25B AND 25BR VOICEBAND GAIN AND DELAY SETS

(J94025B AND J94025BR)

DESCRIPTION, OPERATION, AND MAINTENANCE

CONTENTS PAGE

1. GENERAL

1.01 This section covers the description, operation, and maintenance of the 25B and 25BR voiceband gain and delay measuring sets (J94025B and J94025BR), hereafter referred to as the 25B and the 25BR sets.

1.02 This section is reissued to clarify test procedure of the 25B and 25BR voiceband gain and delay sets and to correct text and schematic diagram errors. Because of extensive changes, arrows have been omitted. This reissue does not affect the Equipment Test List.

1.03 The 25B set is portable, and the 25BR set is arranged for rack mounting. These sets have similar electrical specifications; therefore, information contained in this section will pertain to both sets unless specified otherwise.

1.04 The 25B and 25BR sets replace the 25A voiceband gain and delay measuring set (J94025A). The 25B sets are compatible with the 25A set and can be used interchangeably, unless recorder measurements are required (only the 25B sets provide recorder outputs).

2. GENERAL DESCRIPTION AND OPERATION

PURPOSE OF INSTRUMENT

2.01 The 25B and 25BR sets provide a means for measuring the envelope delay distortion and loss-frequency characteristics of transmission lines, networks, and equipment components having a characteristic impedance of either 600 or 900 ohms. These sets permit measurements in the 300- to 3500-Hz range of frequencies without the use of additional test equipment. If an external oscillator is provided, the frequency range may be extended to 25 kHz. An external frequency counter can also be used if more precise frequency measurements are required.

2.02 Gain, delay, and frequency are presented on single-scale meters for point-by-point measurements. Outputs of the measured data are also provided at separate jacks at the rear of the 25B set and on the front panel of the 25BR set for making continuous recordings of delay versus frequency and/or received level versus frequency with the use of an external X-Y recorder or with an oscilloscope and camera.

2.03 For circuits having 2600-Hz single-frequency signaling facilities, an automatic switching arrangement is provided for skipping the oscillator test frequency beyond 2600 Hz when sweeping through this region. A manual switching arrangement is also provided for removing the transmitted signal from test circuits having signaling frequencies other than 2600 Hz. Without these provisions, operation of the signaling system can occur and cause loss (dropping) of the test connection if the test signal has the same frequency as the single-frequency signaling system.

2.04 ***25B Set Only:*** The List 1 set (see Fig. 1) is a portable set, but with the addition of the List 2 mounting bracket, it can be mounted in a 23-inch rack. Multipled jacks and binding posts are provided on the front panel for connecting to the transmitting and receiving lines. The 309-type jacks for each line are arranged to receive a twin plug (353A type) as well as single plugs. Multipled dial jacks are also provided for connecting a dial or telephone set to the test lines to establish connections. Holding networks are provided in the set, and a switching arrangement permits the interchange of the sending and receiving test lines without losing the test connection. Power and line receptacles are also accessible through a door at the rear of the set for use in connecting to the set when it is used with the List 2 mounting bracket.

2.05 ***25BR Set Only:*** The 25BR set (see Fig. 2) is arranged to be rack mounted. With available brackets (ED-99987-50), it can be mounted in any rack 19 inches or larger. The 25BR set does not have dialing and holding features or facilities for interchanging the transmitting and

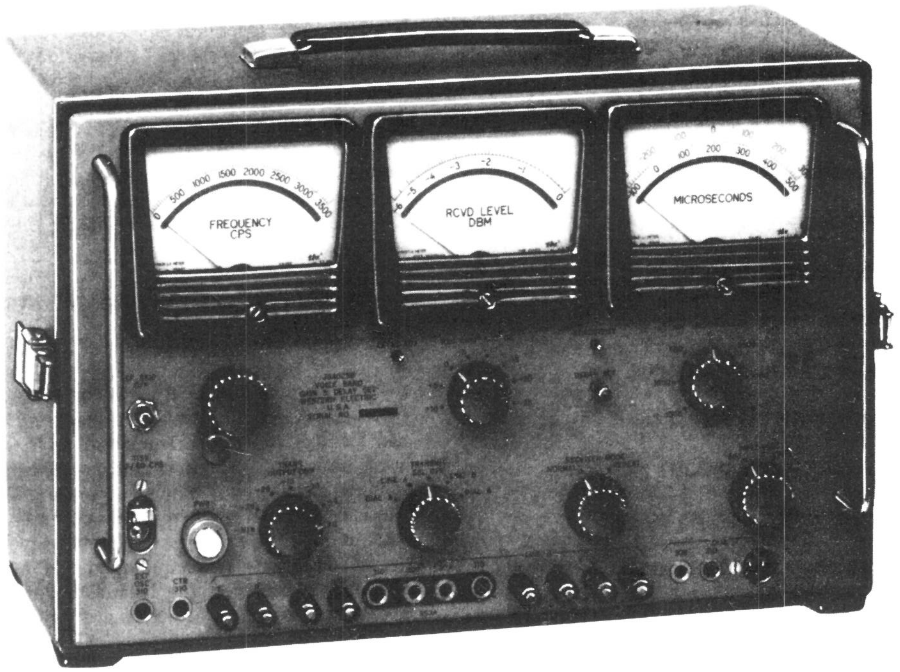

Fig. 1—25B Portable Set

receiving lines. Connectors are provided at the rear of this set for connecting power lines and the transmitting and receiving lines.

GENERAL OPERATION

2.06 Measurements may be made on either a straightaway (one-way) or loop basis. Loop measurements require only one 25-type set operating in the ***normal*** mode and a 4-wire layout. For straightaway measurements, two sets and a return voice-frequency channel are required in addition to the circuit under test.

2.07 The loop method of measurement is frequently used when delay measurements are made; the loop method is also used whenever the maximum possible accuracy of delay value is not required. Whenever measurements are made between the 4-wire terminals of a circuit, the measured loop should consist of the two directions of transmission of the ***same*** circuit. The measured value is then divided by 2 to obtain the circuit delay. The loop method is not recommended when precise delay information on a circuit is required even if the two circuits looped together seem identical in facilities and equipment. The loop method is not recommended because the total measured delay of the loop divided by 2 will usually give only an approximation of the actual delay for each direction.

2.08 Transmission loss- or gain-frequency measurements can be made in several ways:

(a) By using a 25B or 25BR set at both transmitting and receiving ends

(b) By performing a loop measurement using a single 25B or 25BR set at one end

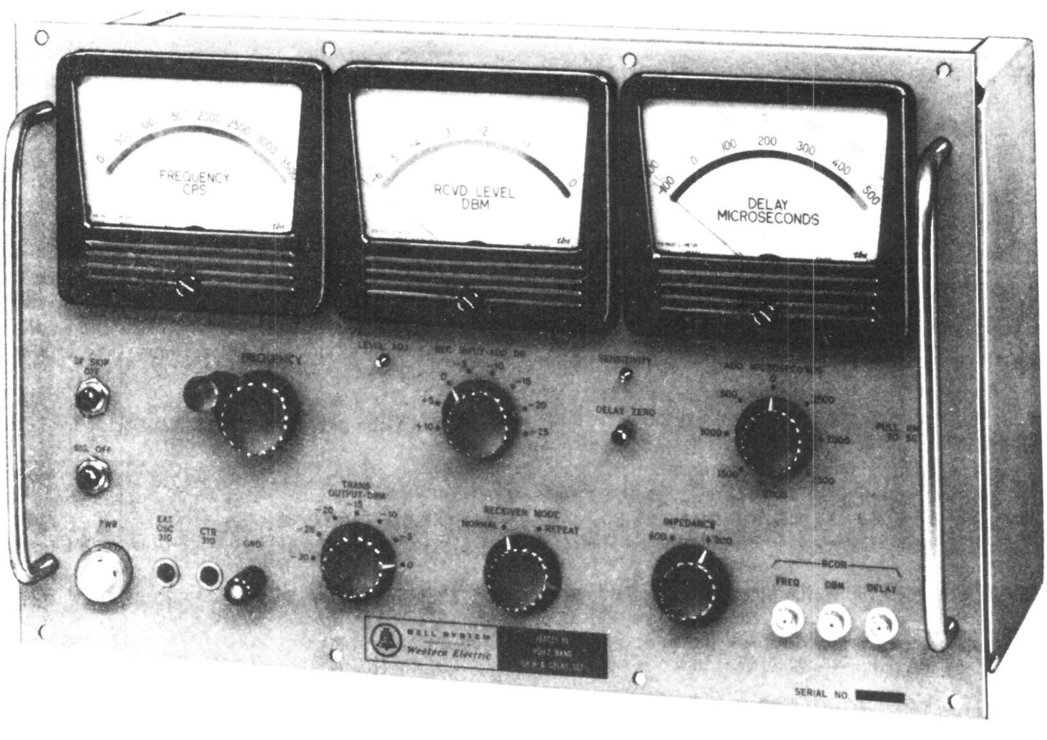

Fig. 2—25BR Rack-mounted Set

(c) By using a 25B or 25BR set as an oscillator at the transmitting end and a 23A transmission measuring set (J94023A) or equivalent at the receiving end

(d) By using a standard milliwatt supply or other suitable oscillator at the transmitting end and a 25B or 25BR set at the receiving end.

The 25B or 25BR set receiver response is flat within 0.1 dB over the 300- to 3500-Hz band of frequencies and has an accuracy of calibration within 0.2 dB at 1000 Hz. The transmitter output, which can be adjusted to an exact value, is also flat within 0.1 dB over the 300- to 3500-Hz band.

2.09 In either a loop or a straightaway (one-way) measurement, the transmitted test signal consists of a double-sideband amplitude-modulated carrier, the frequency of which may be manually varied over the band. The modulating signal is an 83-1/3 Hz sine wave.

2.10 In straightaway measurements, the far-end (or receiving) 25B or 25BR set is operated in the ***repeat*** mode. In this mode, the set recovers the 83-1/3 Hz signal and remodulates this recovered signal on a single-frequency carrier (usually 1800 Hz) and supplies it over the return path to the originating 25B or 25BR set. Because this return carrier frequency (1800 Hz) is not changed during the test, the envelope delay distortion measurement is independent of the delay characteristics of the return path facilities.

2.11 Frequency, loss or gain, and envelope delay distortion information are obtained from the three meters on the face panel. Proportional outputs of the measured data are also provided at separate jacks for making continuous recordings of delay versus frequency and/or received level versus frequency with the use of an external X-Y recorder or with an oscilloscope and camera.

2.12 Envelope delay distortion is indicated on a relative basis with reference to some arbitrary midband frequency. An 1800-Hz or a 2000-Hz frequency is frequently used as a delay reference.

2.13 During straightaway tests with the near-end (transmitting) set in the ***normal*** mode and the far-end (receiving) set in the ***repeat*** mode, the meters of the two sets will indicate as follows:

Near-End Set (Normal Mode):

(a) ***Envelope delay distortion*** of the outgoing line (line under test)

(b) ***Frequency*** of the carrier being transmitted by the near-end set

(c) ***Received level*** of the reference signal on the return path from the far-end set. Note that this loss or gain in level is, in normal operation, only a single-frequency measurement, not the entire frequency characteristic of the return facility.

Far-End Set (Repeat Mode):

(a) ***Received level*** of the signal from the near-end set over the line under test

(b) ***Frequency*** of the carrier being received over the line under test

(c) There will be ***no indication of delay*** since the delay circuits are disconnected in the ***repeat*** mode.

Note: To check the fixed carrier frequency (usually 1800 Hz) being transmitted by the far-end set over the return path, it is necessary to switch the set to the ***normal*** mode and to read the FREQUENCY meter. After the frequency is checked, the set must be returned to the ***repeat*** mode to continue the test.

PERFORMANCE SPECIFICATIONS

2.14 ***Frequency***

Range with internal oscillator:	300 to 3500 Hz
Range with external oscillator:	300 to 25,000 Hz
Accuracy using FREQUENCY meter:	±35 Hz
Accuracy using external counter:	±0.1 percent

2.15 *Amplitude*

Transmitter output:	−30 to 0 dBm (5-dB steps)
Receiver sensitivity:	−30 to +10 dBm
Receiver accuracy for 1000-Hz measurements:	±0.2 dB
Flatness of receiver:	
300 to 3500 Hz	±0.1 dB
300 to 25,000 Hz	±0.25 dB
Flatness of transmitter:	
300 to 3500 Hz	±0.1 dB
300 to 25,000 Hz	±0.5 dB
Flatness, back-to-back:	
600 to 3000 Hz	±0.1 dB
300 to 3500 Hz	±0.15 dB
300 to 25,000 Hz	±0.5 dB

2.16 *Envelope Delay Distortion*

Range:	Unlimited
Overall delay measurement accuracy (see Note 1 below)	
600 to 3500 Hz (internal oscillator)	±10 μs
600 to 25,000 Hz (external oscillator)	±10 μs
300 to 600 Hz (internal or external oscillator)	±20 μs

Note 1: Accuracies of ±5 μs can be obtained for equalized facilities having an envelope delay distortion of 100 μs or less and a gain distortion of ±1 dB or less over the frequency range of 1000 to 2600 Hz. Accuracies of ±5 μs can also be obtained for unequalized facilities by subtracting the envelope delay distortion in the test equipment (determined by a back-to-back measurement) from the measured delay and by maintaining the received level to within ±1.0 dB at each test frequency.

Delay ripple resolution: 300 Hz

Note 2: This is the minimum separation between ripples that can be resolved in a given delay characteristic.

2.17 *Impedance*

Input and output impedance:	600 or 900 ohms
Return loss	>30 dB

Note: The impedances of the transmitter and receiver cannot be selected independently. Both the transmitter and the receiver must work at either 600 or 900 ohms.

2.18 *Longitudinal Balance*

At 300 Hz:	> 65 dB
At 5000 Hz:	> 50 dB

2.19 *Holding Resistance (25B Set Only)*

Input and output dc holding resistance:	700 ohms

2.20 *Approximate Output Voltages at Recorder Jacks (See Notes Below)*

DELAY RCDR:	22.0 μv/μs
FREQ RCDR:	3.6 μv/Hz
DBM RCDR:	1.0 mv/dB

Note 1: For all values it is assumed that a 2000-ohm terminating resistor is connected across the jack.

Note 2: Refer to 4.09 for information on suitable recorders.

2.21 *Environment (Conditions Under Which Above Specifications Should Be Met)*

Input power:	115 ±10 volts, 40 to 400 Hz
Ambient temperature range:	32° to 122° F
Minimum signal-to-noise ratio [as measured with a 3 ( ) NMS having 3-kHz flat weighting]:	20 dB

3. DESCRIPTION OF CONTROLS

3.01 The controls and connections are the same for the 25B and 25BR sets unless specified otherwise. All controls and connections appear on the face panel of these instruments (see Fig. 1 and 2) except:

(a) For the 25B set, the alternate 115-volt power connection and the alternate test line jacks are at the rear of the set for use when rack mounting this set with the list 2 mounting bracket. Also, at the rear of this set are jacks for connecting an external recorder.

(b) For the 25BR set, the 115-volt power and the test line connections are at the rear.

3.02 ***FREQUENCY:*** This control adjusts the frequency of the subcarrier from 300 to 3500 Hz.

3.03 ***EXT OSC Jack:*** This jack disconnects the internal oscillator when an external oscillator is connected to the jack. It is generally used only for gain and delay measurements above the 300- to 3500-Hz band. The jack accepts 310-type plugs.

3.04 ***TRMTR OUTPUT—DBM:*** This control provides transmitted rms power levels from −30 dBm to 0 dBm in 5-dB steps.

3.05 ***LEVEL ADJ:*** This control is used as a calibration vernier on the TRMTR OUTPUT—DBM control to adjust the transmitted power level to an exact nominal value.

3.06 ***CTR Jack:*** This jack permits the use of an external frequency counter for precise frequency measurements and for measuring frequencies above 3500 Hz. The jack accepts 310-type plugs.

3.07 ***RCVR INPUT—ADD DB:*** The input attenuator permits adjustment of the received signal in steps of 5 dB. In use, it is set to a position that brings the RCVD LEVEL meter indication on-scale. The actual received rms power level is then the algebraic sum of the meter reading and the control setting.

3.08 ***RECEIVER MODE:*** This control permits selection of either the ***normal*** or ***repeat*** mode of operation when set to either the NORMAL or REPEAT position, respectively. Selection of either position is covered in 2.06 through 2.13.

3.09 ***TRANSMIT (25B Set Only):*** This control permits transmitting on either line A or line B. When the LINE A position is selected, the set transmits on line A and receives on line B. The LINE B position permits the reverse arrangement. The SIG OFF position, as normally used, permits the signal to be removed from the transmitting line when tests are conducted on circuits with single-frequency signaling facilities. In this position, the lines are also terminated so that test connections will not be lost. The TRANSMIT control permits interchanging the transmitting and receiving lines without releasing the test connection. It also provides a means for connecting the DIAL jacks to either line A or line B for dialing purposes. Once a line connection is established by using a dial handset, the line connection may be switched at will between the line measuring positions and the handset.

3.10 ***SIG OFF (25BR Set Only):*** This control permits removing the signal from the transmitting line when tests are conducted on circuits with single-frequency signaling facilities.

3.11 ***IMPEDANCE:*** This control provides a means for selecting either a 600- or 900-ohm interface impedance.

3.12 ***SF SKIP OFF:*** This control permits disabling the 2600-Hz skip feature.

3.13 ***ADD MICROSECONDS:*** This 8-position, continuously rotatable switch adds or subtracts 500-μs increments of delay to the DELAY meter reading. The knob pointer may be disconnected and reconnected to the switch by a push-pull action to establish a reference 0 at any switch setting.

3.14 ***SENSITIVITY:*** This control adjusts the sensitivity of the DELAY meter.

3.15 ***DELAY ZERO:*** This control is used to select a convenient delay reference point on the DELAY meter for relative measurements. It may be changed as desired to establish a relative 0 point at any particular frequency.

3.16 ***PWR:*** This switch permits controlling the 115-volt ac power to the set. A lamp is located inside the pushbutton and lights when power is on.

3.17 ***LINE A Jack Field (25B Set Only):*** This jack field consists of a multiple of two jacks and a set of binding posts. Jacks are provided for either 309- or 310-type plugs. The binding posts will accept banana-type plugs, spade tips, or wire connections.

3.18 ***LINE B Jack Field (25B Set Only):*** This jack field is similar to the LINE A jack field but permits connection to line B.

3.19 ***DIAL Jacks (25B Set Only):*** These jacks permit connection of a telephone set to establish line connections over line A or line B, depending on the setting of the TRANSMIT switch.

3.20 ***RCDR Jacks:*** These jacks provide outputs of the measurement data for making continuous recordings with an external X-Y recorder or with an oscilloscope and camera.

3.21 ***25B Set Only:*** The LINE A and LINE B jacks are multipled to additional jacks on the rear panel of the set for use in rack-mounted installations. One of the two 115-volt power connectors is located on the rear for use in rack-mounted installations. The two power receptacles are connected to the set wiring through a FRONT-REAR slide switch on the back of the set to isolate the unused receptacle.

3.22 ***25BR Set Only:*** Connectors are provided at the rear of the set for connecting to the LINE A or LINE B inputs. A connector is also provided at the rear for connecting 115-volt power to the set.

4. OPERATING PROCEDURE

CALIBRATION—FRONT PANEL

4.01 The front panel calibration should be checked each time the power is turned on if the set has been off for an hour or more. A warm-up period of at least 20 minutes is desirable before calibration. These adjustments should also be rechecked from time to time after continuous operation for an hour or more. The following procedure should be used for calibration.

STEP	PROCEDURE
1	Connect line power to the set. For a 25B set, line power can be connected to either a front or a rear receptacle. The FRONT-REAR slide switch at the rear of this set must be set to the appropriate position. For a 25BR set, line power can be connected at a rear receptacle only.
2	Set the front panel controls as follows:

CONTROL	SETTING
FREQUENCY	To red mark on meter (approx 1800 Hz)
RCVR INPUT — ADD DB	0
TRMTR OUTPUT — DBM	0
RECEIVER MODE	NORMAL
TRANSMIT (25B Set only)	LINE A or LINE B
IMPEDANCE	600 or 900

STEP	PROCEDURE
3	Connect the set back-to-back by patching the LINE A and LINE B jacks together.
4	Allow a warm-up period of at least 20 minutes.

STEP	PROCEDURE
5	Adjust the LEVEL ADJ control to produce an exact 0 indication on the RCVD LEVEL meter.
	Note: If an external oscillator is used, it should be set to deliver a 2-kHz signal and its output level (approximately +3.0 dBm) should be adjusted for exactly 0 on the RCVD LEVEL meter.
6	Set the RCVR INPUT—ADD DB control to +5 and verify that the RCVD LEVEL meter reading is within ±0.05 dB of the −5 marker. If it is not, the RCVD LEVEL meter should be calibrated as described in Part H of the procedure in 6.01.
7	Return the RCVR INPUT—ADD DB control to 0 and switch the ADD MICROSECONDS control to the position that produces an on-scale DELAY meter indication.
8	Use the DELAY ZERO control to adjust the DELAY meter indication to 0 (black scale).
	Note: It may be necessary to change the ADD MICROSECONDS switch one position clockwise or one position counterclockwise to make this adjustment.
9	Pull out the ADD MICROSECONDS knob and reengage it with its pointer set to 0.
10	Set the ADD MICROSECONDS knob to the 3500 position and adjust the SENSITIVITY control to produce an indication of 500 on the DELAY meter.
11	Reset the ADD MICROSECONDS knob to the 0 position and readjust the DELAY ZERO control to obtain a meter indication of 0.
12	Repeat Steps 10 and 11 until both conditions are met. The set is now calibrated.
	Note: If any of the above conditions cannot be met, it may be necessary to adjust one or more of the internal controls (see 6.01).

LOOP MEASUREMENTS

4.02 Loop measurements are made with a single 25B or 25BR set operating in the ***normal*** mode. The transmitting and receiving facility are looped together at the far end. At the near end, these lines are terminated by the LINE A and LINE B terminals of the 25B or 25BR set. The far-end looping may be done by manual assistance or by dialing where dial circuits and looping equipment are available.

Note: Only 4-wire facilities can be inserted between the set and the looping point.

4.03 The loop method is not recommended when precise envelope delay distortion information on a circuit is required. Even if the two circuits seem to be identical, the total measured envelope delay distortion of the loop when divided by 2 will result in only an approximation of the actual delay in each circuit. Because of the rapidity of the method and because no delay set or testing help is required at the far end, the method is useful in cases when delay trouble is suspected and only an approximate measurement is required. The loop method is also used in measurements on networks or equipment components whenever both input and output terminals are in the same office. The following procedure should be used to make loop measurements.

STEP	PROCEDURE
1	Switch the RECEIVER MODE control to NORMAL.
2	Warm up and calibrate the set as described in 4.01.
3	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If ocilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
4	Set the TRMTR OUTPUT—DBM control to the desired transmitting power level. (A value of −10 dBm0 is suggested for most facilities. When testing wideband data circuits, the actual data level should be used.) ***Note:*** When circuits or networks having a wide bandwidth are measured, measurement errors may result because of harmonic distortion products produced and transmitted from the modulator. This distortion is proportionately ***less*** for lower transmitter levels, down to a level of −15 dBm. Also, when circuits or networks having a low-pass characteristic are measured, measurement errors may result due to 83-1/3 Hz leak from the modulator. The 83-1/3 Hz leak is proportionately ***higher*** for lower transmitter levels, down to a level of −15 dBm. To minimize measurement errors due to these distortions, it is preferable to operate the transmitter at a level of −15 dBm or lower when measuring wide bandwidth circuits and at a level as high as possible when measuring low-pass circuits. See Fig. 3 and 4 for maximum delay error versus relative circuit loss between the distortion and carrier frequencies.
5	To transmit over line A and receive over line B, set the TRANSMIT switch to LINE A. (The LINE B position permits the direction of transmission around the loop to be reversed.) ***Note:*** The 25BR set does not have the feature that allows reversing the direction of transmission. If this is desired, the test lines must be reversed manually at the LINE A (transmit) and LINE B (receive) jacks or at a remote jack field.
6	To set up a connection on a dialed-up basis, connect a dial handset (or equivalent) to the DIAL jack field. The DIAL A and DIAL B positions of the TRANSMIT switch (only on the 25B set) are used for dialing. When the TRANSMIT control is in the DIAL A position, the handset provides holding for the test circuit connected to the LINE A jack field, and the 25B set holding bridge provides holding for lines connected to the LINE B jack field. (The opposite is true when dialing on LINE B.) With the TRANSMIT control in either the LINE A, LINE B, or SIG OFF position, holding for both lines is provided. The TRANSMIT control shorting-type (make-before-break) switch prevents the loss of a held connection when switching from one condition to another. ***Note:*** The 25BR set does not have dialing and holding features. If these features are desired, they must be supplied separately.
7	After the test loop is established, set the IMPEDANCE control to the appropriate 600- or 900-ohm position. (The transmitter and receiver impedances cannot be set separately.)

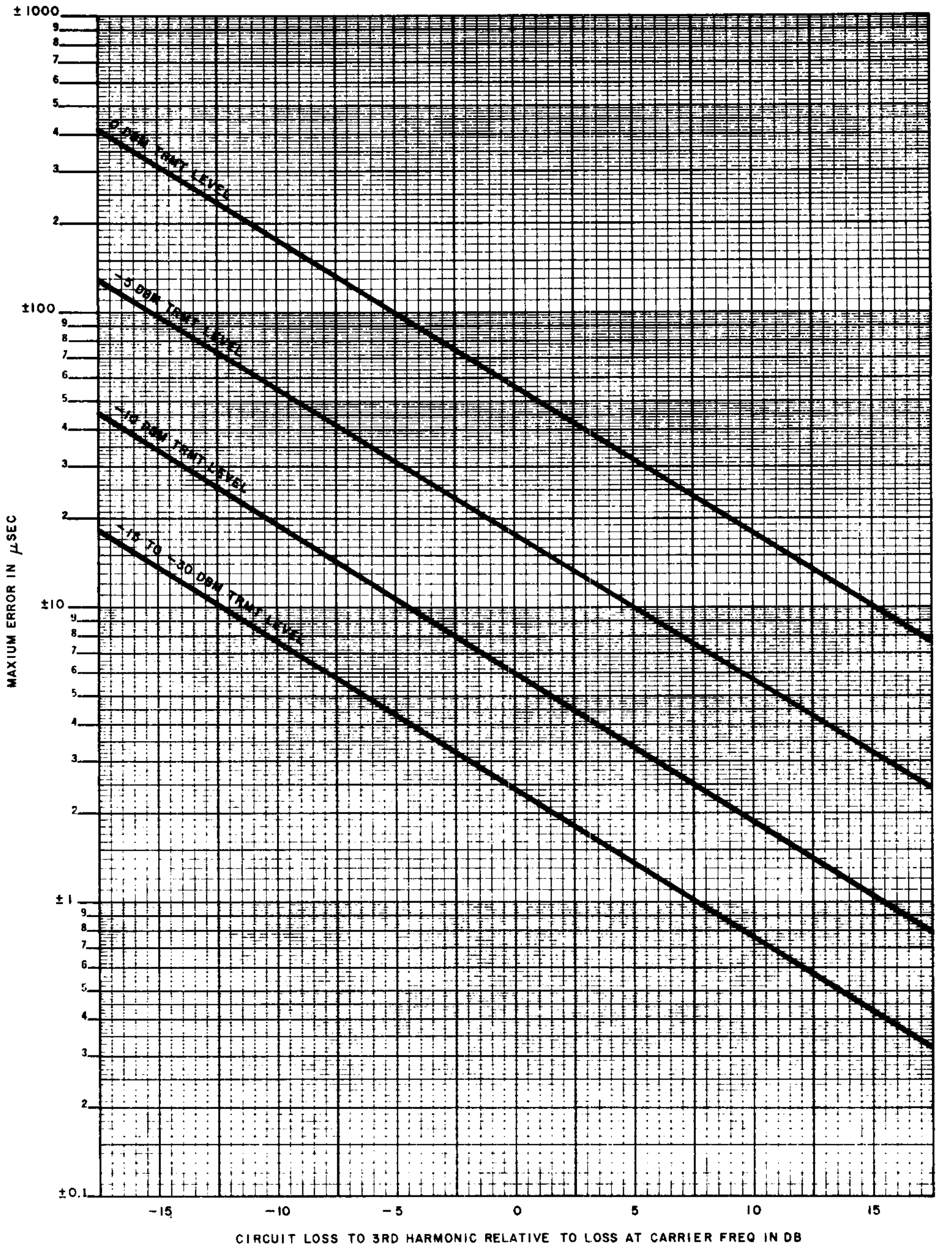

Fig. 3—Maximum Delay Error Due to Modulator Harmonic Distortion Products

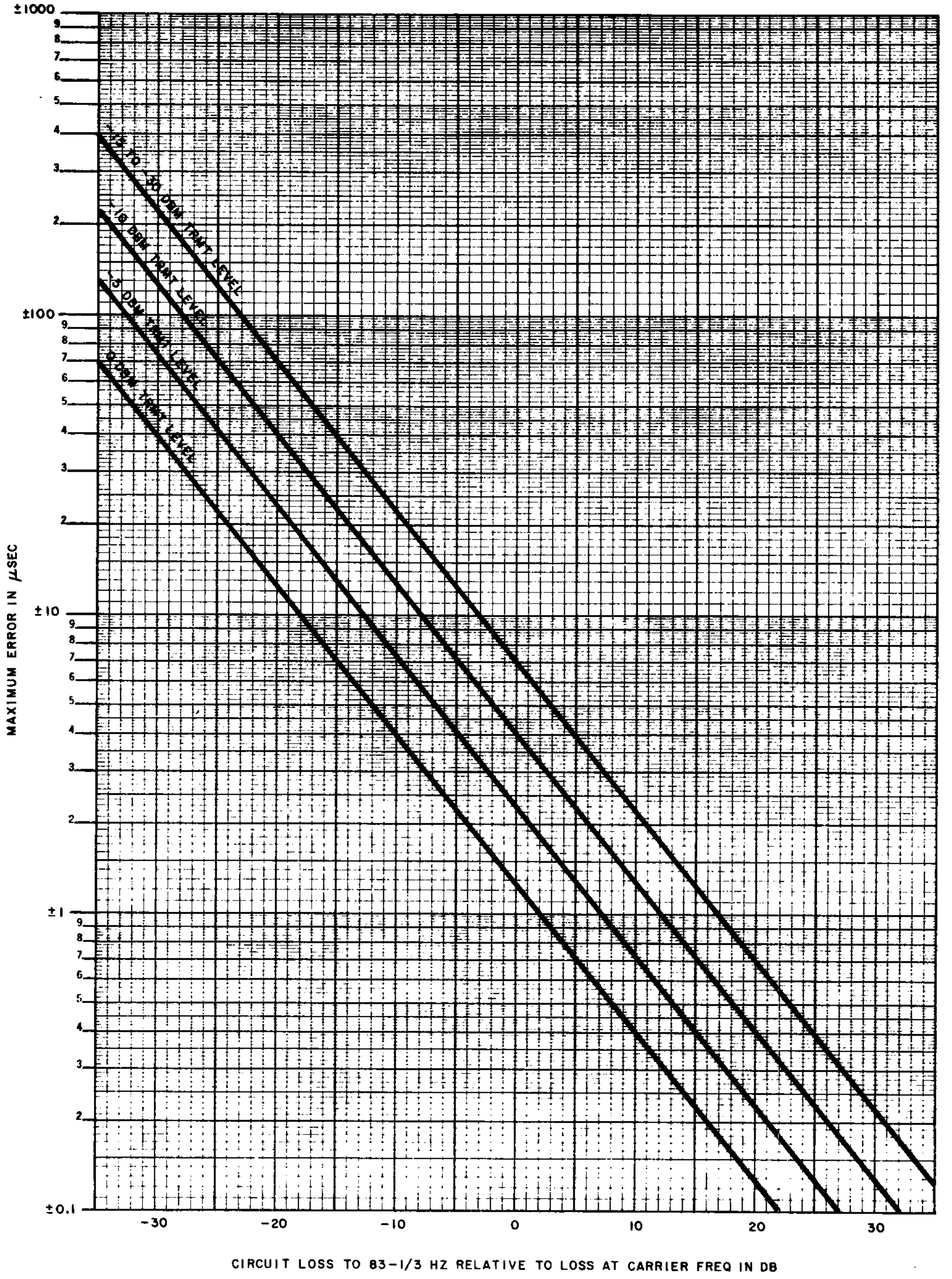

Fig. 4—Maximum Delay Error Due to 83-1/3 Hz Modulation Tone Leak

STEP	PROCEDURE
8	For preliminary adjustment, set the FREQUENCY control for a midband frequency (usually about 1800 Hz). With the set operating in the ***normal*** mode, the FREQUENCY meter indicates the transmitted frequency. An external counter can also be used.
	Note: An external counter connected to the CTR jack may cause errors in the FREQUENCY meter readings due to the effects of loading. If the counter is causing loading errors, it should be disconnected before reading frequency on the FREQUENCY meter. To determine if loading is a problem, observe the FREQUENCY meter reading while connecting the external counter to the CTR jack.
9	Set the RCVR INPUT—ADD DB control to a position that causes the RCVD LEVEL meter to read onscale.
	Note: An on-scale reading must be maintained on this meter at all times in order to minimize amplitude-delay error.
10	Set the DELAY meter for a 0 reference setting as follows:
	(a) Obtain, as nearly as possible, a 0-μs reading by means of the ADD MICROSECONDS switch.
	(b) Adjust the DELAY ZERO control to produce an exact 0 indication.
	Note: The 0 can be on the black scale if predominately positive readings are expected or on the red scale if both positive and negative readings are expected.
	(c) Pull out the ADD MICROSECONDS knob and set the pointer to 0. Push in the knob at this point. Reference 0 has now been obtained at the operating frequency. The reference may be established at any other scale point or any other frequency, as desired.
11	Make loop loss or gain measurements and envelope delay distortion measurements by manually sweeping the internal oscillator frequency control and reading the corresponding meter. Loss or gain is obtained by algebraically adding the RCVD LEVEL meter indication and the RCVR INPUT—ADD DB knob setting and then by subtracting the setting of the TRMTR OUTPUT—DBM knob.
	Example 1:
	RCVD LEVEL meter indication: -4
	RCVR INPUT—ADD DB control setting: $+10$
	TRMTR OUTPUT—DBM control setting: -20
	(a) $(-4) + (+10) = +6$
	(b) $(+6) - (-20) = (+6) + 20 = +26$, or 26-dB gain.

STEP	PROCEDURE
	Example 2:
	RCVD LEVEL meter indication: −3
	RCVR INPUT—ADD DB control setting: −15
	TRMTR OUTPUT—DBM control setting: −10
	(a) $(-3) + (-15) = -18$
	(b) $(-18) - (-10) = (-18) + 10 = -8$, or 8-dB loss.
	Example 3:
	RCVD LEVEL meter indication: ±0
	RCVR INPUT—ADD DB control setting: ±0
	TRMTR OUTPUT—DBM control setting: −5
	(a) $(\pm 0) + (\pm 0) = \pm 0$
	(b) $(\pm 0) - (-5) = (\pm 0) + 5 = +5$, or 5-dB gain.
12	Delay measurements are the algebraic sum of the DELAY meter reading and any 500-μs increments added or subtracted by the ADD MICROSECONDS control. The numbered positions of this switch assist in keeping account of additions to the reference point. It should be noted that the amount of relative delay that may be measured is unlimited; therefore, the number of complete revolutions that the ADD MICROSECONDS control is rotated from the original reference point must be remembered or recorded. The circuit delay is approximately half the delay measured around the loop.
13	The 2600-Hz skip feature automatically skips the oscillator test frequency from 2500 to 2700 Hz or vice versa whenever the test frequency approaches either 2500 or 2700 Hz. This prevents operation of 2600-Hz signaling units and prevents loss of the test connection when measuring on facilities equipped for 2600-Hz signaling. A momentary contact switch is provided for disabling the 2600-Hz skip feature if it is desired to make measurements in the 2500- to 2700-Hz region. To avoid operating single-frequency units having frequencies other than 2600 Hz while sweeping the test frequency through the critical signaling frequency region, perform the following:
	(a) On a 25B set, set the transmit control to the SIG OFF position
	(b) On a 25BR set, depress the SIG OFF pushbutton.

STRAIGHTAWAY MEASUREMENTS

4.04 For straightaway measurements, two sets and a return voice-frequency channel are required in addition to the line being tested. It is ***not*** essential, however, for the return path to be identical or even similar to the test circuit but only to have reasonable loss and noise characteristics at the frequency that the far-end set (repeat mode) transmits.

4.05 The near-end set operates in the ***normal*** mode and is typically arranged to transmit over the test line connected to its LINE A jacks. This set measures the delay characteristics of line A.

4.06 The far-end set operates in the ***repeat*** mode, ie, it recovers the envelope of the test signal transmitted by the near-end set, remodulates this signal on an adjustable frequency carrier (usually 1800 Hz) that remains fixed for the duration of the test, and transmits this signal back over the return path to the LINE B terminals of the near-end set.

> *Note:* A frequency of 1800 Hz is usually chosen for the far-end set because the ***rate of change*** of delay distortion on a voice-frequency facility is generally minimal at this frequency.

4.07 Both sets should be warmed up and calibrated, as described in 4.01, except that only the LEVEL ADJ control on the far-end set requires adjustment since the delay measuring circuits of a set operated in the ***repeat*** mode are not used. In some cases, however, it may be desired to reverse the direction of measurement to measure the delay- and loss-frequency characteristics of return line B. In this case, the far-end set operates in the ***normal*** mode and the near-end set in the ***repeat*** mode. If this operation is contemplated, both sets must be fully calibrated.

4.08 A set operating in the ***repeat*** mode indicates the frequency and received level of the signal received over the test line from the near-end set. The single-frequency return carrier is usually set for 1800 Hz on the FREQUENCY meter (red marker). This frequency can be checked by switching this far-end set to the ***normal*** mode and reading the frequency on the FREQUENCY meter. Return the set to the ***repeat*** mode to continue the test. The following procedure should be used to make straightaway measurements.

STEP	PROCEDURE
	Near-End Set
1	Connect the power and warm up and calibrate the set as described in 4.01.
2	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
3	Connect the test line to the LINE A jack.
4	Connect the return line to the LINE B jack.
5	Dial the connection, if required.
6	Set the RECEIVER MODE control to NORMAL.
7	Set the TRMTR OUTPUT—DBM control to the desired transmitting power level. A value of −10 dBm0 is suggested for most facilities. When testing wideband data circuits, the actual data level should be used.
	Note: When circuits or networks having a wide bandwidth are measured, measurement errors may result because of harmonic distortion products produced and transmitted from the modulator. This distortion is proportionately ***less*** for lower transmitter levels, down to a level of −15 dBm. Also, when circuits or networks having a low-pass characteristic

STEP	PROCEDURE
	are measured, measurement errors may result due to 83-1/3 Hz leak from the modulator. The 83-1/3 Hz leak is proportionately ***higher*** for lower transmitter levels, down to a level of −15 dBm. To minimize measurement errors due to these distortions, it is preferable to operate the transmitter at a level of −15 dBm or lower when measuring wideband circuits and at a level as high as possible when measuring low-pass circuits. See Fig. 3 and 4 for maximum delay error versus relative circuit loss between the distortion and carrier frequencies.
8	Set the TRANSMIT control (25B set only) to LINE A.
9	Set the IMPEDANCE control to the appropriate 600- or 900-ohm position.
10	When the far-end set is operating, set the DELAY meter for reference 0 as described in (a), (b), and (c) under Step 10 of 4.03.
11	Set the RCVR INPUT—ADD DB control to bring the RCVD LEVEL meter reading on scale. (This meter will indicate the gain or loss of the return path at 1800 Hz and should not change during the test.)
12	Slowly sweep the transmitted carrier frequency over the desired range and observe the delay characteristic of the test line on the DELAY meter.
	Far-End Set
1	Connect the power and warm up and calibrate the set as described in 4.01.
2	If recorder measurements are to be made, calibrate the recorder as described in 4.11. If oscilloscope measurements are to be made, calibrate the oscilloscope as described in 4.14.
3	Connect the test line to the LINE B jack.
4	Connect the return line to the LINE A jack.
5	Dial up the connection, if required.
6	Set the RECEIVER MODE control to REPEAT.
7	Set the FREQUENCY control for a frequency of 1800 Hz as described in 4.08.
8	Set the TRMTR OUTPUT—DBM control to the desired input level to the return line.
9	Set the TRANSMIT control to LINE A (25B set only).
10	Set the IMPEDANCE control to the apropriate 600- or 900-ohm position.
11	Set the RCVR INPUT—ADD DB control to bring the RCVD LEVEL meter on scale. (Assumes the originating set is operating.)
	Note: An on-scale reading must be maintained on this meter at all times in order to minimize amplitude-delay error and frequency measurement error (meter and recorder).
12	Record the frequency and the level as received over the test line from the originating set.

RECORDER MEASUREMENTS

4.09 Outputs of the measurement data (received level, delay, and frequency) are provided at jacks for making recordings of delay versus frequency and/or received level versus frequency with the use of an external recorder. Delay versus frequency or received level versus frequency can be measured separately with a single pen recorder such as the Moseley Model H14-7035A, X-Y recorder or equivalent, or can be measured simultaneously with a double pen recorder such as the Moseley Model 136A, X-Y_1-Y_2 recorder or equivalent.

4.10 When making straightaway measurements, the near-end set (***normal*** mode) provides recorder outputs for measuring only delay versus frequency of the test line; the far-end set (***repeat*** mode) provides recorder outputs for measuring only received level versus frequency of the test line. When measuring on a loop basis, the set provides recorder outputs for measuring both delay versus frequency and received level versus frequency of the loop. The following procedure should be used to make recorder measurements.

STEP	PROCEDURE
1	Connect the frequency output at the FREQ RCDR jack on the 25B or 25BR set to the X input on the recorder.
2	Connect the received level output at the DBM RCDR jack or the delay output at the DELAY RCDR jack on the 25B or 25BR set to the Y input on the recorder. *Note:* If a 2-pen recorder is used, both the received level and the delay outputs can be connected simultaneously to separate Y inputs on the recorder.
3	Calibrate the recorder as described in 4.11.
4	If loop measurements are being made, set up the test circuit and the test set as described in 4.03; if straightaway measurements are being made, set up the test circuit and test sets as described in 4.08.
5	Measure the loss- or gain-frequency and/or delay-frequency characteristics of the test circuit by ***slowly turning*** the FREQUENCY control over the desired range. *Note:* If the test frequency is changed too rapidly, some measurement error will result. This error will show up as a vertical displacement between plots of increasing and decreasing frequencies. If this displacement is significant, even when turning the FREQUENCY control slowly, an adjustment should be made as described in Part F of the procedure in 6.01.

4.11 The following procedure should be used to calibrate the recorder.

STEP	PROCEDURE
	X Axis—Frequency
1	Adjust the FREQUENCY control for a frequency of 3500 Hz (or other desired full-scale frequency) on the FREQUENCY meter or on a frequency counter connected to the CTR jack if more precise frequency calibration is required.
	Note 1: It may be necessary to disconnect any inputs at the Y terminals if the pen is driven off-scale vertically while making the adjustment.
	Note 2: An external counter connected to the CTR jack may cause calibration errors due to the effects of loading. If a counter is used for setting a frequency and the counter is causing loading errors, it should be disconnected before calibrating the X-Y recorder. To determine whether or not loading is a problem, observe the recorder pen indication while connecting the external counter to the CTR jack.
2	Connect a shorting strap across the X input terminals of the recorder and adjust the ZERO control (X input) on the recorder for a zero-frequency pen indication.
3	Remove the shorting strap at the X input terminals and adjust the RANGE and VERNIER controls (X input) on the recorder for a 3500-Hz (or other full-scale frequency) indication of the pen.
	Note: It may be necessary to disconnect any inputs at the Y terminals if the pen is driven off-scale vertically while making this adjustment.
4	The X axis is now calibrated.
	Y Axis—Received Level
1	Connect the 25B or 25BR set back-to-back by patching the LINE A and LINE B jacks together.
2	Set the RCVR INPUT—ADD DB control on the 25B or 25BR set to +5 and adjust the ZERO control (Y input) on the recorder for the desired lower-scale pen indication.
3	Set the RCVR INPUT—ADD DB control to 0 and adjust the RANGE and VERNIER controls (Y input) on the recorder for the desired upper-scale pen indication.
4	Repeat Steps 2 and 3 until no further adjustment of the recorder controls is necessary when switching the RCVR INPUT—ADD DB control from +5 to 0.
5	The Y axis is now calibrated for measuring received level. Remove the connection between the LINE A and LINE B jacks and set up the test circuit as described in 4.03 or 4.08.
	Y Axis—Delay
1	Connect a shorting strap across the Y input terminals (delay input) of the recorder and adjust the ZERO control (Y input) on the recorder for the desired pen indication.

STEP	PROCEDURE
2	Remove the shorting strap at the Y input terminals and adjust the ADD MICROSECONDS and DELAY ZERO controls on the 25B or 25BR set for the same pen indication as in Step 1. This should occur when the DELAY meter registers near the lower end of the scale.
3	Turn the ADD MICROSECONDS control one or more positions clockwise or counterclockwise and adjust the RANGE and VERNIER controls (Y input) on the recorder for the desired pen indication. ***Note:*** The DELAY RCDR output has a limited range due to the repetitive nature of the phase comparator. The range will be approximately centered ($\pm$2000 μs) when the ADD MICROSECONDS control is adjusted for an on-scale DELAY meter indication. This range can be optimized by adjusting the FREQUENCY control through the range of interest and determining the minimum delay reading for the network or circuit being measured with the recorder pen lifted. At the frequency of minimum delay, the ADD MICROSECONDS control can then be adjusted for a minimum recorder indication (the recorder ZERO control may require adjustment to maintain the pen on scale). This should allow a measurement range of approximately 3500 μs without any drastic changes due to the phase comparator's reaching the end of its range.
4	The Y axis is now calibrated for measuring delay. Set up the test circuit as described in 4.03 or 4.08.

OSCILLOSCOPE MEASUREMENTS

4.12 Outputs of the measurement data (received level, delay, and frequency) at the recorder jacks can be used for displaying delay versus frequency and/or received level versus frequency characteristic on an oscilloscope, and a photograph of the characteristic can be taken with a scope camera. Any oscilloscope being used for this purpose should meet the following requirements: independent X and Y inputs with variable gain and positioning controls on each input, sufficient sensitivity (see 2.20), facilities for attaching a camera, and a graticule that can be illuminated. A scope camera capable of taking one picture per full frame of film is desirable.

4.13 When making straightaway measurements, the near-end set (***normal*** mode) provides outputs at the recorder jacks for measuring only delay versus frequency of the test line; the far-end set (***repeat*** mode) provides outputs at the recorder jacks for measuring only received level versus frequency of the test line. When measuring on a loop basis, the set provides outputs at the recorder jacks for measuring both delay versus frequency and received level versus frequency of the loop. The following procedure should be used to make oscilloscope measurements.

STEP	PROCEDURE
1	Connect the frequency output at the FREQ RCDR jack on the 25B or 25BR set to the X input on the oscilloscope.
2	Connect the received level output at the DBM RCDR jack or the delay output at the DELAY RCDR jack on the 25B or 25BR set to the Y input on the oscilloscope.
3	Calibrate the oscilloscope as described in 4.14.

STEP	PROCEDURE
4	If loop measurements are being made, set up the test circuit and the test set as described in 4.03; if straightaway measurements are being made, set up the test circuit and test sets as described in 4.08.
5	Adjust the aperture on the scope camera for a minimum opening and the shutter speed for a time-exposed picture.
6	Turn the scale illumination control on the oscilloscope fully counterclockwise (minimum illumination).
7	Adjust the intensity on the oscilloscope so that the beam is just barely visible.
8	Open the shutter on the camera.
9	Adjust the scale illumination control on the oscilloscope fully clockwise (maximum illumination) for sufficient time for the oscilloscope graticule to be exposed on the film; then turn the scale illumination control fully counterclockwise.
10	Measure the loss- or gain-frequency and/or delay-frequency characteristics of the test circuit by ***slowly turning*** the FREQUENCY control over the desired range. ***Note:*** If the test frequency is changed too rapidly, some measurement error will result. This error will show up as a vertical displacement between plots of increasing and decreasing frequencies. If this displacement is significant, even when turning the FREQUENCY control slowly, an adjustment should be made as described in Part F of the procedure in 6.01.
11	Close the camera shutter and develop the picture.

4.14 The following procedure should be used to make oscilloscope calibration.

STEP	PROCEDURE
	X Axis—Frequency
1	Adjust the oscilloscope for external triggering.
2	Adjust the FREQUENCY control for a frequency of 3500 Hz (or other desired full-scale frequency) on the FREQUENCY meter or on a frequency counter connected to the CTR jack if more precise frequency calibration is required. ***Note:*** An external counter connected to the CTR jack may cause calibration errors due to the effects of loading. If a counter is used for setting a frequency and the counter is causing loading errors, it should be disconnected before calibrating the oscilloscope. To determine if loading is a problem, observe the oscilloscope deflection while connecting the external counter to the CTR jack.

STEP	PROCEDURE
3	Connect a shorting strap across the X input terminals of the oscilloscope and adjust the POSITION control (X input) until the beam indicates at the zero-frequency point.
	Note: It may be necessary to disconnect any inputs at the Y terminals if the beam is driven off-scale vertically while making this adjustment or the one in the following step.
4	Remove the shorting strap at the X input terminals and adjust the sensitivity control (X input) until the beam indicates at the 3500-Hz (or other desired full-scale frequency) point.
5	Repeat Steps 3 and 4 until the horizontal scale is calibrated.
	Y Axis—Received Level
1	Connect the 25B or 25BR set back-to-back by patching the LINE A and LINE B jacks together.
2	Set the RCVR INPUT—ADD DB control on the 25B or 25BR set to +5 and adjust the POSITION control (Y input) on the oscilloscope for the desired lower scale beam indication.
3	Set the RCVR INPUT—ADD DB control to 0 and adjust the sensitivity control (Y input) on the oscilloscope for the desired upper scale beam indication.
4	Repeat Steps 2 and 3 until no further adjustment is necessary when switching the RCVR INPUT—ADD DB control from +5 to 0.
5	The Y axis is now calibrated for measuring received level. Remove the connection between the LINE A and LINE B jacks and set up the test circuit as described in 4.03 or 4.08.
	Y Axis—Delay
1	Connect a shorting strap across the Y input terminals on the oscilloscope and adjust the POSITION control (Y input) for the desired lower scale beam indication.
2	Remove the shorting strap at the Y input terminals and adjust the ADD MICROSECONDS and DELAY ZERO controls on the 25B or 25BR set for the same beam indication as in Step 1. This should occur when the DELAY meter indicates near the lower end of the scale.
3	Turn the ADD MICROSECONDS control one position clockwise and adjust the sensitivity control (Y input) on the oscilloscope for the desired upper scale beam indication.
4	Turn the ADD MICROSECONDS control one position counterclockwise and repeat Steps 1, 2, 3, and 4 until no further adjustment of the oscilloscope controls is necessary.
5	The Y axis is now calibrated for measuring delay. Set up the test circuit as described in 4.03 or 4.08.

5. CIRCUIT DESCRIPTION

GENERAL

5.01 The following paragraphs and Fig. 5 through 9 are intended to give a general understanding of the circuit operation of the 25B and 25BR sets. Detailed circuit operation is covered in CD-99770-01 and the associated SD drawings.

5.02 The overall circuit consists of four main parts or circuit packs: the control circuit, the transmitter circuit, the receiver circuit, and the timing circuit. The power supply for the entire circuit, described later, is associated physically with the transmitter circuit pack, but the individual supply transistors are associated with the other circuits. The circuits of the 25B and 25BR sets are identical except for some differences in their control circuits. Description of the circuit operation will pertain to both sets unless specified otherwise.

5.03 The transmitter circuit (FS-6 of Fig. 5) generates the subcarrier frequency, modulates it with the 83-1/3 Hz signal, and transmits the resulting wave via the control circuit output attenuator, switches, and line jacks to the line. When the set is operating in the ***normal*** mode, the transmitter subcarrier oscillator supplies the variable frequency required for the test range desired (300 to 3500 Hz). In this mode, the modulating 83-1/3 Hz signal is received from the divider output of the timing circuit. When the set is operating in the ***repeat*** mode, however, the 83-1/3 Hz signal is received over the incoming test line through the control circuit and receiver circuit. This signal is used to modulate a fixed single frequency (usually set at 1800 Hz) from the transmitter subcarrier oscillator for transmission over the return test line. The use of an external oscillator for measurements above 3500 Hz is described elsewhere in this section. Note that the frequency meter associated with the transmitter will indicate the transmitter oscillator frequency only in the ***normal*** mode. In the ***repeat*** mode, this meter indicates the subcarrier frequency received over the test line. To check the fixed frequency of the oscillator used in the ***repeat*** mode, the mode switch must be turned to the NORMAL position. After the frequency is observed, the mode switch must be returned to the REPEAT position to continue the test.

5.04 The receiver circuit (FS-4 of Fig. 5) receives the signal from the test circuit. The signal level is indicated on the RCVD LEVEL meter. The relative envelope delay at the transmitted subcarrier frequency is indicated on the DELAY meter. When the set is operating in the ***repeat*** mode, the receiver circuit demodulates the received signal, recovers the 83-1/3 Hz envelope, and uses this recovered signal to remodulate the fixed (1800 Hz) subcarrier for return to the originating test location.

5.05 The timing circuit (FS-5 of Fig. 5) generates the 83-1/3 Hz modulating sine wave for the transmitter and a 250-Hz reference signal for envelope delay measurements in the receiver. This reference signal is a narrow pulse, controlled relative in time to the modulating signal in the transmitter. Its timing can be shifted in increments of 500 μs for comparison in the phase comparator with the signal received over the test line for relative delay measurement. When the set is operating in the ***repeat*** mode, the timing circuit is not used, but its 83-1/3 Hz filter provides additional filtering for the envelope signal (received over the test line) before remodulating the fixed frequency carrier that is returned to the near-end set.

TIMING CIRCUIT DETAILS (Fig. 6)

5.06 The 83-1/3 Hz signal is obtained by dividing the 2000-Hz output of the tuning fork oscillator by 24. This division is done in three stages: a four-to-one, a three-to-one, and a two-to-one stage. The first two stages use unijunction transistor divide circuits. The final stage is a flip-flop, or bistable, multivibrator circuit. This flip-flop circuit produces a square-wave output that is then converted to the 83-1/3 Hz sine-wave signal by the tuned filter.

5.07 The other principal function of the timing circuit is the generation of the reference signal used by the phase comparator for delay measurement. The output of the four-to-one divide

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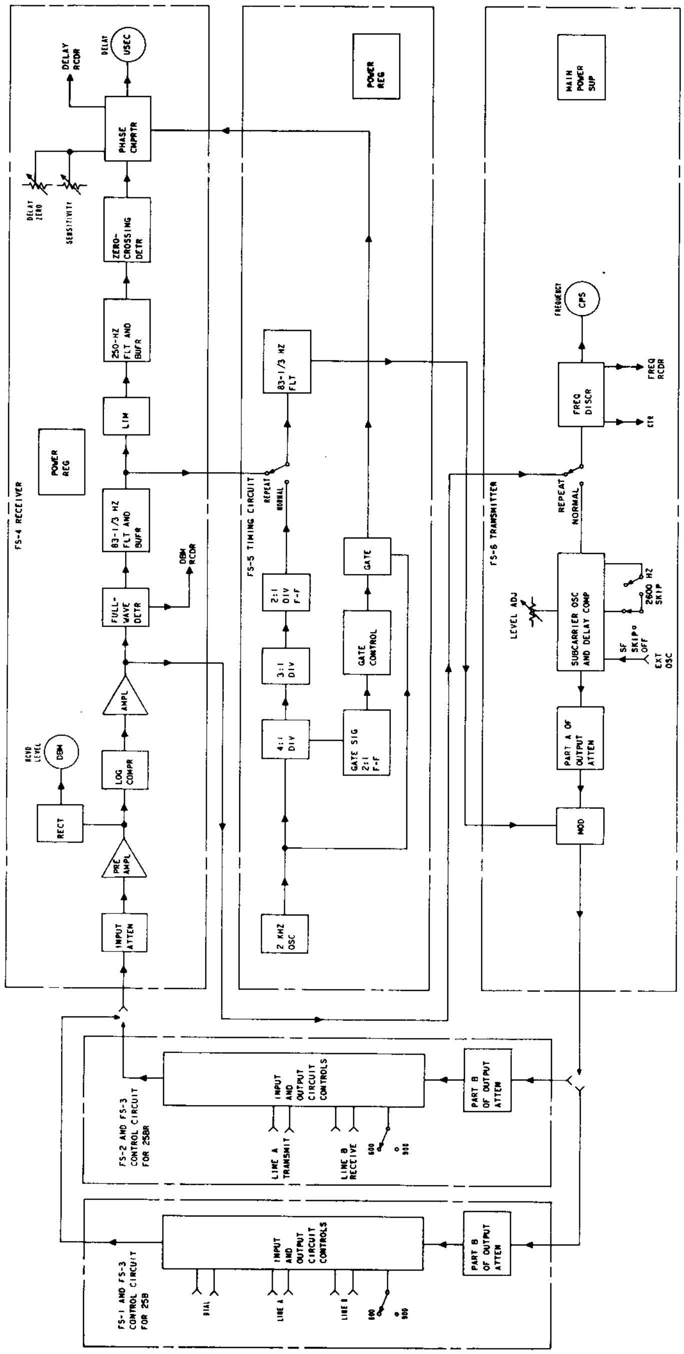

Fig. 5—Block Diagram

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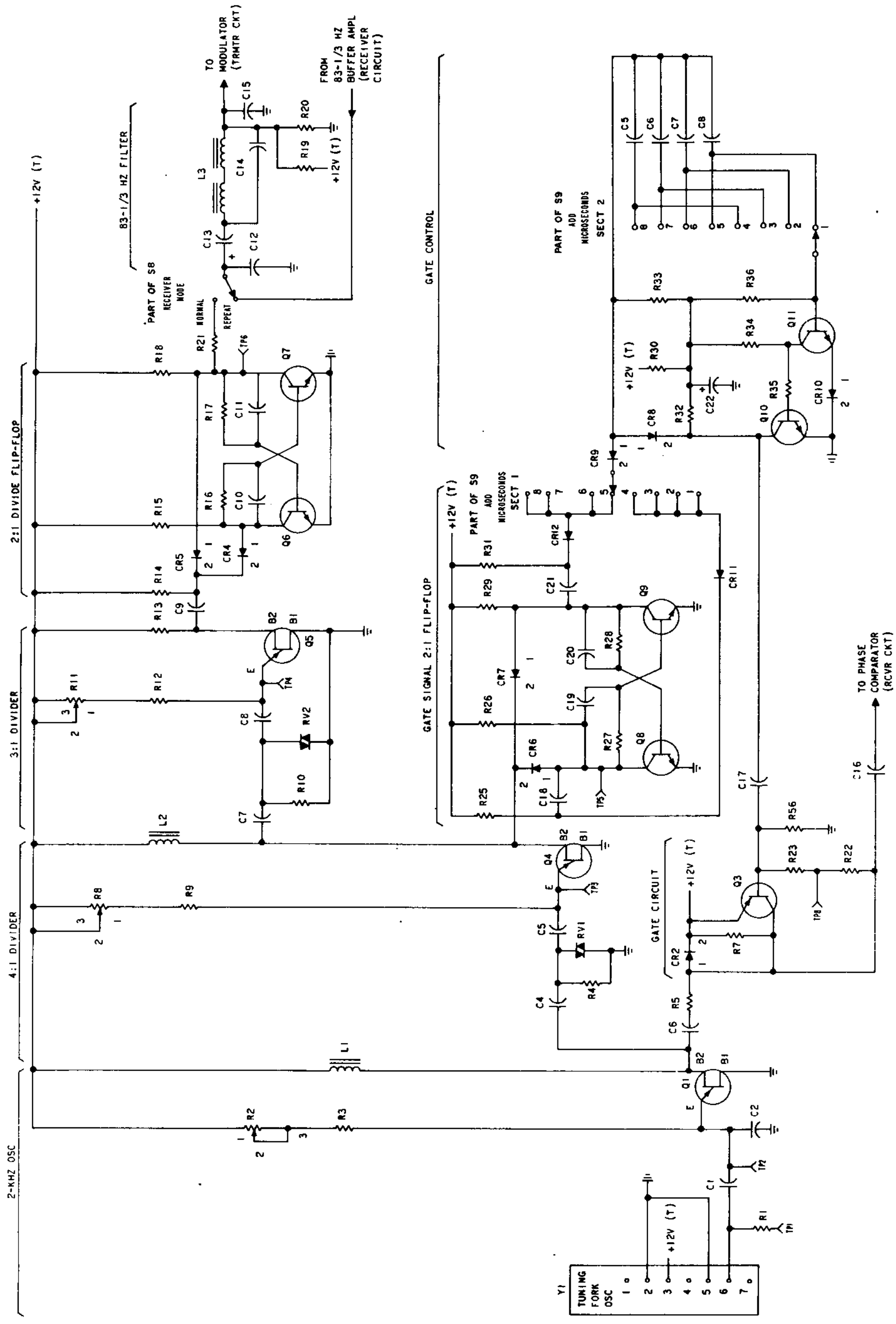

Fig. 6—Timing Circuit, Schematic Diagram

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stage (5.06) is fed to a two-to-one divide flip-flop stage to produce a 250-Hz narrow pulse signal. The 250-Hz pulse can be taken from either side of the two-to-one divide flip-flop circuit. This provides a means for delaying the 250-Hz pulse by 2 ms with respect to the 2000-Hz pulse. The 250-Hz pulse triggers the gate control circuit at a 250-Hz rate. The gate control circuit is a standard monostable multivibrator, and the time that it is in the unstable state during its 4-ms period is controlled by the ADD MICROSECONDS switch. By taking the 250-Hz pulse from both sides of the divide-by-two flip-flop, the gate control circuit generates eight different timing pulses with only four timing capacitors. The gate control circuit provides the means for activating the gate circuit for a 500-μs interval that straddles in time every eighth pulse of the 2-kHz oscillator. The gate circuit transmits every eighth pulse of the oscillator to the phase detector in the receiver circuit as a timing reference signal. Thus, the timing reference signal consists of a narrow pulse at a 250-Hz rate that may be varied in time to the reference point by 500-μs increments, depending on the setting of the ADD MICROSECONDS switch. The gate circuit is an AND type and will pass only those pulses to be used in triggering the reference side of the phase comparator in the receiver circuit.

TRANSMITTER CIRCUIT DETAILS (Fig. 7)

5.08 The transmitter oscillator is a manually tuned Wien bridge oscillator capable of supplying an output signal adjustable over a range of 300 to 3500 Hz. Its output level is adjusted by the LEVEL ADJ control and part of the TRMTR OUTPUT—DBM attenuator. The oscillator output is modulated by the 83-1/3 Hz signal from the timing circuit in the balanced modulator to produce a double sideband, 50 percent amplitude-modulated test signal. When an external oscillator is used, the internal Wien bridge oscillator is disconnected from the circuit.

5.09 The Wien bridge oscillator consists of an RC frequency selective bridge, a source follower that presents a high impedance to the bridge, a 2-stage direct-coupled amplifier, and an emitter follower. The delay compensator circuit follows the oscillator circuit. This circuit compensates for the internal delay distortion of the set so that when it is connected back-to-back (LINE A patched to LINE B), the delay meter indicates ZERO distortion over the frequency band. Compensation is accomplished by driving the DELAY meter with a current that bucks the meter current changes caused by the internal delay changes. The bucking current is obtained by sampling the subcarrier or external oscillator voltage, passing it through a frequency-weighting network, detecting the weighted signal, and transmitting the resulting dc current to the meter in the proper polarity to buck the current caused by the internal delay changes. An adjustment is provided to obtain the magnitude of bucking current.

5.10 The modulator mixes the output of the Wien bridge oscillator and the 83-1/3 Hz envelope signal from the timing circuit and feeds the composite signal to the test line through part of the TRMTR OUTPUT—DBM attenuator and either a 600- or 900-ohm impedance matching pad.

5.11 The frequency meter circuit consists of an emitter follower, a Schmitt trigger circuit, and two detection networks. The detection networks provide dc outputs proportional to the input frequency for operating the FREQUENCY meter and an external recorder. In the ***normal*** mode, the frequency discriminator detects the frequency of the subcarrier oscillator or external oscillator signal, whichever one is used; in the ***repeat*** mode, the discriminator detects the frequency of the received carrier (the action of the Schmitt trigger circuit makes it possible to read the carrier frequency of the composite received signal).

RECEIVER CIRCUIT DETAILS (Fig. 8)

5.12 The input impedance matching pad, input transformer, and level adjusting pad are followed by the 3-stage preamplifier that provides isolation between the rectifier and the log compressor circuit. The diode rectifier allows the positive portions of the received signal to be passed to the RCVD LEVEL meter for level measurement.

5.13 The log compressor circuit compresses the received signal in a way that maintains a constant peak-to-peak envelope amplitude, even if the received level changes. For this reason, the signal levels in the following envelope delay measuring circuits are independent of the received signal level. The logarithmic compressed version of the received test signal will have an envelope that remains constant for a range of about 10 dB of change in received signal amplitude.

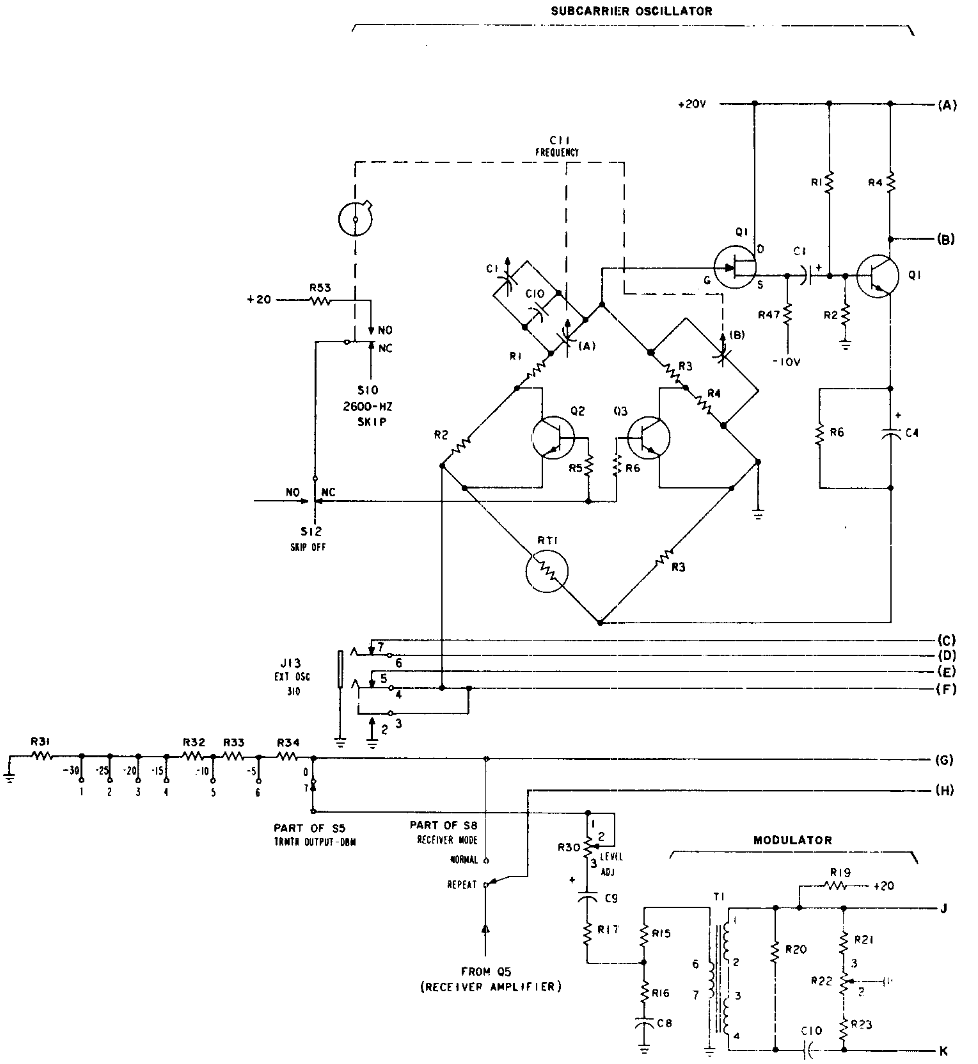

Fig. 7—Transmitter Circuit, Schematic Diagram (Sheet 1 of 2)

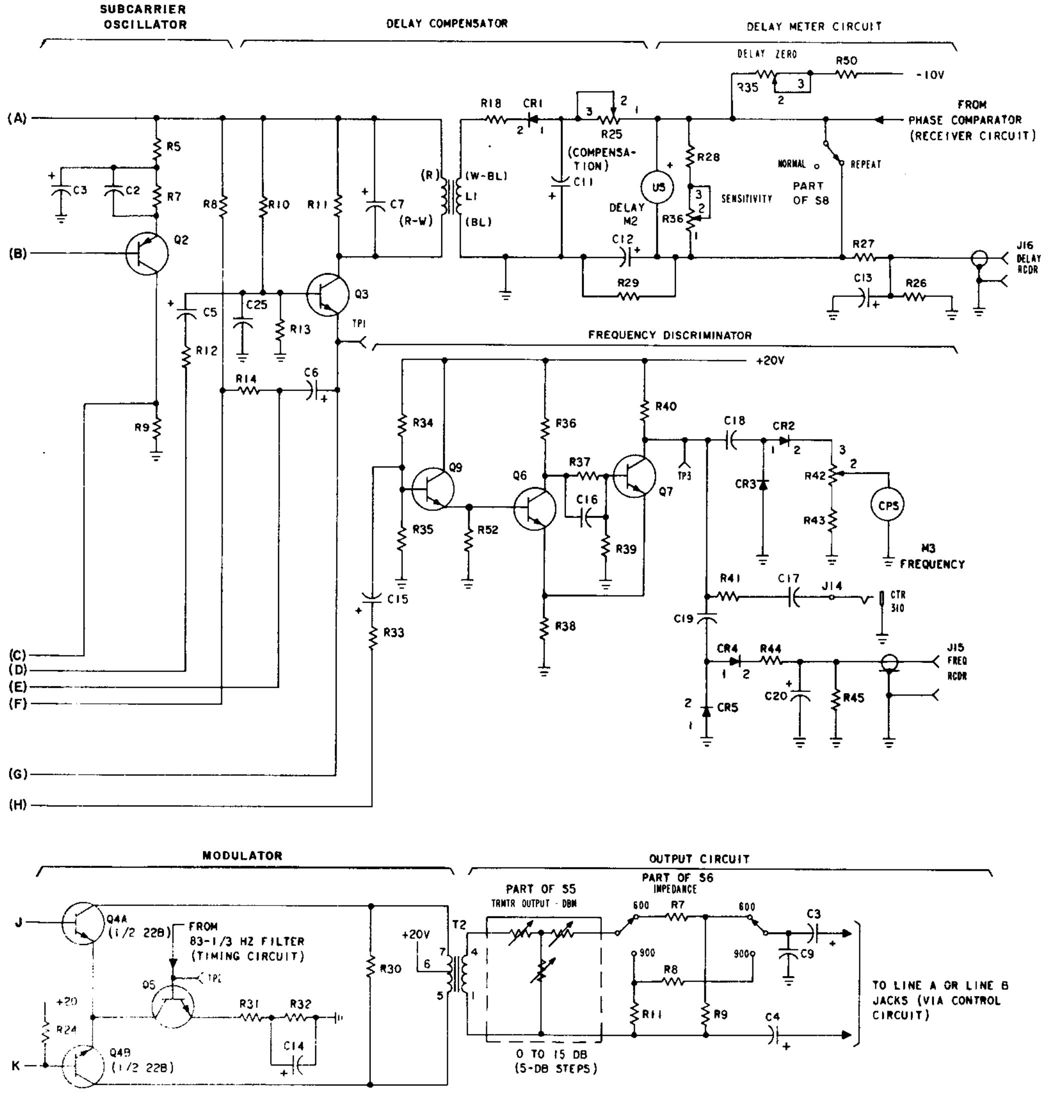

Fig. 7—Transmitter Circuit, Schematic Diagram (Sheet 2 of 2)

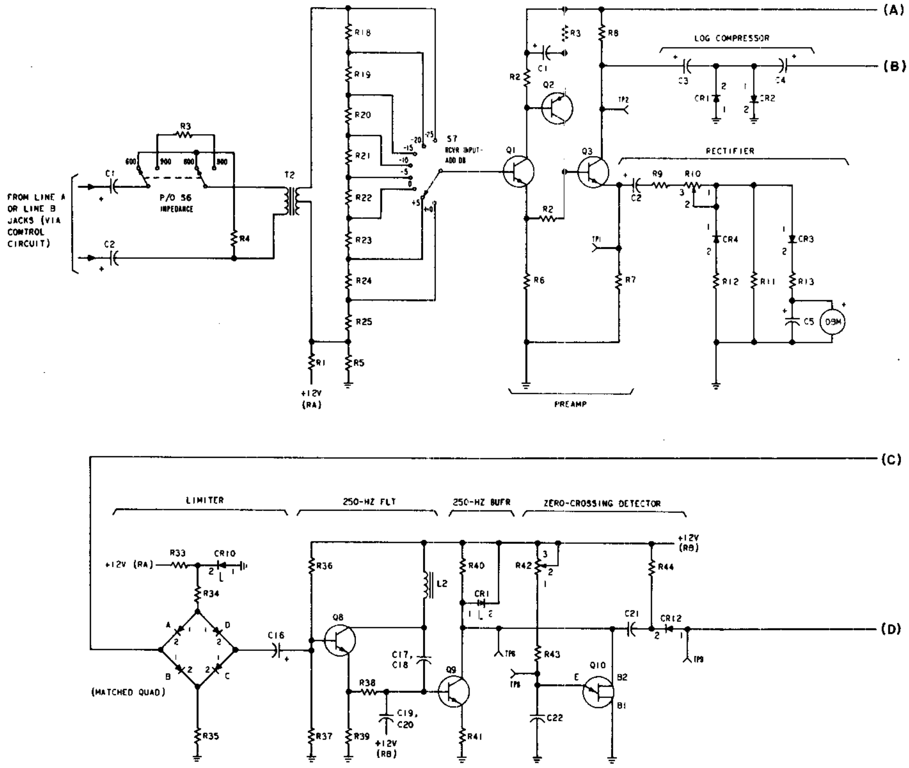

Fig. 8—Receiver Circuit, Schematic Diagram (Sheet 1 of 2)

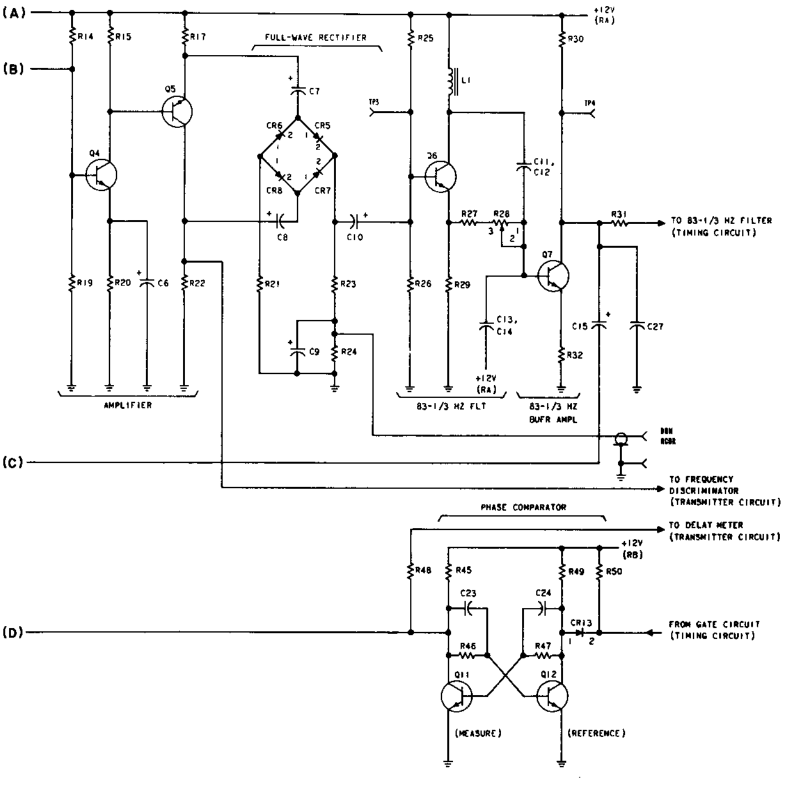

Fig. 8—Receiver Circuit, Schematic Diagram (Sheet 2 of 2)

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5.14 The log compressor is followed by an amplifier providing about 15-dB gain. The signal is then rectified to recover the envelope. After detection, the signal is passed through the 83-1/3 Hz filter to remove harmonic distortion, unwanted carrier frequency components, and noise received from the test line. A portion of the rectified signal is filtered and directed to the DBM RCDR jack for measuring received level versus frequency with an external recorder. The dc component of this signal is proportional to the logarithm of the received input signal.

5.15 The limiter and 250-Hz filter serve to multiply the 83-1/3 Hz signal by 3 to produce a 250-Hz signal. The frequency multiplication makes possible a more accurate measurement of phase shift in the signal. The phase position of the 250-Hz signal is detected in the zero-crossing detector, which generates a narrow pulse at each negative-going zero-crossing of the sine wave. The envelope delay distortion of the test circuit is then measured in the phase comparator circuit by comparing the time of occurrence of the pulses from the zero-crossing detector with the reference signal from the timing circuit.

5.16 The output of the phase comparator consists of a series of pulses at the 250-Hz rate. The pulse width is proportional to the amount of phase shift produced at any one frequency by the test circuit. Therefore, the dc component of this rectangular pulse is a measure of the envelope delay.

POWER SUPPLY DETAILS (Fig. 9)

5.17 The input transformer steps down the line voltage and feeds the full-wave diode rectifier. Some filtering is supplied by the RC network. Regulation is obtained by the combined action of current-limiting diodes CR10A and CR10B and zener diodes CR11 and CR12. The current-limiting diodes are constant-current devices that maintain a constant current through their terminals regardless of the voltage across them (within the limits of 6 to 75 volts). The current-limiting diodes provide regulation against line voltage variations by keeping the current constant through the zener diodes, which, in turn, keep close voltage control on the base of the supply transistors. In addition, the current-limiting diodes (which have a high impedance to alternating current) further reduce the ripple in the supply.

5.18 The current gain of the transistors is such that the transistors supply sufficient power for the set while permitting a small current through the constant-current diodes. The 20-volt output of Q8(CP 3) supplies the transmitter circuit. Q2(CP 2) and Q13 and Q14(CP 1) furnish 12-volt supplies for the timing and receiver circuits, respectively. Zener diode CR13 provides a regulated −10 volts for the delay zero circuit and also for the field effect transistor in the subcarrier oscillator circuit. The 12-volt supply transistors and load resistors are physically associated with the circuit packs they supply. Other components of the power supply are associated with the transmitter circuit pack.

6. MAINTENANCE AND REPAIR

CALIBRATION—INTERNAL ADJUSTMENTS

6.01 The internal calibration adjustments should be checked whenever any of the front panel adjustments cannot be made or when a trouble condition exists. In any event, these adjustments should be checked at least once every six months to ensure good performance of the set. If any of the adjustments are not effective, the instrument should be sent to a repair and calibration center such as a Western Electric distributing house. Unless otherwise stated, all internal calibration adjustments should be made with the front panel controls as described in 4.01. A warm-up period of at least 20 minutes should be allowed before any of these adjustments are made. The following procedure should be used to make internal adjustments.

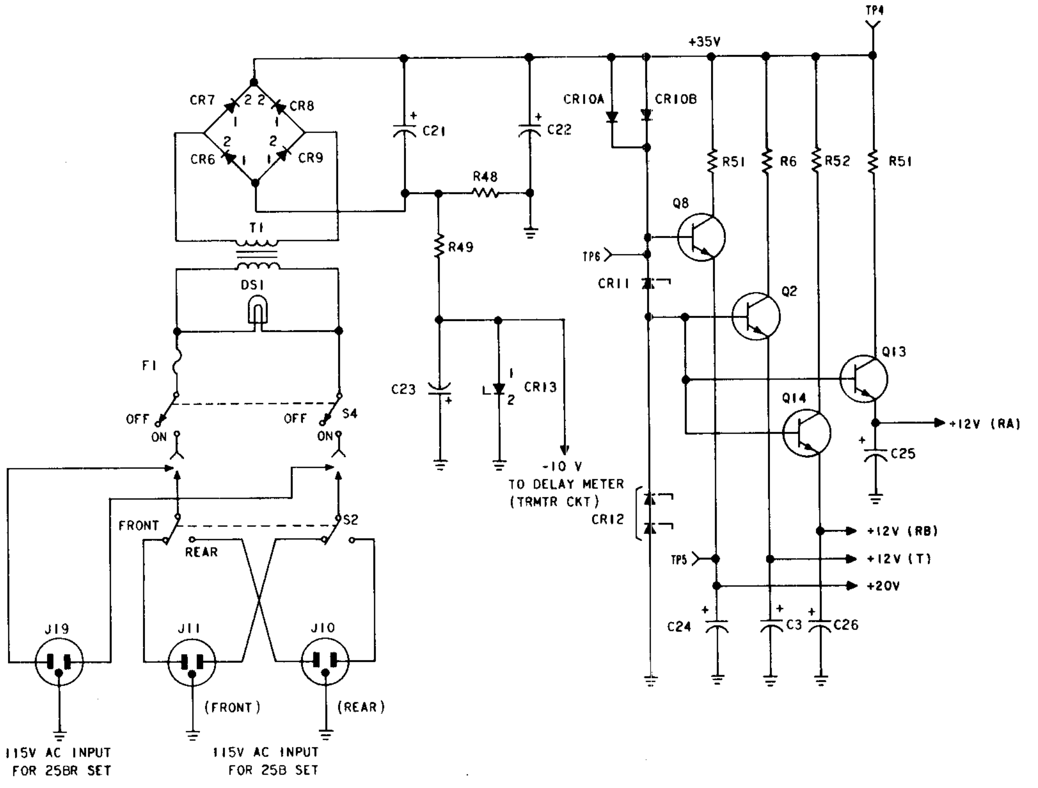

Fig. 9—Power Supply

STEP	PROCEDURE
	A. 2-kHz Oscillator Adjustment
1	Adjust R2 (on timing circuit board CP 2) to the midpoint of the range that produces successive 500-μs sawtooths at TP 2 (emitter of Q1).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 1.
	B. 4:1 Divide Adjustment
1	Adjust R8 (on timing circuit board CP 2) to the midpoint of the range that produces successive 2000-μs sawtooths at TP 3 (emitter of Q4).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 2. Note that the waveform scale is 500 μs/cm so that the timing pulses added to the sawtooth waveform are displayed.

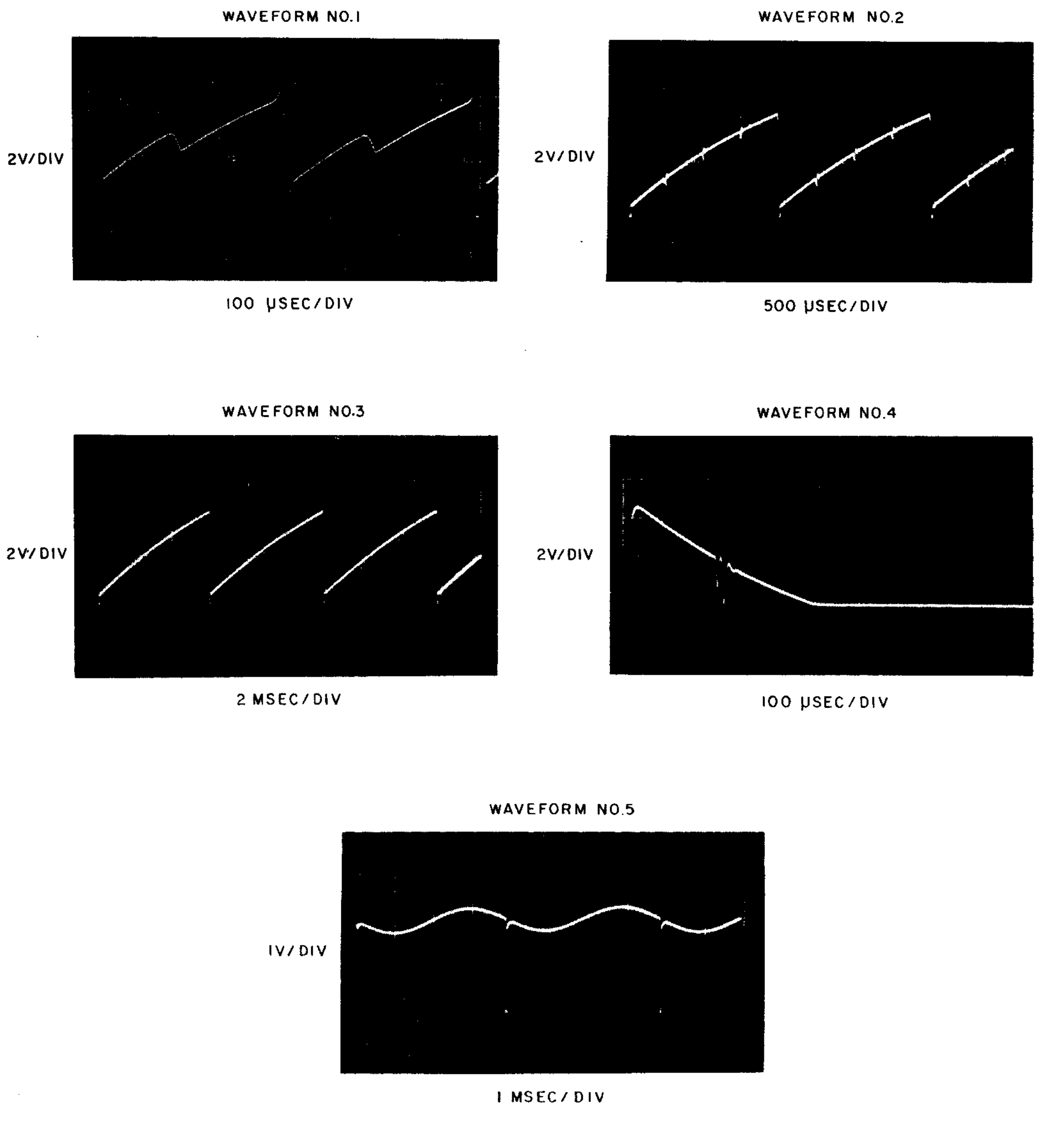

Fig. 10—Waveforms

STEP	PROCEDURE
	C. 3:1 Divide Adjustment
1	Adjust R11 (on timing circuit board CP 2) to the midpoint of the range that produces successive 6-ms sawtooths at TP 4 (emitter of Q5).
2	Verify that the waveform is as shown in Fig. 10, waveform No. 3.
3	Verify that the waveform at TP 8 (junction of R22 and R23 on timing circuit board CP 2) is as shown in Fig. 10, waveform No. 4, for all positions of the ADD MICROSECONDS control.
	D. Modulator Balance Adjustment
1	Insert a 310-type plug, shorted between tip and ring, into the EXT OSC jack.
2	Adjust R22 (on transmitter board CP 3) to minimize the peak-to-peak ripple voltage at either the LINE A or LINE B jacks or binding posts as observed on an oscilloscope.
3	Remove the 310-type plug from the EXT OSC jack.
	E. FREQUENCY Meter Calibration
1	Connect a frequency counter to the CTR jack.
2	Position the set so that the meters are in a horizontal position (facing upward) for a 25B set and in a vertical position for a 25BR set.
3	Adjust the FREQUENCY control for 3500 Hz on the counter.
4	Disconnect the frequency counter and adjust R42 (on transmitter board CP 3) for a reading of 3500 Hz on the FREQUENCY meter.
	F. Subscriber Oscillator Adjustment
	Note: This adjustment should be made only if excessive hysteresis (displacement between plots of increasing and decreasing frequencies) is observed when plotting the received level versus frequency with an X-Y recorder. The 2600 CPS SKIP adjustment (see Part G in the procedure in 6.01) should be checked following any adjustment of this control (C1 on CP 4). The adjustment procedure is:
1	Connect LINE A to LINE B.
2	Connect the FREQ RCDR and DBM RCDR outputs to the respective X and Y inputs of the X-Y recorder.
3	Calibrate the X-Y recorder for a full-scale sensitivity of approximately 5 dB as described in 4.11.
4	Slowly sweep the subcarrier frequency from 300 to 3500 Hz and plot the back-to-back received level on the X-Y recorder.

STEP	PROCEDURE
5	Repeat Step 4, but this time slowly sweep the frequency from 3500 to 300 Hz.
6	Observe the plots of the X-Y recorder. If the two plots fall on top of each other, C1 is in adjustment. If they do not coincide, C1 (CP 4) should be adjusted by trial and error until the deviation between the plots of increasing and decreasing frequencies is minimized.
	G. 2600 CPS SKIP Adjustment
	Note: This adjustment should be made following any adjustment of C1 (see Part F of the procedure in 6.01). The adjustment procedure is:
1	Connect a frequency counter to the CTR jack.
2	Ensure that all shields near the FREQUENCY capacitor (C11) are in place and tightly secured.
3	Adjust the vernier adjustment on the cam, which is mounted on the FREQUENCY capacitor shaft, and the FREQUENCY knob by trial and error until the frequency counter reads 2495 ±5 Hz just before the 2600 CPS SKIP switch actuates when the FREQUENCY knob is turned in a clockwise direction.
	Note: If the vernier adjustment does not have sufficient range, release the two set screws on the cam and position the cam so that the vernier adjustment range is centered at approximately 2495 Hz.
4	Adjust the FREQUENCY knob in a clockwise direction to the point where the 2600 CPS SKIP switch just actuates and verify that the frequency counter reading is 2705 ±20 Hz.
	H. RCVD LEVEL Meter Calibration
1	Remove the connection between LINE A and LINE B.
2	Position the set so that the meters are in a horizontal position (facing upward) for a 25B set and in a vertical position for a 25BR set.
3	Set the TRANSMIT knob to LINE A (25B set only).
4	Set the RCVR INPUT—ADD DB knob to the 0 position.
5	Connect a 1-kHz sine-wave generator, having either a 600- or 900-ohm source impedance and an output level of 0 ±0.03 dBm, to the LINE B input.
6	Set the IMPEDANCE knob to correspond to the source impedance of the 1-kHz generator.
7	Make sure that the set has been turned on for at least 20 minutes before continuing the calibration.
8	Adjust R10 (on receiver board CP 1) for a 0-dBm reading on the RCVD LEVEL meter.
9	Disconnect the 1-kHz generator from LINE B.

STEP	PROCEDURE
10	Patch LINE A to LINE B so that the set is operating back-to-back.
11	Adjust the LEVEL ADJ control (R30) on the front panel assembly for a 0-dBm reading on the RCVD LEVEL meter.
12	Set the RCVR INPUT—ADD DB knob to the +5 position.
13	Adjust the ZERO-ADJUST screw on the front of the RCVD LEVEL meter for a −5 dBm meter reading.
	Note: If this control does not have sufficient range, a coarse control on the rear of the RCVD LEVEL meter should be adjusted to center the adjustment range of the front ZERO-ADJUST control.
14	Set the RCVR INPUT—ADD DB knob to the 0 position and repeat Step 8.
15	Repeat Steps 12, 13, and 14 until the RCVD LEVEL meter reads 0 dBm with the RCVR INPUT—ADD DB knob in the 0 position and reads −5 dBm with the RCVR INPUT—ADD DB knob in the +5 position.
	I. 83-1/3 Hz Buffer Amplifier Output Adjustment
1	Patch LINE A to LINE B so that the set is operating back-to-back.
2	Adjust R28 (on receiver board CP 1) for a peak-to-peak voltage of 4.8 volts at TP 4 (collector of Q7).
	J. Zero-Crossing Detector Adjustment
1	Patch the LINE A and LINE B jacks together.
2	On a 25B set, set the TRANSMIT knob to SIG OFF; on a 25BR set, depress the SIG OFF pushbutton.
3	Adjust R42 (on receiver board CP 1) for a sawtooth period of 4 ms at TP 8 (emitter of Q10).
4	Set the TRANSMIT knob to LINE A on a 25B set or release the SIG OFF pushbutton on a 25BR set and adjust R42 so that the negative-going pulses which are superimposed on a slightly distorted 250-Hz sine wave at TP 6 (base 2 of Q10) coincide with the negative-going zero crossings of the 250-Hz sine wave.
5	Verify that the waveform is as shown in Fig. 10, waveform No. 5.
6	Turn the ADD MICROSECONDS control through all eight positions and verify that the positive portion of the rectangular pulse at TP 9 (collector of Q11 on receiver board CP 1) changes by 500-μs increments with each step of the switch.

STEP	PROCEDURE
	K. Delay Compensation Adjustment
1	Patch the LINE A and LINE B jacks together.
2	Set the IMPEDANCE knob to 600.
3	Set the FREQUENCY knob for a subcarrier frequency of 3 kHz.
4	Adjust the DELAY meter sensitivity as described in Steps 8 through 12 of the procedure in 4.01.
5	Adjust the ADD MICROSECONDS control and the DELAY ZERO control for a reading of zero on the DELAY meter (red scale).
6	Set the FREQUENCY knob for a subcarrier frequency of 300 Hz and adjust R25 (the delay compensation control on transmitter board CP 3) for a reading of zero on the DELAY meter (red scale).
7	Repeat Steps 3, 5, and 6 until the DELAY meter reads zero at both 300 and 3000 Hz without adjustment of the R25 or the DELAY ZERO control.

REPAIR

6.02 If any item of the set is malfunctioning or defective or if it is required that the internal adjustments be made and the necessary test equipment is not available locally, the set should be sent to a repair and calibration center such as a Western Electric distributing house.

6.03 Most trouble conditions will become apparent when the front panel controls are calibrated (see 4.01). These adjustments should be checked frequently to detect a possible trouble condition. If any of the front panel adjustments cannot be made, the internal adjustments should be checked as described in the procedures in 6.01. In general, these adjustments should be checked in the order listed. In this way, a trouble condition can be isolated to a particular circuit. Transistor voltages, waveforms, and a detailed description of the circuit are contained CD-99770-01 to assist in troubleshooting and in repairing a trouble condition. Waveforms are also shown near test points on SD-99770-01 to help isolate a trouble.

7. REFERENCES

7.01 The following documents provide supplementary information for this BSP:

CD-99770-01 SD-99770-01	Common Systems—Transmission Measuring—25B and 25BR Voiceband Gain and Delay Sets
801-250-160	J94025—Type Voiceband Gain and Delay Set—Common Systems

NOTES