through R103, R104, and R107 at the grid of mark-keyer V26. A space (negative) signal applied at the grid of V23A causes an opposite reaction to occur. The title *space keyer* has been applied to V24B not because it keys the teletypewriter printer loop circuit with a space character, but because the tube itself conducts (and is thus *keyed*) when a negative signal is present at the contact grid of V23A. The function of V24A and B is to cause V25 and V26 to conduct or not conduct depending upon the mark or space output from the discriminator circuit. V25 and V26, in turn, influence the current flow in the teletypewriter loop circuit. A +2-volt input from the discriminators will drive V25 and V26 tubes to full conduction.

e. If, for any reason, the rf carrier in both channels fails, relays K1 and K2 (fig. 29) ground the plate of keyer amplifier V24A. This places the grid (pin 7) of V24B at a negative potential and the voltage at the slider arm of potentiometer R104 at a positive potential. Tubes V25 and V26, therefore, will conduct and produce the same effect that exists when a mark signal is transmitted through the keyer circuit. This condition is maintained as long as the carrier is shut off, but is removed automatically as soon as the carrier is again received. Both relays must be closed when CHANNEL SELECTOR switch S5 is in the A+B position if the carrier-control mark-hold circuit is to operate. When both relays are energized, the plate of tube V24A is connected to contacts 4-5 on K2, through switches S8 and S3 to contacts 4-5 on K1, and then to ground. For single-receiver operation, only the relay associated with the particular channel circuit being used is connected by S5A for the carrier-control mark-hold feature.

43. Afc Limiter Amplifier
(fig. 30)

a. During operation, the 50- and 29.3-kc intermediate frequencies may drift. If no corrective means were provided for such conditions, the teletypewriter dc output signals would be biased or distorted. To minimize the biasing effect, part of the signal from the input circuits is fed to separate afc circuits. If the intermediate frequency changes for any reason, the afc circuit brings it back to its proper value by mechanically tuning the oscillator. To connect either afc circuit, AFC switch S2 must be in the ON position, the AFC-XTAL-MARK HOLD switch S1 (or S7 in channel B) must be turned to an AFC position, and the AFC SHIFT ADJUSTMENT must be set for the proper mark (par. 45). The first section of each afc circuit consists of a four-tube limiting amplifier to remove undesirable amplitude variations from the frequency shift signals and also to apply a constant voltage to the input of the afc discriminator diode V8.

b. Band-pass filter Z1 of channel A is terminated with the resistive load formed by resistors R13 and R14. The signal from Z1 is fed to the grid (pin 1) of the first limiting amplifier V4, through grid current limiting resistor R15. Tube V4 is a sharp cutoff pentode. Low level positive and negative peaks, between plate saturation and cutoff of the tube, are amplified. High-level signals, however, cause V4 to be driven to cutoff and plate saturation on negative and positive peaks, respectively. At the point of plate saturation, grid current flows through R15 and develops a negative bias which effectively reduces positive peak input signals. On high negative peaks, the tube is cut off. Therefore, any undesired voltage peaks impressed on the carrier are clipped. Cathode bias resistor R20 is bypassed by capacitor C17. The screen grid voltage is taken from the junction of the divider network consisting of R204 and R22. This screen grid voltage controls the stage gain. Capacitor C19 is the screen bypass capacitor. Resistor R23 is the plate load resistor and resistor-capacitor combination R21 and C18 forms a decoupling network. The output from the plate of tube V4 is coupled to tube V5 through coupling capacitor C21 and resistor R24. The output from the plate also is applied, through coupling capacitor C20, to the cathode of signal rectifier V11.

c. The low-level signals, too small to cause plate saturation or cutoff in V4, are amplified by V5, a sharp cutoff pentode. The higher level signals have the undesired negative peaks clipped by the operation of one section of V6, a dual-diode tube. A negative voltage is applied to the plates of V6. Peaks more negative than −3 volts from the output of V4 cause the cathode (pin 1) of V6 to become more negative than the plate. This condition causes current to flow heavily, effectively creating a short circuit and removing the negative peaks. The positive peaks, after amplification in V5, become negative peaks at the plate of V5 because of the 180° phase reversal between the control

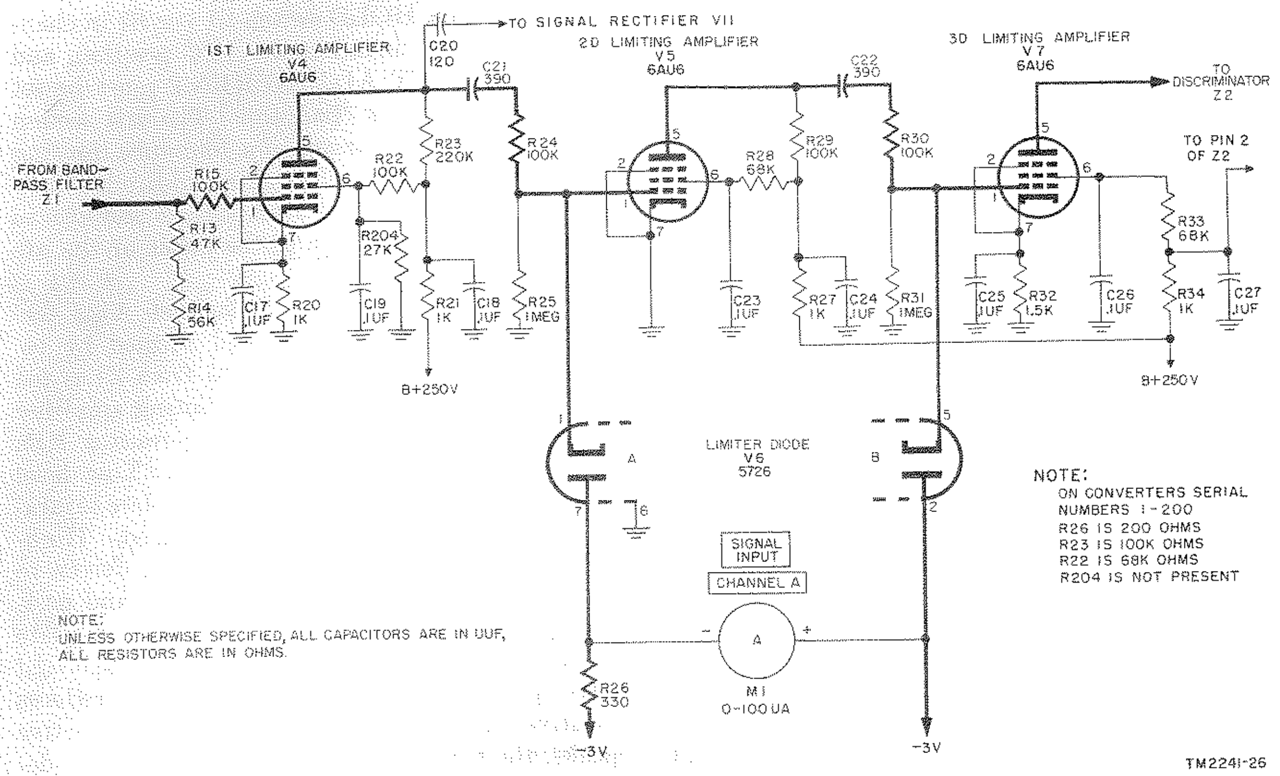

Figure 30. Afc limiter amplifier, simplified schematic diagram.

grid and plate. This strong negative peak is applied to the other cathode (pin 5) of tube V6. Peaks more negative than −3 volts make the cathode more negative than the plate, causing current to flow through the tube and remove the negative peaks. Accordingly, weak or strong input signals are approximately at the same level when they are applied to the grid (pin 1) of V7 for further amplification. The output from V7 is applied to the primary winding of the 50 kc discriminator transformer in Z2.

d. Meter M1, connected across pins 2 and 7 of V6, serves as a SIGNAL INPUT indicator for channel A. The meter will read on inputs as low as 100 microvolts. Resistor R26 is shunted across M1 to prevent damage to the meter in the presence of strong signals.

e. Tubes V30, V31, V32, and V33 form a similar limiting amplifier for channel B afc signals. Channel B differs slightly from channel A at the output of band-pass filter Z6. The output of band-pass filter Z1, in channel A, is delivered to a simple resistive matching network. In channel B, a matching-dividing network is used to attenuate the output of Z6. The additional attenuation in channel B is used to compensate for a difference in gain between the 50 kc channel A if., and the 29.3 kc channel B if. This difference in gain occurs in other stages. The matching-dividing network in the output of Z6 consists of the simple L attenuator formed by resistors R123 and R124. These resistors are shown in the complete converter schematic, figure 62. The output from V33 is applied to the primary winding of the 29.3 kc discriminator transformer in Z7.

44. Afc Discriminator

(fig. 31)

a. The afc discriminator circuit produces a dc voltage change at the grids of V9 for any drift in the intermediate frequency. This dc *error* signal, after amplification, controls a motor-driven capacitor, C8, which brings the if. to its proper value by tuning the oscillator until the *error* is zero. Any if. drift is undesirable since it results in a distorted signal at the diversity discriminators.

b. The operation of the afc discriminators is similar to that of the diversity discriminators. Refer to paragraph 41*a* through *c*. In channel A, one secondary winding of the transformer of Z2

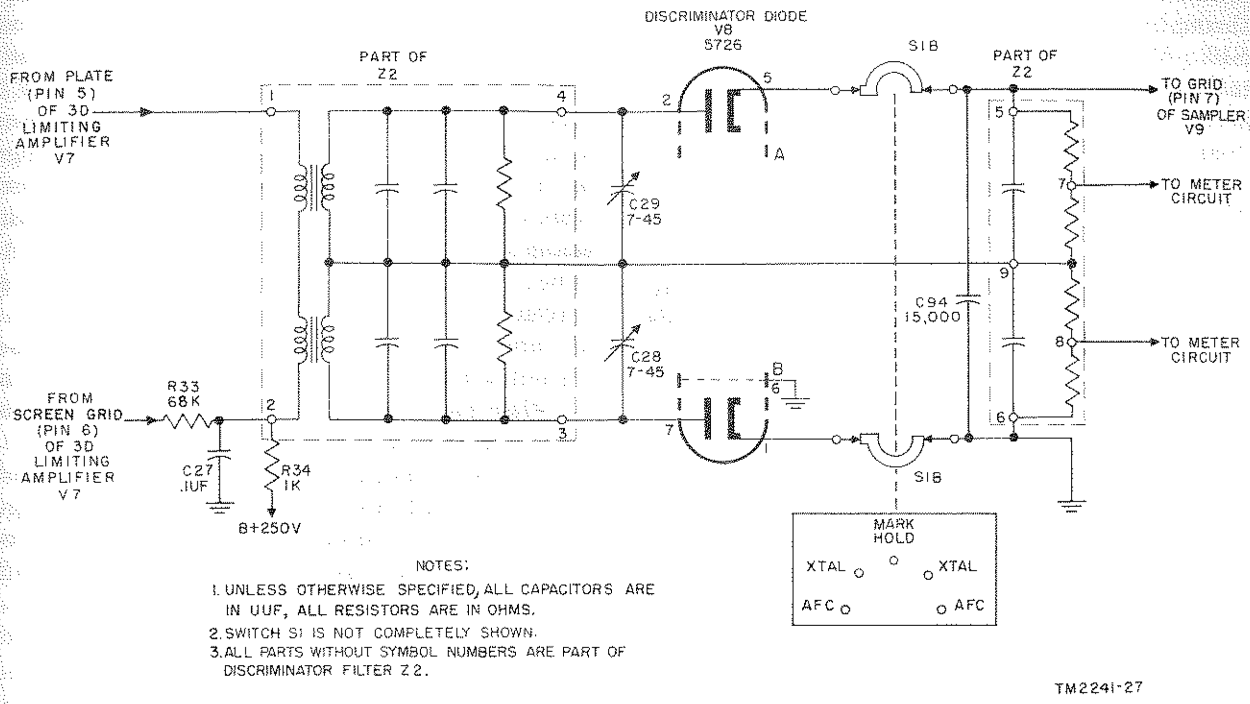

Figure 31. Afc discriminator, simplified schematic diagram.

is tuned to approximately 1,000 cycles above 50 kc and the other winding to approximately 1,000 cycles below 50 kc. Neither secondary tuned circuit is resonant at the center frequency of 50 kc, but both are off resonance by approximately the same amount. At 50 kc, the signal voltage developed across each secondary tuned circuit will be relatively small and have the same magnitude. Therefore, equal and opposite signal voltages are coupled to the two diodes of V8 at 50 kc, the rectified output voltages are the same across each resistive load but of opposite polarity, and the net output voltage is zero. When the if. signal is above 50 kc, the secondary tuned circuit between terminals 4 and 9 develops a greater voltage because the intermediate frequency is closer to the resonant frequency of this tuned circuit. The secondary voltage developed across the tuned circuit between terminals 9 and 3 is now less than at 50 kc because the if. is further removed from its resonant frequency. With less signal voltage applied to diode pins 1 and 7 and more to diode pins 2 and 5 for an if. drift above 50 kc, the pins 2 and 5 diode provides greater rectified output voltage than the other diode and a net output voltage of positive polarity is obtained. The positive voltage increases linearly for an increasing shift away from 50 kc, up to approximately 1,000 cycles. Similarly, the output voltage is negative when the if. is below the center frequency of 50 kc. A typical **S**-shaped discriminator response curve is shown in figure 25. For channel B, the operation of the afc discriminator is identical except that the center intermediate frequency is 29.3 kc. Capacitors C94 and C95 are connected across the discriminator load resistors of V8 and V34, respectively. The capacitors serve to bypass the high frequency components of the detected signal information.

c. Switch sections S1B and S7B, in the output circuits of the two afc discriminators, allow for reversing the polarity of the dc output signals. This provides a means for always having a net positive voltage for a mark and a net negative voltage for a space. Reversal of output polarity in the channel A afc circuit is accomplished by section B of switch S1 which reverses the cathode connections to tube V8. For channel B, section B of switch S7 is used to reverse the cathode connections to the diode discriminator, V34.

d. Meter M3 (fig. 62) is connected across output terminals 7 and 8 of transformer discriminator Z7 to allow for observing the operation of the discriminator. An identical meter M4 is connected across the output of discriminator transformer Z2 through contacts of PRESS TO TEST switch S10. Meter M4 is also used for other electrical measurements in the converter circuit and is connected to the various circuits by switch S11 (par. 50).

45. Sampler and Shift Reference Stages

(fig. 32)

a. Each sampler stage uses a dual triode, V9 in channel A and V35 in channel B. The two grids (pins 2 and 7) of each sampler tube are tied together and connect to the outputs of their respective discriminator networks, Z2 for channel A and Z7 for channel B. Load resistors R37 and R147 are also connected to the outputs of Z2 and Z7, respectively. Referring to channel A, positive and negative pulses, representing mark-space signals, are applied to the grids of V9 which is biased by cathode resistor R38. On mark signals, the grids of V9 become positive and conduction takes place. This charges capacitor C30 with a voltage which depends on the discriminator output for a given frequency shift. The charge on C30 remains nearly constant as long as the mark frequency input to Z2 does not change. A change in frequency shift is compensated by the AFC SHIFT ADJUSTMENT control (*c* below). However, a change in if. frequency will result in a change in the positive voltage representing a mark pulse. This changes the charge on C30 which, in turn, changes the bias on the shift reference tube, V10A. When a space (negative) signal is received, V9 is driven to cutoff. Under this condition, V9 acts as an infinite impedance to the charge on C30 and capacitor C30 maintains its charge since there is no other path for discharge. This action holds the grid of V10A at a positive potential.

b. Any if. frequency drift fed to the afc discriminator will cause the mark (positive) voltage applied to V9 to become more or less positive, depending on the direction of the drift. A drift toward a higher frequency increases the positive voltage at the grid of V9, which then conducts more current and causes C30 to charge to a higher voltage. Tube V9 conducts less for drifts in fre-

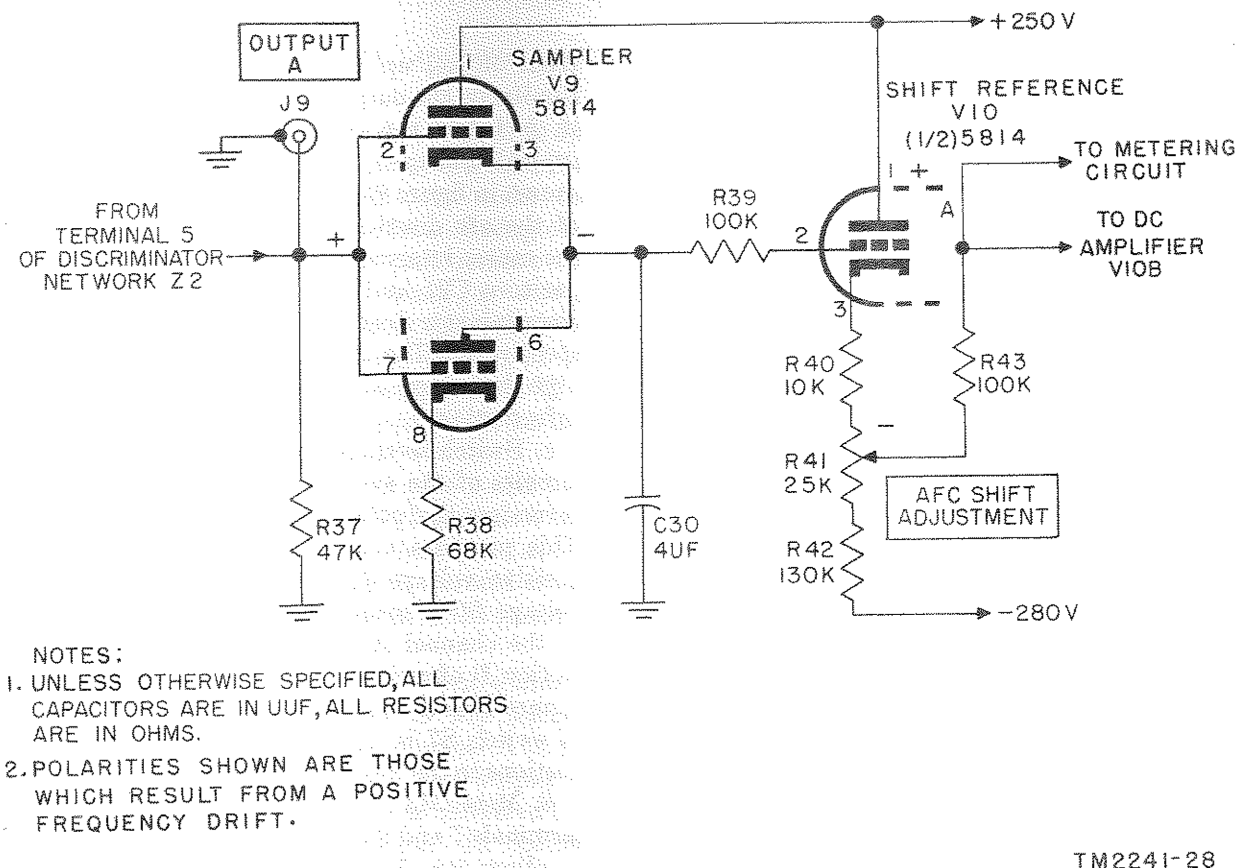

Figure 32. Sampler and shift reference stage, schematic diagram.

quency below the correct if. mark value. Capacitor C30, in this case, discharges to a lower voltage. Rapid frequency changes caused by normal mark-space keying do not affect the charge on C30 because of the large time constant involved in discharge. The charge on C30 is applied as signal voltage to the shift reference tube, V10. Thus, the sampler stage permits only long, general frequency drifts to appear as signal changes to the grid of the shift reference tube.

c. Each shift reference stage is essentially a cathode follower circuit utilizing one section of a dual triode, V10A in channel A and V36A in channel B. Referring to channel A, resistors R40 and R42 together with potentiometer R41 form the load resistance network. The slide arm of the AFC SHIFT ADJUSTMENT, R41, connects to the grid of the first dc amplifier, V10B, through grid limiting resistor R43. Potentiometer R41 is adjusted to apply a 0-volt potential to the grid of V10B when the mark frequency is correct. This balances the afc motor circuit and holds the oscillator on frequency during afc operation. A deviation in the charge on C30 resulting from a drift in mark frequency changes the signal to tube V10A and the voltage at the slide arm of potentiometer R41 will no longer be zero. An unbalanced condition then exists in the dc amplifier stages which actuate the oscillator-capacitor drive-motor B1. The direction of rotation is determined by the direction of frequency drift from the 50 kc center if. frequency. The motor rotates or tunes capacitor C8 until the oscillator brings the mark frequency back to its correct value. To maintain dc amplifier balance under normal operating conditions, adjustments for changes in frequency shift within the range of 150 to 1,000 cycles are made by means of the AFC SHIFT ADJUSTMENT control (R41).

46. Dc Amplifier Stages

(fig. 33)

a. In the dc amplifier stages, an error signal appearing at the slide arm of AFC SHIFT ADJUSTMENT potentiometer R41 is amplified and fed to the two grids of the motor drive tube as a push-pull output. Three dual triodes are used in the dc amplifier stages, V10B, V12, and V14 in channel A, and V36B, V38, and V39 in channel B. Each stage is a direct-coupled amplifier with resistive connections between stages. No blocking capacitors or coupling transformers are used. Except for reference symbols, the channel A and channel B dc amplifier stages are identical.

b. In channel A, the grid of first dc amplifier tube V10B is connected to potentiometer R41 through current-limiting resistor R43. Any error signal impressed on the grid of V10B is amplified. The cathode is grounded through resistor R44. Resistor R45 serves as the plate-load resistor. A voltage-dividing network is formed by R46 and R48 and potentiometer R47. The slide arm of potentiometer R47 is connected to the control grid (pin 2) of inverter tube V12 through current-limiting resistor R51.

c. The dual-triode inverter tube, V12, forms a differential amplifier having a single input terminal and two output terminals. An input error signal to V12A (from the first dc amplifier) is applied to grid 2; grid 7 of tube V12B remains fixed at ground potential. The signal is coupled to V12B by cathode resistor R53. The output voltage between the plates (pins 1 and 6) is the same as if the input voltage were applied in conventional push-pull. The push-pull nature of the inverter stage, acting as a differential amplifier, is shown by the curves of figure 34. By symmetry, the output voltage is zero at zero input voltage. Resistors R52 and R54 are the plate-load resistors, and R53 is the cathode resistor common to both triode sections. The two separate output voltages are fed from the plates through resistive networks to second dc amplifier V14. Resistors R58 and R59 and potentiometer R57 form a voltage divider across the output of V12A. Resistor R60 connects to the grid of V14B. Resistors R55 and R56 and potentiometer R57 form a similar voltage divider across the output of V12B. Resistor 61 connects to the grid of tube V14A.

d. The second dc amplifier, V14, provides additional amplification for each of the two outputs of inverter tube V12. Both cathodes are grounded to form two simple triode amplifiers. Tube V14A amplifies the signal from V12B, and V14B amplifies the signal from V12A. Plate-load resistor R64 forms a voltage divider with resistors R63 and R62. Plate-load resistor R65, for the A section of tube V14, forms a voltage divider with resistors R66 and R68. Amplified out-of-phase signals from the inverter are supplied to the motor drive circuit through grid current-limiting resistors R67 and R69.

e. To summarize the operation of motor drive circuit, a positive error voltage appearing at the

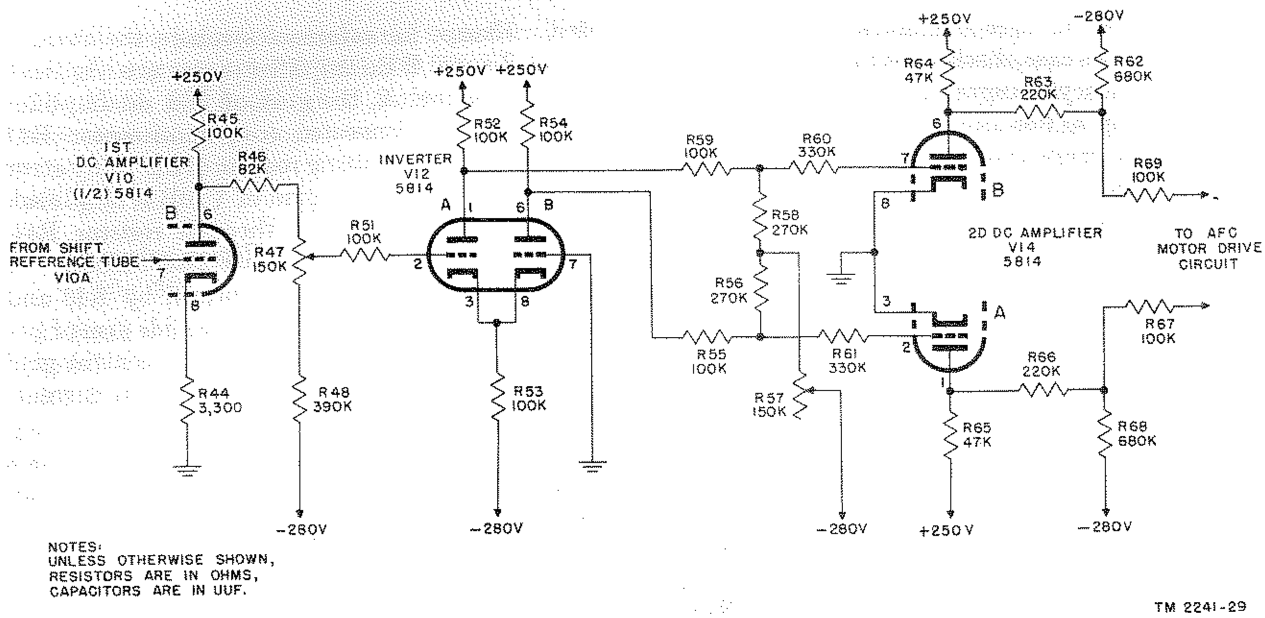

Figure 33. Dc amplifier stages, schematic diagram.

grid of cathode follower V10A is reflected through resistors R40, R41, and R43 and drives the grid of tube V10B more positive. In conducting more heavily, the plate voltage of tube V10B becomes lower. This lower voltage is applied to the control grid of tube V12A and is sufficient to cut off this section of the tube. The increased voltage at the plate (pin 1) is applied to the grid of tube V14B and causes it to conduct. Since the cathodes of tubes V12A and V12B are common, cutting off V12A makes the grounded grid of V12B become more positive with respect to its cathode and causes V12B to conduct. The resulting lowered voltage at the plate (pin 6) is applied through the voltage divider to the control grid (pin 2) of the tube V14A, cutting it off. With tube V14B conducting and tube V14A cut off, negative and positive signals are applied to tubes V15B and V15A. Motor B1 (par. 47) then operates to decrease the capacitance of C8; this reestablishes a correct converter if. of 50 kc. With no error signal present, the overall balance of the dc amplifier stages is obtained by means of channel A dc amplifier adjustments R47 and R57. Both potentiometers are accessible from the top of the chassis and may be adjusted with a screwdriver. Refer to figure 10 and paragraph 63*b*(2).

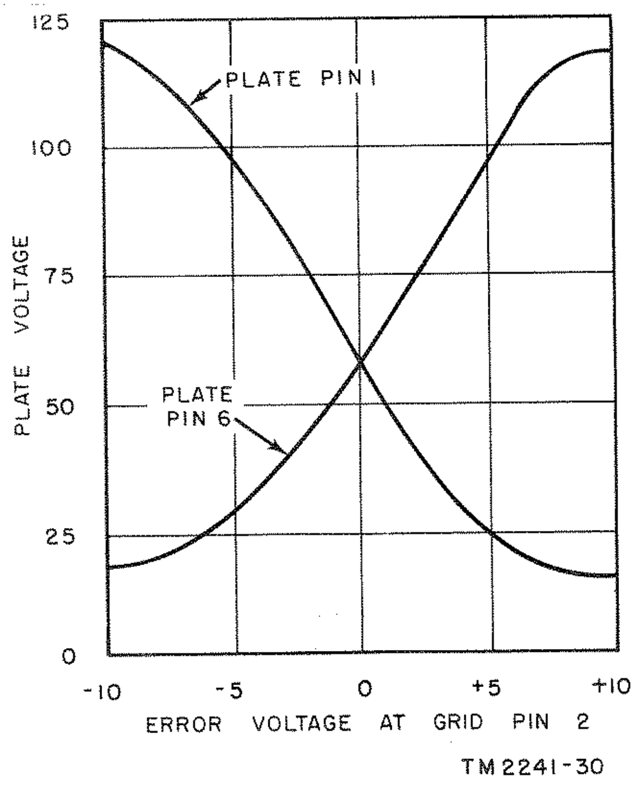

Figure 34. Inverter characteristic curves.

47. Motor and Motor Drive Circuit
(fig. 35)

a. The channel A afc circuit terminates in the motor drive stage which uses dual-triode tube V15 to control the direction and amount of rotation of motor B1. Motor B1 is coupled to oscillator tuning capacitor C8 through a gear train of approximately 4,500-to-1 ratio. Any rotation of B1 is observable on a *spinner* disk marked AFC INDICATOR on the front panel. A friction-clutch arrangement permits manual tuning of capacitor C8 by means of the DRIFT INDICATOR knob on the front panel. The friction clutch, gear train, motor B1, and tuning capacitor C8 are mounted in one replaceable inclosure, afc unit Z9. Also included in Z9 is cam operated switch S4 which closes the power circuit to warning bell I 1 when either extreme of the tuning capacitor range is reached. For channel B, afc motor-capacitor assembly Z10 is identical and is interchangeable with Z9. Tube V40, in the motor drive circuit, controls afc unit Z10.

b. Commonly called drag-cup motors, B1 and B2 are ac followup devices using the principle of the induction-disk watt-hour meter. An exploded pictorial diagram of a drag-cup motor is shown in figure 36. The rotor is very light, consisting of a nonmagnetic cup on a shaft. The cup rotates within a conventional distributed-pole two-phase stator and a fixed round lamination stack which is used to complete the magnetic circuit. The field windings set up eddy currents in the drag cup which react with the air gap flux to produce motor torque. One phase (winding CD) is excited continuously from the ac line through two parallel starting capacitors, C32 and C33, and the normally closed contacts of relay K1. Capacitors C32 and C33 are used to obtain a 90° phase shift for producing a two-phase rotating field from the single-phase ac line. The other phase (winding AB) is fed as a load in the cathode circuits of afc motor drive tube V15. With no error signal from the afc discriminator, the dc amplifiers are balanced and a cutoff bias of approximately −25 volts is applied to each grid of the motor drive tube. Any error signal caused by a drift in the if. will drive one grid of the motor drive tube more positive and the other more negative causing one triode section to draw current and the other to become completely deenergized. The current is rectified in passing through the triode section and is fed as 60 cps pulsating dc to phase winding AB of the drag-cup motor. When the mark signal drifts toward a frequency lower than the 50-kc center frequency, the motor turns as a result of this half-wave rectified ac. The direction of rotation depends on which triode section is conducting. Each triode section acts as a switch for changing the phase winding AB of B1 from one-

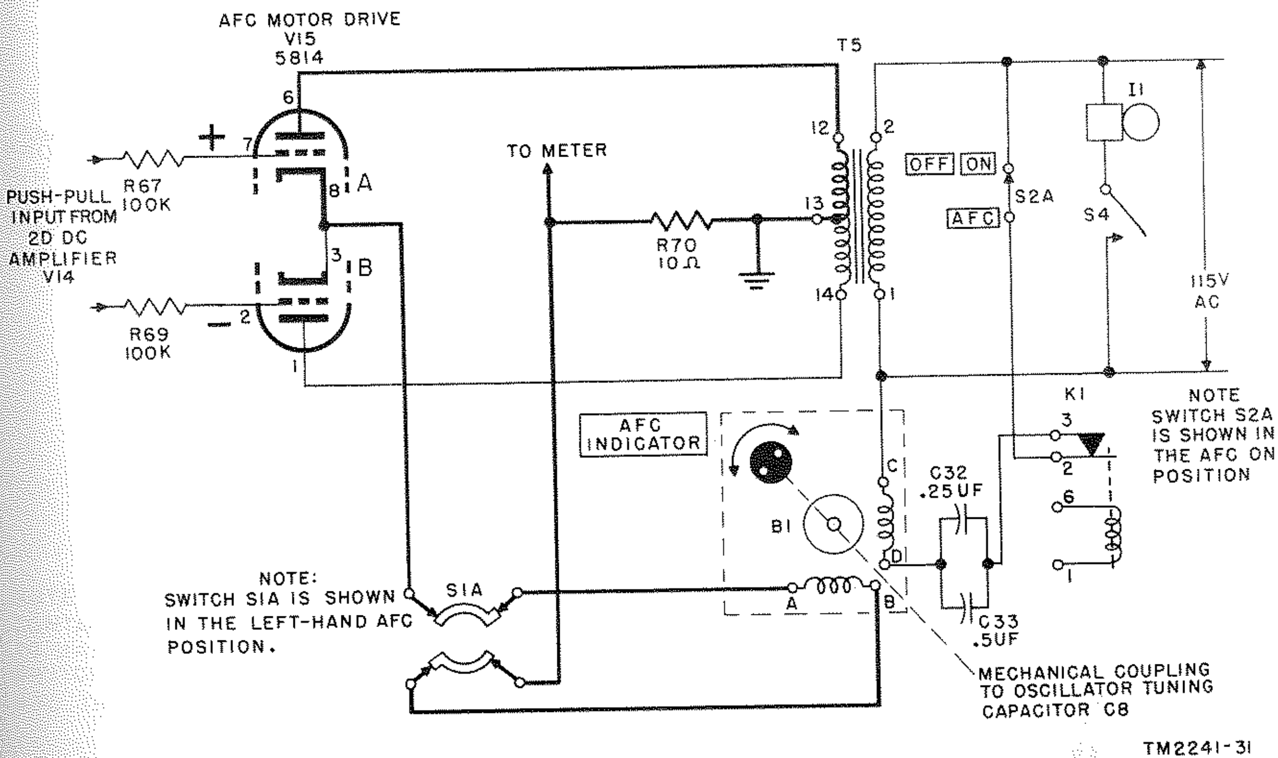

Figure 35. Motor and afc motor drive circuit, simplified schematic diagram.

half of center-tapped transformer T5 to the other. Reversal of the two-phase motor is accomplished by electronically reversing the phase of the current in winding AB.

c. When the mark frequency drifts away from the 50-kc center frequency in the direction of a higher frequency, the grid of V15A becomes more positive and the grid of V15B (fig. 35) more negative. This causes V15A to conduct, and the current passes through the top half of the secondary winding of T5, through R70 and phase winding AB of B1, and back to the cathode through switch S1A. Because of the phasing between the two windings of B1, the motor turns in such a direction as to cause an unmeshing of the plates of C8 resulting in a decrease in capacitance. The decrease in capacitance continues until the oscillator brings the if. back to 50 kc and the dc amplifiers again are balanced. When the mark signal drifts below 50 kc, the grid of V15B becomes more positive and tube V15A is cut off. Tube V15B conducts and current passes through the lower half of the secondary winding of T5. The phasing in phase winding AB is changed by 180° and the motor turns in the opposite direction, meshing the capacitor plates. This causes the oscillator frequency to decrease which, in turn, raises the mark signal frequency back to its original value. When the afc discriminator output is reversed by switch section S1B, section S1A of the same switch reverses phase winding AB and the operation of motor B1 is reversed. The current through motor winding AB may be measured by the metering circuit which connects across series resistor R70 when metering switch S11 is in position R57 (fig. 39).

d. Motor winding CD is excited continuously from the ac line through a set of normally closed contacts on relay K1. The K1 relay contacts open on weak or failing signals, thus disabling motor B1. This prevents B1 from detuning the oscillator on noise in its attempt to reduce the error signal to zero.

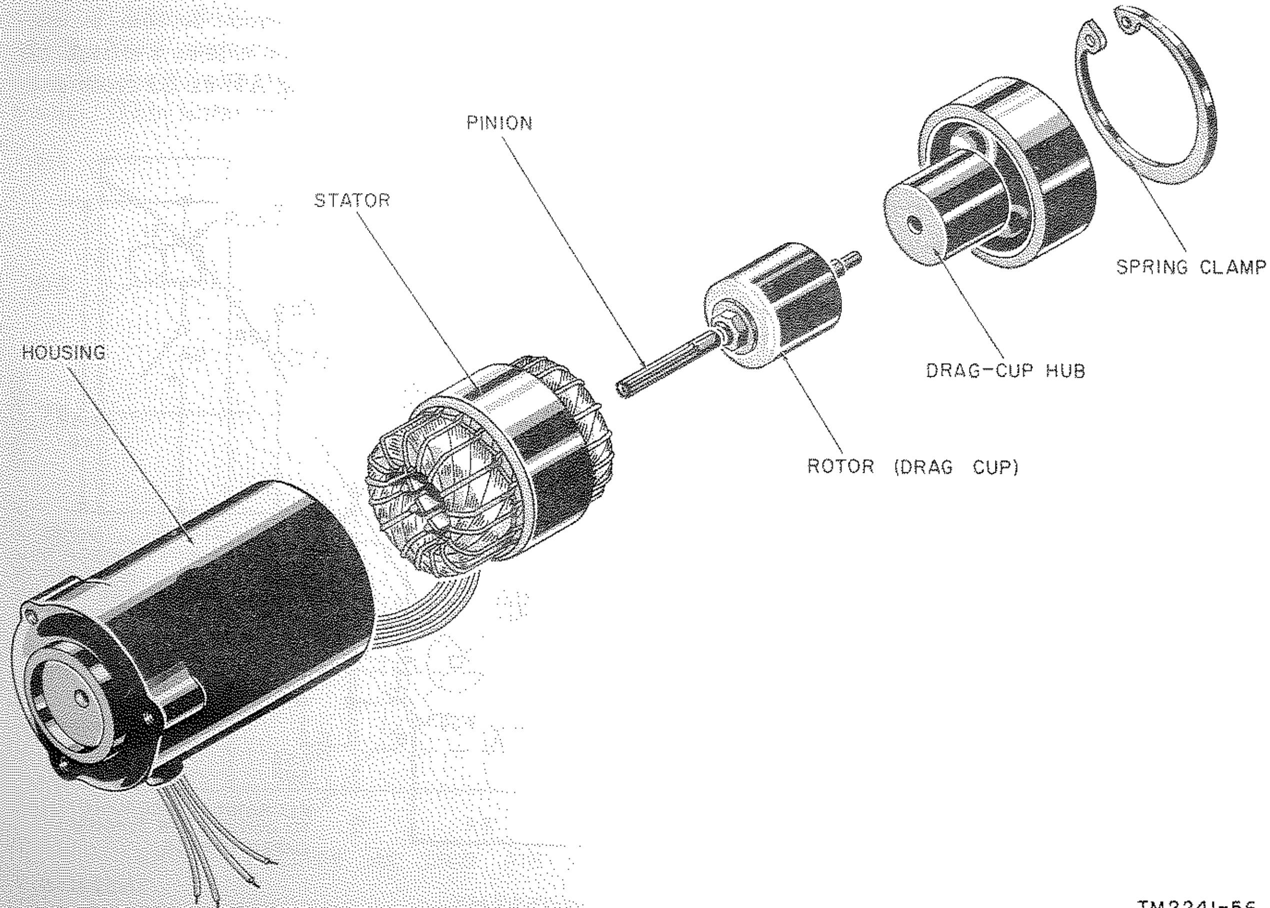

Figure 36. Exploded view of motor B1.

48. Threshold Control Circuit
(fig. 37)

a. The threshold control circuit holds a mark signal on the TY loop circuit and disables the afc motor if the incoming carrier fails. Each circuit consists of a signal rectifier tube and a threshold amplifier tube. Except for reference symbols, the threshold control circuits are the same for channel A and channel B.

b. In channel A, part of the if. signal at the plate of first afc limiting amplifier V4 is fed through coupling capacitor C20 to signal rectifier tube V11. Tube V11 is a twin diode with the cathode of diode A tied to the plate of diode B. The input signal from V4 is applied at this junction point. A −3 volt potential is applied to the plate (pin 7) of V11A through AFC THRESHOLD LEVEL potentiometer R50. Input signals to V11 more negative than −3 volts cause diode A to conduct. Current is rectified in passing through V11A and continues through R50 to the −3 volt line. Tube V11B, with its resistor-capacitor (C31–R49) return to ground, restores the circuit to equilibrium when tube V11A is not conducting.

c. The dc signal output from the signal rectifier is amplified by threshold amplifier tube V13. The level of the signal impressed on the grid of V13 is adjusted by AFC THRESHOLD LEVEL control R50. When V11 conducts on strong signals, the current through R50 drives the grid of tube V13 negative. This causes V13 to cut off and current decreases through relay K1 which is connected in the plate circuit. With the relay deenergized, movable contacts 2 and 3 close for afc motor circuit operation and contacts 4 and 5 open, ungrounding the mark-hold line. This condition is maintained as long as the carrier remains strong, and is removed automatically as soon as the carrier drops in strength.

d. Motor B1 is connected to the 115-volt power

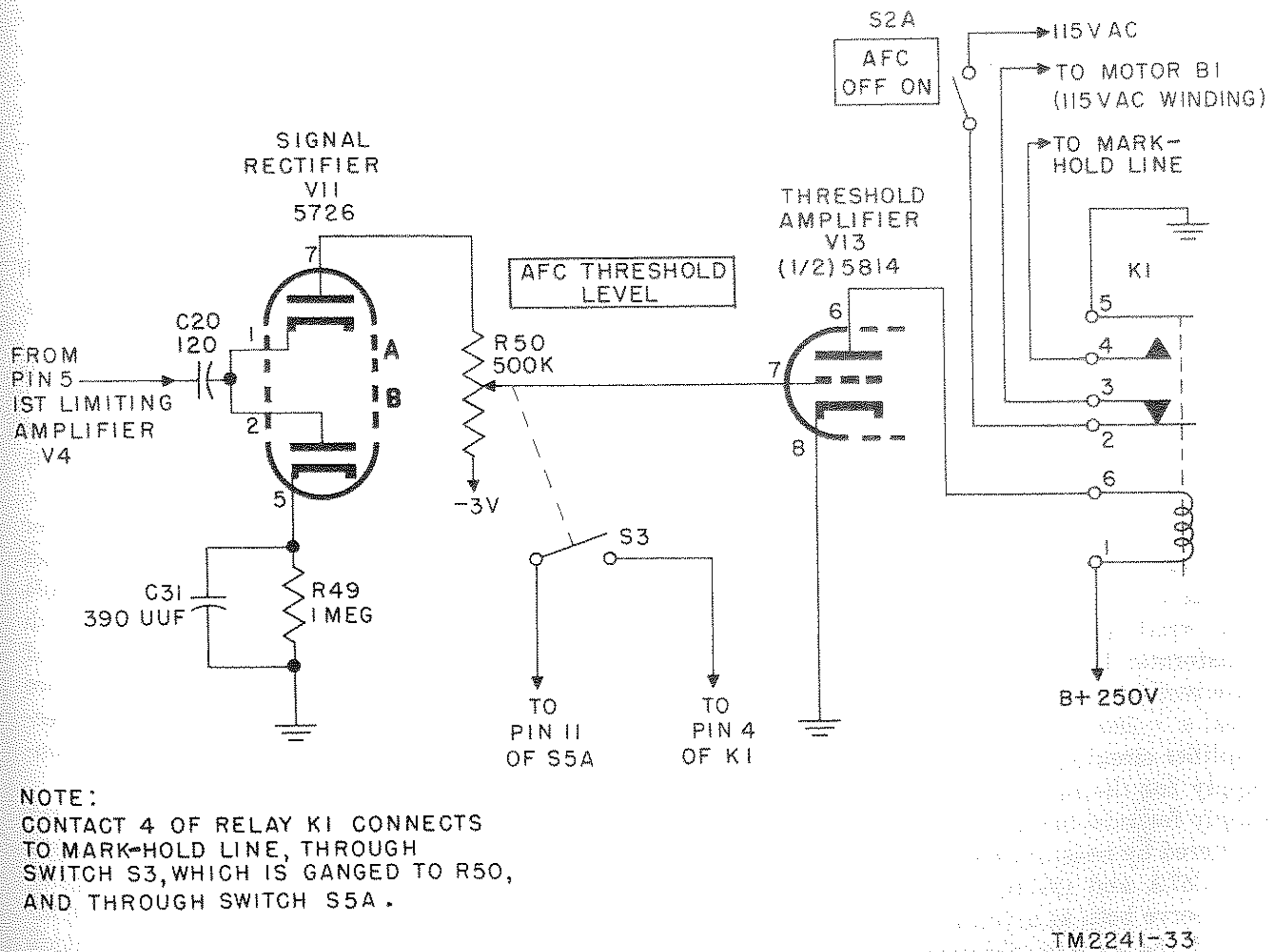

Figure 37. Threshold control circuit, schematic diagram.

line through contact points 2 and 3 on relay K1 and afc switch S2A. Thus, the motor is disabled when switch S2A is in the OFF position or when relay K1 is energized due to a failing signal. With relay K1 energized (when the signal fails), normally open contact points 4 and 5 ground the markhold line through switch S3 and CHANNEL SELECTOR switch S5A.

49. Power Supply

The power supply circuit (fig. 38) supplies filament voltages and three high-voltage (hv) dc potentials for the operation of the converter.

a. Power Input Circuit. The 115-volt, 50- to 60-cycle primary power supply is connected by a cable assembly to receptacle J8 on the converter. The power leads then are connected through 3-ampere fuses F1 and F2 to filter Z8, through the contacts of toggle switch S9, to winding 1–2 of power transformer T5. Neon lamp I 2, in series with dropping resistor R181, is connected across primary winding 1–2 of T5 to indicate when the power circuit is energized.

b. Full-Wave Rectifiers for Positive 0.33- and 250-Volt Supplies. Rectifier tubes V42, V43, and V44 with filament windings 3–4–5 and hv windings 12–13–14 of transformer T5, provide a +250-volt dc supply. This supply is filtered by series choke coils L3 and L4 and capacitors C88, C89A, and C89B. Resistor R191 serves as a peak current-limiting resistor. Bleeder resistors R194 and R195 are connected across the output terminals of the +250-volt supply to stabilize the voltage and to discharge the filter capacitors when the converter is turned off. A voltage divider consisting of resistors R192 and R193 provides a potential at their junction of +0.33 volt required to measure B+ in the metering circuit.

c. Full-Wave Rectifier for Negative 280-, 35-, 8-, 3-, and 0.37-Volt Supplies. Rectifier V41, filament windings 3–4–5, and hv windings 6–7–8 of transformer T5, are connected in an inverted full-wave rectifier circuit to provide five negative supplies: a −280 volt supply for the keyer and dc amplifier circuits, a negative 35-, 8-, and 0.37-volt supply for the metering circuits, and a −3 volt supply for tube biasing. The output of tube V41 is filtered by resistors R182 and R183 and capacitors C87A and C87B. Resistors R184 through R190 serve both as a voltage-dividing network to tap off the various negative potentials required by the converter and as a bleeder network.

d. Full-Wave Rectifier for Positive 130-Volt Dc Loop Supply. Rectifier V45, filament windings 3–4–5, and hv windings 9–10–11 of transformer T5, are connected in a full-wave rectifier circuit to provide approximately +100 volts supply for the TY loop supply, depending on the printer load. Filtering is accomplished by series choke coil L5 and capacitors C90A and C90B. Resistor R196 acts as a bleeder resistor for stabilizing the output voltage.

50. Metering Circuits
(fig. 39)

The frequency-shift converter is provided with microammeters M1, M2, M3, and M4 for checking the operation of the various circuits. Meters M1 and M2, connected permanently across pins 2 and 7 of limiter diodes V6 and V32, indicate the input levels of signals at the two converter input terminals. Meter M3 is connected permanently across terminals 7 and 8 of discriminator transformer Z7. This meter measures the channel B discriminator output voltage. Meter M4 is connected to terminals 2 and 5 on PRESS TO TEST switch S10. Normally, M4 measures the channel A discriminator output voltage. When switch S10 is depressed, meter M4 is connected to switch S11 for metering various voltages throughout the converter during alinement and adjustments. Switch S11 has 12 positions, 3 of which are unused (fig. 39).

a. R109 Position. In position 1, meter M4 is connected in series with multiplier R199 across meter shunt R106. The meter indicates the loop current through mark-keyer tubes V25 and V26.

b. R94 Position. In position 10, meter M4 indicates the voltage at the grid of keyer amplifier tube V24A. In series with multiplier R200, meter M4 connects to the slide arm of potentiometer R94 and to the −8 volt tap in the power supply. With R94 properly adjusted for −8 volts at the grid of V24A, meter M4 reads 0, indicating a balance against the −8 volts at the power supply. Section A of S11 grounds the input to the keyer amplifier, grid 7 of V23A.

c. R99 Position. In position 11, meter M4 measures the voltage at the grid of space-keyer tube V24B. The meter, in series with multiplier R198, connects from the slide arm of potentiometer R99 to ground. Section A of S11 grounds the input to the keyer amplifier, grid 7 of V23A.

d. R104 Position. In position 12, meter M4

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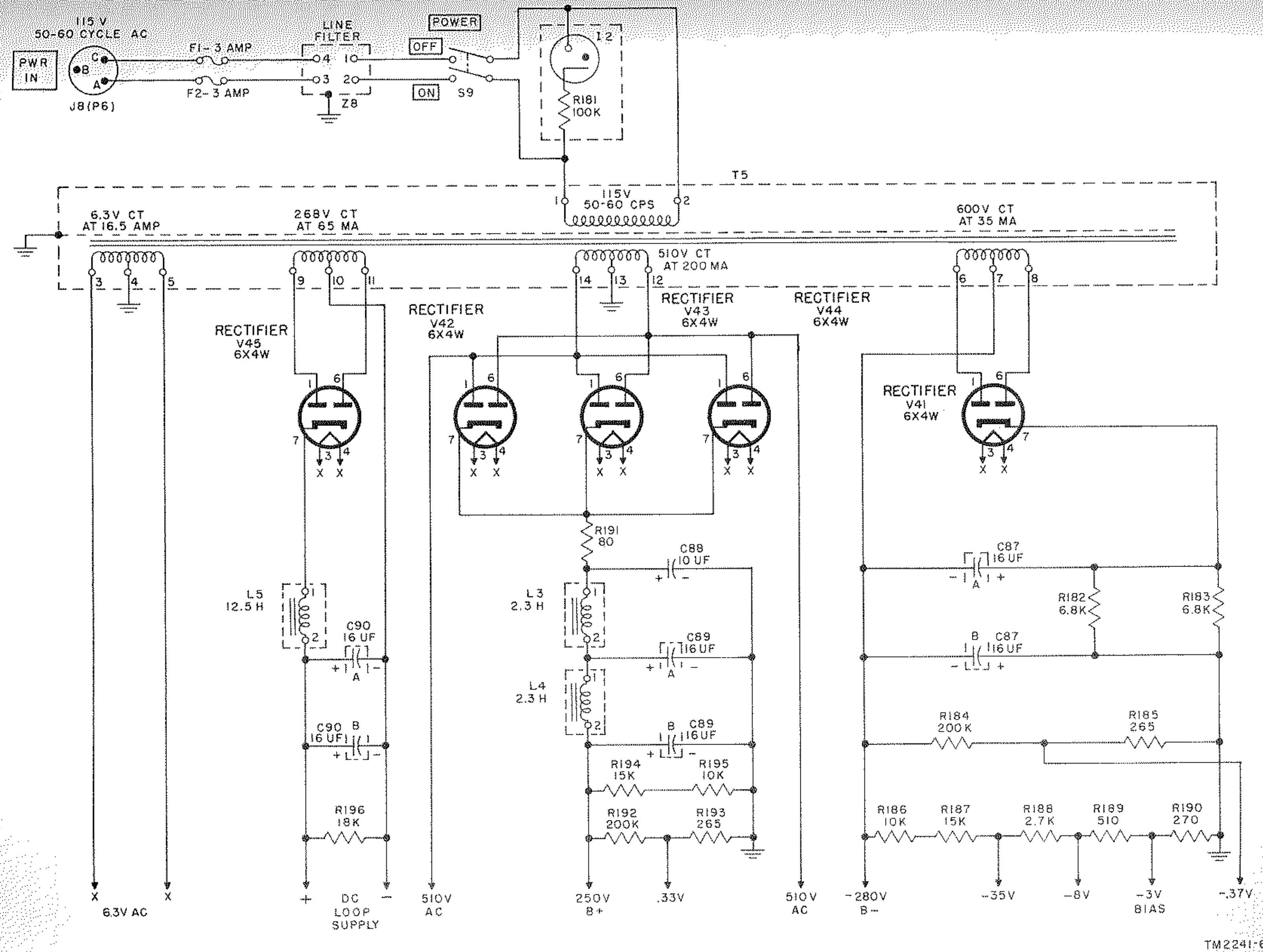

Figure 38. Power supply, schematic diagram.

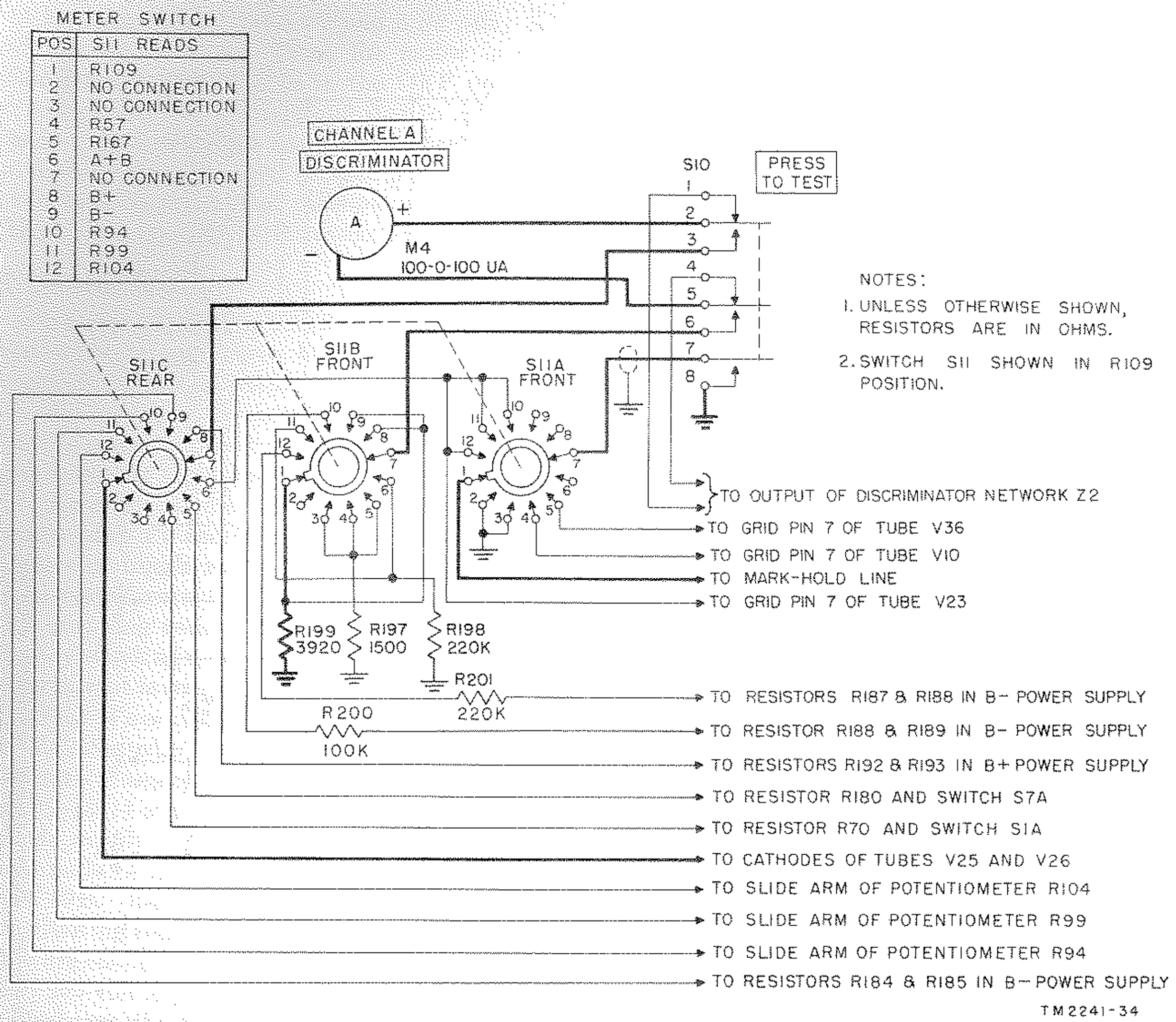

Figure 39. Metering circuit, schematic diagram.

measures the voltage at the grids of mark-keyer tubes V25 and V26. The meter, in series with multiplier R201, connects to the slide arm of potentiometer R104 and to the −35 volt tap in the power supply. With R104 properly adjusted for −35 volts at the grids of V25 and V26, meter M4 reads 0, indicating a balance against the −35 volts at the power supply.

e. B− Position. In position 9, meter M4 is connected in series with multiplier R199 to measure the voltage across B− power-supply resistor R185. When the B− power supply is at −280 volts, a −0.37 volt drop is produced across R185 by the current flowing through it. This causes a −94 deflection on M4 which, when multiplied by 3, indicates a voltage of approximately −280.

f. B+ Position. In position 8, meter M4 is connected in series with multiplier R199 to measure the voltage across B+ power-supply resistor R193. A B+ power-supply output of 250 volts will cause M4 to deflect to +84 or approximately 250 volts.

g. A+B Position. In position 6, meter M4 is connected across the output of Z5 through multiplier R198. It indicates the combined output voltage of both diversity discriminators.

h. R167 Position. In position 5, meter M4 is connected across R180 and through multiplier R197. The meter indicates the current through one-phase winding of afc motor B2.

i. R57 Position. In position 4, meter M4 is connected across R70 and through multiplier R197. The meter indicates the current through one-phase winding of afc motor B1.

CHAPTER 6

FIELD MAINTENANCE

Note. This chapter contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and equipment available and by the skill of the repairman.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

51. Troubleshooting Procedures

a. General. The first step in servicing a defective piece of electronic equipment is to localize the fault. Localization means tracing the fault to the major circuit responsible for the abnormal operation of the set. The second step is to isolate the fault. Isolation means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors or capacitors and shorted transformers, often can be located by sight, smell, and hearing. The majority of faults, however, must be isolated by *checking voltages and resistances.*

b. Voltage and Resistance Measurements, Differences in Sets. The tube socket resistance and voltage measurement chart (fig. 42) applies to all converter units except those with serial numbers from 1 to 200. For these, the following resistances and voltages apply:

Voltages and Resistance Measurements, Differences in Sets

Tube and pin No.	Voltage and/or resistance
V4, pin 2	3.4V.
V4, pin 5	120K and 30V.
V4, pin 6	85K and 170V.
V4, pin 7	3.4V.
V16, pin 2	3V.
V16, pin 5	115K and 30V.
V16, pin 6	85K and 165V.
V16, pin 7	3V.
V17, pin 2	3V.
V17, pin 5	115K and 30V.
V17, pin 6	85K and 165V.
V17, pin 7	3V.
V30, pin 2	3.4V.
V30, pin 5	120K and 30V.
V30, pin 6	85K and 170V.
V30, pin 7	3.4V.

c. Tests. The tests listed below aid in isolating the source of trouble. To be effective, the procedure should be followed in the order given. Remember that servicing should cause no further damage to the equipment. First, trouble should be localized to a single stage or circuit. Then the trouble may be isolated within that stage or circuit by appropriate voltage, resistance, and continuity measurements. The service procedure is summarized as follows:

(1) *Visual inspection.* The purpose of visual inspection is to locate any visible trouble such as loose, broken, or charred parts. Through this inspection alone, the repairman frequently may discover the trouble or determine the stage in which the trouble exists. This inspection is valuable in avoiding additional damage to the equipment which might occur through improper servicing methods and in forestalling future failures.

(2) *Power supply resistance measurements.* These measurements (par. 55) prevent further damage to the equipment from possible short circuits. Since this test gives an indication of the condition of the filter circuits, its function is more than preventive.

(3) *Troubleshooting chart* (fig. 40). The trouble symptoms listed in this chart will aid greatly in localizing trouble.

(4) *Operational test.* The operational test (par. 57) is important because it frequently indicates the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. In order to utilize

this information fully, all symptoms must be interpreted in relation to one another.

(5) *Intermittents.* In all these tests, the possibility of intermittents should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the set. It is possible that the trouble is not in the converter itself but in the installation (cabling to receivers, power cables, or teletypewriter connection), or the trouble may be caused by external conditions. In this event, test the installation, if possible.

52. Troubleshooting Data

Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Consult the following troubleshooting data.

Fig.	Par.	Description
40		Troubleshooting chart.
41		Frequency Shift Converter CV-116/URR, tube location.
42		Tube socket resistance and voltage measurements, converter units serial numbers 201 up.
43		Resistor and capacitor board voltages and resistances.
51		Circuit for measuring relay current.
52		Adjusting relay K1 or K2.
62		Frequency Shift Converter CV-116/URR, serial numbers 1-200, schematic diagram.
63		Frequency Shift Converter CV-116/URR, serial numbers 201 and higher, schematic diagram.
64		Cabling diagram, Frequency Shift Converter, CV-116/URR.
	54	Dc resistances of transformers and coils.
	55	Checking B+ circuits for shorts.
	57	Operational test procedures.
	59	Relay adjustments.
	61 through 63	Alinement procedures.

53. Test Equipment Required for Field Maintenance

The test equipment recommended for troubleshooting Frequency Shift Converter CV-116/URR is listed below. The technical manuals associated with the test equipment also are listed.

Test equipment	Technical Manual
Multimeter TS-352/U	TM 11-5527
Electronic Multimeter TS-505/U	TM 11-5511
Electron Tube Test Set TV-7/U	TM 11-5083
RF Signal Generator Set AN/URM-25	TM 11-5551
Frequency Meter Set SCR-211-( )	TM 11-300

54. Dc Resistances of Transformers and Coils

The dc resistances of the transformer windings and the coils in the converter are listed below:

Caution: Do not attempt to make resistance measurements with the power on.

Transformer or coil	Terminals	Ohms
T1	1-2	0.25*
	3-4	4.9 aprx
T2	1-2	0.25*
	3-4	4.9 aprx
T3	1-2	0.25*
	3-4	4.9 aprx
T4	1-2	0.25*
	3-4	4.9 aprx
T5	1-2	0.7
	3-4	0.1*
	4-5	0.1*
	6-7	150
	7-8	150
	9-10	13
	10-11	13
	12-13	28
	13-14	28
Z1	1-2	5.2
	3-4	5.3
Z2	1-2	4.7
	3-4	4.5
	3 or 4-9	2.2
	5-6	202K
	7-8	2,000
Z3	1-2	4.7
	3-4	4.5
	3 or 4-9	2.2
	5-6	202K
	7-8	2,000
Z4	1-4	17
	3-4	16
	3 or 4-9	8
	5-6	202K
	7-8	2,000
Z5	1-3	15K
	1-2	infinite
	2-3	infinite
	4-6	10K
	4-5	infinite
	5-6	infinite
Z6	1-2	17.7
	3-4	17.5

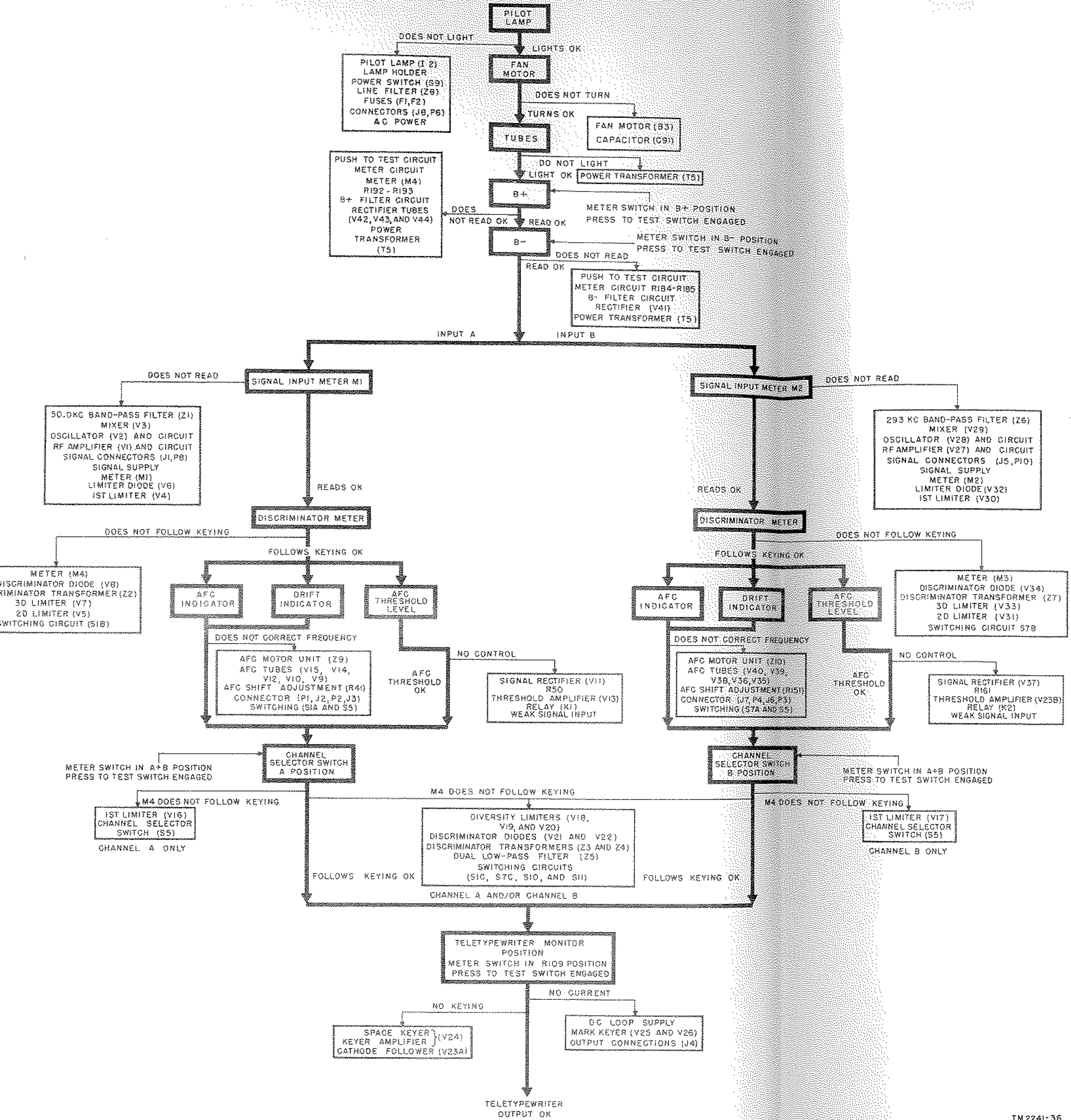

Figure 40. Troubleshooting chart.

Transformer or coil	Terminals	Ohms
Z7	1–2	17
	3–4	16
	3 or 4–9	8
	5–6	202K
	7–8	2,000
Z8	1–4	0.5*
	2–3	0.5*
K1	1–6	10K
K2	1–6	10K
B1	A–B	1,500
	C–D	1,500
B2	A–B	1,500
	C–D	1,500
B3	Green-red	330
	White-blue	410
L1	3–4	2
L2	3–4	2
L3		61
L4		61
L5		154

*Resistance negligible, 0.5 ohm or less. These values will give an indication of 0 ohms when measured by Multimeter TS-352/U.

55. Checking B+ Circuits for Shorts

a. Trouble within the converter often may be detected by checking the resistance of the hv circuits to ground before applying power to the equipment, thus preventing damage to the power supply. Check for the following resistance readings before attempting to operate the unit, leave the power cable disconnected while taking the measurements.

(1) From B+ to ground, the resistance should be 16K regardless of the position of the front panel switches. Measure between the red lead terminal of C89B and chassis ground (fig. 46).

(2) In the negative power supply, the resistance should be 18K regardless of the positions of the front panel switches. Measure between the white lead terminal of C87B and chassis ground (fig. 46).

(3) From pin D on J4 to pin 5 on V25 (loop power supply), the resistance should be 18K regardless of the positions of the front panel switches.

(4) From B− (white lead of C87B) to pin 1 of V41 (winding 6–7 of T5), the resistance should be 150 ohms.

(5) From B− (white lead of C87B) to pin 6 of V41 (winding 7–8 of T5), the resistance should be 150 ohms.

(6) From ground to pin 1 of V42 (winding 13–14 of T5), the resistance should be 28 ohms.

(7) From ground to pin 6 of V42 (winding 12–13 of T5), the resistance should be 28 ohms.

b. If the measured resistances differ materially from the values listed, first check the filter capacitors associated with the particular supply. Then look in the associated circuits for leaky or shorted capacitors, or for resistors that have changed values.

56. Troubleshooting Chart

The chart (fig. 40) is supplied as an aid in locating trouble in the converter. This chart lists the visual symptoms which the repairman observes while making a few simple tests. *The chart also indicates how to localize trouble quickly to the input, diversity, afc, or power-supply sections of the converter.* Once the trouble has been localized to a stage or circuit, a tube-check, and voltage and resistance measurements of this stage or circuit ordinarily should be sufficient to isolate the defective part. Normal voltage and resistance measurements are given in figures 42 and 43.

57. Operational Test Procedures

a. General. With the converter divorced from the teletypewriter system, troubleshooting can be performed with a minimum of equipment and parts. In addition to the equipment shown in figure 44, Frequency Meter Set SCR–211 is required.

b. Components and Connections Required. Connect RF Signal Generator Set AN/URM–25 to INPUT A or INPUT B as shown in figure 44Ⓐ or Ⓑ. Connect a 500-ohm, 2-watt resistor to J4 as shown in figure 44Ⓒ. This resistor replaces the output loop so that the converter may be operated under simulated operating conditions. The signal generator should be set to the frequency normally fed to input jacks J1 and J5 by the radio receivers used with the converter in actual operation. Resistance and voltage measurements require an electronic multimeter such as Electronic Multimeter TS–505/U.

c. Power-Supply Check. The satisfactory operation of the converter depends upon the proper voltages being applied to the various tube elements. These voltages may be checked regularly by observing the rectified output voltages of the power supply.

(1) To check the output voltages of the power supply, turn the metering switch knob successively to the positions indicated, depressing the PRESS TO TEST switch, and see that the readings are within the limits shown in the chart below.

Metering switch position	Meter M4 reading (E)	Actual reading
B−	93±5	3×E or 280±14 volts
B+	83±4	3×E or 250±12 volts

(2) If these readings are not obtained, measure to see that the converter input voltage is 115 volts ac ±10 percent. If it is, see figure 40 and check the circuit elements listed under "B+" and "B−", "Does Not Read O. K."

d. Input Circuits. The locations of screwdriver controls T1 and T2 involved in the procedures which follow are shown in figure 45.

(1) Connect the signal generator to INPUT A connector J1 of the converter, and set the signal generator frequency to a value corresponding to that of the if. input from the radio receivers. Set the input at 5,000 microvolts. This voltage requirement is based on the use of a signal generator of low output impedance. Do not connect an input to INPUT B connector J5 while making tests on channel A.

(2) Connect the electronic multimeter from pin 7 of tube V3 to ground, and adjust the tuning slugs in transformers T1 and T2 for maximum indication on the multimeter (set up to indicate ac voltage). If the multimeter reading fails to indicate a maximum peak of approximately 1.5 volts ac, test the tube and check the associated circuit elements. Misalinement of this stage will cause reduced output to the mixer and low readings on M1.

Note. At each step, it is assumed that all previous steps were completed satisfactorily. Isolate and clear any trouble located before proceeding with any succeeding steps.

(3) Rotate channel A AFC-XTAL-MARK HOLD switch S1 to the XTAL position and CHANNEL SELECTOR switch S5 to position A. Connect the electronic multimeter from pin 2 of tube V2 to ground and observe the reading on the multimeter (−7 volts dc). If the multimeter fails to give an indication, test tube V2 and check the associated circuit elements. Meter M1 also should give an indication. If it does not, tube V4, V5, or V6, meter M1, or the associated circuit elements is probably defective.

(4) Rotate channel A AFC-XTAL-MARK HOLD switch S1 to the AFC position. With the electronic multimeter still connected as described in (3) above, the multimeter still should indicate −7 volts dc. If the multimeter fails to give an indication, check coil L1 and sections D and E of switch S1.

(5) Transfer the signal generator from INPUT A to INPUT B. Repeat the steps outlined in (1) through (4) above for the channel B input circuits.

(6) Connect the electronic multimeter from pin 1 of V4 to ground to check the overall operation of the rf section. Tune the signal generator from approximately 10 kc below to 10 kc above the INPUT A frequency. The multimeter should indicate a definite peak voltage at the INPUT A frequency. If the multimeter fails to indicate a peak reading, check tube V3 and its associated circuit elements.

e. Afc Limiting Amplifiers. After checking the rf input circuits according to the procedure above, check the afc limiting amplifiers in accordance with the following:

(1) Connect the signal generator to INPUT A and adjust its frequency to the if. of the receiver normally used in conjunction with this converter. Connect the electronic multimeter from pin 5 or V7 to ground.

(2) Vary the output level of the signal generator from 50 to 100,000 microvolts. The multimeter should indicate a relatively constant reading of approximately 50 volts ac over the entire range of input level. Check tubes V4, V5, V6, and V7 and their associated circuit elements if abnormal readings are indicated on the multimeter.

(3) Transfer the signal generator from INPUT A to INPUT B. Repeat the steps outlined in (1) and (2) above for the channel B afc limiting amplifiers.

f. Afc Discriminator Circuits. The locations of the connection points involved in the following procedures are shown in figures 9 and 42.

(1) Connect the signal generator to INPUT A. Set the signal generator to the operating frequency and adjust its output to 10,000 microvolts. Connect the electronic multimeter across the + and − terminals of meter M4. Throw the AFC switch to the OFF position.

(2) The multimeter should read zero, indicating correct discriminator tuning. If a zero reading is not obtained, change the input signal frequency slightly.

(3) Disconnect the signal generator from the INPUT A jack. The object now is to decrease the frequency of the signal generator by 1 kc to simulate a spacing signal. To do this accurately, tune Frequency Meter SCR–211 to the operating frequency as described in TM 11–300. Couple the signal generator to the frequency meter. Zero-beat the frequency meter to the signal generator. Reduce the frequency of the frequency meter by 1 kc and zero beat the signal generator to the frequency meter. Uncouple the frequency meter and again connect the signal generator to the INPUT A jack. The multimeter now should indicate a negative 30±5 volts dc.

(4) Now increase the frequency of the frequency meter by 2 kc (1 kc above the operating frequency) and zero-beat the signal generator to the frequency meter as described in (3) above. Uncouple the frequency meter from the signal generator and connect the latter to the INPUT A jack. The multimeter now should indicate a positive 30±5 volts dc. If the conventional discriminator response described herein and in (3) above is not obtained, check V8, Z2, S1B, and the associated circuit wiring.

(5) Transfer the output of the signal generator from INPUT A to INPUT B. Repeat the steps outlined in (1) through (4) above for the channel B afc discriminator circuit.

g. Dc Amplifier Stages and Motor Drive Circuit. The locations of the controls involved in the following procedures are shown in figures 8 and 9.

(1) Throw the afc switch to the OFF position.

(2) Connect the signal generator to INPUT A. Set the signal generator to obtain a zero reading on M4 and adjust its output to 5,000 microvolts.

(3) Throw the afc switch to the ON position and adjust the channel A AFC SHIFT ADJUSTMENT control to stop the channel A AFC INDICATOR. At this point, meter M4 should indicate approximately +15 microamperes. If this reading is not obtained, see (5) below.

(4) Gradually decrease the frequency of the applied signal by several hundred cycles. The channel A AFC INDICATOR should spin in one direction. Gradually increase the frequency of the applied signal by several hundred cycles. The channel A AFC INDICATOR now should spin in the opposite direction.

(5) If the procedure above fails to give the indicated results, check the settings of potentiometers R47 and R57 as described in paragraph 63. If the operation is still not normal after adjusting R47 and R57, check tubes V9, V10, V12, V14, and V15, afc unit Z9, and associated circuit elements.

(6) Transfer the output from the signal generator to INPUT B. Repeat the steps outlined in (1) through (5) above, for the corresponding circuits in channel B.

h. Diversity Limiting Amplifiers.

(1) Connect the signal generator to INPUT A and adjust its output to the operating frequency. Connect the electronic multimeter from pin 5 of V20 to ground.

Rotate the CHANNEL SELECTOR switch to position A.

(2) Vary the output level of the signal generator from 50 to 100,000 microvolts. The multimeter should indicate a relatively constant reading of approximately 50 volts ac over the entire range of input levels. If abnormal readings are indicated on the multimeter, check tubes V16, V18, V19, and V20, and their associated circuit elements.

(3) Rotate the CHANNEL SELECTOR switch to the A + B position. Repeat procedure in (2) above. Check section B of switch S5 if normal readings are not obtained on the multimeter.

(4) Rotate the CHANNEL SELECTOR switch to position B. Repeat procedure in (2) above. With the procedure in (1) through (3) above completed satisfactorily, the most likely cause for abnormal multimeter readings in this procedure will be tube V17, section B of switch S5, or their associated circuit elements.

i. Diversity Discriminators.

(1) The following procedure requires one signal generator. Connect the output to the INPUT A and INPUT B jacks. Adjust the signal generator to the if. output of the receivers which normally are used, and set the output level at 10,000 microvolts. Connect the electronic multimeter

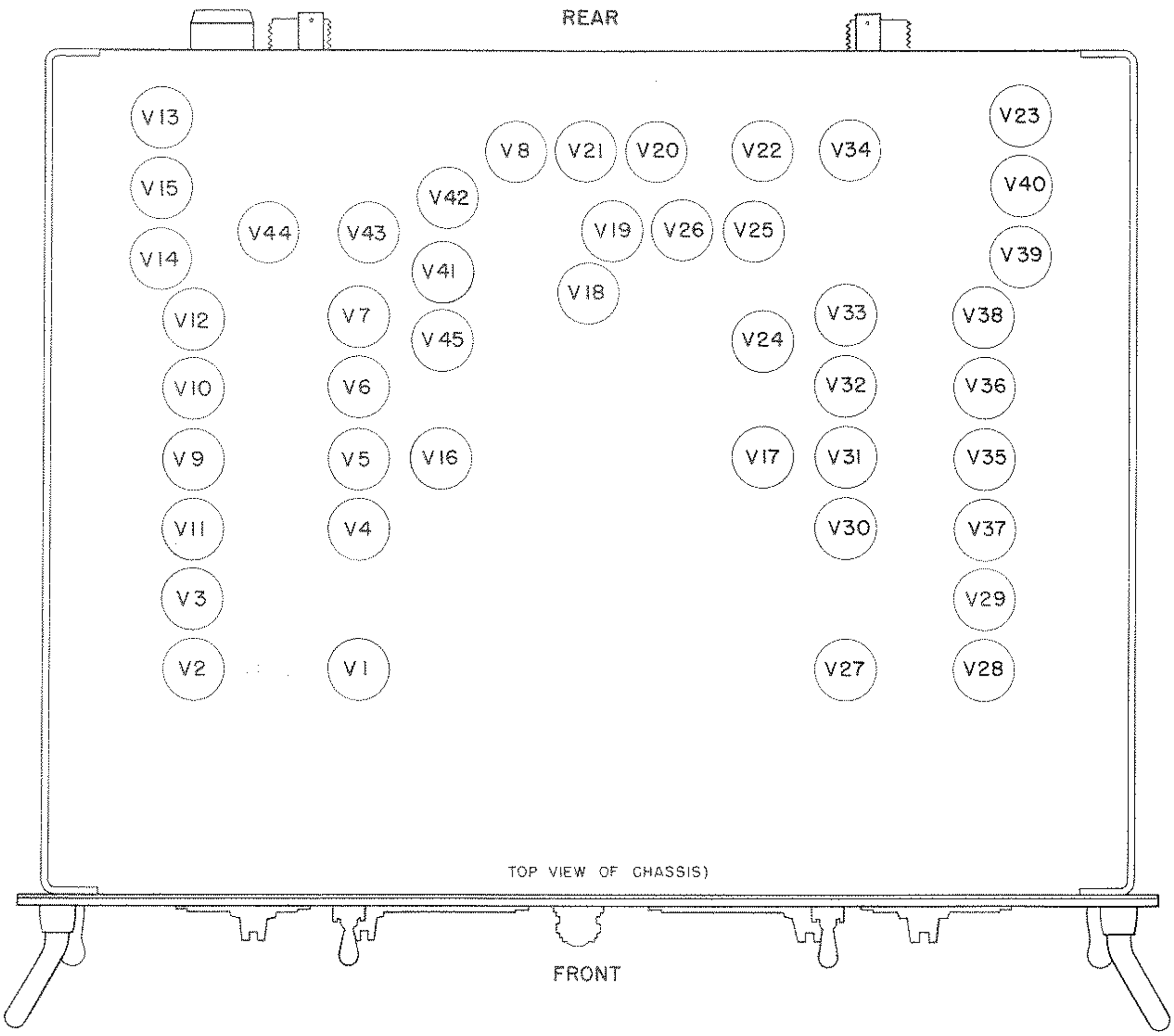

Figure 41. Frequency Shift Converter CV-116/URR, tube location.

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EL SELECTOR
Repeat procedure
the procedure in
e completed satis-
ely cause for ab-
ings in this proce-
ection B of switch
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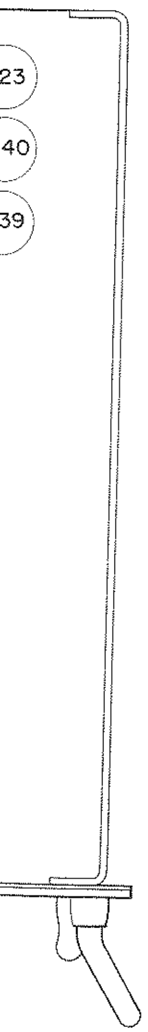

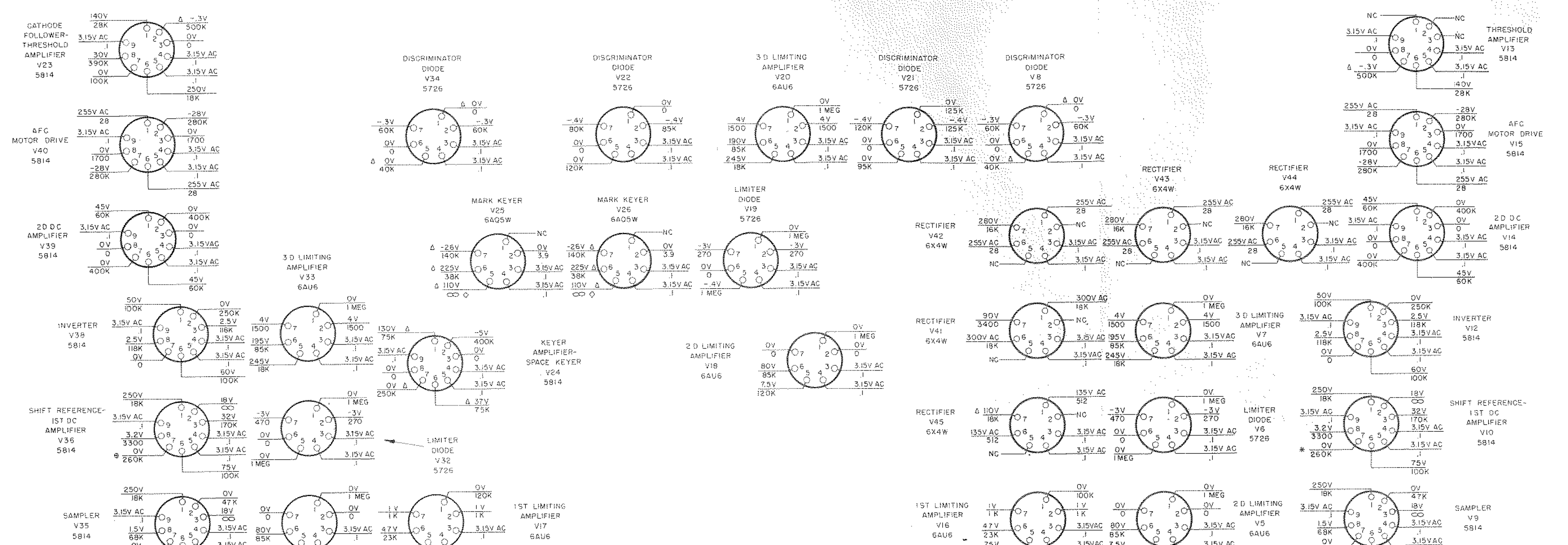

NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE MEASUREMENTS WERE TAKEN UNDER THE FOLLOWING CONDITIONS:
   (A) 115V AC, 60-CYCLE INPUT
   (B) 500 OHM, 4 WATT LOAD ACROSS TERMINALS A & D OF J4 (TTY OUTPUT)
3. FRONT PANEL CONTROLS SET AS FOLLOWS:
   - [POWER] (S9) [ON]
   - [AFC] (S2) [ON]
   - [AFC THRESHOLD] (S3 & S8) [OFF]
   - [CHANNEL SELECTOR] (S5) [A+B] POSITION
   - [AFC, XTAL, MARK HOLD] (S1 & S7) LEFT HAND [AFC] POSITION
4. ∞ INDICATES INFINITE RESISTANCE
5. NC INDICATES NO CONNECTION
6. ALL RESISTANCES ARE IN OHMS UNLESS OTHERWISE SPECIFIED
7. † ZERO RESISTANCE WITH [CHANNEL SELECTOR] IN [B] POSITION
8. ‡ ZERO RESISTANCE WITH [CHANNEL SELECTOR] IN [A] POSITION
9. * BEFORE TAKING MEASUREMENTS ON THIS TUBE AND/OR V12, V14, V15, BE CERTAIN THAT [AFC SHIFT ADJUSTMENT] (R41) IS SET TO GIVE ZERO VOLTS AT PIN 7 OF V10.
10. ⊕ BEFORE TAKING MEASUREMENTS ON THIS TUBE AND/OR V38, V39, V40, BE CERTAIN THAT [AFC SHIFT ADJUSTMENT] (R151) IS SET TO GIVE ZERO VOLTS AT PIN 7 OF V36.
11. Δ VALUES DEPENDENT ON CONTROL SETTINGS.
12. ◇ 18.5 K WHEN 500 OHM RESISTOR IS ACROSS TERMINALS A & D OF J4 (TTY OUTPUT).

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Figure 42. Tube socket resistance and voltage measurements for converter units, serial numbers 201 up.

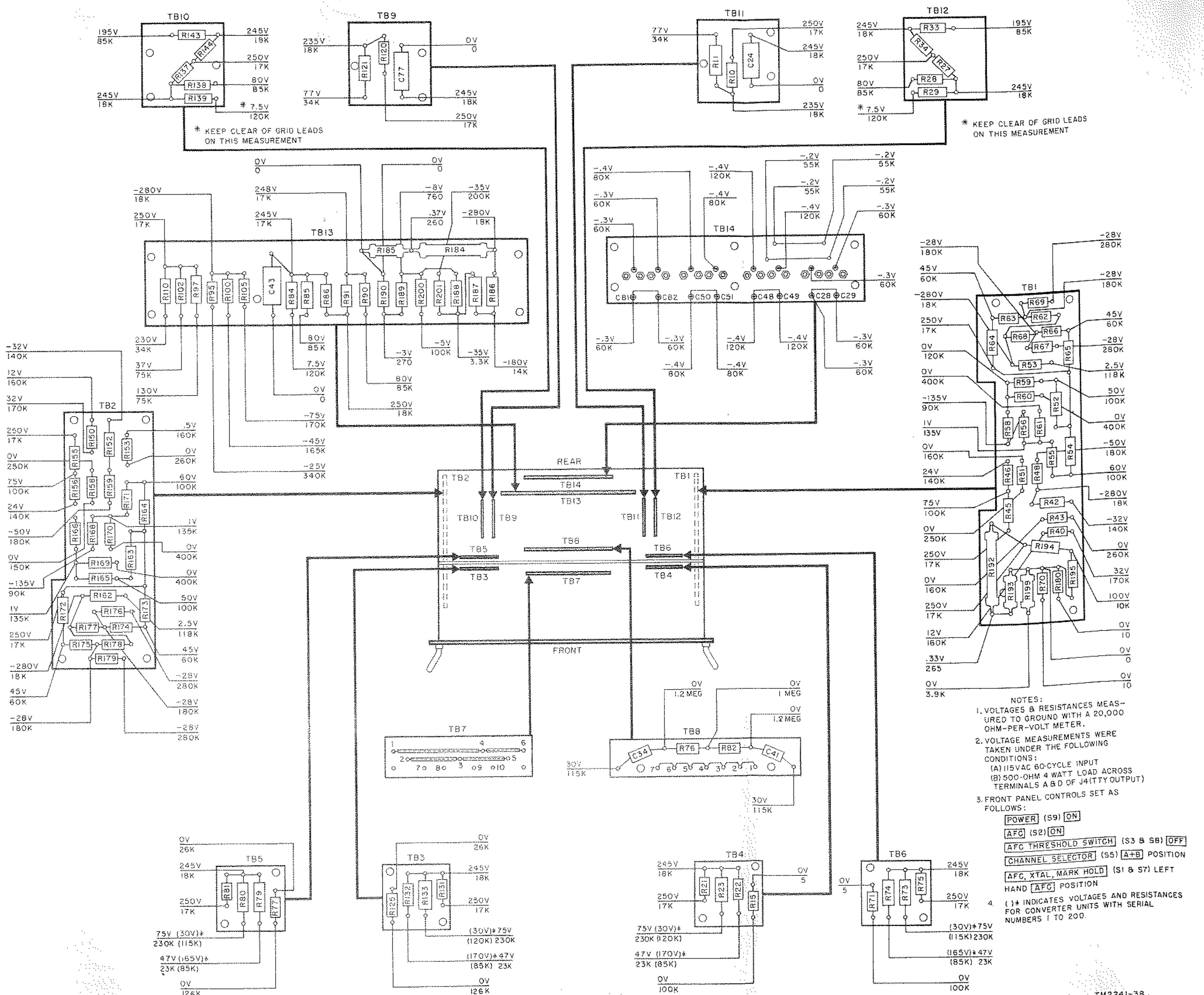

Figure 43. Resistor and capacitor board voltages and resistors.

to indicate dc voltage between terminal 3 of low-pass filter Z5 and ground. Rotate the CHANNEL SELECTOR switch to the A+B position.

(2) The multimeter should read zero, indicating correct discriminator tuning. If a zero reading is not obtained, change the input frequency slightly.

(3) Decrease the frequency of the applied signal to both INPUT A and INPUT B by 1 kc to simulate a spacing signal. Follow the procedure given in *h* (3) above. Make sure the multimeter indicates a negative 30±5 volts dc. Increase the applied frequency 1 kc for a marking signal by following the procedure in *f* (4) above. The multimeter should indicate approximately 30±5 volts dc in the positive direction. If the conventional discriminator response just described is not obtained, check tubes V21, V22, discriminator networks Z3 and Z4, switches S1C and S7C, low-pass filter Z5, and the associated circuit elements.

j. Keyer and Output Circuits.

(1) Connect the signal generator to INPUT A. Set the signal generator to the operating frequency and adjust its output to 5,000 microvolts. (The signal generator is at the operating frequency when the DISCRIMINATOR meter M4 indicates zero.) Connect the electronic multimeter across the 500-ohm resistor in the tty output circuit (*b* above). Rotate the CHANNEL SELECTOR switch to position A.

(2) Decrease the frequency of the applied signal by approximately 1 kc to simulate a spacing signal. The multimeter should indicate zero. Gradually increase the applied frequency approximately 2 kc (1 kc above the operating frequency) for a marking signal. As the signal generator is tuned through the operating frequency, the reading on the electronic multimeter should change instantaneously from 0 to 30±5 volts dc. The point at which this change occurs is indicated on DISCRIMINATOR meter M4 by the meter needle passing through zero.

(3) If the procedure above fails to give the indicated results, check the settings of potentiometers R94, R99, and R109 as described in paragraph 63. If the operation still is not normal after adjusting the keyer potentiometers, check tubes V23, V24, V25, and V26, and associated circuit elements.

Section II. REPAIRS

58. Replacement of Parts

a. General. Most of the parts in Frequency Shift Converter CV-116/URR are readily accessible and are easily replaced if found to be faulty. Careless replacement of parts often causes new faults to develop. Whenever the unit is serviced, observe the following precautions:

(1) Be careful when cover plates are removed. Dangerous voltages are exposed.

(2) Before a part is unsoldered, note the position of the leads. If the part (such as a transformer or switch) has a number of connections, tag each lead.

(3) When removing screws from parts, try to keep the screws in individual groups corresponding to the components which they fasten to the chassis. This will speed the reassembly process.

(4) Be careful not to damage other leads by pulling or pushing them out of the way.

(5) Do not allow drops of solder to fall into the set; they may cause short circuits.

(6) A carelessly soldered connection may create a new fault. It is very important to solder the joints well. A poorly soldered joint can be one of the most difficult faults to find. For specific instructions on replacing the UG-88/U connectors, see figure 50.

(7) When a new part is installed, it should be placed exactly as the original. A part which has the same electrical value, but different physical size, may cause trouble in hf circuits. Give particular attention to proper grounding when replacing a part. Use the same ground as in the original wiring.

b. Disassembly of Afc Unit Z9. Afc unit Z9 is an assembly located on the underside of the converter chassis (fig. 47). The essential components

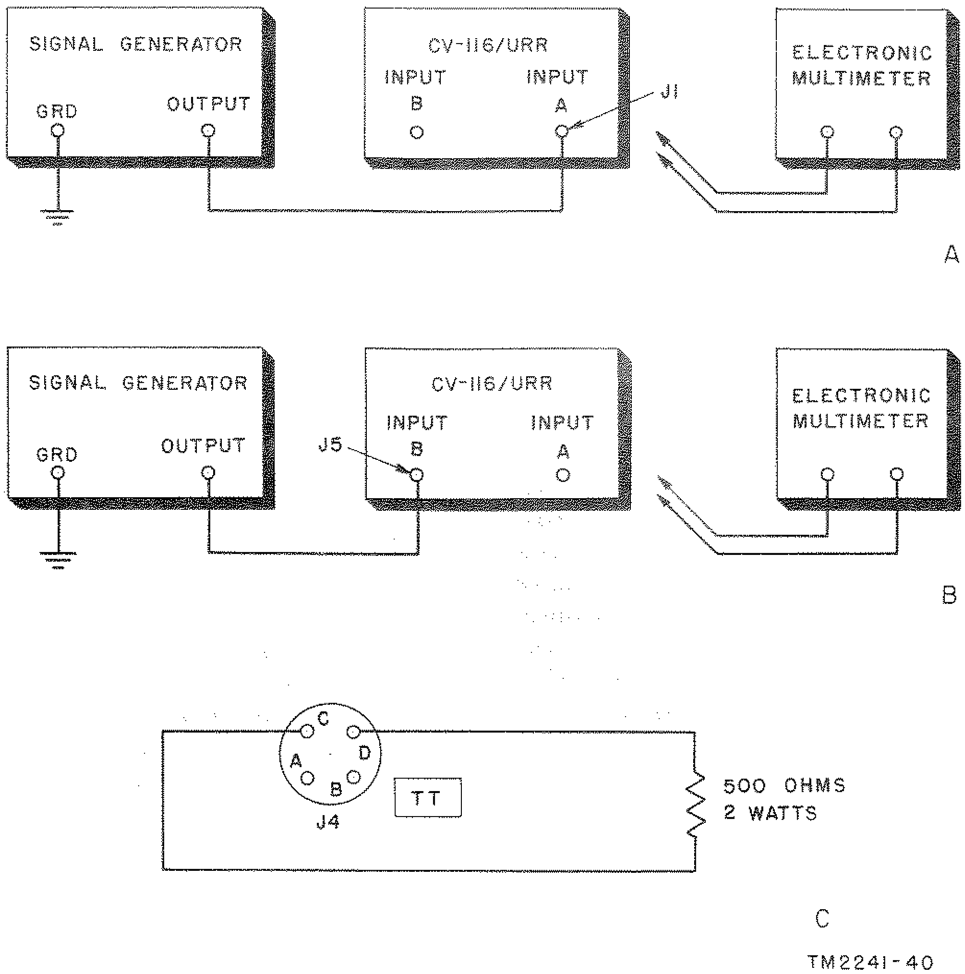

Figure 44. Setup for troubleshooting equipment when divorced from system.

mounted inside Z9 are shown in figure 48. These components consist of variable capacitor C8, a gear train for mechanically linking the capacitor to motor B1, and limit switch S4. Switch S4 completes the circuit for a warning bell when C8 has been driven near minimum or maximum capacity. A friction clutch connects C8 to front panel DRIFT INDICATOR knob E14. The front panel AFC INDICATOR is a spinner disk geared to the motor shaft, and it indicates motor rotation when the afc circuit is correcting. The motor leads terminate in connector J3, and the capacitor leads terminate in coaxial connector J2. Both of these receptacles are located on the rear of Z9.

(1) To remove Z9 from the converter, rest it on a fairly level surface in an inverted position.

(*a*) Disconnect P1 from J2 by rotating the locking ring 90° and withdrawing the plug.

(*b*) Disconnect P2 from J3 by undoing the locking sleeve and withdrawing the plug.

(*c*) Remove DRIFT INDICATOR knob E14 by removing the screw that holds it to the shaft extending from Z9 through the front panel.

(*d*) Remove the four 7/8-inch No. 8–32 screws that hold Z9 to the front panel.

(*e*) Lift Z9 clear of the converter for further disassembly.

(2) To disassemble Z9 for access to S4, B1, and C8, remove the 1/4-inch No. 6–32 screw located next to J2 and J3 on the rear of Z9. Carefully remove the dust cover by

pulling it squarely off. Avoid striking any of the components within.

Caution: Do not remove the two 2¾-inch hexagonal studs that hold the mounting bracket for J2 and J3 or the screws that hold the studs will be released in the gear case. This will necessitate further disassembly of the unit for their recovery.

(3) To remove capacitor C8, remove the two ¼-inch No. 6–32 flat-head screws that hold the mounting bracket for J2 and J3 to the hexagonal studs. Wire slack will allow the bracket to be laid back so that C8 may be lifted clear.

(*a*) Unsolder the yellow leads that connect the stator and rotor of C8 to J2.

(*b*) Remove the four ¼-inch No. 4–40 screws that hold the capacitor mounting plate to the gear case casting.

(*c*) Lift the capacitor and its associated mounting bracket clear of the gear case casting. A slight force is required to withdraw the capacitor and capacitor mounting bracket assembly. The assembly will seem to bind because of the friction effect of coupling O 11.

(4) To remove B1, remove the three screws on the panel end of Z9 which are recessed most deeply. These three 1-inch No. 6–32 screws can be further identified by their alinement with the mounting bosses of the motor. Lift the motor free of the gear case.

(5) To remove S4, remove the two 7/16-inch No. 4–40 screws that hold the microswitch

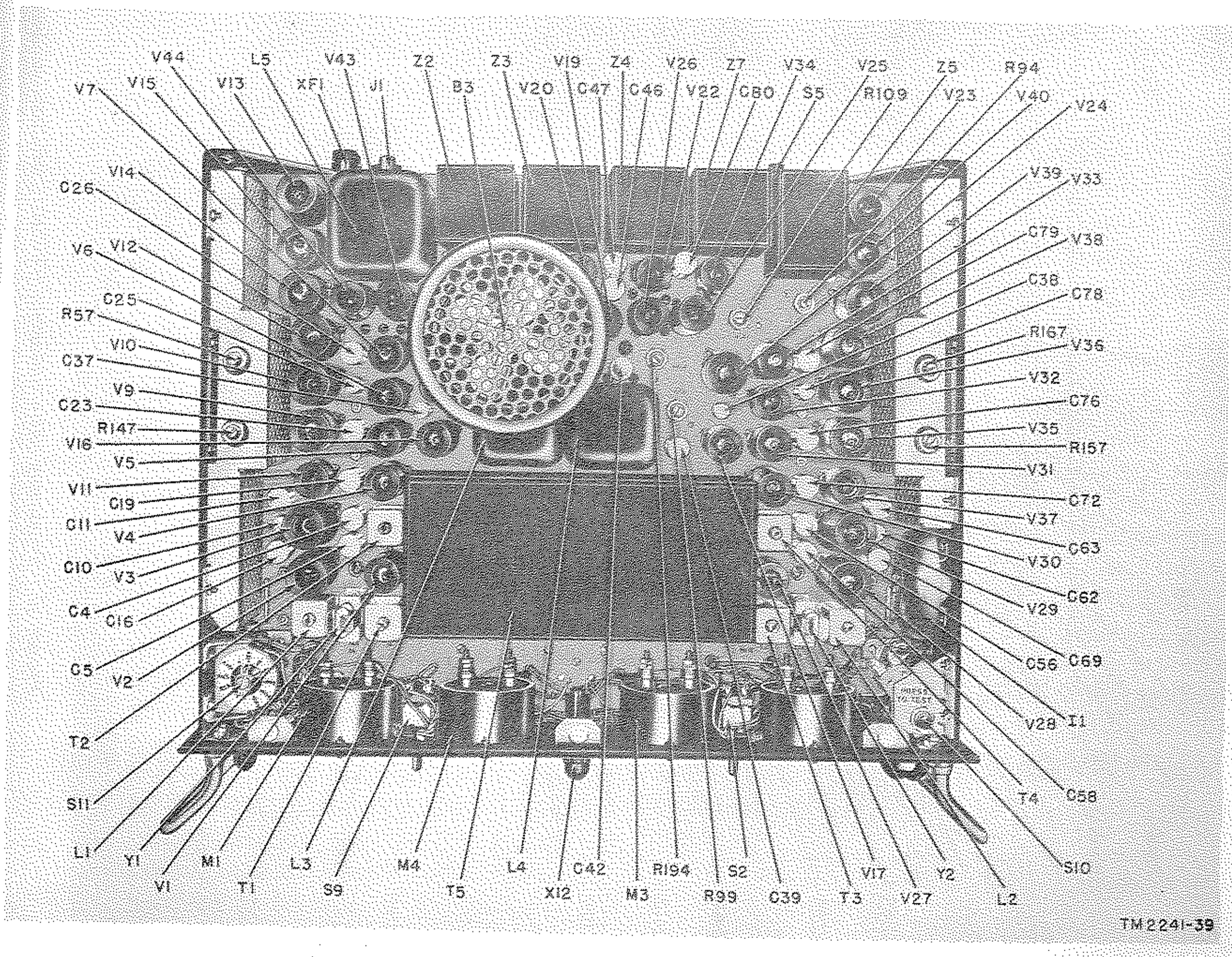

Figure 45. Frequency Shift Converter CV–116/URR, top view.

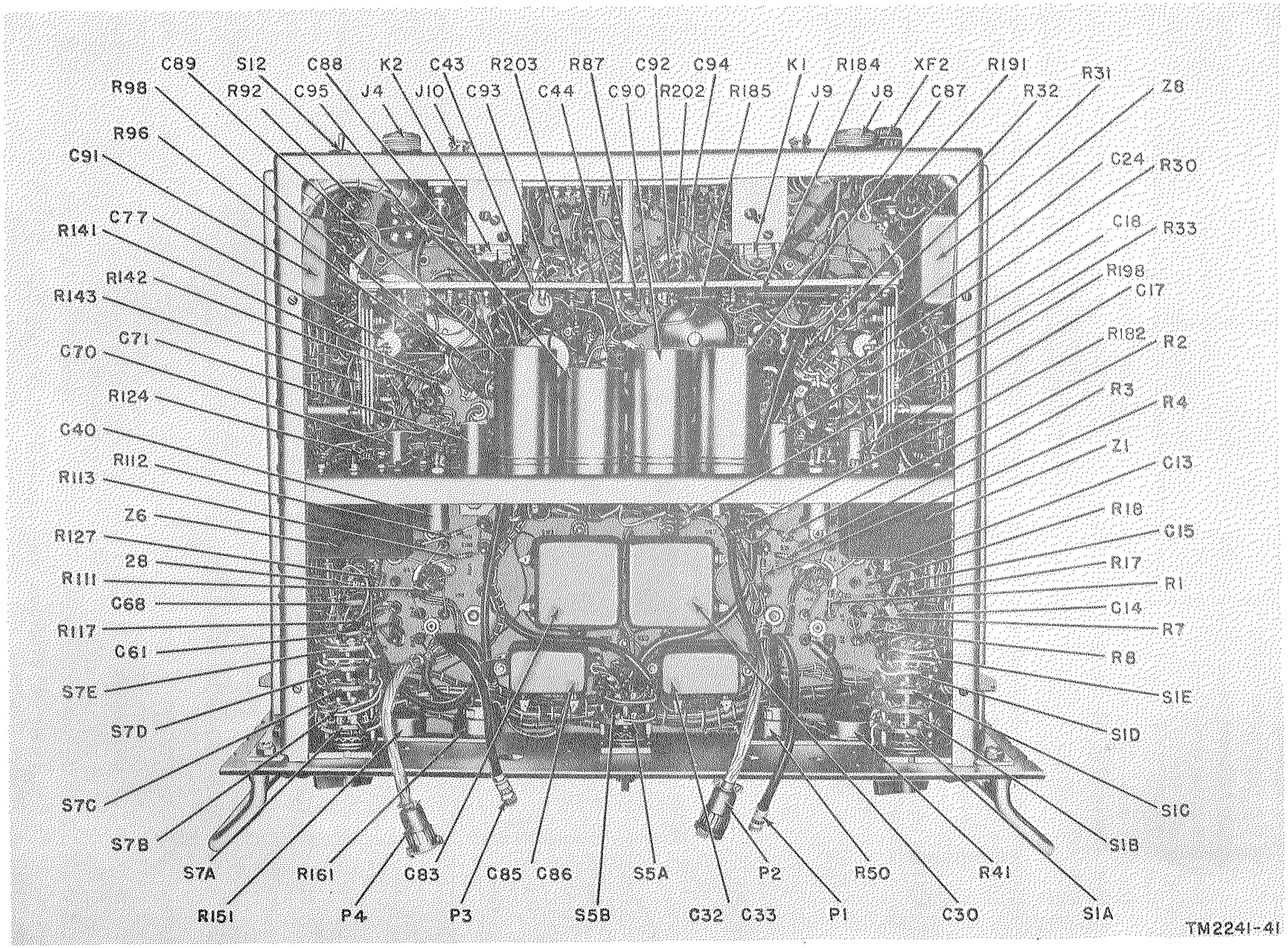

Figure 46. Frequency Shift Converter CV–116/URR, bottom view, with afc units removed.

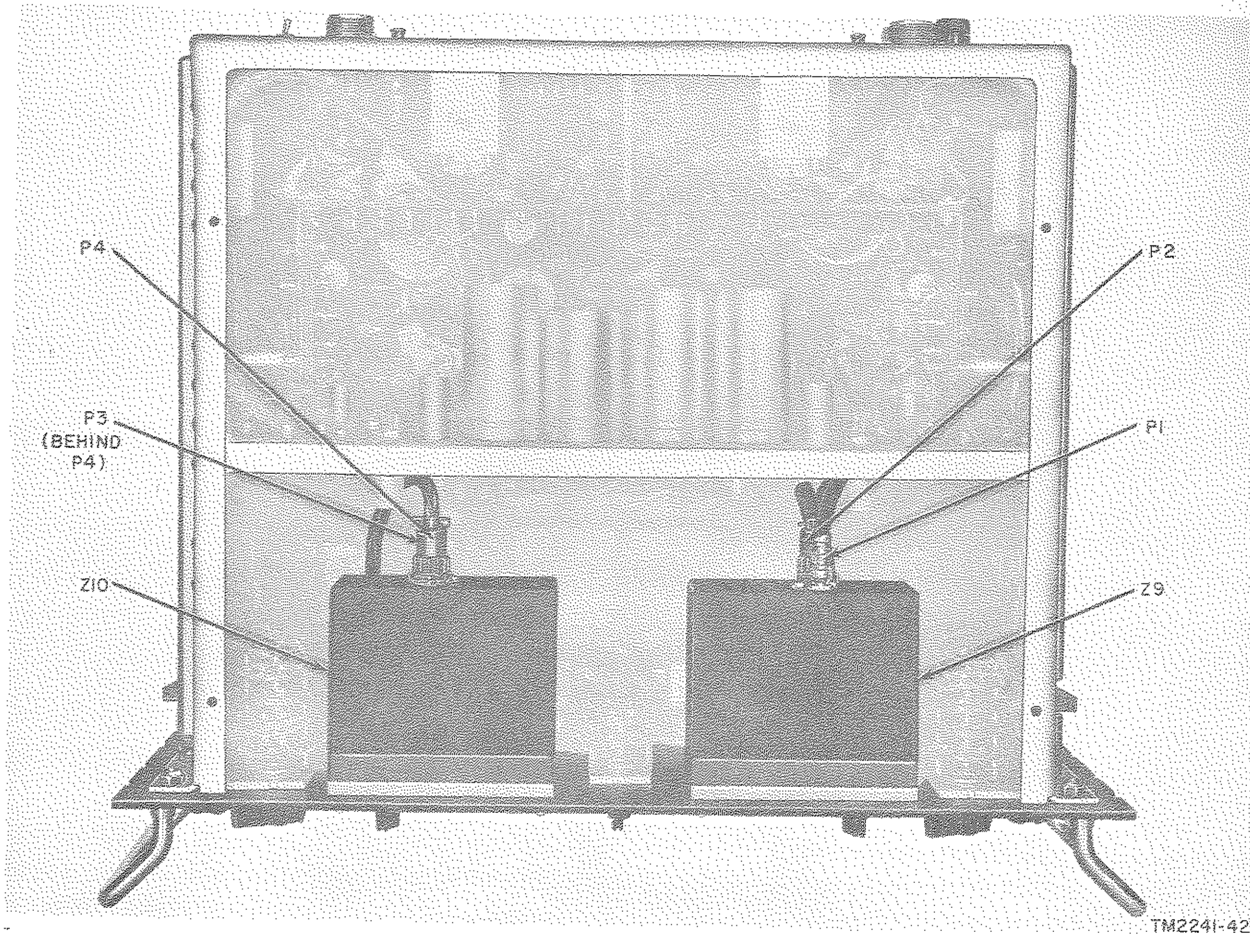

Figure 47. Frequency Shift Converter CV–116/URR, bottom view, showing afc units in place.

and roller bracket to the gear case. Remove the microswitch and roller bracket by unsoldering the blue and violet leads.

(6) To disassemble gear case of Z9 for access to gear train, remove the five shallow set 5/16-inch No. 6–32 screws from the panel end of Z9. Note that the remaining three screws hold the motor in place and are recessed more deeply in clearance holes. The motor need not be removed when entering the gear case. Hold the plane of the gear case cover horizontally, and remove the cover vertically upward so that the gears will remain in their proper relative position. The cover is kept in alinement by two pins which offer substantial friction as the cover is removed. If it is necessary to pry off the cover, be careful to pry evenly to avoid bending the key pins and gear shafts. The gear train can be reached when the cover of the gear case is removed.

(7) To remove the clutch assembly, loosen the two Allen-head screws on the switch activating cam (located on the rear of the gear case), and withdraw the clutch and gear assembly.

(8) To remove the spinner assembly, gently pry off the clear plastic cap protecting the indicating spinner. The spinner and its driving gear now may be disassembled by removing the No. 2–56 nut on the top of the spinner.

Note. Disassembly of afc unit Z10 and its component parts, motor B2, switch S6, and capacitor C60 is similar to disassembly of afc unit Z9.

c. Removal of Alarm Bell. To remove alarm bell I 1, pull back the sleeving over the two black leads and then unsolder the connections. Remove

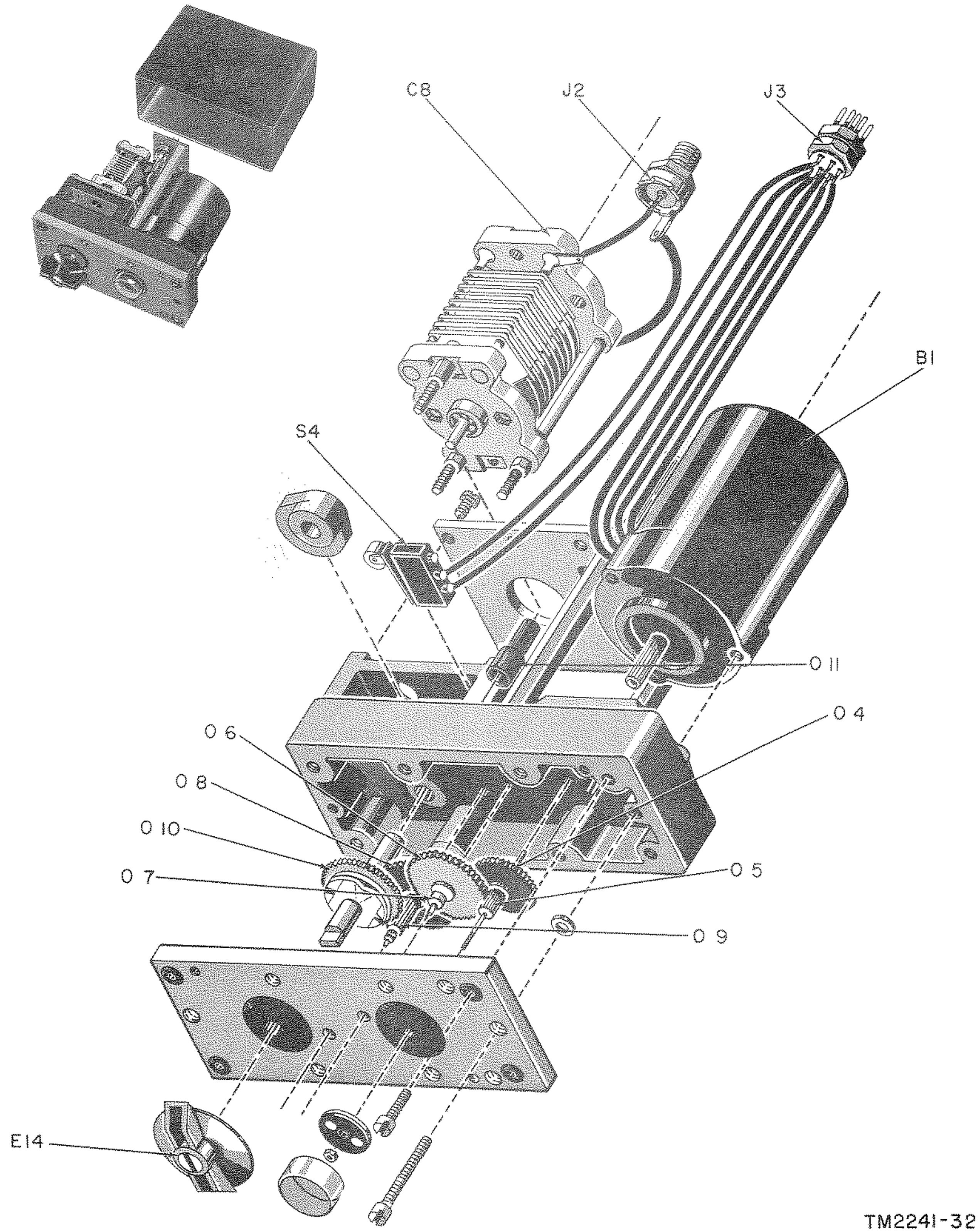

Figure 48. Exploded view of afc unit Z9.

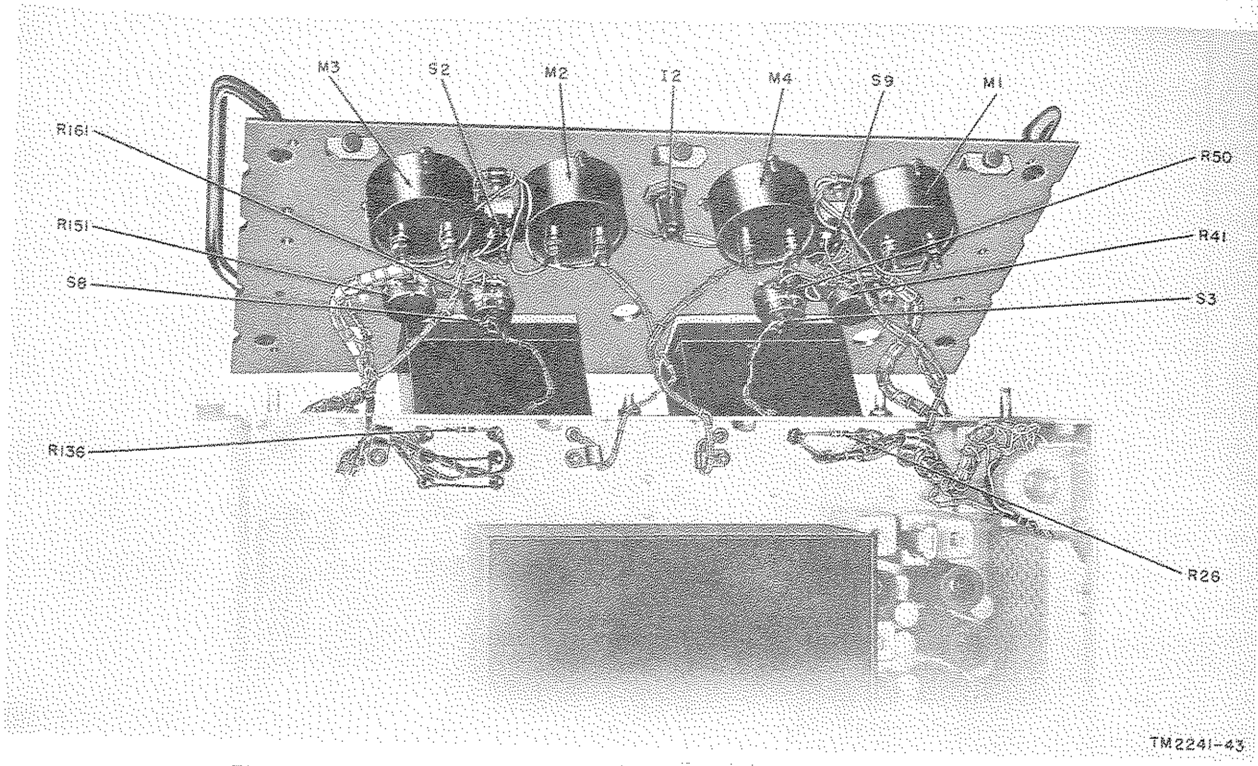

Figure 49. Frequency Shift Converter CV-116/URR, rear of front panel.

the two screws that hold the bell support bracket to the chassis and pull the assembly away. Remove the alarm bell from the bracket.

d. Replacement of Fan Motor. To remove fan motor B3, unsolder the four motor leads from the tie points located on the bottom of the chassis. Remove the fan guard. Unscrew the motor support bracket. Lift the assembly away from the unit at the top. Unscrew the motor from the support bracket.

59. Relay Adjustments

a. General. Relays K1 and K2 are single-coil relays. The adjustment requirements are both mechanical and electrical. The mechanical requirement consists of the proper armature travel. The electrical requirements are the specified currents through the winding which should cause the relay to operate or to release from the operated position. When checking the requirements, the armature must be operated *electrically* to insure accuracy of the setting.

b. Cleaning. The greatest source of relay failures is the presence of particles of dirt or lint between contacts or around the hinge pin. When cleaning the relays, proceed as follows:

(1) Remove the relay from the bracket by removing the two retaining screws. Position the relay on either side of the bracket so that its working parts are exposed for cleaning. Be careful not to damage the relay leads or other wiring.

(2) Carbon tetrachloride may be used to remove grease or oil from contacts. Deposit small drops of the carbon tetrachloride on the contacts with a toothpick. Do not rub. Be careful not to spill any liquid on the spoolheads and insulators.

(3) Cut several strips of paper about one-half inch wide to be used in burnishing the contacts. Do not burnish the contacts until they have dried thoroughly. To burnish the normally open contacts, place the paper strip between the contacts, and press the contacts together with a matchstick to give a slight pressure against the paper strip. At the same time, pull the strip of paper between the contacts. The desired result usually is obtained by pulling a clean strip of paper between the contacts two or three times. In the case of the normally closed con-

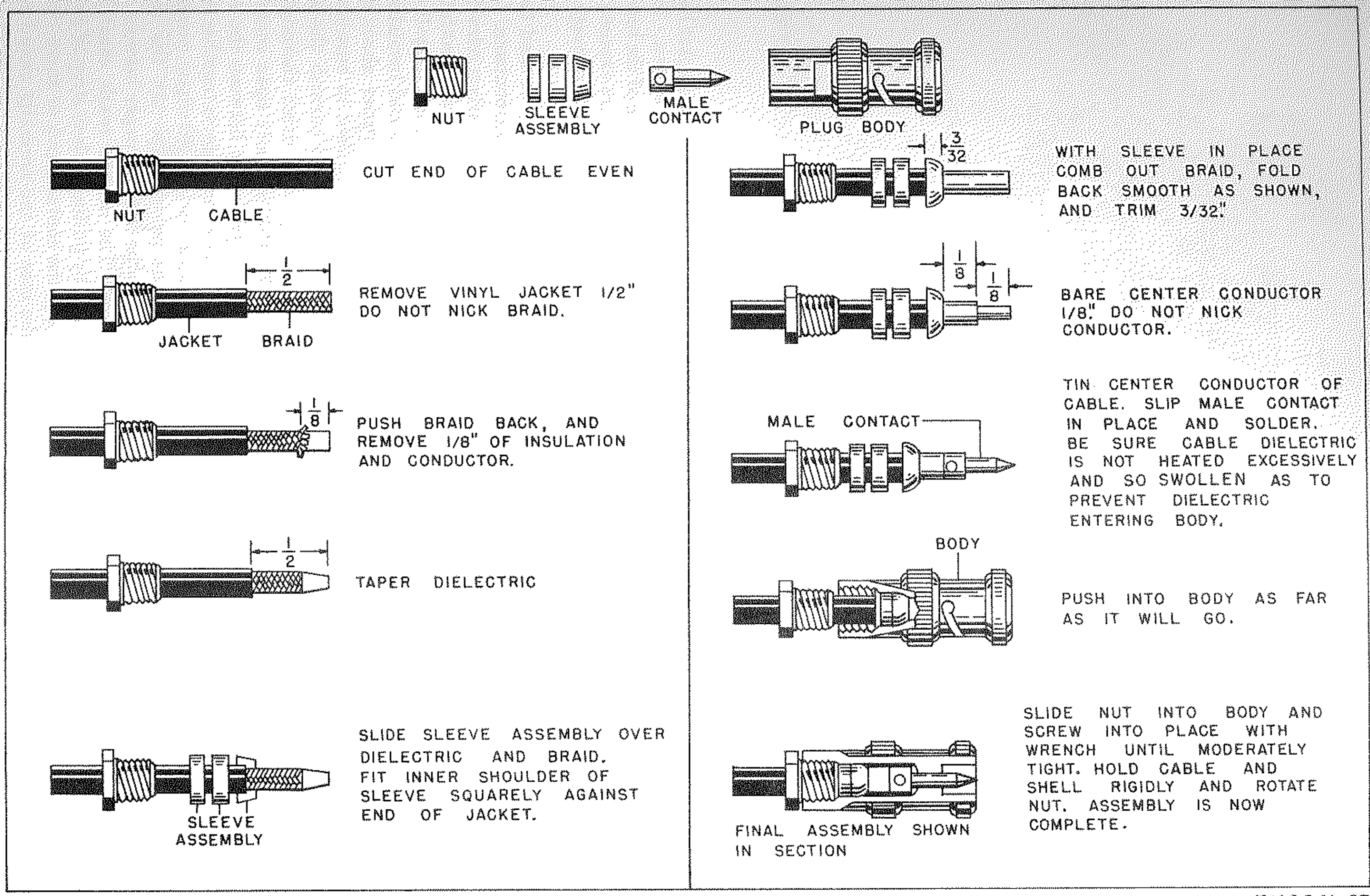

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Figure 50. Replacement of connectors.

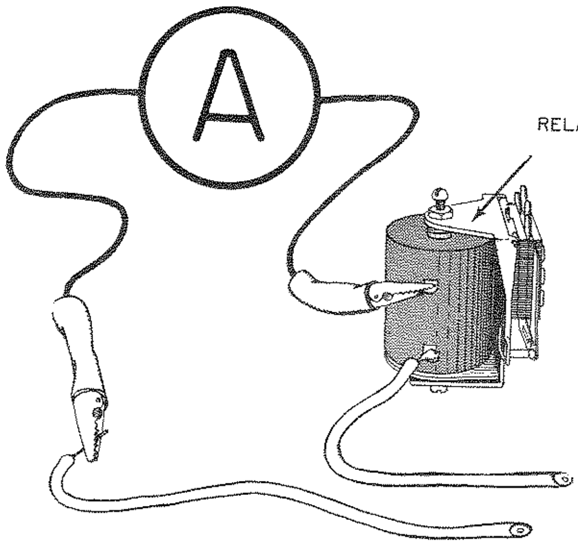

Figure 51. Circuit for measuring relay current.

tacts, the tension of the spring leaves usually furnishes enough pressure against the paper burnisher.

(4) Clean the opening between the armature adjusting screw and the pole face in a similar manner by drawing a strip of paper between the two surfaces.

(5) Deposit several drops of carbon tetrachloride on the hinge pin to clean out any foreign material or grease.

(6) Replace the relay on its mounting bracket.

c. Adjustment of Relay. The armature travel must be adjusted whenever relay K1 or relay K2 fails to meet the following electrical requirements: operate, 4.5 to 5 ma; release, 3.2 to 3.8 ma. Always make the relay meet these current requirements after every cleaning. To check the operation of relay K1 or relay K2, proceed as follows:

(1) Remove the relay from the relay bracket by removing the two retaining screws. Position the relay on either side of the bracket so that its working parts are exposed for adjustment. Be careful not to damage the relay leads or other wiring.

(2) Unsolder one of the leads to the relay winding. Connect Multimeter TS–352/U (using the 10-ma range) in series with this unsoldered lead and the winding (fig. 51).

(3) Connect either a receiver or a signal generator to the INPUT A or INPUT B jack. Tune the signal source until DISCRIMINATOR meter M4 indicates zero. Note the frequency of the signal source. Decrease this frequency by 1 kc. A steady space signal now is being applied to the converter. Adjust the afc THRESHOLD LEVEL control to obtain the *operate* current of 4.5 to 5 ma. At the same time, observe the operation of the relay contact points. The printer can be used as an indication of operation for one set of contacts and the afc circuit as an indication of the other set. By means of the same control, reduce the current to the release value; the relay should release. When the relay closes (operates), the printer should shift from space to mark operation and the afc should be disabled. When the relay opens (releases), the printer shifts back to space operation and the afc is reestablished.

(4) The make-and-break operation of the contacts also can be checked with Multimeter TS–352/U. To check the operation of the mark-hold contacts, connect the meter between ground and pin 4 of the relay. The voltage at this point when the contacts are open is approximately 130 volts dc. To check the afc contacts, connect the meter between pins 2 and 3 of the relay. The voltage should be 115 volts ac when the contacts are open.

(5) If the relay fails to meet the current requirements, adjust it as shown in figure 52. Use a small screwdriver. To change the pull-in operating point, loosen the two contact assembly screws as indicated in A, figure 52 and slide the entire assembly to adjust the gap between armature and pole face. Decrease the gap if the current required for pull-in is too high. Increase the gap if the contacts pull in at a very low current. Be sure the screws are tightened after making the proper adjustment. To make the relay release at a lower value of current, turn the armature adjusting screw in (fig. 52Ⓑ).

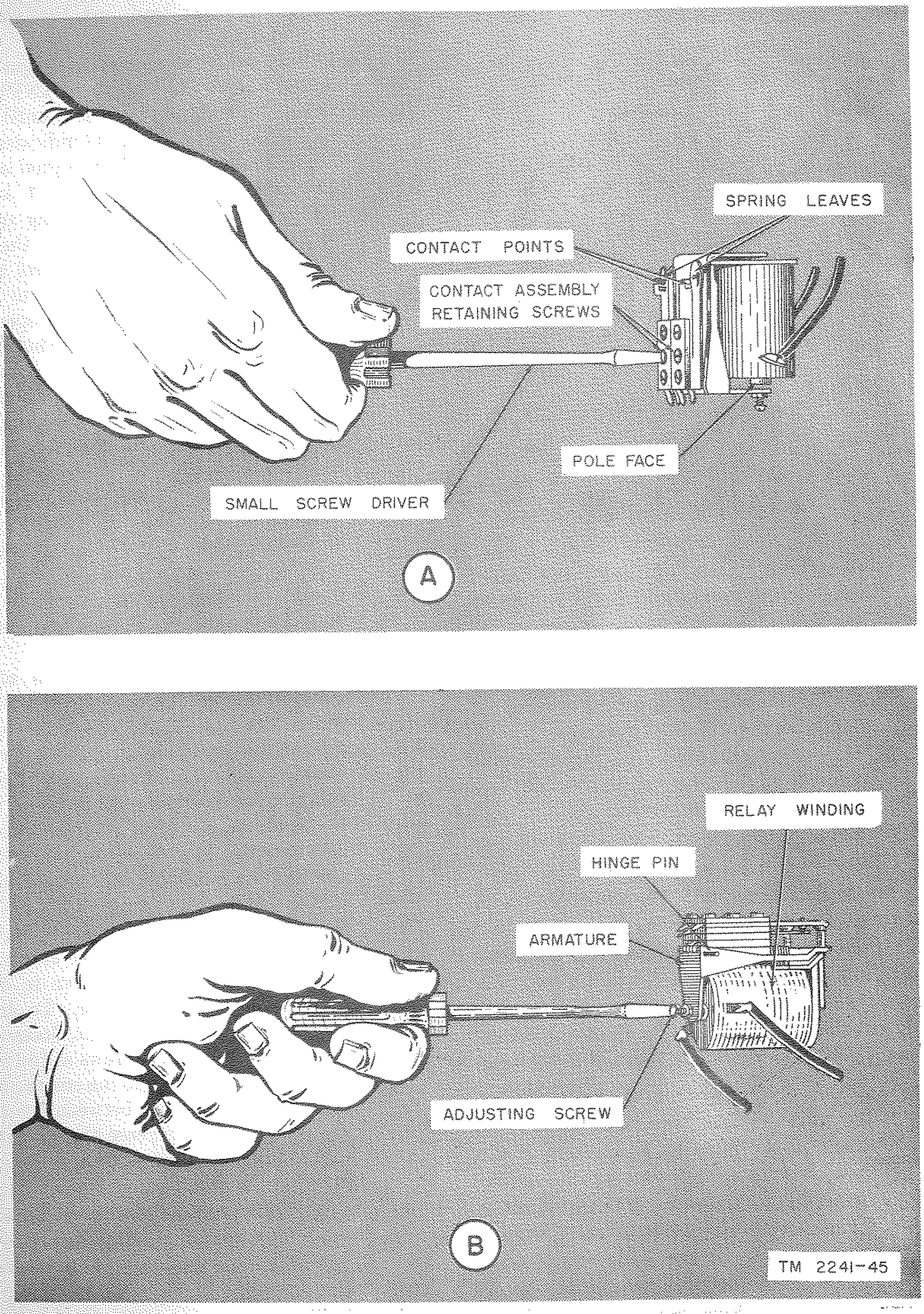

Figure 52. Adjusting relay K1 or K2.

Turning the screw out increases the current necessary to cause the relay points to open.

(6) After adjustment, replace the relay on its mounting bracket.

60. Refinishing

Instructions for refinishing badly marred panels on exterior cabinets are given in TM 9–2851. Also refer to paragraph 35.

Section III. ALINEMENT PROCEDURES

61. Rf Alinement

a. Alinement of Channel A Input Circuit. The converter is equipped with the crystals necessary for operation with a receiver having an if. frequency of 455 kc. A 405-kc crystal is used in channel A to produce a converter frequency of 50 kc. A 425.7-kc crystal is used in channel B to produce an if. in this channel of 29.3 kc. To use the converter with receivers having an if. other than 455 kc, it is necessary to realine the input circuits of the converter. In channel A, use a crystal (Y1) whose frequency is 50,000 kc below the receiver if. output frequency. The converter may be alined either with a receiver tuned to a strong rf carrier or a signal generator delivering a 2,000-microvolt signal equal to the if. of the receiver intended to be used. To aline channel A, short out INPUT B with a small piece of wire and proceed as follows:

(1) Throw the POWER switch on. Set the CHANNEL SELECTOR switch to position A. Throw the AFC switch to the OFF position. Place the channel A AFC-XTAL-MARK HOLD switch either in the left- or the right-hand XTAL position. No other switches affect the adjustments which follow. Loosen the tuning slug locknuts on the top of transformers T1 and T2 (fig. 45). Adjust T1 and T2 to obtain a maximum deflection of channel A SIGNAL INPUT meter M1. If meter M1 goes to full-scale reading, decrease the output of receiver A and continue to tune T1 and T2 for maximum indication. Tighten the locknuts slightly after they are set properly; be careful to maintain the peak meter reading.

(2) Set the channel A AFC-XTAL-MARK HOLD switch to AFC and the DRIFT INDICATOR to zero leaving the other switches as previously set. Loosen the tuning slug locknut on the top of coil L1 (fig. 45). The oscillator adjustment now may be made. The oscillator will tune either 50 kc above or 50 kc below the input signal as indicated on the SIGNAL INPUT and DISCRIMINATOR meters. Proper tuning is 50 kc below the input signal. To obtain the correct tuning, the simplest procedure is to turn the slug of L1 all the way down (in a clockwise direction) and then tune to the first maximum indication on the channel A SIGNAL INPUT meter by raising the slug until channel A DISCRIMINATOR meter M4 indicates zero. After adjustment, lock the slug in place by holding the slug in position and tightening its lower locking nut against the shoulder of the can.

b. Alinement of Channel B Input Circuit. The method of adjustment for channel B is identical with that used for channel A, except for the if. frequency settings. Use a crystal (Y2) whose frequency is 29.3 kc below the input frequency. Short out INPUT A. Plug in a signal generator delivering a 2,000-microvolt signal at the if. frequency of the receiver being used to feed channel B.

(1) Set the channel B AFC-XTAL-MARK HOLD switch to XTAL. Loosen the tuning slug locknuts on top of transformers T3 and T4 (fig. 45). Adjust T3 and T4 to obtain a maximum deflection of channel B SIGNAL INPUT meter M2. If meter M2 goes to full-scale reading, decrease the output of receiver B and continue to tune T3 and T4 for a maximum indication. After adjustments, lock the slugs in place.

(2) Set the channel B AFC-XTAL-MARK HOLD switch to AFC, and the DRIFT INDICATOR to zero. Loosen the tuning slug locknut on top of L2 (fig. 45). Turn the slug of L2 all the way down. Tune to the first maximum indication on the channel B SIGNAL INPUT meter

by raising the slug until the channel B DISCRIMINATOR meter indicates zero. Lock the slug in place.

62. Discriminator Alinement

a. Alinement of Channel A Discriminators. Turn on the signal generator and allow it to reach a stable operating temperature (approximately 15 minutes). All discriminator tuning adjustments are located at the rear of the chassis (fig. 9). Set the channel A AFC-XTAL-MARK HOLD switch to XTAL and the CHANNEL SELECTOR to A. Proceed as follows:

(1) Set tuning capacitors C28 and C29 to half capacity (slots vertical).

(2) Connect the signal generator to INPUT A. Tune the generator for a reading of zero on channel A DISCRIMINATOR meter M4.

(3) Turn metering switch S11 (fig. 10) to the A+B position. In this position, M4 (channel A DISCRIMINATOR meter) indicates the combined output of discriminator circuits Z3 and Z4 when the PRESS TO TEST switch is pressed.

(4) While depressing the PRESS TO TEST switch, adjust capacitors C48 and C49 to obtain a zero reading on meter M4. If this is impossible, retune the signal generator slightly so that A+B indicates zero and then release the PRESS TO TEST switch. Retune C28 and C29 for a zero reading on the DISCRIMINATOR meter. The object of this procedure is to tune both the channel A afc discriminator and the channel A diversity discriminator to zero output for an identical input frequency to INPUT A.

b. Alinement of Channel B Discriminators. All discriminator tuning adjustments are located at the rear of the chassis (fig. 9). Set the channel B AFC-XTAL-MARK HOLD switch to XTAL and the CHANNEL SELECTOR to B. Proceed as follows:

(1) Set tuning capacitors C81 and C82 to half capacity (slots vertical).

(2) Connect the signal generator to INPUT B. Tune the generator for a reading of zero on channel B DISCRIMINATOR meter M3.

(3) Turn metering switch S11 (fig. 10) to the A+B position. In this position, M4 (channel A DISCRIMINATOR meter) indicates the combined output of discriminator circuits Z3 and Z4 when the PRESS TO TEST switch is pressed.

(4) While holding down the PRESS TO TEST switch, adjust capacitors C50 and C51 to obtain a zero reading on meter M4. If this is impossible, retune the signal generator slightly so that A+B indicates zero and then release the PRESS TO TEST switch. Retune C81 and C82 for a zero reading on the channel B DISCRIMINATOR meter. The object of this tuning procedure is to get channel B DISCRIMINATOR and A+B meter to indicate zero for an identical input frequency to channel B.

63. Keyer and Afc Adjustments
(fig. 10)

a. Keyer Adjustments. Rotate the CHANNEL SELECTOR switch to position A and the channel A AFC THRESHOLD LEVEL control to OFF. This prevents a mark-lock condition which would unbalance the keyer circuits. Make the following settings in sequence:

(1) Set meter switch S11 to the R94 position. Push the PRESS TO TEST switch and adjust potentiometer R94 for zero on meter M4. (This puts approximately −8 volts on grid pin 2 of tube V24A.)

(2) Set switch S11 to the R99 position. Push the PRESS TO TEST switch and adjust potentiometer R99 for a zero reading on meter M4. (This results in a zero bias on grid pin 7 of the tube V24B.)

(3) Set switch S11 to the R104 position. Push the PRESS TO TEST switch and adjust potentiometer R104 for zero on meter M4. (This puts approximately −35 volts on the control grids of tubes V25 and V26.)

(4) With a printer connected to the tty output, set switch S11 to position R109. Push the PRESS TO TEST switch and adjust potentiometer R109 to 60 microamperes as read on DISCRIMINATOR meter M4. This reading multiplied by 1,000 is 60 milliamperes, the proper loop current.

(5) If a printer is not available, connect a resistive load (125 to 500 ohms) across pins D and A of J4 and adjust potentiometer R109 to 60 microamperes. This reading multiplied by 1,000 is 60 milliamperes.

b. Channel A Afc Adjustments. Rotate the CHANNEL SELECTOR switch to position A, the channel A AFC-XTAL-MARK HOLD switch to the AFC position, and set the AFC THRESHOLD LEVEL control to OFF. Tune in a strong signal on channel A or connect a signal generator set to deliver the receiver if. at 2,000 microvolts at INPUT A. Throw the AFC switch to the ON position. Adjust the motor circuit in the following manner:

(1) Set switch S11 to the R57 position.

(2) Push the PRESS TO TEST switch and adjust potentiometers R57 and R47 for a minimum current through meter M4 and also for motor balance as indicated by a stopping of the channel A AFC INDICATOR. This is accomplished by first stopping the motor with R47, reducing the current indicated on M4 with R57, rebalancing the motor with R47, and again reducing the current until the motor balances at a current of approximately 1 microampere through M4.

c. Channel B Afc Adjustments. Rotate the channel SELECTOR switch to a position B, the channel B AFC-XTAL-MARK HOLD switch to the AFC position, and set the AFC THRESHOLD LEVEL control to the OFF position. Tune in a strong signal on channel B and throw the AFC switch to the ON position. Adjust the motor circuit in the following manner:

(1) Set switch S11 to the R167 position.

(2) Push the PRESS TO TEST switch and adjust potentiometers R167 and R157 for a minimum current through meter M4 and also for a motor balance as indicated by a stopping of the channel B AFC INDICATOR. These adjustments are identical with those described in *b*(2) above.

Section IV. FINAL TESTING

64. General

This section is intended as a guide to be used in determining the quality of Frequency Shift Converter CV–116/URR repaired at higher echelon levels. The minimum test requirements outlined in the following paragraphs may be performed by maintenance personnel with adequate test equipment and the necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory results during operation. The tests given in paragraphs 65 through 70 should be performed in the order given. Before performing any of the tests that follow, check the B+ and B− voltages (par. 57*c*).

65. Test Equipment

The following equipments, or equal, are required to perform the tests in this section:

Test equipment	Technical manual
Multimeter TS–352/U	TM 11–5527
Electronic Multimeter TS–505/U	TM 11–5511
RF Signal Generator Set AN/URM–25	TM 11–5551
Frequency Meter Set SCR–211–( )	TM 11–300
Frequency Meter FR–67/U	TM 11–2698
Teletypewriter TG–7–B	TM 11–352

66. Rf Circuit Tests

a. Connect the test equipment as shown in figure 53.

b. Adjust the signal generator to the frequency normally fed to INPUT A from the receiver and set it for a 10,000-microvolt output. The voltage at the grid (pin 7) of V3 should be approximately 1.3 volts ac.

c. Adjust the rf signal generator to 5 kc above and 5 kc below the normal INPUT A frequency. Observe the voltage at pin 7 of V3 for each setting. The reading should be approximately 0.9 volt ac.

d. Repeat the test described in *c* above for frequencies 10 kc above and below the frequency normally fed to INPUT A. The meter B readings at pin 7 of V3 should be approximately 0.45 volt ac. The response should be close to that shown by the curve in figure 54.

e. Repeat the tests described in *a* through *d* above on channel B. Connect electronic multimeter B to the grid (pin 7) of V29 and the rf signal generator to INPUT B. Again, observe that the response of the rf amplifier is close to that shown in figure 54.

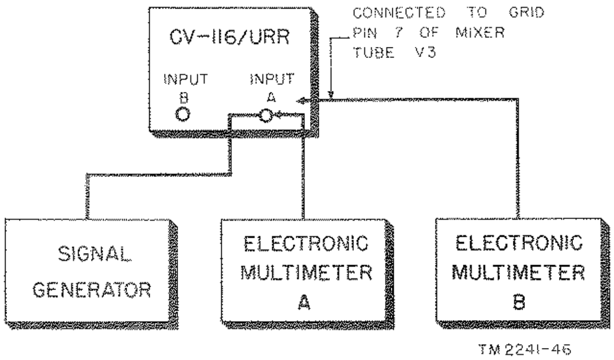

Figure 53. Setup for channel A rf circuit tests.

67. Limiting Amplifier Tests

a. Connect the test equipment as shown in figure 55.

b. Adjust the signal generator to the frequency normally fed to INPUT A from the receiver.

c. Adjust the output level of the signal generator to give an indication of 50 microvolts on electronic multimeter A. The voltage at the plate (pin 5) of V7 should be approximately 50 volts ac.

d. Change the signal level at INPUT A to 100 microvolts. The voltage at the plate of V7 should again be approximately 50 volts ac.

e. Adjust the signal level at INPUT A to 500, 1,000, 2,000, 5,000, 10,000, and 100,000 microvolts. Observe the readings on meter A at each successive change in input level. The plate voltage reading at each input level should remain relatively constant at approximately 50±5 volts ac as shown in figure 56.

f. Repeat the tests described in *b* through *e* above on channel B. In channel B, tube V33 is the third afc limiting amplifier.

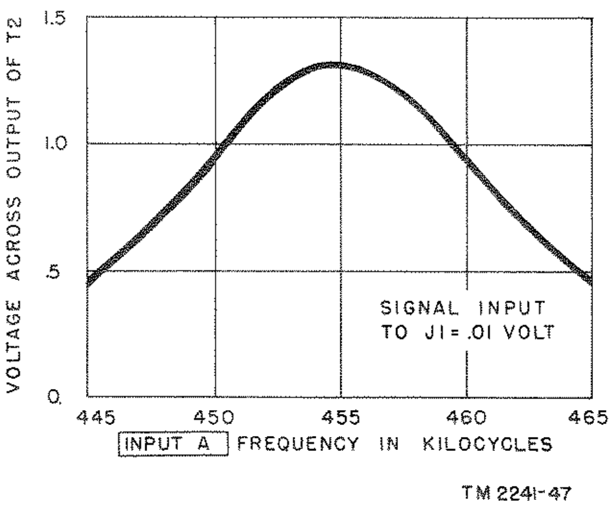

Figure 54. Channel A rf amplifier response curve.

g. Rotate the CHANNEL SELECTOR switch to the B position and short out INPUT A. Connect electronic multimeter B to the plate (pin 5) of the third diversity-limiting amplifier V20. Adjust the output level of the rf signal generator to give an indication of 50 microvolts at INPUT B. Electronic multimeter B should indicate approximately 50 volts ac.

h. Repeat the tests outlined in *d* and *e* above for the setup described in *g* above. The curve in figure 56 also applies to the diversity-limiting amplifier section.

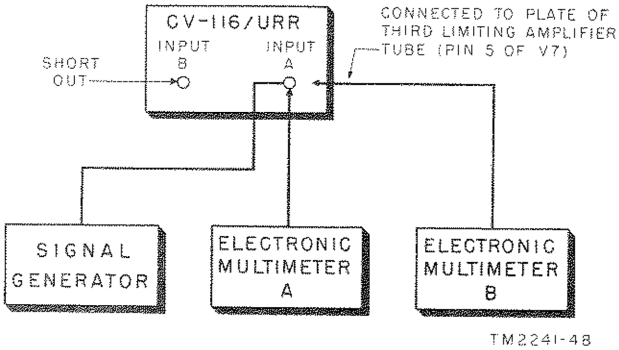

Figure 55. Setup for channel A limiting amplifier tests.

68. Discriminator Tests

a. Throw the AFC switch to OFF and connect the signal generator to INPUT A. Set the signal generator to the operating frequency and adjust its output to 10,000 microvolts.

b. The channel A DISCRIMINATOR meter M4 should read zero, indicating correct discriminator tuning. If a zero reading is not obtained, change the input signal frequency slightly.

c. Decrease the frequency of the applied signal by 425 cycles and check to see that meter M4 gives an indication of −50. Continue to decrease the frequency of the applied signal to a point 1 kc lower than the operating frequency. Meter M4 now should indicate slightly off scale to the left. Increase the applied frequency 425 cycles above the operating frequency and check to see that meter M4 indicates +50. A further increase to 1 kc above the operating frequency should drive M4 slightly off scale to the right.

d. Shift the signal generator from INPUT A to INPUT B. Repeat procedure described in *b* and *c* above for the channel B discriminator.

e. Rotate the CHANNEL SELECTOR switch to position B and set metering switch S11 to posi-

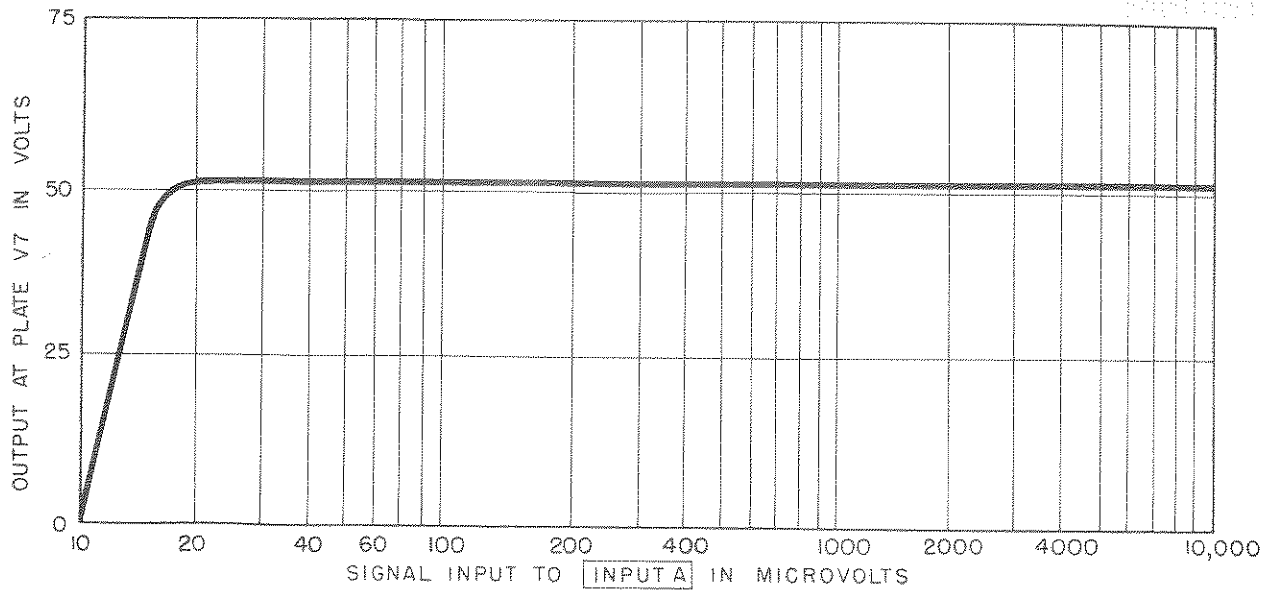

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Figure 56. Response curve at output of third limiting amplifier.

tion A+B. Repeat the steps described in *b* and *c* above, while depressing PRESS TO TEST switch S10 and observing meter M4.

69. Band-Pass Filter Tests

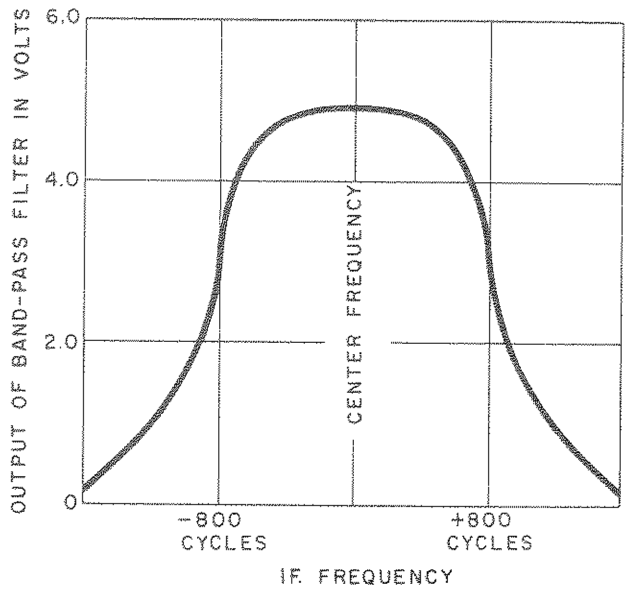
a. Apply an input of 10,000 microvolts at the frequency normally fed to INPUT A from the receiver.

b. Connect an electronic multimeter across band-pass filter Z1.

c. Rotate channel A AFC-XTAL-MARK HOLD switch S1 to the XTAL position.

d. Slowly tune the signal generator to give a peak reading on the multimeter. This peak, which occurs at the center if. frequency, should be approximately 5 volts ac.

e. Tune the signal generator 800 cycles above and below the center frequency and observe the multimeter readings at each setting. The response of the band-pass filter should be close to that shown in figure 57.



TM 2241-50

Figure 57. Band-pass filter response curve.

70. Threshold Control Tests

a. Connect the rf signal generator and one electronic multimeter to INPUT A as shown in figure 58Ⓐ. Connect another multimeter across afc THRESHOLD LEVEL potentiometer R50 as shown in B, figure 58Ⓑ.

b. Adjust the signal generator to the frequency normally fed to INPUT A from the receiver.

c. Slowly vary the output level of the signal generator from 0 to 3,000 microvolts. Observe the dc voltage readings on multimeter B. The readings should increase in the negative direction from 0 volts to approximately −40 volts (at an input signal of 2,000 microvolts) and then remain relatively constant at −40±5 volts for any further increase in input voltage from the signal generator.

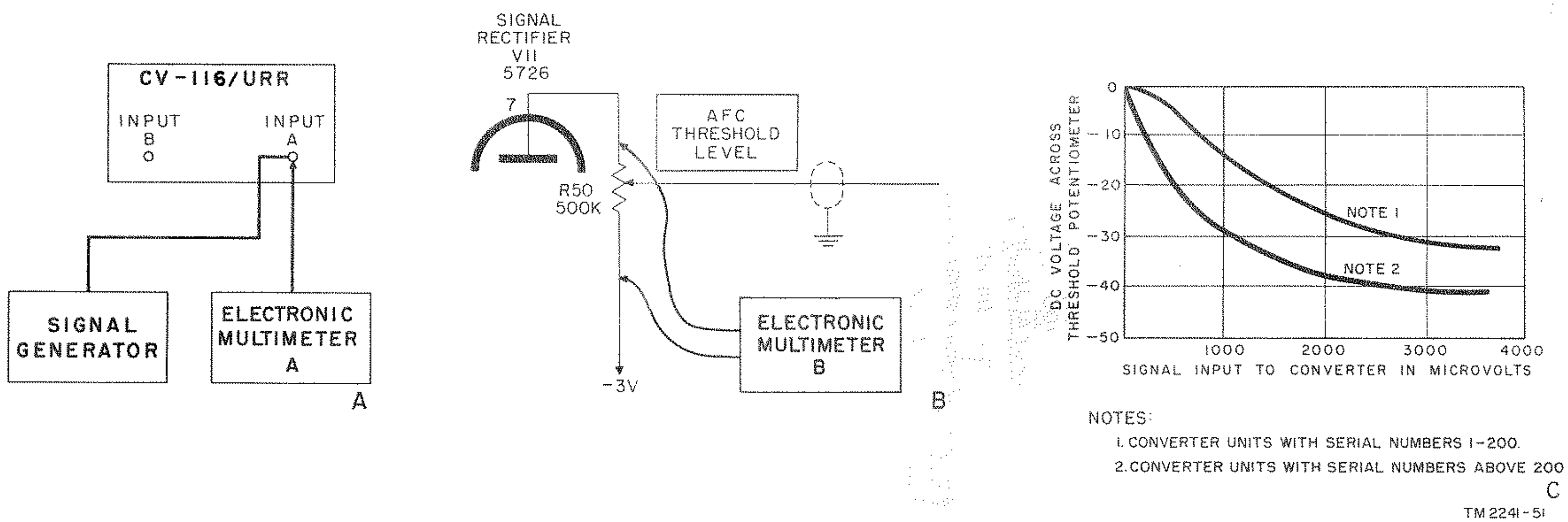


Figure 58. Setup for channel A threshold control test.

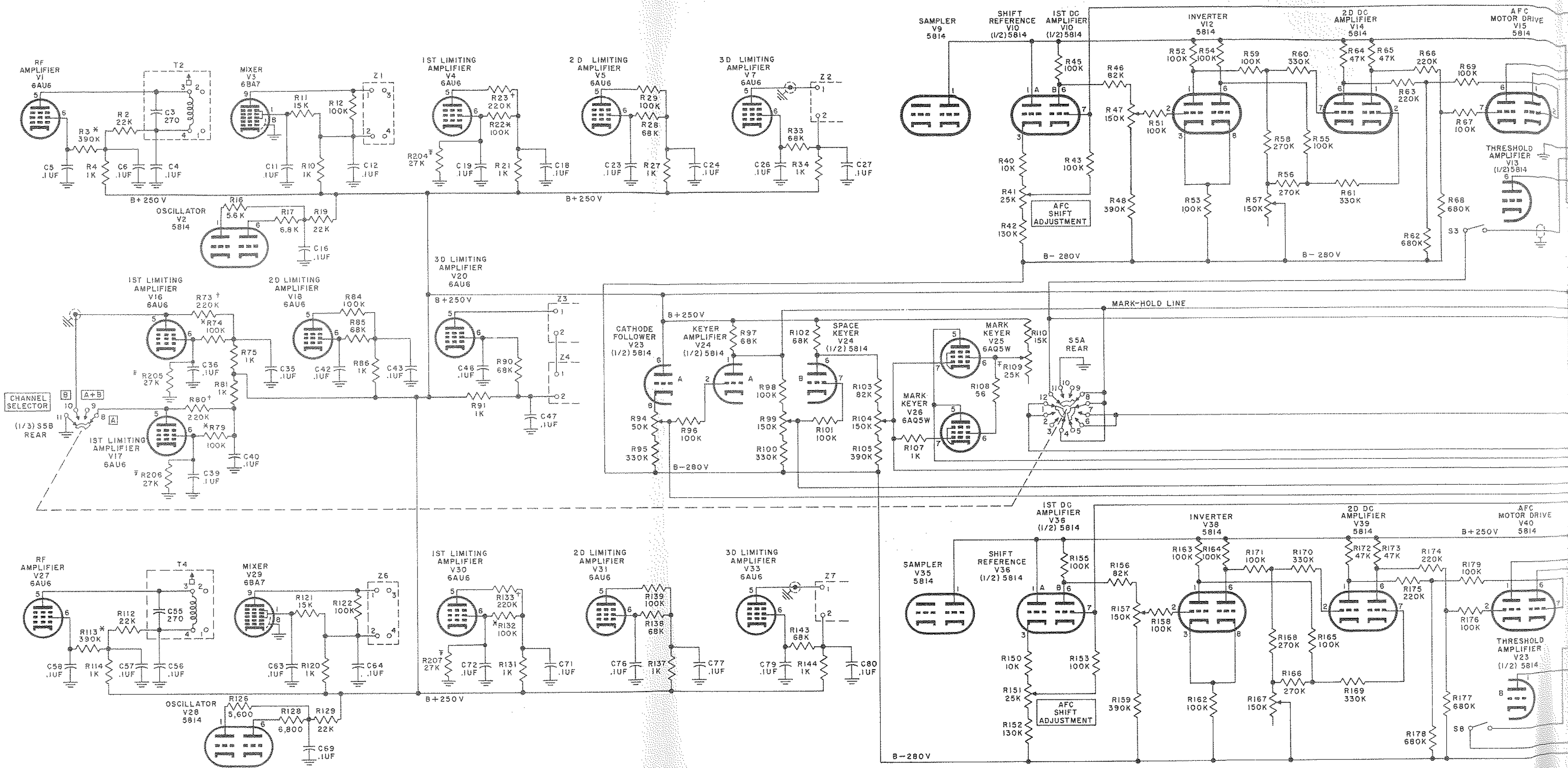


Figure 59. B+ voltage distribution diagram.