this is completed, both antennas will be properly adjusted for transmission as well as reception. This procedure is carried out with the aid of the section for antenna and reflector adjustments and Section 409-306-503 for measurement of the received signal strength.

(d) Once both antenna assemblies are aligned for maximum received signal strength, recheck the transmitter frequency at each location and verify that transmitter power is maximized as described in Section 409-304-501.

(e) Retouch the factory adjustment of receiver klystron tuning as given in Section 409-306-502. Do this at each end of the hop and follow Section 409-306-503 calibration procedure to measure the received signal level. **Record this initial lineup value and the AGC indication for future reference.**

(f) Calculate the nominal received signal level by subtracting the indication for the *previous* transmitter of transmitter power output (as indicated on the lower meter of the control panel with the switch in the RF PWR position) from the measured received signal level.

Example: Suppose the measured received signal level is -33 dBm and the lower meter on the control panel for the previous transmitter indicates $+1.5$ dB with the switch in the RF PWR position, then the nominal received signal level is $-33 - (+1.5) = -34.5$ dBm.

(g) Compare the nominal received signal level with the calculated received signal level for this particular hop, which will have taken account of the particular path and antenna-waveguide configurations. Note that the received signal level is measured with respect to the 1307 bandpass filter preceding the modulator and the correction for the transmitter power output includes the effect of the 15A directional coupler, 1B isolator, and 90-degree bend at the transmitter. Therefore, in adding the waveguide component losses to obtain the calculated received signal for comparison with the nominal received signal level, do not include the loss of the 1307 bandpass filter, the 15A directional coupler, the 1B isolator, or the 90-degree bend.

(h) With knowledge of the equipment arrangements at both radio stations, lengths of flexible waveguide, gains of the preceding transmitting antenna and local receiving antenna, and the path loss, the power level arriving at the input of the local receiver may be computed. Adding the gain stamped on the modulator-preamplifier gives the received signal level at the receiver IF and baseband input. To determine the approximate gain of the modulator-preamplifier for systems equipped with an early List 3 modulator-preamplifier, subtract 9.0 from the conversion factor stamped on the unit.

Requirement: The received signal level shall be within 2 dB of the calculated level.

Note 1: If this requirement is not met, an investigation should be made to find the source of excess attenuation.

Note 2: Early List 3 versions are those List 3 modulator-preamplifiers which are stamped with a conversion factor. Later List 3 versions are stamped with a conversion gain.

Note 3: Local atmospheric conditions may cause fading. The received signal level measurement should not be made during fading periods.

(i) Since the instruments used to measure the received signal level are not highly accurate, it can be expected that the results will only approximate the calculated levels. If there is reason to believe that the received signal is not what it should be, an investigation should be made to find the source of error.

(j) If not previously done, check out the order-wire connection by means of voice communication between ends of the hop under test.

2.03 After completing the above for each hop, perform the following tests and adjustments.

(a) Check initial calibration and alignment of the net loss measurement and adjustment in order-wire channel in accordance with Section 409-303-501.

SECTION 409-303-500

- (b) Check the alarm indicating circuit at the alarm control panel in accordance with Section 409-310-502.
- (c) Verify the alarm indications at the control circuit in accordance with Section 409-310-501.
- (d) Check initial calibration of the trouble location by measurement of interrogating tones in accordance with Section 409-303-501.
- (e) Check gain-frequency measurements in accordance with Section 409-303-501.
- (f) Check noise measurement in accordance with Section 409-303-501.
- (g) Check the noise-loading characteristics, in accordance with Section 409-303-503, of systems that have been modified as indicated in 1.02 of this section.
- (h) Check the envelope delay and linearity of a radio hop, in accordance with Section 409-303-504, of systems that have been modified as indicated in 1.02 of this section.

2.04 This completes the initial installation lineup procedure.

3. NONDIVERSITY SYSTEMS

In Service

3.01 Certain of the tests and adjustments in Section 409-303-501 may be performed in service. These tests and adjustments should be coordinated with the control center of the system to ensure against inadvertent disruption of service.

Out of Service

3.02 All of the tests and adjustments in Section 409-303-501 may be performed out of service. It is necessary to secure a release from the control center to remove the system from service.

4. DIVERSITY SYSTEMS

4.01 When making tests on a system in service, the particular hop under test must be isolated before making any adjustments. In order to maintain service over the other leg of the diversity pair, the diversity switch must be locked on the

side *not* under test. This requires that the diversity switch at the receiving end of the hop be manually operated. See Chart 1 for detailed instructions.

5. USE OF TEST EQUIPMENT

5.01 Refer to Section 104-440-300 for operating instructions for the J99262AA TL test set.

5.02 When using the VOM, care should be exercised that this instrument is used in the horizontal position only. If the bearings are even slightly worn, there may be a difference in the voltage indications taken in the vertical and horizontal positions. Since the VOM is tested in the horizontal position, it is advisable that it always be used in this position so that indications will be uniform.

5.03 When using the meter unit, care should be exercised that the meter zero has been adjusted in the same place in which the meter unit will be used the majority of the time.

6. SUGGESTIONS FOR EASIER ALIGNMENT

6.01 To facilitate alignment procedures, a remote meter for observing AGC voltages can be provided for a technician on the tower or ground. This can provide better coordination for adjusting the antenna system. A typical arrangement would consist of a 50- or 60-microampere meter connected through an adjustable 200k-ohm rheostat to the AGC(+) and AGC(-) jacks or ground on the receiver IF and baseband unit. This arrangement is shown in Fig. 1. In addition, Fig. 1 specifies the electrical connections necessary for TL-1 systems that have equipment other than the J99296G receiver IF and baseband unit. For a received signal large enough to be in the 40-dB regulating range of the receiver, the voltage to ground of the AGC jack on the J99296G receiver IF and baseband unit is approximately -3 to -5 volts. If the TL-1 system has other equipment than the J99296G receiver IF and baseband unit, for example the J99262G receiver unit, the voltage to ground of the AGC jack is approximately -6 volts. If a 1000-ohm meter is used and the rheostat can be set to zero without placing the meter off scale, the meter sensitivity (change of indication for a 1-dB change of signal power) is approximately 12 times the sensitivity of the AGC meter. The received signal increases with better antenna alignment and, as the rheostat is adjusted to keep the meter on scale, the sensitivity decreases. The 60-microampere scale of the VOM

can also be used, resulting in a sensitivity approximately twice that of the meter unit. A low-input signal below -80 dBm is below the receiver regulating range and results in approximately zero voltage to ground at the AGC jack. The diode, wired as shown in Fig. 1, protects the meter against a large reverse current if the signal is lost during alignment. A change in such low signal gives no meter indication. In this case, refer to 6.02.

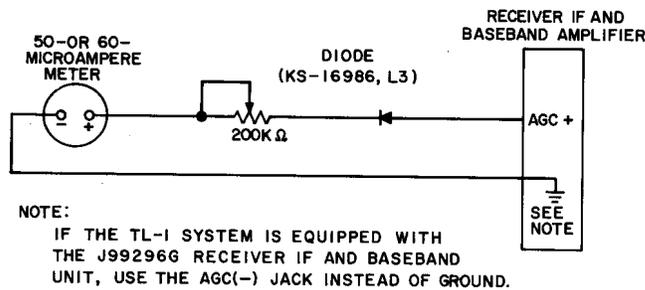


Fig. 1—Circuit for Remotely Measuring the Relative Received Signal Strength—Schematic Diagram

6.02 If visual alignment does not produce a signal in the regulating range, the VOM, set on the 3-volt range, should be connected to the LIM IN jacks of the J99296G receiver IF and baseband unit observing the proper polarity. An indication between 0 and 0.6 volt shows that the input signal is below the receiver regulating range. This indication permits finding the signal and improving the alignment up to 0.6 to 0.8 volt when the AGC holds the LIM IN voltage constant. Final alignment can be completed using the meter unit or remote meter.

6.03 Two other procedures for antenna alignment are described in the following paragraphs. These procedures are useful where either the J99296G receiver IF and baseband unit, the J99262G receiver unit, or the J99351J FM receiver unit (a unit of a new IF amplifier and FM receiver arrangement) is provided. The first of the two procedures uses a 1000-Hz tone transmitted over the radio channel to the receiver. The receiving antenna is then oriented to produce the best reception of the tone. The second method utilizes the transmission of an unmodulated RF carrier to the receiver. The receiving antenna is then oriented to produce the least noise.

6.04 In the first of the two methods, a 1000-Hz tone at -10 dBm is connected into the transmitter BB IN jack at the far repeater or station. A 2B or 3A noise measuring set is connected to the local RCVR OUT jack of the J99296G unit (or the J99262G unit or the J99351J unit). The high gain of the noise set, its selectivity, and the selectivity of the human ear to 1000-Hz permits detection of a received signal considerably below the regulating range of the receiver. The antenna can then be oriented to obtain the clear 1000-Hz tone as observed on a monitoring earphone connected to the noise set output. The squelch circuit must be disabled for this measurement. After contact has been established with the aid of the 1000-Hz tone, the squelch circuit should be enabled and the tone removed when final alignment can be completed. Final alignment may be completed by using the AGC meter indication. Where either the J99296G receiver IF-to-baseband unit or the J99262G receiver unit is provided, the remote meter circuit or VOM arrangement described in 6.01 and 6.02 may be used. Where the new IF amplifier and FM receiver arrangement is provided, either the AGC meter indication or the second method, described in 6.05, may be used for final antenna alignment.

6.05 The second of the two methods makes use of a 37B transmission measuring set (TMS) connected to the RCVR OUT jack of either the J99262G, J99296G, or J99351J unit. An unmodulated RF carrier is transmitted from the far repeater or station to the local receiver. With the 37B TMS tuned to 4 MHz, the receiving antenna is oriented to produce minimum noise as indicated on the 37B TMS. Due to the action of the FM receiver, the baseband noise (which is greatest at high frequencies) decreases as the received signal strength increases. This method is more sensitive to changes in received signal strength, primarily because the change in noise (as indicated on the 37B TMS) is greater than the change in the AGC meter indication for a corresponding change in received signal strength. The squelch circuit must be disabled when using this method. As the antenna alignment is refined and the received signal strength increases, the noise at the RCVR OUT jacks will diminish. In order to further refine the alignment, loss to the received signal can be introduced by operating the local waveguide switch on the waveguides that are equipped with a switch to partially short-circuit the waveguide. The resulting reduction in received signal strength causes an increase in noise at the

SECTION 409-303-500

RCVR OUT jack and further refinement of the antenna alignment can be made. The noise power at the RCVR OUT jacks, as indicated on the 37B TMS, should be maintained at approximately -85 dBm to maintain sensitivity to changes in received signal strength.

7. RECEIVED RF SIGNAL LEVEL

7.01 After initial installation and a period of normal operation, the received signal level may indicate below normal on the AGC meter. This may be caused by a low output of the transmitter, by a fade in the radio path, or by misalignment of the antenna system (antennas, reflectors, towers, waveguide runs, and feed horns). The output power of the transmitter can be checked by monitoring the RF power with the meter unit. Fades last from a few seconds to the length of time required for a heavy rainstorm, but the received signal returns to normal after the fade. If the received signals at each end of the path are

appreciable less than normal by the same amount, the fault is probably in the common transmitter and receiver path and a check of the signal path (antennas, reflectors, towers, waveguide runs, and feed horns) should be made. A received signal that is less than normal in only one receiver will probably be traced to a defective or faulty receiver modulator-preamplifier or IF and baseband unit.

Note 1: Since the combination of antenna gains and path loss results in approximately 1 dB more received signal at 11.7 GHz than at 10.7 GHz, calculated signals should be adjusted depending on the carrier frequency.

Note 2: The indication of the AGC meter is only an approximation of incoming RF carrier level because of its sensitivity to temperature variations.

8. CHART

CHART 1

PROCEDURES FOR REMOVING AND RESTORING SERVICE

This chart contains the recommended procedures for removing and restoring service on a TL-1 radio channel. The necessity for this action and the proper procedures to be followed must be positively established prior to any action that affects service.

STEP

PROCEDURE

Removing Service—Nondiversity System

- 1 Once the necessity for removing service from a receiver on a nondiversity channel has been established and permission obtained, the alarm and control center need only be informed of the time and duration of the service interruption and then to proceed with the maintenance or test procedures.

Removing Service—Diversity System

- 2 Secure the necessary permission and inform the alarm and control center of the time and duration of the receiver down time.
- 3 Check with the alarm and control center that no alarm conditions exist. If none exist, proceed directly to Step 5.

CHART 1 (Cont)

STEP	PROCEDURE
4	<p data-bbox="407 449 1549 512">If an alarm does exist, measure the dc voltage on the PIL MON LEV (pilot-tone monitor level) jacks for each channel in turn with the VOM.</p> <p data-bbox="407 543 1549 606">Note: The PIL MON LEV jacks for the regular channel are accessible on the diversity switch panel behind the duct cover.</p> <p data-bbox="407 638 1057 669">Requirement: The VOM indicates -5 to -10 volts.</p> <p data-bbox="407 701 1549 764">Note 1: If the requirements is met, the pilot tone is present; if the requirement is not met (-3 volts or less indicated on the VOM), the pilot tone is absent.</p> <p data-bbox="407 795 1166 827">Note 2: The diversity system alarm conditions are as follows:</p> <ul style="list-style-type: none"><li data-bbox="418 858 1036 890">(a) Pilot tone present on both channels—no alarm<li data-bbox="418 921 1549 984">(b) Pilot tone absent on both channels—no diversity alarm (but a major alarm due to total absence of pilot tone)<li data-bbox="418 1016 1344 1047">(c) Pilot tone present on one channel, absent on the other—diversity alarm <p data-bbox="407 1079 1252 1110">Caution: <i>Do not proceed until the alarm condition is resolved.</i></p>
5	<p data-bbox="407 1142 1549 1205">Determine the active channel by measuring with the VOM (use 3-Vdc scale) from the K4 jack to ground at the diversity switch panel.</p> <p data-bbox="407 1236 1549 1299">Note: The presence of approximately -3 Vdc indicates that the diversity channel is active; zero volt indicates that the regular channel is active.</p>
6	<p data-bbox="407 1331 1549 1457">To determine that the transmission on the channel which will carry the service is stable and that no fading is apparent, set the selector switch to AGC. Then, reference to Fig. 2, 3, 4, and 5 will indicate the approximate received signal level based on the AGC indication obtained for the channel being measured.</p>
7	<p data-bbox="407 1488 1549 1551">Once it is determined that the transmission conditions are suitable, operate the MAN switch from the AUTO position to the channel which is to remain active (REG or DIV).</p>
8	<p data-bbox="407 1583 1549 1646">If the transmitter is equipped with a J99302BF disconnect unit, proceed directly to Step 11.</p>
9	<p data-bbox="407 1709 1386 1740">Remove the patch cord at the BB IN jack on the transmitter baseband amplifier.</p> <p data-bbox="407 1803 1549 1900">Note: Whenever the patch cord to a transmitter baseband amplifier BB IN jack is removed, a level rise of approximately 3.5 dB occurs on the adjacent channel of the diversity pair. To restore the signal to the proper level, perform Step 10.</p>

CHART 1 (Cont)

STEP

PROCEDURE

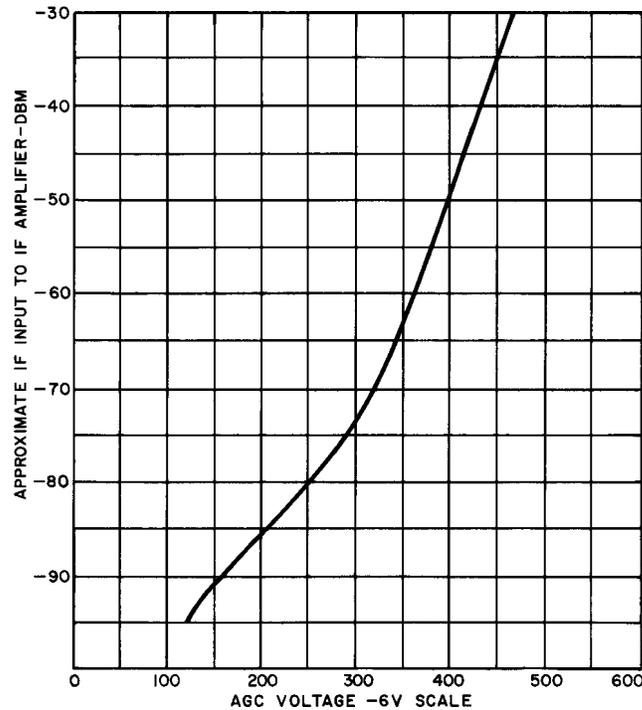


Fig. 2—Typical TL-1 Receiver AGC Characteristics

- 10 Attach the 75-ohm termination that is provided with the TL test set to the end of the patch cord after removal from the BB IN jack.

Note: The transmitter and receiver are now removed from service. The remaining steps apply only to systems that have transmitters equipped with a J99302BF disconnect unit.

- 11 On the XMTR DISC ATTEN unit, operate rotary switch S1 to DISC.
- 12 Operate the ATTEN rotary switch counterclockwise to MAX.
- 13 Remove the patch cord between XMTR DISC ATTEN jack J2 and the XMTR CONT jack BB IN.

Caution: Do not remove the connection to XMTR DISC ATTEN jack J1 since this will introduce hits on the system.

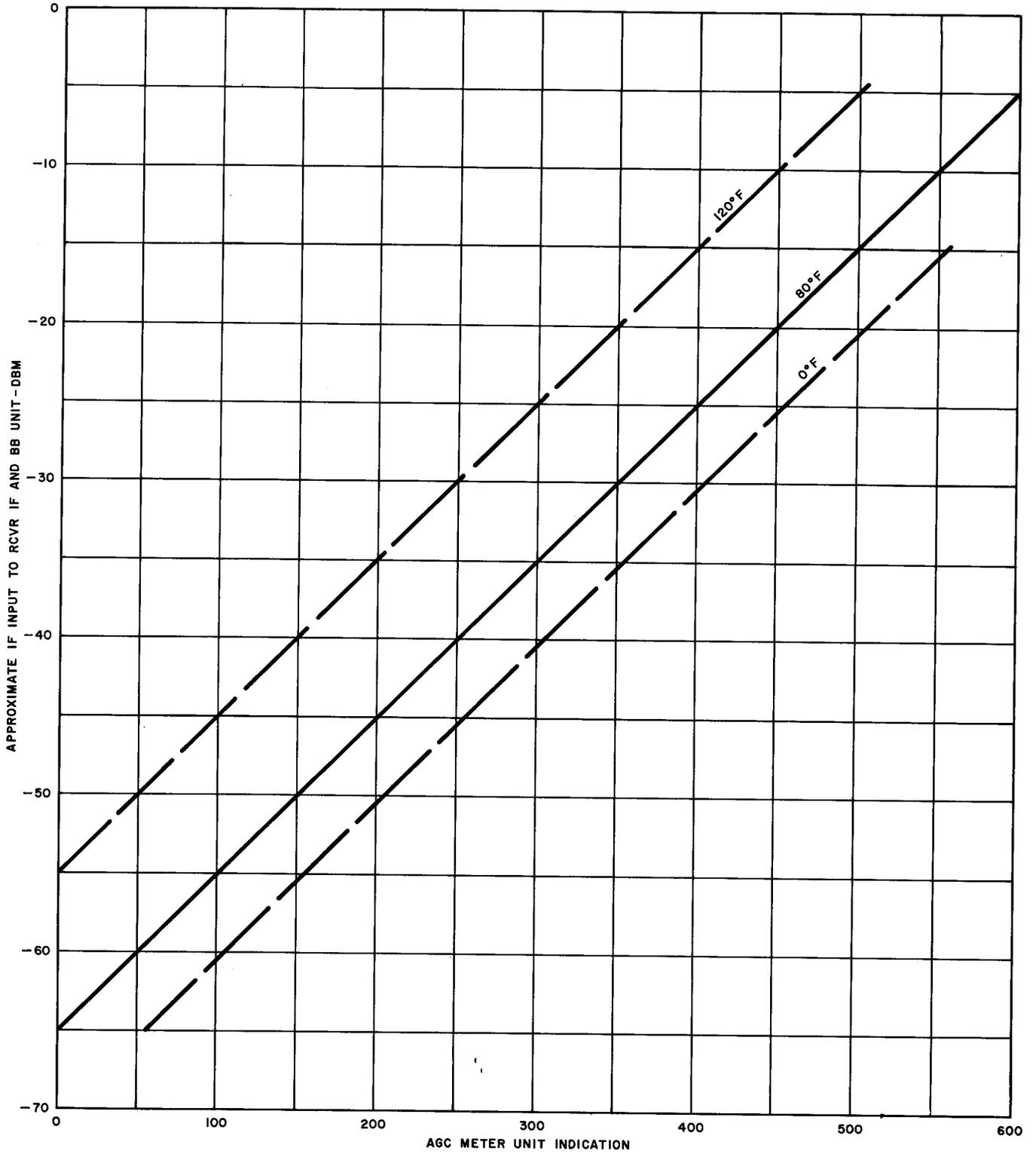


Fig. 3—Receiver AGC Characteristics—all J99296G-2 Units Prior to List 3, H Units

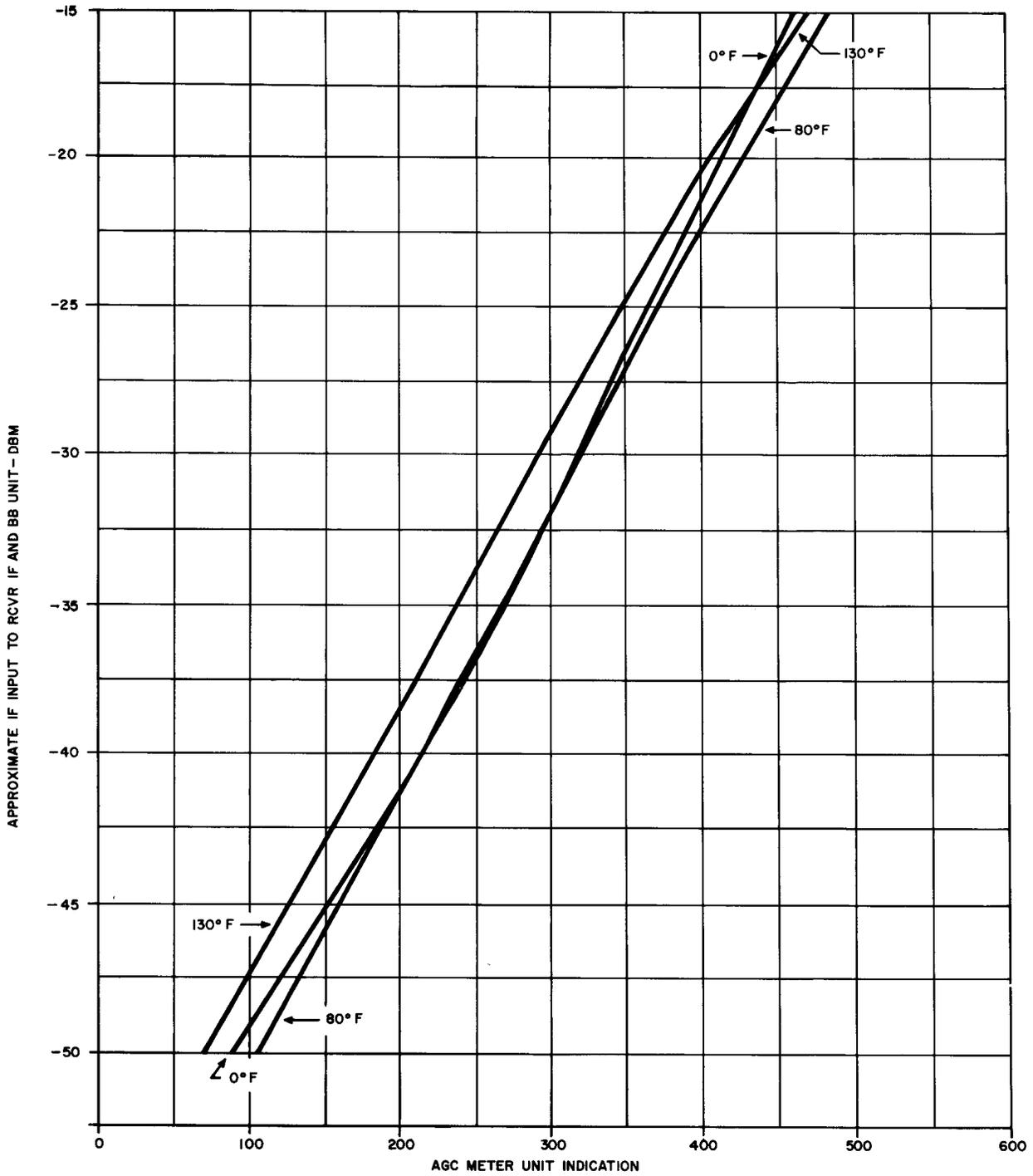


Fig. 4—Receiver AGC Characteristics—J99296G-2, List 3, H Units

CHART 1 (Cont)

STEP	PROCEDURE
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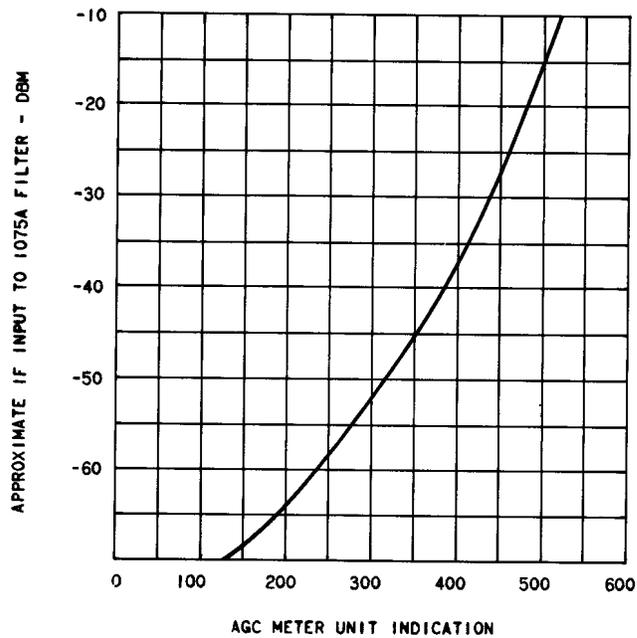


Fig. 5—Receiver AGC Characteristics—J99351E Unit

Restoring Service—Nondiversity System

- 14 When restoring service on a nondiversity system, be certain that all connections are made. Before restoring service, contact the alarm and control center for verification of service continuity and assurance that no alarms exist.

Restoring Service—Diversity System

- 15 When restoring service on a diversity system, be certain that all connections are in place and notify the alarm and control center that the units are being restored to service.
- 16 If the system has a transmitter that is equipped with a J99302BF disconnect unit, proceed directly to Step 22.
- 17 Detach the 75-ohm termination from the patch cord.
- 18 Reconnect the patch cord to the BB IN jack.

CHART 1 (Cont)

STEP	PROCEDURE
19	On the diversity switch panel, operate the MAN switch to the AUTO position.
20	On the radio bay, check that the waveguide switch is in the ON position.
21	Verify, with the alarm and control center, that service continuity is established and that no alarm exist. <i>Note:</i> The transmitter and receiver are now restored to service. The remaining steps apply only to systems that have transmitters equipped with a J99302BF disconnect unit.
28	Reconnect the patch cord between XMTR DISC ATTEN jack J2 and XMTR CONT jack BB IN.
23	Operate the ATTEN rotary switch clockwise to the NORM position.
24	Operate rotary switch S1 to the NORM position.
25	On the diversity switch panel, operate the MAN switch to the AUTO position.
26	On the radio bay, check that the waveguide switch is in the ON position.
27	Verify with the alarm and control center that service continuity is established and that no alarms exist.
