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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

FIELD AND DEPOT MAINTENANCE MANUAL

RECEIVER, RADIO R-943/USD-1



HEADQUARTERS, DEPARTMENT OF THE ARMY

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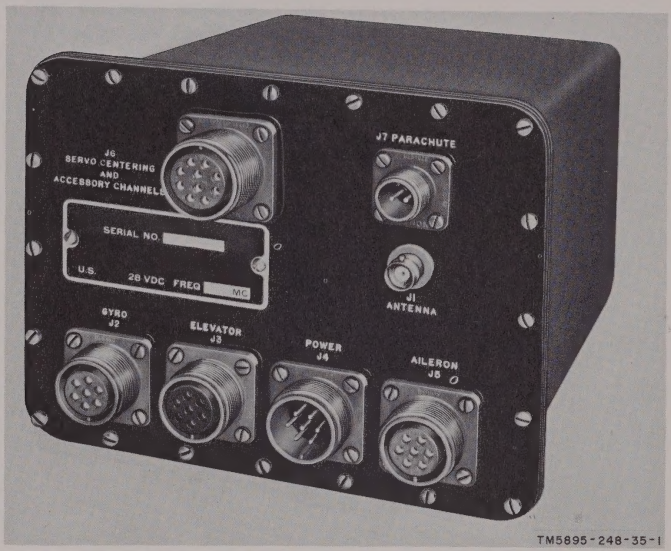


Figure 1. Receiver, Radio R-943/USD-1.

CHAPTER 1
INTRODUCTION

1. Scope

a. This manual covers field and depot maintenance for Receiver, Radio R-943/USD-1 (fig. 1). It includes instructions appropriate to third, fourth, and fifth echelons for troubleshooting, testing, aligning, and repairing the equipment, replacing maintenance parts, and repairing specified maintenance parts. It also lists tools, materials, and test equipment for third, fourth, and fifth echelon maintenance. Detailed functions of the equipment are covered in the theory sections.

b. Organizational maintenance for this equipment is contained in TM 11-1550-200-12.

c. The appendix to this manual contains references.

d. The glossary contains a list of definitions.

e. Forward all comments on this manual to Commanding Officer, U. S. Army Signal Publications Agency, Fort Monmouth, N. J.

2. Forms and Records

For applicable forms and records, refer to paragraph 2, TM 11-1550-200-12.

3. System Application

a. Receiver, Radio R-943/USD-1 (receiver), is an ultrahigh frequency (uhf), frequency-modulated (fm) receiver that is used in flight control systems of drone aircraft. This receiver operates in the frequency range of 406 to 420 megacycles, and is capable of receiving six channels of control information.

b. The receiver is used in conjunction with ground control station equipment to provide remote flight control of the drone. Radiofrequency (rf) signals modulated with audiofrequency (af) signal pulses, having appropriate duty cycles to effect the desired changes in attitude of the drone, are transmitted by the ground control station. The receiver receives and changes the varying duty cycles into direct-current (dc) voltages that operate relays in the drone control circuits to provide the desired flight control or function. An airborne gyro unit is used in conjunction with the receiver to provide automatic flight stabilization of the drone about its roll and pitch axes.

c. The functional relationship between major components of the flight control equipment is shown in figure 2. Selection of the desired drone flight attitude by the ground control station operator is accomplished by operating the controls on the ground control station, master flight control box (or remote flight control box). The electrical signals from the master flight control box are applied to the coder. The signals are converted by the coder into composite audiofrequency modulation signal pulses of appropriate duty cycles and frequency to effect the desired flight attitude change. The composite audio signal from the coder consists of a combination of the signals of 10.76 and 13.7 kilocycles (kc) for pitch and roll commands respectively, together with any of the on-off accessory commands. The frequencies of the on-off accessory commands which may be selected are 7.5, 8.46, 9.54, or 12.14 kc, for instantaneous chute, camera, nite lite, and spare channels. The audio signals for the pitch and roll channels are pulsed on and off 15 times per second. The proportion of the *on* time to the *off* time in each channel varies, and is controlled by the manual controls located on the master flight control box. The proportion of the *on* to *off* time of the pitch and roll channels, provides proportional pitch and roll control commands for the drone. The composite audio signal output of the coder is applied to the ground control station transmitter to frequency-modulate the rf carrier.

d. The frequency-modulated rf carrier output from the transmitter is picked up by two airborne antennas and applied through the antenna switcher to the receiver. Two antennas are used to eliminate any structural or terrain shading or multipath effects of the radio signal. The receiver amplifies and demodulates the frequency-modulated rf carrier to obtain six audio command signals. These audio command signals are applied to their respective control circuits. The roll and pitch command signals are changed into polarized voltages

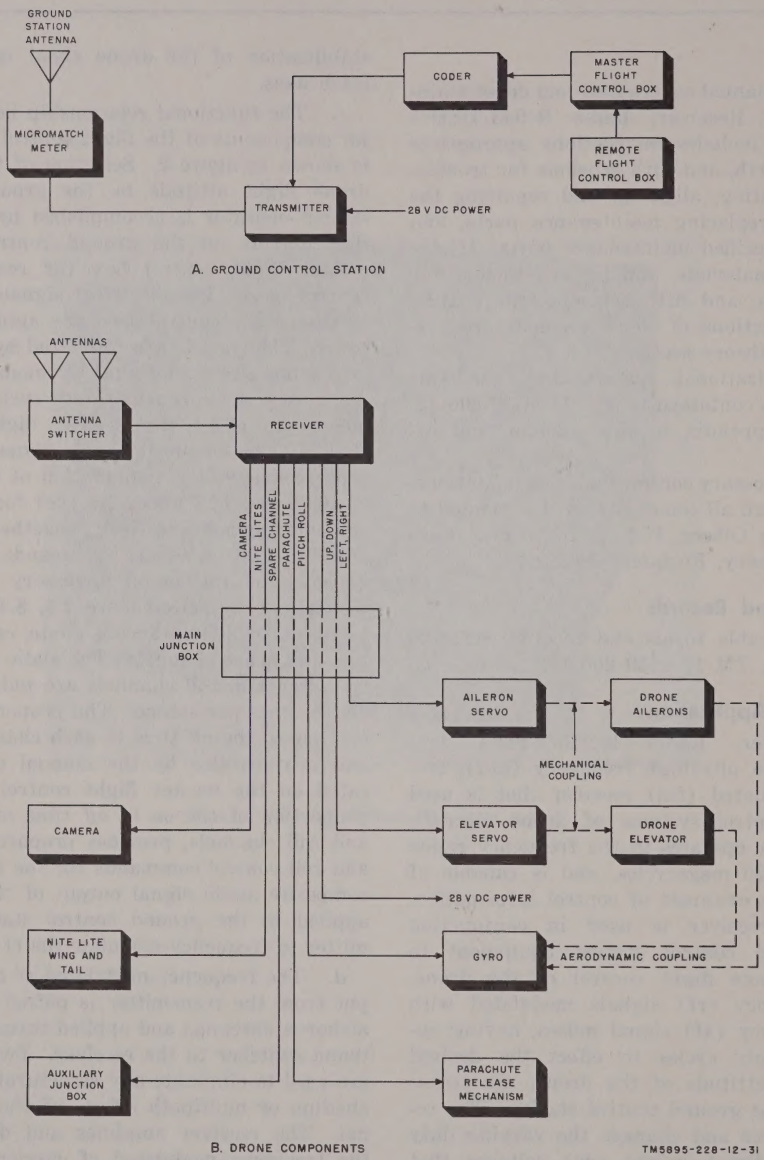


Figure 2. Flight control system, functional block diagram.

that actuate micropositioners. These micropositioners control the 28-volt dc circuits operating the servos that move the drone ailerons and elevator corresponding to the flight command. The chute command signal is applied through a detector and amplifier to energize a relay. This relay interrupts the parachute holding solenoid circuit, located in the drone, and releases the parachute. The auxiliary (camera, nite lite, and spare channel) signals operate relays that turn on the camera, wing and tail nite lites, and any other auxiliary equipment that may be installed in the drone.

e. The flight control equipment also includes a gyro for automatic flight stabilization. Through aerodynamic coupling, the gyro senses change in the flight attitude and develops roll and pitch signals proportional to the flight attitude changes. These roll and pitch signals are applied to the roll and pitch command circuits respectively to actuate the control surfaces, and correct the change in flight attitude.

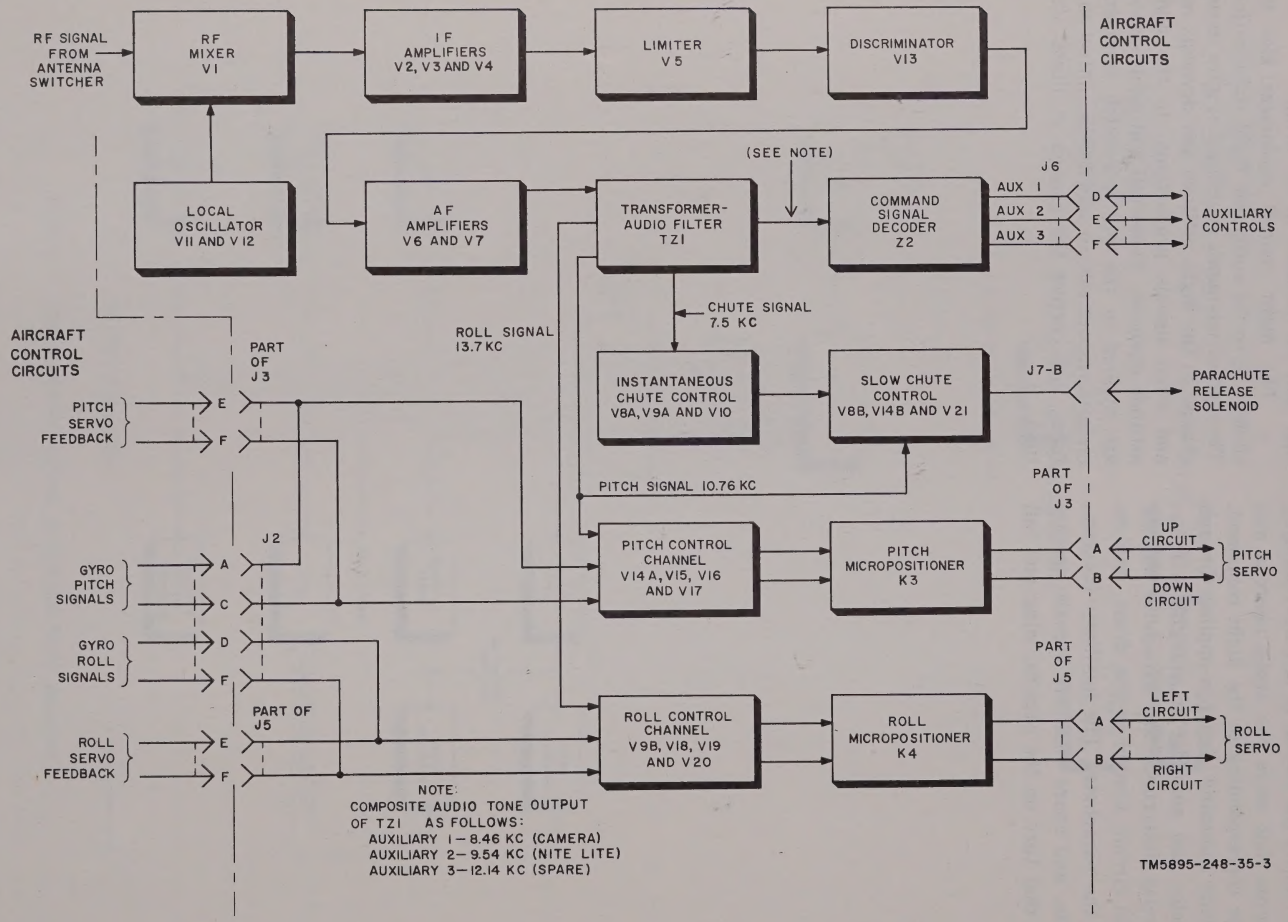


Figure 3. Receiver, block diagram.

CHAPTER 2
THEORY

4. Block Diagram Analysis
(fig. 3)

The receiver is a fixed-tuned, superheterodyne receiver operating in the 406- to 420-megacycle (mc) frequency range. It receives, amplifies, and demodulates a frequency-modulated rf carrier of predetermined frequency within this range and converts the audio output that is obtained into polarized voltages. These voltages operate micropositioners and relays to control the flight attitude or auxiliary equipment in the drone. A maximum of six command channels can be received and demodulated by the receiver. Functions of the receiver stages are designed in *a* through *n* below.

a. Rf Mixer V1. Rf mixer V1 heterodynes the rf signal received from the antenna switcher with the local oscillator signal, and applies the difference frequency to the intermediate-frequency (if) amplifiers.

b. Local Oscillator V11 and V12. The local oscillator stage generates and supplies the local oscillator signal to the rf mixer. This stage consists of a crystal oscillator and three doubler amplifiers. The crystal oscillator frequency is multiplied eight times by the three doubler circuits.

c. If Amplifiers V2, V3, and V4. If amplifiers V2, V3, and V4 amplify the difference frequency received from the mixer stage. This stage consists of three pentode amplifiers, each with tuneable input and output if transformers. The output from the if amplifiers is applied to limiter V5.

d. Limiter V5. Limiter V5 eliminates if signal amplitude variations. Because the discriminator is amplitude sensitive, this action is necessary to prevent any amplitude distortion in the composite af signal. The output of the limiter is coupled to discriminator V13.

e. Discriminator V13. Discriminator V13 converts the frequency changes of the if signal to an audiofrequency signal. The if signal input to the discriminator is obtained from the limiter. The discriminator output is applied to af amplifiers V6 and V7.

f. Af Amplifiers V6 and V7. Af amplifiers V6 and V7 amplify the discriminator audio output. The output of the af amplifier stage is applied to transformer-audio filter TZ1.

g. Transformer-Audio Filter TZ1. Transformer-audio filter TZ1 separates the composite audio signal from the af amplifier stage into four different outputs; a composite audio tone of the three auxiliary channels, the roll, the pitch, and the chute signals. The auxiliary channels composite audio tone is applied to command signal decoder Z2. The pitch signal is applied to the pitch control channel (V14A, V15, V16, and V17) and the slow chute control (V8B, V14B, and V21). The roll signal is applied to the roll control channel (V9B, V18, V19, and V20). The chute signal is applied to the instantaneous chute control (V8A, V9A, and V10).

h. Command Signals Decoder Z2. Command signal decoder Z2 receives any combination of the three auxiliary channel command frequencies from transformer-audio filter TZ1. This decoder separates the tones corresponding to the three auxiliary channels, rectifies the tone, and uses the resultant dc voltage to operate relays which provide ground connections for the appropriate output circuits. The command signal decoder is a potted, transistorized unit. It contains three audio filter units together with their associated detectors, amplifiers, and relays.

i. Pitch Control Channel V14A, V15, V16, and V17. Pitch control channel V14A, V15, V16, and V17 receives the pitch control signal at an audiofrequency of 10.76-kc, and converts this signal into two dc voltages. One of these voltages represents the *on* time of the 10.76-kc signal, and the other represents the *off* time. These dc voltages, added to the pitch servo feedback (indicating the pitch servo action) and the gyro pitch signals (representing flight attitude changes), are applied to two bridge detector amplifiers operating in push pull. When these amplifiers are unbalanced, they develop an up or down command for the pitch micropositioner.

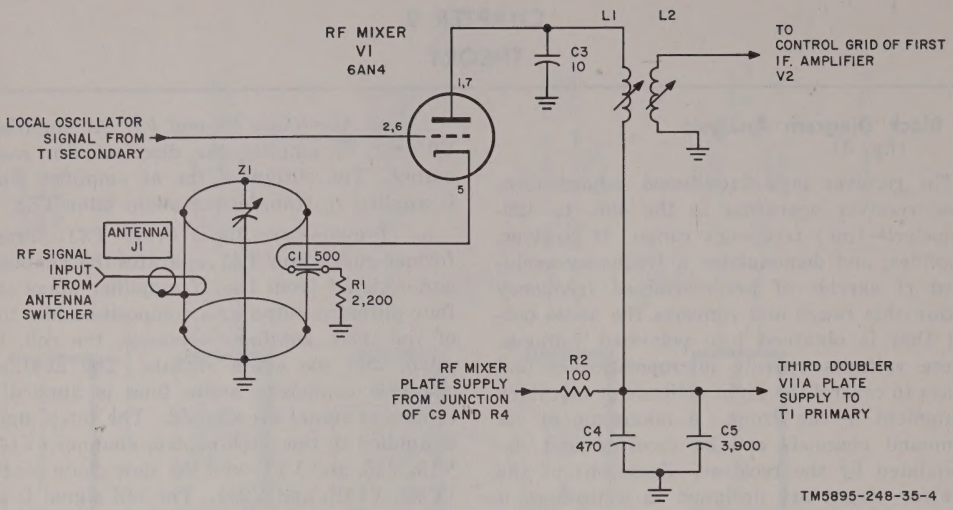


Figure 4. Rf mixer V1, partial schematic diagram.

j. Pitch Micropositioner K3. Pitch micropositioner K3 receives the unbalanced output from the two pitch bridge detector amplifiers and completes either the up or down circuit for the pitch servo to correspond to the unbalanced condition of the pitch channel.

k. Roll Control Channel V9B, V18, V19, and V20. Roll control channel V9B, V18, V19, and V20 receives the roll control signal at an audiofrequency of 13.7-kc and converts this signal into two dc voltages. One of these voltages represents the *on* time of the 13.7-kc signal, and the other represents the *off* time. These dc voltages, added to the roll servo feedback (indicating the roll servo action) and the gyro roll signal (representing flight attitude changes), are applied to two bridge detector amplifiers operating in push pull. When these amplifiers are unbalanced, they develop a left or right command for the roll micropositioner.

l. Roll Micropositioner K4. Roll micropositioner K4 receives the unbalanced output from the two roll bridge detector amplifiers, and completes either the left or right roll servo circuit to correspond to the unbalanced condition of the roll channel.

m. Slow Chute Control V8B, V14B, and V21. Slow chute control V8B, V14B, and V21 receives a portion of the pitch signal, and uses this signal to energize a relay. When the relay is energized, it completes the ground circuit for the parachute release solenoid. If the pitch signal is lost, either by pressing the CHUTE DELAYED button on the master flight control box or because of a loss of rf carrier, the slow chute control relay denergizes after a predetermined delay period. This allows the parachute release solenoid to release the parachute. Additional control of the parachute release solenoid is obtained from the instantaneous chute control. The output of this control is applied to the slow chute control channel to release the parachute.

n. Instantaneous Chute Control V8A, V9A, and V10. The instantaneous chute control receives the chute signal at an audiofrequency of 7.5-kc from transformer-audio filter TZ1, and uses this signal to control the operation of the slow chute control circuit. This stage consists of command rectifier V8A, command amplifier V9A, and chute channel relay control V10. When a 7.5-kc chute signal is received, as a result of pressing the CHUTE INSTANT button on the master flight control box, the instantaneous chute control overrides the delayed action of the slow chute control. This causes immediate release of the parachute.

5. Rf Mixer V1, Stage Analysis (fig. 4)

Rf mixer V1 heterodynes the rf signal received from the antenna switcher and the local oscillator signal, and applies the difference frequency to the intermediate-frequency amplifiers.

a. The frequency-modulated rf carrier signal from the ground control station transmitter is picked up by the two airborne antennas and is connected through the antenna switcher and ANTENNA connector J1 to a radiation loop within rf transformer Z1, which consists of a coaxial line section with an internal variable capacitor and two coupling loops. This coaxial line section is tuned to provide a high Q, high efficiency, rf transformer at the receiver operating frequency. The input coupling loop, connected between J1 and the outer conductor, applies the rf signal from the antenna to the transformer. The output loop, connected through resistor R1 to the outer conductor, couples the rf signal within the transformer to the mixer cathode. The internal variable capacitor causes an increase or decrease in the electrical length of the coaxial line, to change its resonant frequency.

b. The rf signal input to the mixer is applied directly to the cathode, and the local oscillator signal is connected to the grid from the secondary of transformer T1. The mixer is operated near cutoff by the large cathode resistor, R1. Feedthrough capacitor C1 bypasses any current variations to ground and maintains a constant voltage across R1.

c. The rf carrier and local oscillator signals are combined within V1, and the 33.5-mc difference frequency (if signal) is developed across the plate parallel resonant circuit consisting of coil L1 and capacitor C3. This if signal is transformer-coupled by L1 and L2 to the control grid of if amplifier V2.

d. The plate voltage for V1 is obtained from the 28-volt bus through decoupling filter R2, C4, and C5. This filter network also supplies plate voltage to third doubler V11A.

6. Local Oscillator V11 and V12, Stage Analysis

Local oscillator V11 and V12 generates and supplies the local oscillator signal to the rf mixer. This stage consists of crystal oscillator and first doubler V12 (fig. 5), and second and third doublers V11 (fig. 6).

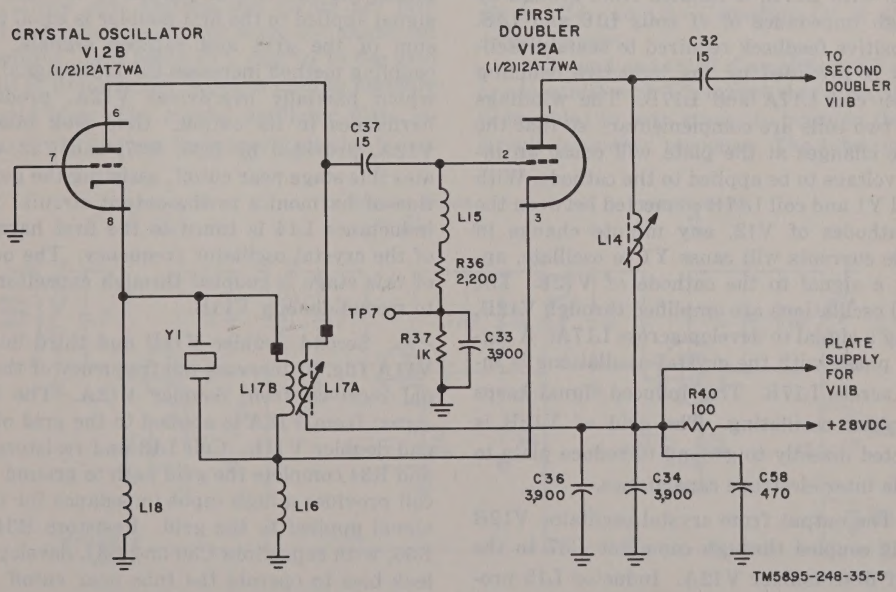


Figure 5. Local oscillator V12B and doubler V12A, partial schematic diagram.

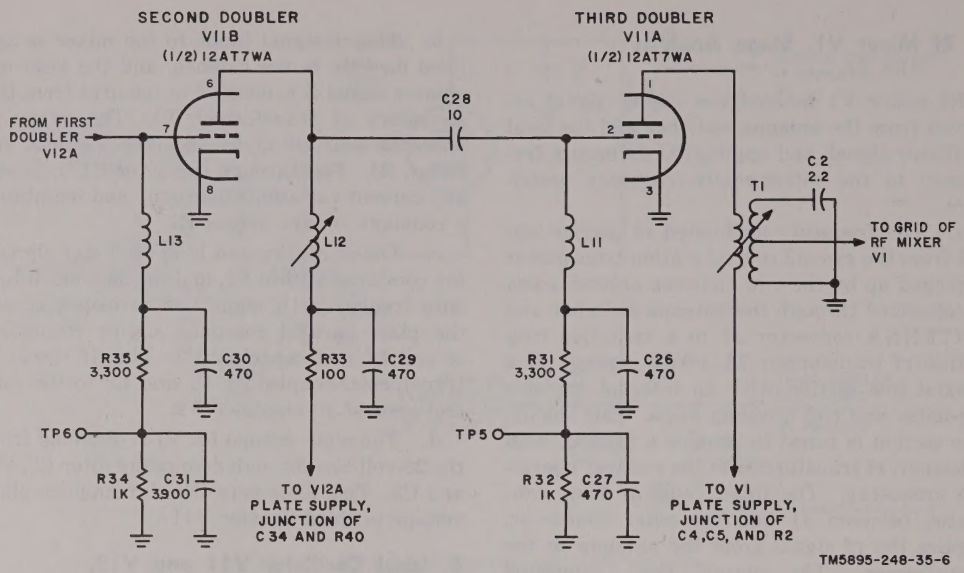


Figure 6. Second doubler V11B and third doubler V11A, partial schematic diagram.

a. Dual triode V12 is a crystal controlled oscillator and frequency doubler. Crystal oscillator V12B is a transformer-coupled, grounded-grid oscillator. Crystal Y1, connected in parallel with L17B, is isolated from ground by the high impedance of rf coils L16 and L18. The positive feedback required to sustain oscillations is provided by the inductive coupling between coil L17A and L17B. The windings of the two coils are complementary so that the voltage changes at the plate will cause an in-phase voltage to be applied to the cathode. With crystal Y1 and coil L17B connected between the two cathodes of V12, any minute change in cathode currents will cause Y1 to oscillate, applying a signal to the cathode of V12B. The crystal oscillations are amplified through V12B, causing a signal to develop across L17A. A signal in phase with the crystal oscillations is induced across L17B. This induced signal keeps the crystal oscillating. The grid of V12B is connected directly to ground to reduce plate to cathode inter-electrode capacitance.

b. The output from crystal oscillator V12B plate is coupled through capacitor C37 to the grid of first doubler V12A. Inductor L15 provides the high input impedance for V12A. The cathode of V12A (returned to ground through L16) receives an oscillator signal 180° out of phase to the plate output signal. With signals applied to the grid and the cathode 180° out of phase, the effective amplitude of the oscillator signal applied to the first doubler is equal to the sum of the grid and cathode signals. This coupling method increases the input signal level which partially overdrives V12A, producing harmonics in its output. Grid leak bias for V12A, provided by R36, R37, and C33, operates this stage near cutoff, assisting the generation of harmonics in the output circuit. Plate inductance L14 is tuned to the first harmonic of the crystal oscillator frequency. The output of this stage is coupled through capacitor C32 to second doubler V11B.

c. Second doubler V11B and third doubler V11A (fig. 6) increase the frequency of the signal received from doubler V12A. The input signal from V12A is applied to the grid of second doubler V11B. Coil L13 and resistors R35 and R34 complete the grid path to ground. The coil provides a high input impedance for the rf signal applied to the grid. Resistors R34 and R35, with capacitors C30 and C31, develop grid leak bias to operate the tube near cutoff. The output of the second doubler is obtained across

tuned plate inductance L12, which is tuned to provide maximum impedance at four times the crystal oscillator frequency. The output from V11B is coupled through capacitor C28 to the grid of third doubler V11A. Coil L11 provides a high input impedance for the third doubler. The grid leak bias is developed by resistors R31 and R32 and capacitors C26 and C27. The plate output of the third doubler is applied to the primary of rf transformer T1. The secondary winding of T1 and parallel capacitor C2 forms a parallel resonant circuit tuned to eight times the oscillator frequency. The center tap of T1 is connected directly to the grid of rf mixer V1.

d. The plate supply voltages for the local oscillator stage are obtained from two filter networks. The plate voltages for crystal oscillator V12B, doubler V12A, and second doubler V11B are obtained from the 28-volt bus connected through decoupling filter R40, C34, C36, and C58 (fig. 5). The plate voltage for second doubler V11B is also filtered by decoupling network R33 and C29 (fig. 6). The plate voltage for third doubler V11A is obtained from the 28-volt bus through decoupling filter R2, C4, and C5 (fig. 4).

e. Three grid voltage test points are provided in the local oscillator stage for alignment procedures. Test point TP7 (fig. 5) in the grid circuit of first doubler V12A is used to measure the grid bias. The crystal oscillator plate inductance (L17A) can be properly aligned by adjusting for maximum voltage indication at TP7. In like manner, test point TP6 (fig. 6) can be used to monitor the output of first doubler V12A. Test point TP5, located in the grid circuit of V11A, is used to monitor the output of second doubler V11B.

7. If Amplifiers V2, V3, V4, Stage Analysis (fig. 7)

If amplifiers V2, V3, and V4 amplify the if signal output from rf mixer V1, and apply the amplified if signal to limiter V5. These three if amplifier circuits are similar.

a. The output of the rf mixer V1 (fig. 4) is inductively coupled to the grid of the first if amplifier through L1 and L2. Coil L2 and fixed capacitor C6 (fig. 7) is the input resonant circuit for V2. The if voltage developed across the parallel resonant circuit, is applied directly to the grid of first if amplifier V2. Cathode bias for class A operation is developed by cathode resistor R3 and bypass capacitor C7. The plate output signal is developed across the plate parallel resonant circuit consisting of capacitor C8 and coil L3. To provide inductive coupling between the first and second if amplifiers, L3 and L4 are mounted close to each other. Plate voltage is decoupled from the supply by R4 and C9. Capacitor C9 is also the screen bypass.

b. Second and third if amplifiers V3 and V4 are identical with V2, except that a resistor has been added in both stages to broaden the plate circuit frequency response. The tube type and

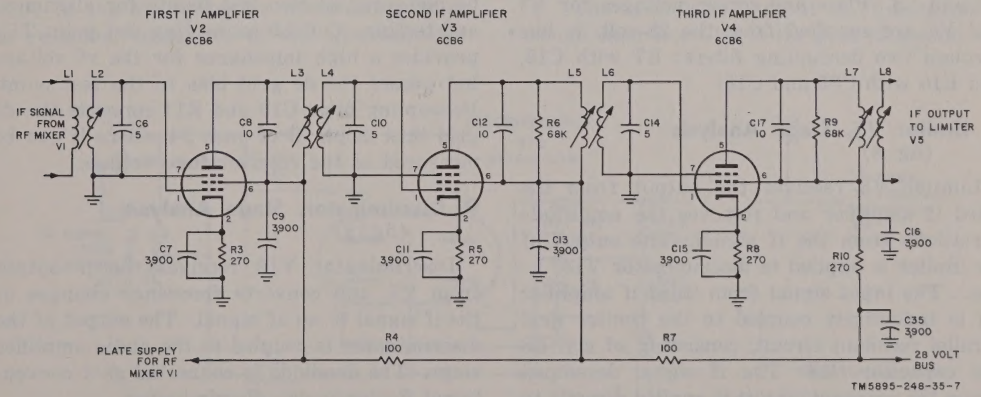


Figure 7. If amplifiers V2, V3, and V4, partial schematic diagram.

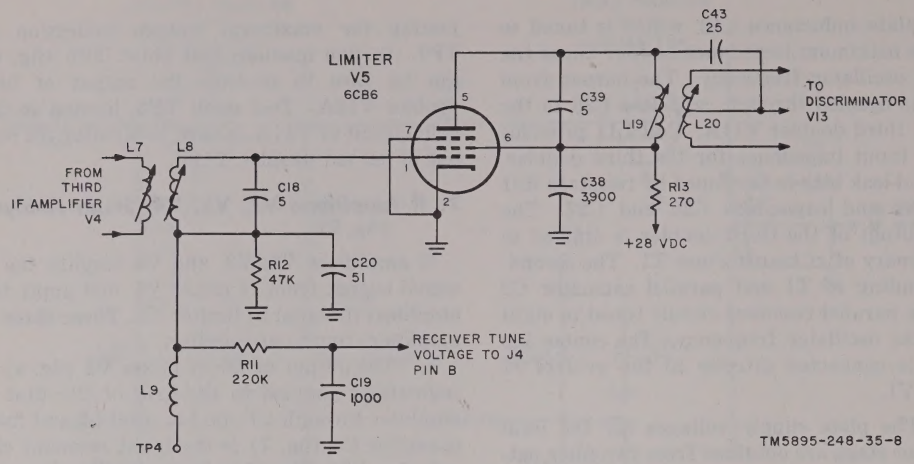


Figure 8. Limiter V5, partial schematic diagram.

other components are identical with the components used in the first if amplifier. The grid parallel resonant circuits consist of coils L4 and L6, with capacitors C10 and C14, respectively. The cathode bias for V3 and V4 is provided by cathode resistors R5 and R8 bypassed with capacitors C11 and C15. The plate resonant circuits consist of coils L5 and L7, in parallel with capacitors C12 and C17. Resistors R6 and R9 are connected parallel with their respective tank circuits, to broaden frequency response. Transformer coupling between the second and third if amplifiers is obtained by inductive coupling between L5 and L6. Coupling between the third if amplifier and limiter is provided by L7 and L8. Plate and screen voltages for V3 and V4 are supplied from the 28-volt dc bus through two decoupling filters; R7 with C13, and R10 with C35 and C16.

8. Limiter V5, Stage Analysis
(fig. 8)

Limiter V5 receives the output from the third if amplifier and removes the amplitude variations from the if signal. The output of the limiter is applied to discriminator V13.

a. The input signal from third if amplifier V4 is inductively coupled to the limiter grid parallel resonant circuit, consisting of coil L8 and capacitor C18. The if signal developed across the resonant circuit is applied directly to the grid of V5. Grid leak bias for the limiter stage is obtained from resistor R12 and capacitor C20. The limiter circuit clips both the positive and negative if signal peaks. On the positive peaks, clipping takes place because the signal is of sufficient amplitude to drive the grid positive, causing grid current to flow. Negative peak clipping occurs because the negative peaks of the signal voltage and bias drives the tube into cutoff. The limiter plate parallel resonant circuit consists of capacitor C39 and coil L19. The output from the plate circuit is inductively coupled to the discriminator.

b. The limiter plate supply voltage is obtained from the 28-volt bus through decoupling filter C38 and R13. The limiter grid bias can be measured at two test points for alignment and testing. Coil L9 connecting test point TP4 provides a high impedance for the rf voltage but passes the dc grid bias to the test point. Decoupling filter C19 and R11 connects the dc grid bias to pin B of jack J4 where it can be measured as the receiver tune voltage.

9. Discriminator, Stage Analysis
(fig. 9)

Discriminator V13 receives the if output from V5, and converts frequency changes of the if signal to an af signal. The output of the discriminator is coupled to the audio amplifier stage. The duodiode is connected as a conventional Foster-Seeley discriminator.

a. The input signal is inductively coupled

to the input parallel coil and capacitor circuit, consisting of L20 and C40. In addition to inductive coupling, capacitive coupling between L19 and the center tap of coil L20 is provided by capacitor C43. Signals from each end of L20 are applied to the separate plates of V13. The rectified signal at the cathode, pin 1, develops a negative output at the top of load resistor R42. Capacitor C41, in parallel with R42, filters the if component from the rectified signal. The rectified signal at the cathode, pin 5, develops a positive output at the top of R43 and is filtered by C42. The algebraic sum of the two rectified outputs is coupled through L10 to the audio amplifier stage.

b. Conversion from frequency modulation to amplitude modulation (am) takes place in the input discriminator transformer consisting of L19 and L20. The voltage induced in the secondary (L20) is 90° out of phase with the current in the primary winding (L19). The primary voltage coupled through capacitor C43 and developed across inductor L21 is applied to the center tap of the secondary. This voltage combines with the induced secondary voltages on each side of the center tap in such a way that the resultant voltage on one side of the secondary leads the primary voltage, and the voltage on the other side lags the primary voltage by the same phase angle when both circuits are resonated to the unmodulated if signal. Outputs of each end of the secondary (L20) are applied to the separate plates of V13. If the intermediate-frequency signal applied to the primary winding (L19) of the discriminator transformer is at the resonant frequency of the discriminator transformer, the voltages rectified by the two sections of the duodiode are equal and of opposite polarity; therefore, the resultant output is zero. If the frequency of the if signal changes, then a shift in the relative phase of the voltage components will cause an increase in the output amplitude on one side of the secondary and a corresponding decrease in amplitude on the other side. This will cause a negative or positive output voltage from the two diodes, depending on the direction of if change. As the input frequency varies, the output changes from positive to negative; this is the audiofrequency output of the discriminator. Coil L10 connects the af signal from the discriminator to the input of first af amplifier V6, and filters any rf or if signal that may be present at the discriminator. Test point TP8 is provided to monitor the composite af output or to observe the "S" frequency response curve during if and discriminator alignment.

10. Af Amplifiers V6 and V7, Stage Analysis (fig. 10)

Af amplifiers V6 and V7 receive the composite af output from the discriminator and amplify it to obtain sufficient power for the transformer-audio filter.

a. The composite af output from the discriminator is coupled through C21 to the grid of first af amplifier V6. Grid leak bias developed across grid resistor R14 establishes class A operation. Resistor R17 is the plate load. The output at the plate is coupled to the second af amplifier. Resistor R15 is the screen resistor and capacitor C22 is the screen bypass.

b. The amplified af output of V6 is coupled through capacitor C23 to the grid of second af

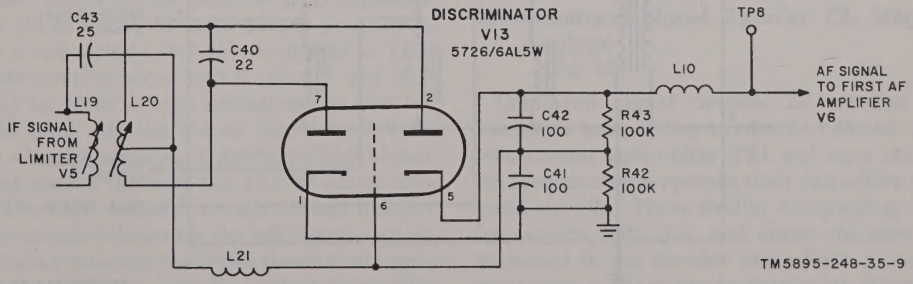


Figure 9. Discriminator V13, partial schematic diagram.

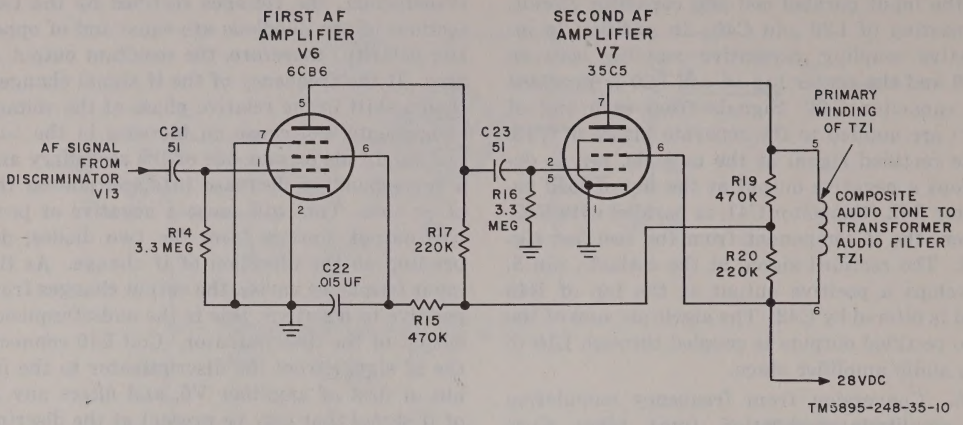


Figure 10. Af amplifiers V6 and V7, partial schematic diagram.

amplifier V7. Grid leak bias for class A operation is developed across resistor R16. The plate output is developed across the primary of transformer-audio filter TZ1 and Resistors R19 and R20.

c. Plate and screen voltages for the first and second af amplifiers are obtained from the 28-volt dc source. The screen of the second af amplifier is directly connected to the voltage source. Resistors R19 and R20 form a voltage divider that provides plate and screen voltages for the first af amplifier and degenerative feedback to reduce distortion of the composite audio signal.

11. Transformer-Audio Filter TZ1, Detailed Analysis

(fig. 11)

Transformer-audio filter TZ1 separates the composite audio signal output of the second af amplifier into the following four command channels; a composite tone of the auxiliary channels, a roll channel, a pitch channel, and a chute control channel.

a. Transformer-audio filter TZ1 consists of an audio output matching transformer and three audio filters connected across the secondary of the transformer. This circuit is com-

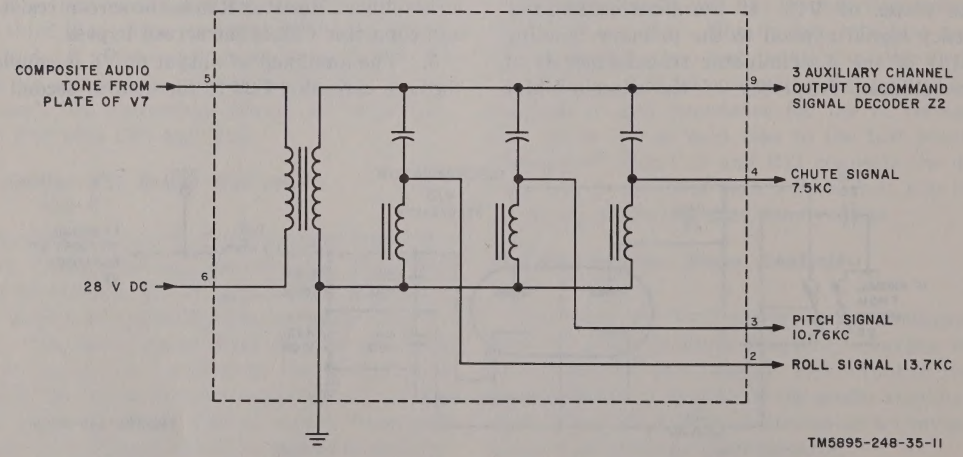


Figure 11. Transformer-audio filter TZ1, schematic diagram.

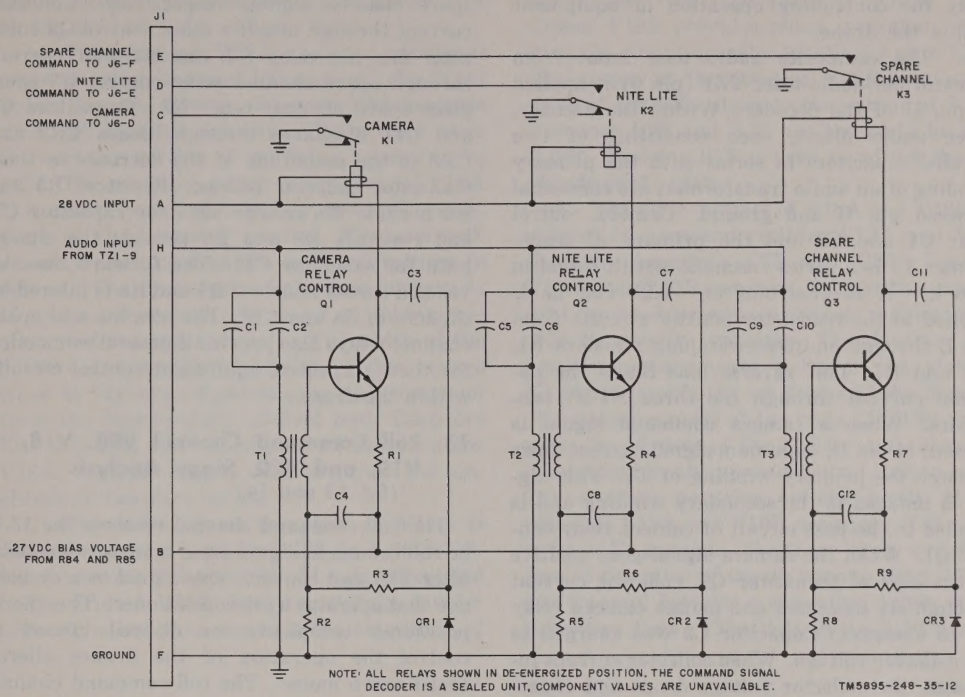


Figure 12. Command signal decoder Z2, schematic diagram.

pletely contained in a hermetically sealed metal case.

b. The primary winding of the transformer-audio filter is the plate load for second af amplifier tube V7. The induced voltage in the transformer secondary is the composite tone of the flight command signals. The transformer matches the plate impedance of V7 to the impedance of the audio filters. Each of the series resonant audio filters consists of a capacitor and a choke tuned to their proper frequency. When a roll signal (13.7 kc) is applied to TZ1, the two circuits tuned to 7.5 (chute) and 10.7 (pitch) kc offer a high impedance to this incoming tone, and the circuit tuned to 13.7 kc offers a low impedance. Therefore a high signal current passes through the 13.7-kc series circuit. The high current through the coil induces a large output voltage for the roll signal output. In a similar manner, the other two circuits produce pitch and chute signals at their respective resonant frequencies. The audio outputs at pins 2, 3, and 4 are the roll signal at a frequency of 13.7 kc, the pitch signal at a frequency of 10.7 kc, and the instantaneous chute signal at a frequency of 7.5 kc. The remaining signal components of the composite audio tone consisting of the camera, nite lite, and spare signals at 8.46, 9.54, and 12.14 kc respectively are unaffected by the series filter circuits. These signal components are available at pin 9.

12. Command Signal Decoder Z2, Stage Analysis

(fig. 12)

Command signal decoder Z2 receives the composite tone of the auxiliary channels from transformer-audio filter TZ1 and uses each of the frequencies to operate their respective command circuits. Three similar command circuits for camera, nite lite, and spare channels are contained in the decoder unit. Each circuit is capable of separating its respective command frequency and using the signal to operate a

relay for controlling operation of equipment within the drone.

a. The composite audio tone input from transformer-audio filter TZ1 (pin 9) is applied to pin H of the decoder. Within the decoder, three audio filters, each consisting of two parallel capacitors in series with the primary winding of an audio transformer, are connected between pin H and ground. Camera control filter C1 and C2 and the primary of transformer T1 is a series resonant circuit tuned to 8.46 kc. A reverse bias of +0.27 volt dc is applied to the transistor emitter circuits from pin B through emitter swamping resistors R1, R4, and R7. This reverse bias limits the no-signal current through the three NPN transistors. When a camera command signal is present at pin H, maximum signal current flows through the primary winding of T1. This signal is induced in the secondary winding and is applied to the base circuit of camera relay control Q1. When the camera signal goes positive at the base of transistor Q1, collector current through Q1 increases and causes camera relay K1 to energize. Capacitor C3 was charged to the collector voltage. When collector current increases, the collector voltage drops and capacitor C3 discharges the full amplitude of collector voltage change through diode CR1. When the camera signal causes the base of transistor Q1 to go negative, the collector current will start to decrease, causing the collector voltage to rise. Capacitor C3 will start to charge to the increasing collector voltage through resistors R2 and R3. This charging current causes a positive voltage drop across R2 which is applied to the base circuit as forward bias to maintain current flow through camera relay control Q1 during the camera signal negative half-cycles. This prevents camera relay K1 from deenergizing during negative half-cycles of the camera command signal. Capacitor C4 filters this base voltage to maintain a constant forward bias during the presence of the camera signal. Camera relay K1 completes the ground path for the camera control circuit in the drone.

b. The nite lite and spare channels are similar to the camera channel. Control filters C5 and C6, with the primary of T2 tuned to 9.54 kc, and C9 and C10, with the primary of T3 tuned to 12.14 kc, separate the nite lite and spare channel signals respectively. Collector current through nite lite relay control Q2 energizes nite lite relay K2, and collector current through spare channel relay control Q3 energizes spare channel relay K3. Capacitors C7 and C11 discharge through diodes CR2 and CR3 to the amplitude of the decrease in their transistor collector voltage. Resistors R5 and R6 provide the charge path for capacitor C7, and resistors R8 and R9 provide the charge path for capacitor C11. The forward bias developed across resistors R5 and R8 is filtered by capacitors C8 and C12. The nite lite and spare channel relays also provide a ground connection for their respective equipment control circuits within the drone.

13. Roll Command Channel V9B, V18, V19, and V20, Stage Analysis (fig. 13 and 14)

The roll command channel receives the 13.7-kc roll command signal from transformer-audio filter TZ1 and converts this signal to a dc voltage that operates a micropositioner. The micropositioner completes the desired circuit to control the operation of the drones aileron (roll) servo motor. The roll command channel also receives dc voltages representing the aileron position and the drones roll attitude. These signals are combined and used to control the roll servo for autopilot operation. Included in this stage are af pulse detector V9B, pulse clipper V18A and V18B, command rectifier V19A and V19B, bridge detector amplifier V20A and V20B, and roll micropositioner K4.

a. The 13.7-kc roll signal from transformer-audio filter TZ1, pin 2, is applied through resistor R24 to the grid of af pulse detector V9B. Resistor R24 isolates the grid of V9B from the audio filter circuit. Plus 14 volts fixed bias applied to the cathode causes V9B to amplify only the positive portion of each cycle of the audio signal. This bias is obtained from the filament circuit of V18. The audio signal half-cycles at the plate of V9B are partially filtered by the integrating circuit consisting of plate resistor R53 and capacitor C73. Because of the comparatively long time constant of this resistor-capacitor combination, C73 does not completely charge and discharge between audio cycles. The output of V9B consisting of negative pulses representing the *on* time of the

audio signal is coupled through capacitor C74 to the grid of pulse clipper V18A.

b. Pulse clipper V18A provides additional wave shaping and amplification of the input pulses (square waves). Resistor R54 provides grid leak bias for this tube. Tube V18A clips the negative portion of the pulses applied to its grid. The resultant output at the plate of V18A is a square wave with 13.7-kc sawtooth variations in the negative portion. The sawtooth variations are used as the antihunt voltage (*e* below). The frequency of the square wave is 15 cycles per second (the *on-off* switching frequency of the audio signal). The width of the positive and negative portions of this square wave is variable, depending on the command from the master flight control box. Resistors R91 and R55 are the plate load resistors for V18A. Resistor R55 is used to adjust the amplitude of the plate output.

c. The output from the plate of V18A is coupled through capacitor C95 to voltage divider network R76 and R77. The signal applied to the grid of V18B from the voltage divider network is less than one-half the amplitude of the output from the plate of V18A. Pulse clipper V18B provides phase inversion; otherwise, the circuit operates identically with V18A. The output at the plate of V18B is a square wave of opposite phase to the output of V18A. Resistors R92 and R78 are the plate load for V18B. Resistor R78 is used to adjust the amplitude at the plate.

d. The plate outputs of V18A and V18B are coupled to command rectifier V19A and V19B through capacitors C75 and C96. Rectifier V19A and V19B removes the positive component to produce square waves varying from zero to negative voltages. The duration of a negative square wave pulse at the plate of V19A represents the *on* time and the duration of a negative pulse at the plate of V19B represents the *off* time of the 13.7-kc audio signal as determined by the ground control station coder. The average negative voltage levels at the plates of V19A and V19B are equal, if the duty cycle is 50 percent. The term "duty cycle" refers to the ratio of the *on* time to the 1/15-second interval between consecutive pulses (pulse repetition time). The duty cycle is 50 percent

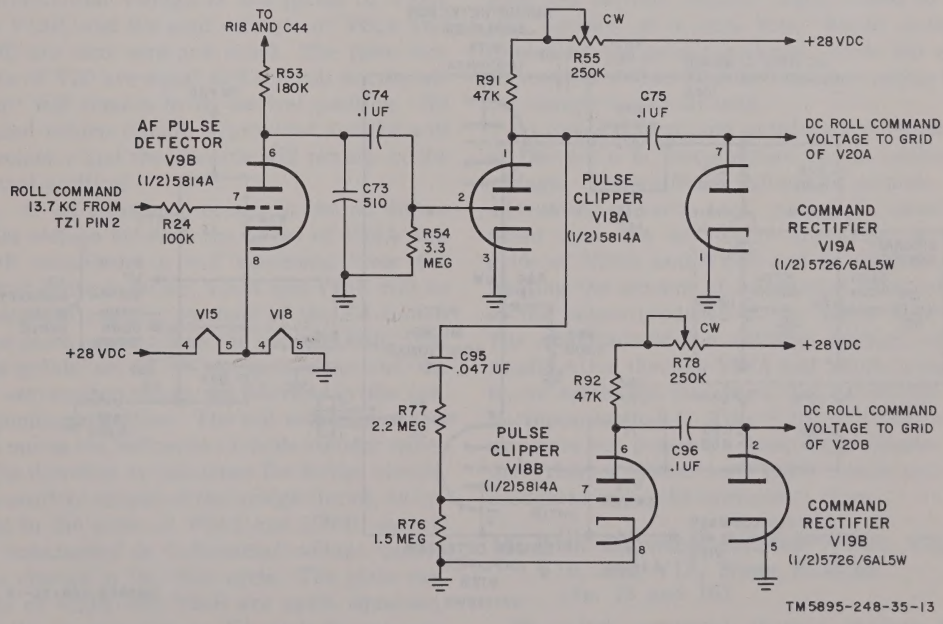


Figure 13. Roll channel command circuit, partial schematic diagram.

when the *on* time equals one-half of the pulse repetition time. The duty cycle established by the ground control station is variable from approximately 20 to 80 percent. If the duty cycle is greater than 50 percent, the plate voltage of V19A will be negative for a longer period of time than the plate voltage of V19B. Therefore, the average negative dc potential at the plate of V19A is greater than the average dc potential at the plate of V19B. A dc differential voltage will exist between the plates of V19, with the plate of V19B positive with respect to the plate of V19A. The polarity of this differential voltage will be reversed, if the duty cycle is less than 50 percent.

e. The negative-going square waves at the plates of V19A and V19B are applied to the grids of V20A and V20B through resistors R56 and R78, respectively. Capacitors C77 and C98 integrate these voltages into average dc levels. Amplifier V20A and V20B is connected to form a bridge detector amplifier. The plate of each tube section is connected to one side of the roll micropositioner K4 coil. The coil center tap is connected directly to the 28-volt dc plate supply. The cathodes of the two tube sections are connected to opposite ends of variable resistor R87. The wiper of this resistor is connected to ground through resistor R58. Resistor R58 is the common cathode resistor and resistor R87 adjusts the cathode bias voltage to obtain equal plate current through both sections of the bridge detector amplifier.

f. Roll micropositioner K4 is an ultrasensitive, polarized, two-pole, three-position relay. This relay is energized by a current differential between the two coil windings. When the current through both sections of V20 are equal, the magnetic flux lines from both coils are equal and the relay armature will remain in the neutral position. When the current through one tube section exceeds the current through the other section, the relay armature will close a set of contacts. These contacts complete the ground circuit for the roll servomotor and the roll servomotor rotates to move the ailerons in the corresponding direction. If the other tube section draws the greater amount of current, the opposite set of contacts will close, causing the servomotor to rotate in the opposite direction. Two resistor-capacitor filters, R59, R60, R81, C82, and C83, are connected from each

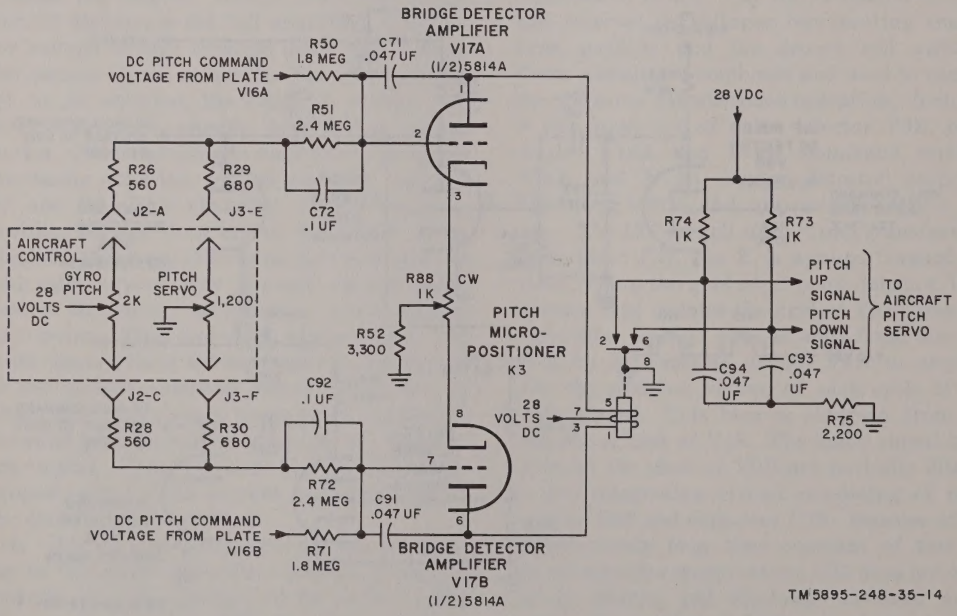


Figure 14. Roll bridge detector amplifier and micropositioner, simplified schematic diagram.

of the roll micropositioner outputs, between the 28-volt bus and ground. These filters are used to bypass the effects of the antihunt voltage (*b* above) applied to the micropositioner.

g. The gyro roll and the roll servo variable resistors are connected with resistors R25, R27, R82, and R83 to form a bridge circuit. The positive voltages from this bridge circuit are applied to the grids of V20A and V20B to balance or unbalance the bridge detector amplifier according to changing flight attitude or aileron movement. The wiper of the gyro roll variable resistor is connected to +28 volts and the wiper of the roll servo variable resistor is connected to ground. The junction of R25 and R80 is connected to the grid of V20A and the junction of R27 and R83 is connected to the grid of V20B.

h. If the wipers of gyro roll and the roll servo variable resistors are centered, the bridge output voltages applied to both grids of V20 are positive and equal. Also, if the duty cycle is 50 percent, the dc differential voltages on the plates of V19A and V19B are negative and equal. Under this condition, the positive voltage from the bridge circuit cancels the negative dc differential voltage at the plates of V19A and V19B, and the grid voltages of V20A and V20B are near zero and equal. The plate currents of V20 are equal and the roll micropositioner will remain in its neutral position. No ground return circuit is provided for the roll servomotor and the ailerons will remain in the neutral position.

i. If an unbalance occurs in the dc differential voltage between the plates of V19A and V19B caused by a roll command from the ground control station, V20A and V20B will be unbalanced causing one-half of the K4 coil to draw more current than the opposite half. The appropriate set of K4 contacts close and the roll servomotor moves the ailerons in the corresponding direction. The roll servomotor also also moves the roll servo variable resistor wiper in the direction to rebalance the bridge circuit. The positive output of the bridge circuit, as applied to the grids of V20A and V20B, cancels the unbalanced dc differential voltage caused by a change in the duty cycle. The plate currents of V20A and V20B are again equalized, and the micropositioner K4 contacts are neutralized. The roll servomotor will stop, since the ground return is removed. The amount of servo movement is therefore directly related to the duty cycle which, in turn, is determined by the ground control station operator.

j. The gyro senses any changes in roll flight attitude of the drone and moves the gyro variable resistor wiper, producing a potential which causes an unbalance at the grids of V20A and V20B. This unbalance is amplified by V20A and V20B and a set of K4 contacts are closed. The aileron servo moves in the proper direction until the roll servo variable resistor wiper causes the grid voltages of V20A and V20B to be equalized. The contacts of K4 are then opened, the roll servomotor stops, and the drone assumes the corrected flight attitude.

k. A certain amount of anticipation is available to provide rapid recovery if a gust of wind causes the drone to roll at a high rate. The rapid movement of the gyro roll variable resistor wiper causes the bridge output to change at a fast rate. The resulting instantaneous voltage change is coupled through capacitors C77 and C98 to the grids of V20A and V20B. The amplitude of this voltage is much larger than the voltage normally produced when the gyro roll variable resistor wiper moves to its new position at a slow rate. Rapid contact closure of the micropositioner causes the roll servometer to immediately begin correcting for the change in roll attitude.

l. Speed control and prevention of hunting of the servo is accomplished by an antihunt voltage. The antihunt voltage is actually an alternating-current (ac) potential superimposed upon the dc voltage appearing at the grids of V20A and V20B and is obtained by limiting the amount of integration of filtering of the pulses produced at the plates of V9B. The amplitude of the antihunt voltage, after amplification through V20A and V20B, is equal to, or somewhat less than, the sensitivity of micropositioner K4. Also, if the antihunt voltage were not present, a small dc unbalance at the grids of V20A and V20B would not be enough to cause the contacts to close.

14. Pitch Command Channel V14A, V15, V16, and V17, Stage Analysis (fig. 15 and 16)

The pitch command channel receives the 10.76-kc. pitch command signal from trans-

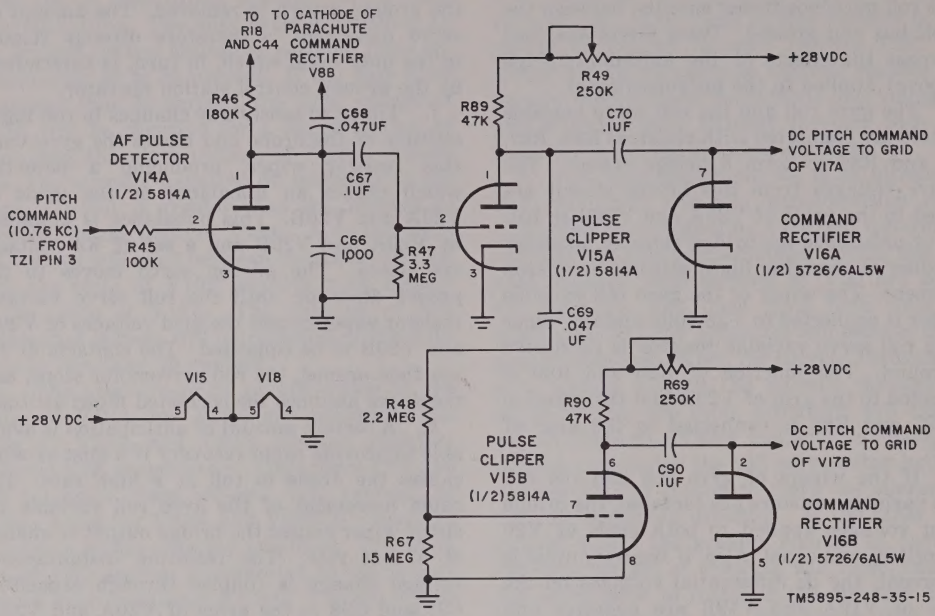


Figure 15. Pitch command channel circuit, simplified schematic diagram.

former-audio filter TZ1 and converts this signal to a dc voltage that operates a micropositioner. The micropositioner completes the desired circuit to control the operation of the drone elevator (pitch) servomotor. The pitch command channel also receives dc voltages representing the elevator position and the drone pitch attitude. These signals are combined and used to control the pitch servo for autopilot operation. Included in this circuit are af pulse detector V14A, pulse clipper V15A and V15B, command rectifier V16A and V16B, bridge detector amplifier V17A and V17B, and pitch micropositioner K3.

a. The 10.76-kc pitch signal from pin 3 of transformer-audio filter TZ1 is applied through isolation resistor R45 to the grid of af pulse detector V14A. Plus 14 volts fixed bias applied to the cathode causes V14A to amplify only the positive portion of each audio signal cycle. This bias is obtained from the junction of the filament circuit for V15 and V18. The audio signal half-cycles at the plate of V14A are partially filtered by integrating circuit consisting of plate resistor R46 and capacitor C66. Because of the comparatively longtime constant of this resistor-capacitor combination, capacitor C66 is not allowed to charge and discharge between cycles. The output of V14A, consisting of negative pulses representing the *on* time of the audio signal, is coupled through C67 to pulse clipper V15A. In addition, an output of the pulse detector is coupled through capacitor C68 to parachute command rectifier circuit V8B.

b. Pulse clipper V15A provides additional wave shaping and amplification of the input pulses (square wave). Resistor R47, connected between V15A grid and ground provides bias for this tube. Pulse clipper V15A clips the negative portion of the pulses applied to its grid. The resultant output at the plate of V15A is a square wave with 10.76-kc sawtooth variations in the negative portion. The sawtooth variations are used as the antihunt voltage for the pitch channel (*h* below). The frequency of the square wave is 15 cycles per second (the *on-off* switching frequency of the audio signal). The width of the positive and negative portions of this square wave is vari-

able, depending on the command from the master flight control box. Resistors R89 and R49 are the plate load resistors for V15A. Resistor R49 is used to adjust the amplitude of the plate output.

c. The plate output of V15A is coupled through capacitor C69 to voltage divider network R48 and R67. The signal applied to the grid of V15B from the voltage divider network is less than one-half the amplitude of the output from the plate of V15A. Pulse clipper V15B provides phase inversion; otherwise, its circuit operates the same as V15A. The output at the plate of V15B is a square wave of opposite phase to the output of V15A. Resistors R90 and R69 are the plate load for V15B. Resistor R69 is used to adjust the amplitude at the plate.

d. The plate outputs of V15A and V15B are coupled to command rectifier V16A and V16B through C70 and C90. Tube V16A and V16B removes the positive component to produce square waves varying from zero to negative voltages. The duration of a negative square wave pulse at the plate of V16A represents the *on* time, and the duration of a negative pulse at the plate of V16B represents the *off* time of the 10.76-kc audio signal as determined by the ground control station coder. The average negative voltage levels at the plates of V16A and V16B are equal if the duty cycle is 50 percent. The duty cycle, established by the ground control station, is variable from approximately 20 to 80 percent. If the duty cycle is greater than 50 percent, the plate voltage of V16A is negative for a longer period of time than the plate voltage of V16B. Therefore, the average negative dc potential at the plate of V16A is greater than the average dc potential at the plate of V16B. A dc differential voltage exists between the plates of V16, with the plate of V16B positive with respect to the plate of V16A. The polarity of this differential voltage will be reversed when the duty cycle is less than 50 percent.

e. The negative-going square waves at the plates of V16A and V16B are applied to the grids of V17A and V17B through resistors R50 and R71. Capacitors C72 and C92 integrate these voltages into average dc levels. Sections A and B of V17 are connected to form a bridge detector amplifier. The plate of each tube section is connected to one side of pitch micropositioner K3 coil. The coil center tap is connected directly to the 28-volt dc plate supply. The cathodes of the two tube sections are connected to opposite ends of variable resistor R88. The wiper of this variable resistor is connected to ground through resistor R52. Resistor R52 is the common cathode resistor and resistor R88 is used to adjust the cathode bias voltage to obtain equal plate currents through both sections of the bridge detector amplifier.

f. Pitch micropositioner K3, identical with roll micropositioner K4 (par. 13*f*), is energized by a current differential between the two sections of V17. The ground circuit for the pitch servomotor is completed when the current through one tube exceeds the current through the other section, and the servomotor rotates to move the elevators in a given direction. If the other tube section draws the greater amount of current, the opposite set of contacts close, causing the servomotor to rotate in the opposite direction. Two resistor-capacitor filters, R73, R74, R75, C93, and C94, are connected from each of the pitch micropositioner outputs between the 28-volt bus and ground. These filters are used to bypass the effects of the antihunt voltage (*b* above) applied to the micropositioner.

g. The gyro pitch and pitch servo variable resistors are connected with resistors R26, R28, R29, and R30 to form a bridge circuit. The positive voltages from this bridge circuit are applied to the grids of V17A and V17B, to balance or unbalance the bridge detector amplifier according to changing flight attitude or aileron movement. The wiper of the gyro pitch variable resistor is connected to +28 volts and the wiper of the pitch servo variable resistor is connected to ground. The junction of R26 and R29 is connected to the grid of V17A, and the junction of R28 and R30 is connected to the grid of V17B. The operation of this bridge circuit is identical with the bridge circuit in the roll channel control circuits (par. 13*h* through *k*).

h. Speed control and prevention of hunting of the servo is accomplished by an antihunt voltage. The antihunt voltage is actually an ac potential superimposed upon the dc voltage appearing at the grids of V17A and V17B and

is obtained by limiting the amount of integration or filtering of the pulses produced at the plate of V15A. The amplitude of the antihunt voltage, after amplification through V17A and V17B, is equal to, or somewhat less than, the sensitivity of micropositioner K3. Also, if the antihunt voltage were not present, a small dc unbalance at the grids of V17A and V17B would not be enough to cause the contacts to close.

15. Parachute Control Channel V8B, V14B, and V21, Stage Analysis (fig. 17)

The parachute control channel operates parachute relay K2. When K2 is energized, the ground return for the drone parachute release solenoid circuit is completed. As long as this ground return is maintained, the drone parachute cannot be released. When a loss of pitch signal to the parachute control channel occurs, either intentionally by actuation of the CHUTE DELAYED switch located on the ground control station flight control, or because of signal loss or receiver failure, the contacts of relay K2 will open. The parachute release solenoid will deenergize releasing the parachute. The parachute control channel consists of command rectifier V8B, command amplifier V14B, parachute relay control V21, and parachute relay K2.

a. Two inputs are applied to the parachute control channel. One, the 10.76-kc pitch signal at pin 3 of transformer-audio filter TZ1, is applied through R44 to the plate of command rectifier V8B. The other input is the rectified and inverted 15-cycle per second (cps) positive pulses representing the pitch signal *on* time. These pulses are obtained from the plate of pitch af pulse detector V14A, and coupled through C68 to the cathode of command rectifier V8B. Capacitor C88 bypasses any high frequency component to ground. The command rectifier rectifies the input pitch signal. The output of the command rectifier is developed across cathode load resistors R61 and R86. Resistor R86 is used to adjust the amplitude of the rectified voltage at the cathode of V8B. The positive voltage at the cathode of V8B, due to the rectification of the pitch signal and the pitch *on* time pulses coupled through C68, is applied to integrating network R62 and C89.

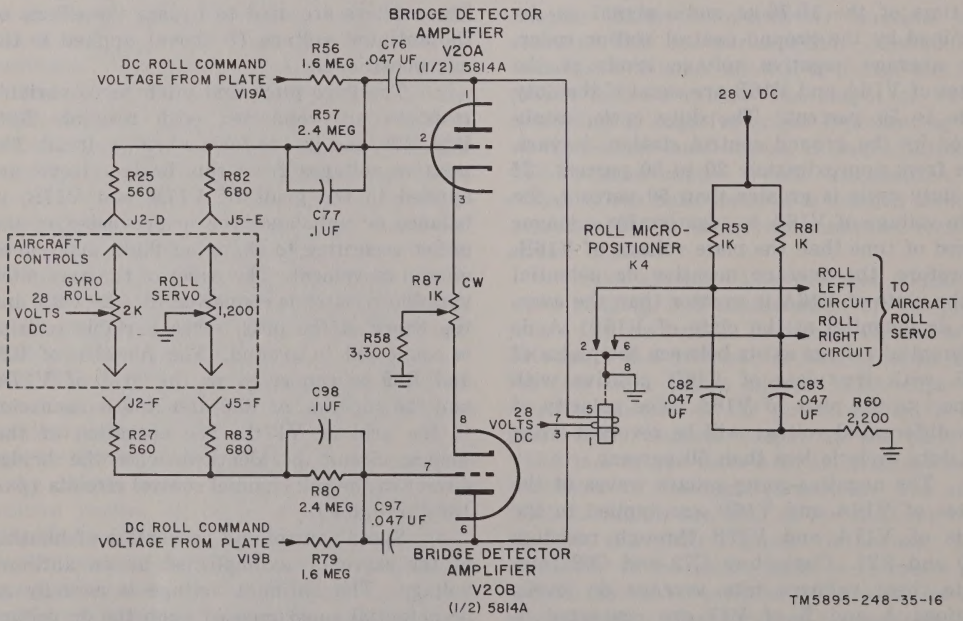


Figure 16. Pitch bridge detector amplifier and micropositioner, simplified schematic diagram.

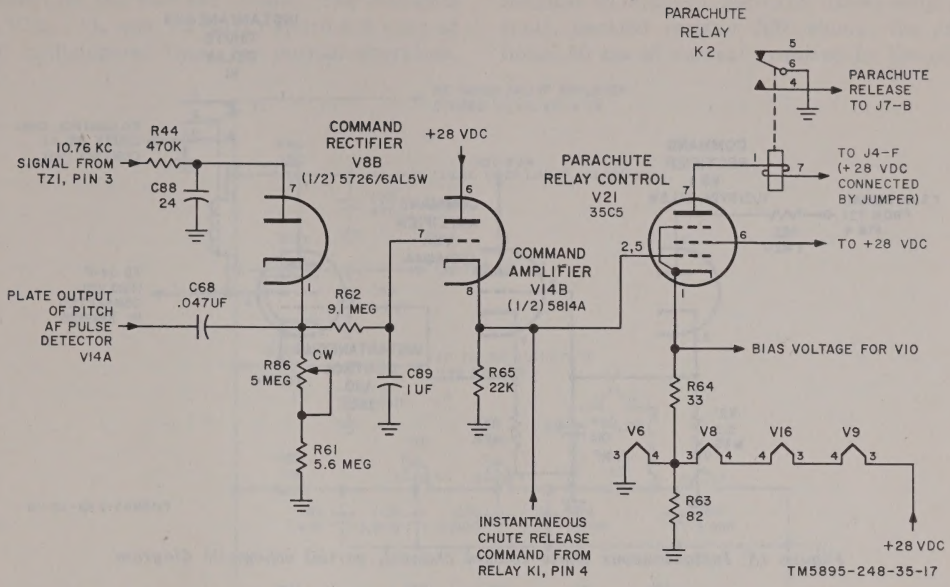


Figure 17. Parachute control channel, partial schematic diagram.

Capacitor C89 charges to the amplitude of the positive pulses developed across command rectifier load resistors R86 and R61. This charge is maintained fairly constant between pulses by the long time constant combination of resistor R62 and capacitor C89. The potential developed across C89 is applied to the grid of command amplifier V14B.

b. Command amplifier V14B is a conventional cathode follower. The output of V14B, developed across cathode load resistor R65, is applied directly to the control grid of V21. With no voltage applied to the grid, V21 is biased below cutoff by the voltage developed across V6 filament and parallel resistor R63. Resistor R64 isolates the cathode of V21 from the filament circuit. Since parachute relay K2 is in series with the plate of V21, conduction of V21 energizes K2 and the parachute release solenoid ground return is completed. During normal operation, if the pitch signal is lost, the positive potential applied to C89 is removed and C89 discharges through resistors R61, R86, and R62. Because of the longtime constant of the discharge path, the positive potential on the grid of V14B is maintained for approximately 10 seconds and thus prevents the parachute from being released for the same period. The purpose of this time delay is to prevent undesired parachute release by momentary signal loss.

16. Instantaneous Chute Control Channel V8A, V9A, and V10, Stage Analysis (fig. 18)

The instantaneous chute control channel provides a voltage upon receipt of the instantaneous chute command. This voltage overrides the action of the parachute control channel (par. 15) to release the drone parachute. The instantaneous chute control channel consists of command rectifier V8A, command amplifier V9A, instantaneous control V10, and instantaneous chute relay K1.

a. The 7.5-kc input to the instantaneous chute control channel, obtained from pin 4 of transformer-audio filter TZ1, is connected through isolating resistor R23 to the plate of command rectifier V8A. The input af voltage is rectified by V8A, and filtered by resistor-capacitor filter R21 and C24 to obtain a positive dc voltage. This dc voltage is applied to the control grid of command amplifier V9A.

b. Command amplifier V9A is a conventional cathode follower used to isolate the com-

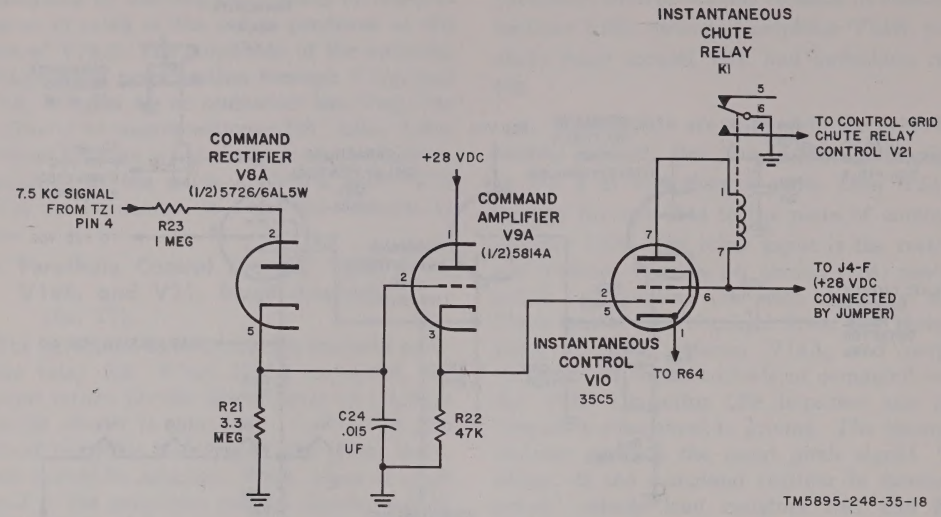


Figure 18. Instantaneous chute control channel, partial schematic diagram.

mand rectifier from the instantaneous control stage. The plate of V9A is connected directly to the 28-volt dc bus. The output of command amplifier V9A is developed across cathode load resistor R22. This positive output voltage is applied directly to the control grid of instantaneous control V10, which is cathode biased below cutoff by the same voltage that was applied to the cathode of V21 (par. 15*b*). When the positive voltage applied to the grid of V10 is of sufficient amplitude, the tube conducts and instantaneous chute relay K1 is energized. When the relay is energized, a ground connection is applied through contacts 4 and 6 of K1 to the control grid of parachute relay control V21 (fig. 17). Parachute relay control V21 is thus forced to cutoff and parachute relay K2 deenergizes, releasing the parachute.

17. Plate, Screen, and Filament Supply Voltage Circuit

(fig. 19)

The plate, screen, and filament supply voltage is obtained from the drone 28-volt dc supply. This voltage is connected to the receiver at pin D of POWER connector J4. Normal voltage required for operation of the receiver is between 22 and 30 volts dc.

a. The plate and screen supply voltages are obtained directly from pin D of POWER connector J4. Capacitors C79 and C44 filter the rf and lower frequency variations from the line. No additional filtering except for individual stage decoupling is used in the receiver 28-volt distribution circuit. Rf mixer and if amplifier stages V1, V2, V3, and V4 receive the plate and screen voltage directly through their individual decoupling filters. Local oscillator stage V11 and V12 receives plate and screen voltages through decoupling filter R40 and C58. The plate and screen voltages for limiter V5 is supplied through decoupling filter R13 and C38. The voltage for af pulse detectors V9B and V14A is decoupled with R18 and C44. All other plate and screen voltages are supplied by plate and screen circuits connected directly to the 28-volt dc input.

b. The filament circuit consists of the various tube filaments connected in series and parallel combination between the 28-volt dc input and ground. The filaments of V12, V11, V1, and V2 are connected together as one series circuit. Resistor R39 reduces the 28-volt input to approximately 24 volts. Capacitors C53, C54, C55, C56, and C57, connected between the individual filaments in this series circuit and ground, bypass any rf signal that may be

present on the filament circuit. The filaments of V12, V11, and V2 each require 6.3 volts at 300 milliamperes (ma) for normal operation. Because VI filament normally draws only 250 (ma), parallel resistor R38 shunts the additional 50 ma of current required by the other

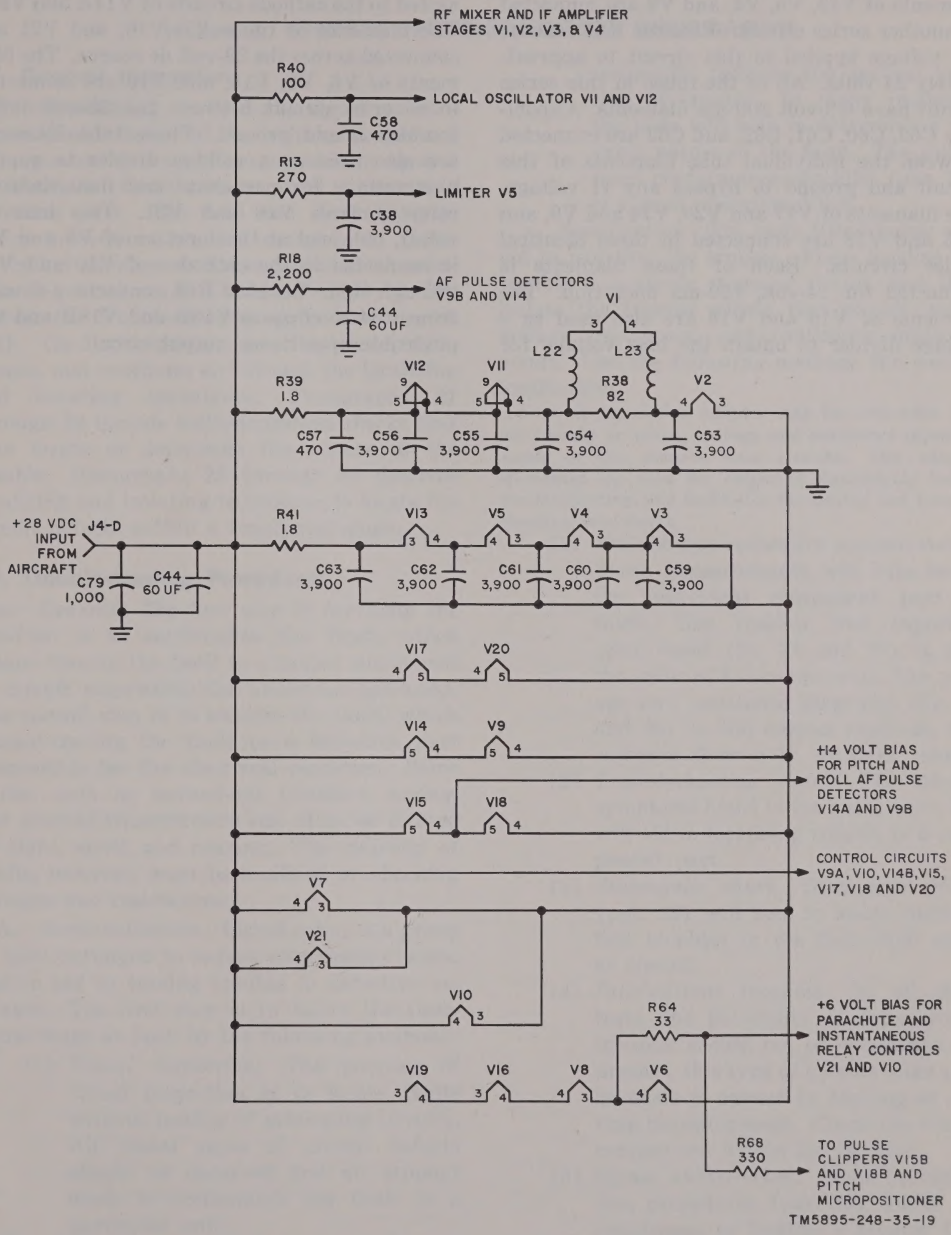


Figure 19. Plate, screen, and filament supply voltage circuit, simplified schematic diagram.

tubes in this series circuit. Coils L22 and L23, in series with the filament of V1, reduce the effects of cathode to filament capacitance. The filaments of V13, V5, V4, and V3 are connected in another series circuit. Resistor R41 reduces the voltage applied to this circuit to approximately 24 volts. All of the tubes in this series circuit have 6.3-volt 300-ma filaments. Capacitors C59, C60, C61, C62, and C63 are connected between the individual tube filaments of this circuit and ground to bypass any rf voltage. The filaments of V17 and V20, V14 and V9, and V15 and V18 are connected in three identical series circuits. Each of these filaments is connected for 14-volt, 150-ma operation. The filaments of V15 and V18 are also used as a voltage divider to obtain the bias voltage for pitch and roll af pulse detectors V14A and V9B. The positive 14-volt bias obtained from the junction of V15, pin 4, and V18, pin 5, is connected to the cathode circuits of V14A and V9B. The filaments of tubes V7, V10, and V21 are connected across the 28-volt dc source. The filaments of V6, V8, V16, and V19 are connected in a series circuit between the 28-volt input connection and ground. These tube filaments are also used as a voltage divider to supply bias voltage for parachute and instantaneous relay controls V10 and V21. This bias (6 volts), obtained at the junction of V8 and V6, is connected to the cathodes of V10 and V21 through R64. Resistor R68 connects +6 volts from R64 to clippers V15B and V18B and the pitch micropositioner output circuit.

CHAPTER 3
TROUBLESHOOTING

Section I. GENERAL TROUBLESHOOTING INFORMATION

18. General Instructions

Troubleshooting at field and depot maintenance level includes all the techniques outlined for organizational maintenance and any special or additional techniques required to isolate a defective part. The field and depot maintenance procedures are not complete in themselves but supplement the organizational maintenance procedures in TM 11-1550-200-12. The systematic troubleshooting procedure begins with the operational and sectionalization checks, and continues on through the localizing and isolating techniques. Paragraphs 21 through 24 include sectionalization checks that may locate or determine the nature of the trouble. Paragraphs 25 through 30 describe localizing and isolating techniques to locate the circuit defects within a functional stage.

19. Troubleshooting Procedures

a. General. The first step in servicing the receiver is to sectionalize the fault, which means tracing the fault to a major component or circuit responsible for abnormal operation. The second step is to localize the fault, which means tracing the fault to a defective part responsible for the abnormal condition. Some faults, such as burned-out resistors, arcing, and shorted transformers can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistances.

b. Sectionalization. Listed below is a group of tests arranged to reduce unnecessary work, and to aid in tracing trouble in defective receivers. The first step is to locate the functional stage at fault by the following methods:

(1) *Visual inspection.* The purpose of visual inspection is to locate faults without testing or measuring circuits. All visual signs of circuit defects should be observed and an attempt made to sectionalize the fault to a particular unit.

(2) *Operational tests.* Operational tests frequently indicate the general location of trouble. In many instances the tests will help in determining the exact nature of the fault. The equipment performance checklist (par. 22) is a good operational test.

c. Localization. The tests listed below will aid in isolating the trouble. First, localize the trouble to a single stage or circuit, and then isolate the trouble within that circuit, using voltage, resistance, and continuity measurements. Use the following methods for trouble localization.

Note. A test socket adapter may be used when signal tracing or taking voltage and resistance measurements of the electron tube circuits. This adapter eliminates the need for extensive disassembly before troubleshooting, and facilitates the testing and troubleshooting procedures.

(1) *Voltage and resistance measurements.* These measurements will help locate the individual component part at fault. Use resistor and capacitor color codes (fig. 36 and 37) to find the value of the components. Use voltage and resistance diagrams (fig. 27 and 28) to find normal readings, and compare them with readings taken.

(2) *Troubleshooting chart.* The trouble symptoms listed in the chart (par. 27) will aid in localizing trouble to a component part.

(3) *Stage-gain chart.* Stage-gain chart (par. 29) will help to locate hard-to-find troubles in the individual stage or circuit.

(4) *Intermittent troubles.* In all these tests, the possibility of intermittent troubles should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the equipment. Check the wiring connections within the receiver.

(5) *Signal substitution.* Signal substitution procedures (par. 28) enable the repairman to localize a trouble to a stage.

20. Test Equipment Required

The following chart lists suggested test equipment which may be used by third, fourth, or fifth echelon personnel for troubleshooting the receiver; the associated technical manuals, and the assigned common names are also listed.

Test equipment	Technical manual	Common name
Audio Frequency Coder KY-294/USD-1[a]	TM 11-5821-215-12	Coder
Audio Oscillator TS-382E/U	TM 11-2684A	Audio Oscillator
Automatic Pilot Servomotor TG-71/USD-1[b]	TM 11-1550-200-12	Roll and pitch servo (2 required)
Automatic Roll and Pitch Control C-2903/USD-1[b]		Gyro
Electron Tube Test Set TV-7/U	TM 11-5083	Tube tester
Electronic Voltmeter ME-30B/U	TM 11-5132	Ac vtvm
Multimeter AN/URM-105	TM 11-6625-203-12	Multimeter
Multimeter ME-26B/U	TM 11-6625-200-12	Vtvm
Oscilloscope OS-46/U	TM 11-5131	Oscilloscope
Signal Generator SG-351/USD-1	TM 11-6625-322-12	Signal generator
Signal Generator TS-452/U	TM 11-2695	Sweep generator
Surveillance Drone Control C-2941/USD-1[a]	TM 11-5821-215-12	Master flight control box
Surveillance Drone Test Set TS-1299/USD-1	TM 11-5895-249-12	Test set
Tool Kit, Electronic Equipment TK-103/USD-1		Toolkit

a Components of Flight Control Groups OA-2380/USD-1 and OA-2381/USD-1
b Components of Surveillance Drone OA-2343/USD-1

Section II. SECTIONALIZING TROUBLES

21. Visual Inspection

Inspect the radio receiver before operating it. This will save time and may also avoid further damage to the equipment. Proceed as follows:

a. Examine the gasket for cracks, deformation, or other indications of deterioration.

b. Inspect the connectors for the following:
(1) Bent or broken pins.
(2) Broken or chipped inserts.
(3) Evidence of arcing.
(4) Crossed or damaged threads.
(5) Corroded contact surfaces.

c. Check tubes for broken or bent pins, and chipped or cracked envelopes.

d. Examine the relays for broken or bent pins and damaged, distorted cases.

e. Examine the tube and relay sockets for evidence of broken contacts and chipped or cracked insulation.

f. Examine the resistors for evidence of broken leads and distorted or burnt insulation.

g. Examine the capacitors for broken leads, distorted or burnt insulation, and evidence of dielectric leakage or dielectric breakdown.

h. Inspect the coils for loose mountings, burned, open, or deteriorated windings.

i. Examine the terminal boards for cracked insulation.

j. Check the wiring for burned or worn insulation.

k. Examine the solder joints for loose connections or cold solder joints.

l. Make a thorough inspection of mounting hardware, and note any evidence of looseness.

22. Equipment Performance Checklist (fig. 20)

a. General. The equipment performance checklist is a procedure to check equipment operation systematically. All corrective measures that the repairman can perform are given in the *corrective measures* column. When using the checklist, start at the beginning and follow each step in order. Perform the action instructions and observe the specified indicator for normal indication. If the normal indication is not obtained, perform the maintenance procedures given under corrective measures. If the corrective measures indicated do not correct the fault, refer to section III for the isolating procedure.

b. Description of Performance Check. The equipment performance check is performed by



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Automatic Roll and Pitch Control C–2903/USD–1[b]		Gyro
Electron Tube Test Set TV–7/U	TM 11–5083	Tube tester
Electronic Voltmeter ME–30B/U	TM 11–5132	Ac vtvm
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Multimeter ME–26B/U	TM 11–6625–200–12	Vtvm
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(4) Crossed or damaged threads.
(5) Corroded contact surfaces.

c. Check tubes for broken or bent pins, and chipped or cracked envelopes.

d. Examine the relays for broken or bent pins and damaged, distorted cases.

e. Examine the tube and relay sockets for evidence of broken contacts and chipped or cracked insulation.

f. Examine the resistors for evidence of broken leads and distorted or burnt insulation.

g. Examine the capacitors for broken leads, distorted or burnt insulation, and evidence of dielectric leakage or dielectric breakdown.

h. Inspect the coils for loose mountings, burned, open, or deteriorated windings.

i. Examine the terminal boards for cracked insulation.

j. Check the wiring for burned or worn insulation.

k. Examine the solder joints for loose connections or cold solder joints.

l. Make a thorough inspection of mounting hardware, and note any evidence of looseness.

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b. Description of Performance Check. The equipment performance check is performed by

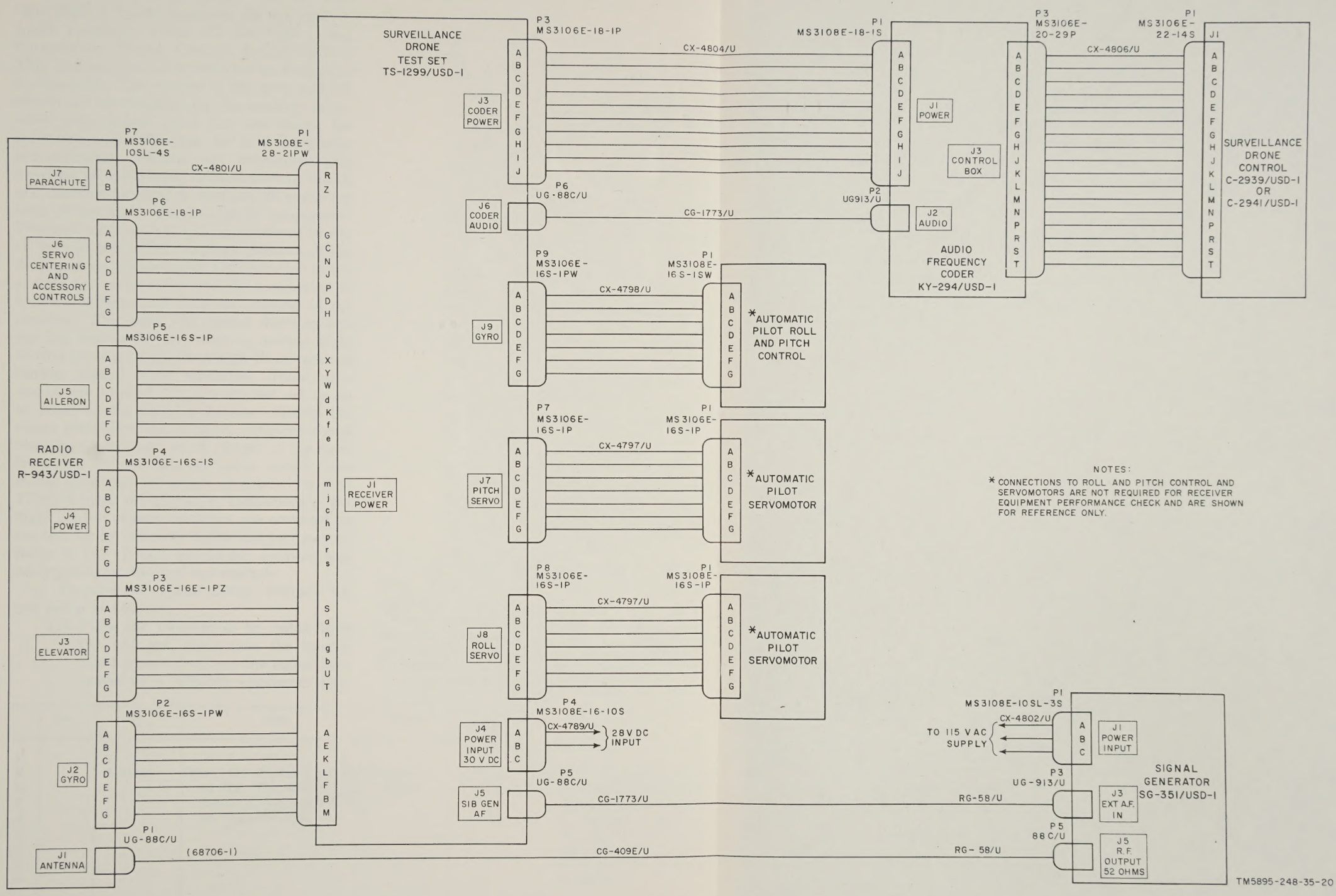
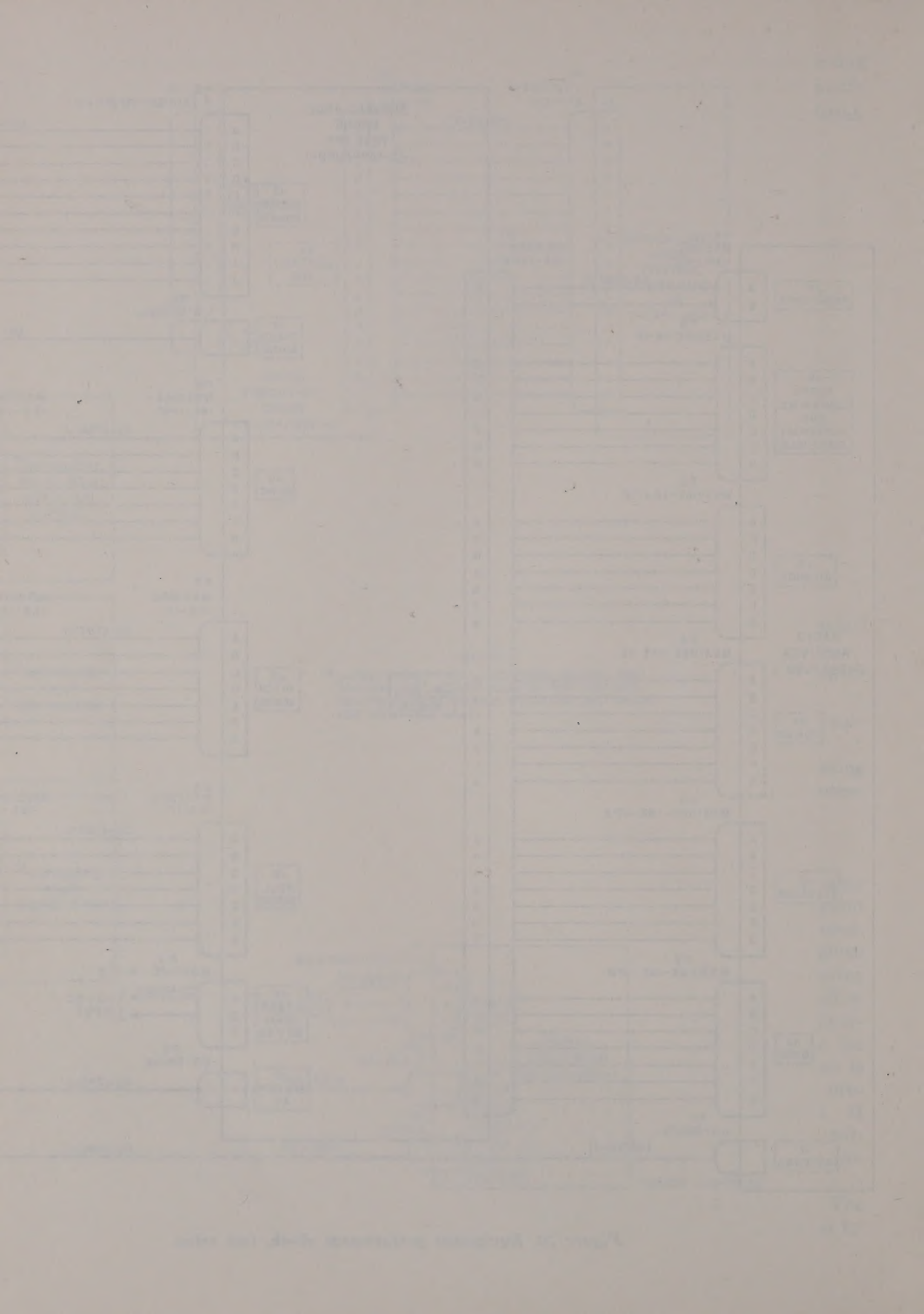


Figure 20. Equipment performance check, test setup.



using the Surveillance Drone Test Set TS-1299/USD-1, Signal Generator SG-351/USD-1, Audio Frequency Coder KY-294/USD-1, and Surveillance Drone Control C-2939/USD-1. This equipment is interconnected as illustrated in figure 20. Connections to the gyro and the servos are not required for the receiver equipment performance check but are shown for reference only. The test set is a completely self-contained, portable test instrument that provides all indicators, interconnecting cables, and controls required to perform all necessary tests of the flight control system components. This test set is used to make operational checks of the roll, pitch, and auxiliary channels of the flight control system coder, the operation of the system gyro and servos, and the monitoring of various voltages and currents existing in the receiver. The coder and master flight control box are used in this test setup to provide flight control commands identical with those received during normal flight operation. These commands are applied through the test set as an af input to the signal generator. Within the signal generator, the af flight command signal frequency-modulates an rf carrier at the same frequency of the receiver being tested. The signal generator rf output is applied to ANTENNA input receptacle J1. Indications of the flight control system operation are provided on the test set by indicator lights and two meters. Refer to TM 11-5895-249-12 for locations and descriptions of the test set controls.

c. Preparation of Test Setup. Prepare the test setup as follows:

(1) Place the receiver to be tested with the test set, the coder, the master flight control box, and the signal generator on a suitable workbench having 30-volt dc and 115-volt ac power sources available.

(2) Interconnect the receiver, test set, coder, and master flight control box (fig. 20); use the cable assemblies included with the test set. Each of the connectors on the multiple cable that connects the receiver to the test set is tagged to indicate its proper receiver connector.

(3) Connect the signal generator EXT. A.F. IN connector to the test set SIG. GEN. AF connector; use one of the coaxial cables supplied with the signal generator. Connect the second coaxial cable between the signal generator RF OUTPUT connector and receiver ANTENNA connector J1.

(4) Adjust the signal generator output frequency to the receiver frequency. Adjust the signal generator rf output level to 500 microvolts. Turn the signal generator MODULATION switch to EXT, and adjust the deviation level to ±300 kc.

Note. The deviation indicator is an average reading device, and will not indicate ±300 kc when the pulsing output of the coder is being monitored. It is therefore necessary to adjust the deviation level, using an external audio source with a frequency of approximately 10 kc and a root mean square (rms) output level of 1.5 volts.

d. Equipment Performance Check Procedure. Proceed with the equipment performance check test as outlined.

Note. Throughout the following performance tests, the control settings made in c above apply unless otherwise specified. All controls and indicators referred to are located on the test set unless otherwise specified.

e. Equipment Performance Checklist.

	Step	Unit	Action	Indicator	Normal indication	Corrective measures
PREPARATORY	1	Test set	Turn the POWER switch to ON. Set RECEIVER meter selector switch to 30 VOLT SCALE.	Receiver meter.	28 to 30 vdc.	Adjust VOLTAGE control for normal indication. If normal indication cannot be obtained, a short in the receiver dc circuit is indicated. Refer to paragraph 25*d* for isolating procedure.

	Step	Unit	Action	Indicator	Normal indication	Corrective measures
PREPARATORY	2		Set receiver meter selector switch to INPUT 3 A SCALE.	Receiver meter.	1.8 to 2.2 amperes dc.	If indication is approximately zero, an open dc circuit is indicated. If indication is above normal, a resistive short is indicated. Check the 28-volt dc circuits in the receiver (par. 25*d*).
EQUIPMENT PERFORMANCE	3		Set pulse length meter selector switch to RCVR TUNE.	Pulse length meter.	Needle deflects to right-hand portion of meter.	Check all tubes in rf section of receiver. Replace any defective tubes. Replace oscillator crystal with a known good crystal of the correct frequency. If defect is not corrected, refer to paragraph 27*d*, item 3, for the isolating procedure.
	4		Rotate ROLL SERVO control to 0 position.			
			Slowly rotate ROLL GYRO control towards zero.	Indicator lights above ROLL SERVO control.	Lights go out when ROLL GYRO control is at 0±5°.	An unbalance in roll bridge detector amplifier or defective roll micropositioner is indicated.
						Check V20 (fig. 21) on tube tester; replace if weak or defective.
						If V20 checks normal on the tube tester, check the roll micropositioner K4 (par. 24) and replace, if defective.
						If defect is not corrected, refer to paragraph 27*d*, items 15 and 16 for the isolating procedure.
	5		Rotate PITCH SERVO and PITCH GYRO controls to 0 position.	Indicator lights above PITCH SERVO controls	Lights go out when PITCH GYRO control is at ±5°.	Unbalance in pitch bridge detector amplifier or pitch micropositioner K3 is indicated; check V17 (fig. 21) and replace, if weak or defective.
						If V20 checks normal on the tube tester, check the

	Step	Unit	Action	Indicator	Normal indication	Corrective measures
EQUIPMENT PERFORMANCE						pitch micropositioner K3 (par. 24) and replace, if defective. If defect is not corrected, refer to paragraph 27*d*, items 17 and 18 for the isolating procedure.
	6	Master flight control box	Rotate ROLL COMMAND knob until pulse length meter indicates 70 percent duty cycle, ± correction factor for 50 percent.			
		Test set	Position ROLL SIMULATED-SERVO switches to SERVO.			
			Rotate ROLL GYRO control until roll servo pointer is at zero.	ROLL GYRO Control.	50 R ±5°.	If ROLL GYRO control indication is abnormal, defective roll command channel is indicated. Check V9, V18, V19, V20 (fig. 21). Replace any tubes that are below the rated transconductance, or if two sections of the same tube differ.
	7	Master flight control box	Rotate control PITCH COMMAND knob until pulse length indicates 65 percent duty cycle, ± correction factor for 50 percent.			
		Test set	Position PITCH SIMULATED SERVO switch to SERVO.			
			Rotate PITCH GYRO control until PITCH SERVO pointer is at zero.	PITCH GYRO control.	30 D ±3°.	If PITCH GYRO control indication is abnormal, defective pitch command channel is indicated.
		Master flight control box	Rotate PITCH COMMAND knob until pulse length meter indicates 35 percent, ± correction factor for 50 percent.			Check V14, V15, and V16 (fig. 21). Replace any tubes that are below the rated transconductance, or if two sections of the same tube differ.
		Test set	Rotate PITCH GYRO control until PITCH SERVO pointer is at zero.	PITCH GYRO control.	30 U ±3°.	If all tubes are in good condition, check pitch micropositioner K3 (par. 24) and replace if defective.

	Step	Unit	Action	Indicator	Normal indication	Corrective measures
EQUIPMENT PERFORMANCE		Master flight control box and test set	Rotate all pitch controls on master flight control box and test set to zero or neutral position.			
	8	Test set	Remove connectors from both servos.			
			Place ROLL SIMULATED-SERVO switch to SIMULATED.			
			Rotate ROLL SERVO control clockwise until two indicator lights above control go out.	ROLL SERVO control.	20 L ±5°.	Same as step 6.
			Rotate ROLL GYRO control to 40 L.			
			Rotate ROLL SERVO control counter-clockwise until two indicator lights above control go out.	ROLL SERVO control.	20 R ±5°.	Same as step 6.
	9	Test set	Position PITCH SIMULATED-SERVO switch to SIMULATED.			
			Rotate PITCH GYRO control to 30° D.			
			Rotate PITCH SERVO control counter-clockwise until two indicator lights above control go out.	Pitch SERVO control.	18 U ±5°.	Same as step 7.
			Rotate PITCH GYRO to 30° U.			
			Rotate PITCH SERVO control clock-wise until two indicator lights above control go out.	PITCH SERVO control.	18 D ±5°.	Same as step 7.
	10	Test set	Set the RECEIVER meter selector switch to 30 VOLT SCALE.			
			Rotate VOLTAGE control until receiver meter indicates 22.5 vdc.			

	Step	Unit	Action	Indicator	Normal indication	Corrective measures
EQUIPMENT PERFORMANCE			Set the RECEIVER meter selector switch to CHUTE RELAY 30 MA SCALE.	Receiver meter and CHUTE indicator light.	4.5 ma.	If relay current is less than 4.5 ma, c check V8B, V14B, V21 or relay K2 (fig. 21). Replace the defective tube or relay. If defect is not corrected, refer to paragraph 27*d*, item 25 for the isolating procedure.
		Master flight control box.	Depress CHUTE DELAYED switch button.	CHUTE indicator light and receiver meter on test set.	After approximately 10 seconds, indicator light extinguishes and receiver meter indication is zero.	Check V8B, V14B, V21, or relay K2 (fig. 21), and replace as necessary. If defect is not corrected, refer to paragraph 27*d*, item 25.
			Release CHUTE DELAYED switch.			
	11	Master flight control box.	Depress CHUTE INSTANT switch button.	CHUTE indicator light and receiver meter on test set.	CHUTE indicator light extinguishes. Receiver meter indicates 4.5 ma.	Defective instantaneous chute control channel or K1 is indicated. Check tubes V8A, V9A, and V10 (fig. 21) and, replace as necessary. Otherwise replace relay. If defect is not corrected, refer to paragraph 27*d*, items 27, 28, and 29 for the isolating procedure.
			Release CHUTE INSTANT switch button.			
		Master flight control box.	Momentarily depress CAMERA, NITE LITE, and spare switch buttons.	CAMERA, NITE LITE, and SPARE indicator lights on test set.	Indicator lights light when applicable switch button is depressed.	Defective audio filter Z2 is indicated. Replace filter. If this does not correct the defect, refer to paragraph 27*d*, item 30 for the isolating procedure.

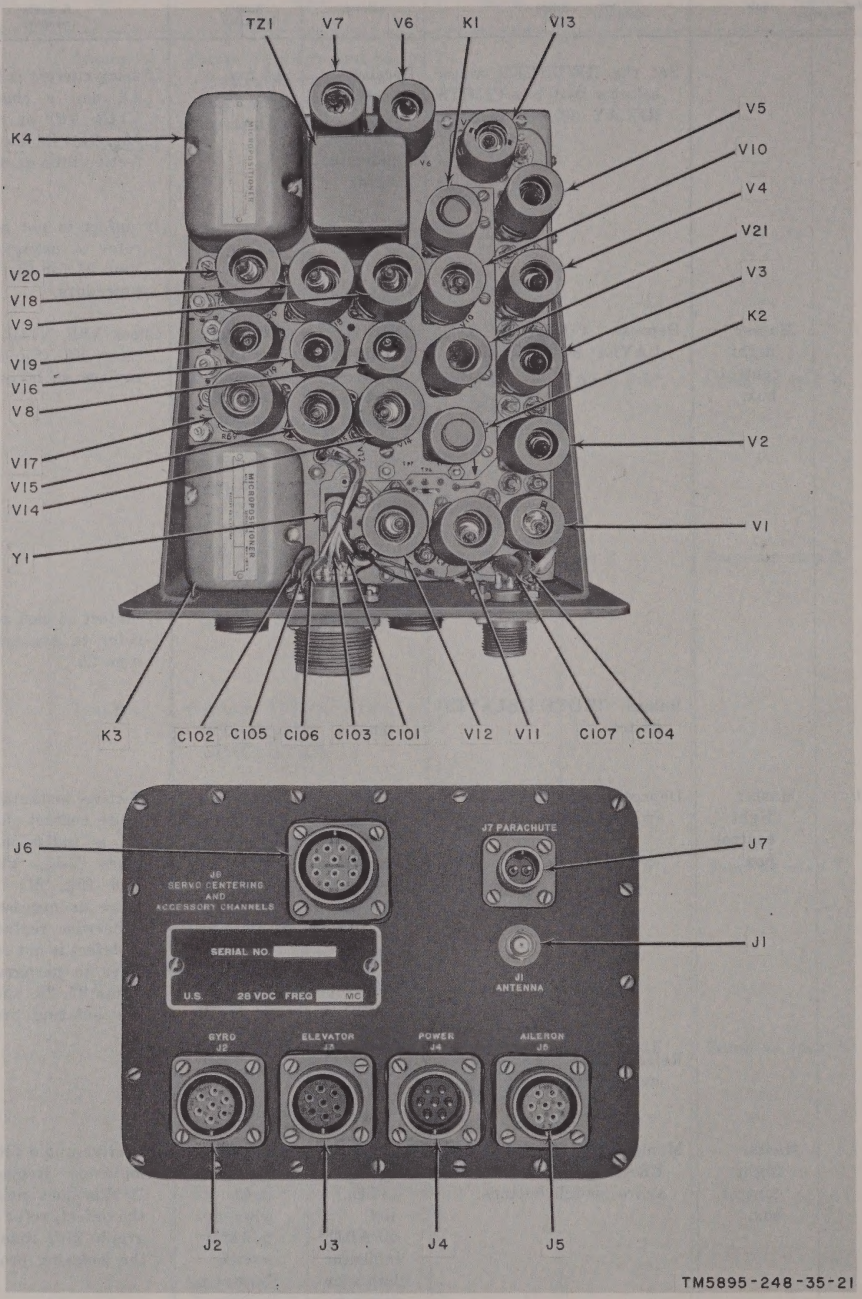


Figure 21. Receiver top and front view, components location.

23. Tube Testing Techniques

When trouble occurs, check all cabling and connections, and perform the equipment performance check before removing any tubes. The equipment performance check generally indicates the tubes that are causing the trouble. If other troubles occur, which are not indicated in the performance check, try to isolate the trouble to a component or stage. Refer to figure 21 for location of tubes on the radio receiver chassis. If tube failure is suspected, use the following procedure as required to check the tubes.

Caution: **Do not rock or rotate a tube when removing it from a socket; pull it straight out with a tube puller. Rocking or rotating may bend the pins or break the tube.**

a. Using Tube Tester. Remove and test one tube at a time. Discard a tube only if its defect is obvious or if the tube tester shows it to be defective. If a tube tests at or near its minimum test limit on the tube tester, it should be discarded. Return the original tube to its socket, or insert a new tube if required, before testing the next tube.

b. Tube Substitution Method. Substitute a suspected tube with a new tube. If the equipment remains inoperative, remove the new tube and replace the original tube. Repeat this procedure with each suspected tube until the defective tube is located.

24. Micropositioner Testing

The operation of the roll and pitch micropositioner (K3 and K4, fig. 21) can be tested on the tester set. Proceed with the test as indicated in *a* through *j* below.

Note. All controls and indicators given in the following test procedures are located on the tester set. Refer to TM 11-5895-249-12 for location of the tester set controls.

a. Insert the micropositioner in the MICROPOSITIONER TEST socket on the tester set.

b. Turn the tester set pulse length meter selector switch to MP ADJUST.

c. Turn the MP TEST switch to L.

d. Rotate the MP ADJUST control until one of the MICROPOSITIONER indicators light.

e. Note that the pulse length needle is positioned between the two red MP test lines on the meter.

f. Rotate the MP ADJUST control until the meter needle is at zero.

g. Turn the MP TEST switch to R and repeat the procedures given in *c* through *e*.

h. If the indicators flicker (seem unsteady) or do not light, there may be dirt between the micropositioner contacts.

i. Clean the micropositioner by removing the cover and passing a strip of smooth bond paper between the contacts and applying a small amount of pressure against the moveable contacts.

j. If the contacts require cleaning, repeat the procedures given in *c* through *h* to check the operation of the micropositioner. The micropositioner may require adjustment after cleaning the contacts or if either of the micropositioner test indicators light before or after the meter needle has passed the indicated area on the meter face. Refer to paragraph 34 for adjustment procedure.

Section III. TROUBLESHOOTING

Caution: **Do not remove or replace parts before reading the instructions in paragraph 33.**

25. Checking Filament and B+ Circuits

a. When to check. When any of the following conditions apply, check for short or open circuits and clear the troubles before applying power.

(1) When the receiver is being serviced and the nature of the abnormal symptoms is not known.

(2) When abnormal symptoms reported from steps 1 and 2 of the equipment performance checklist (par. 22) indicate possible voltage supply troubles.

b. Conditions for Tests. To prepare for the filament and B+ tests, perform the following steps:

(1) Disconnect all cables from the receiver.

(2) Remove the receiver from its case.

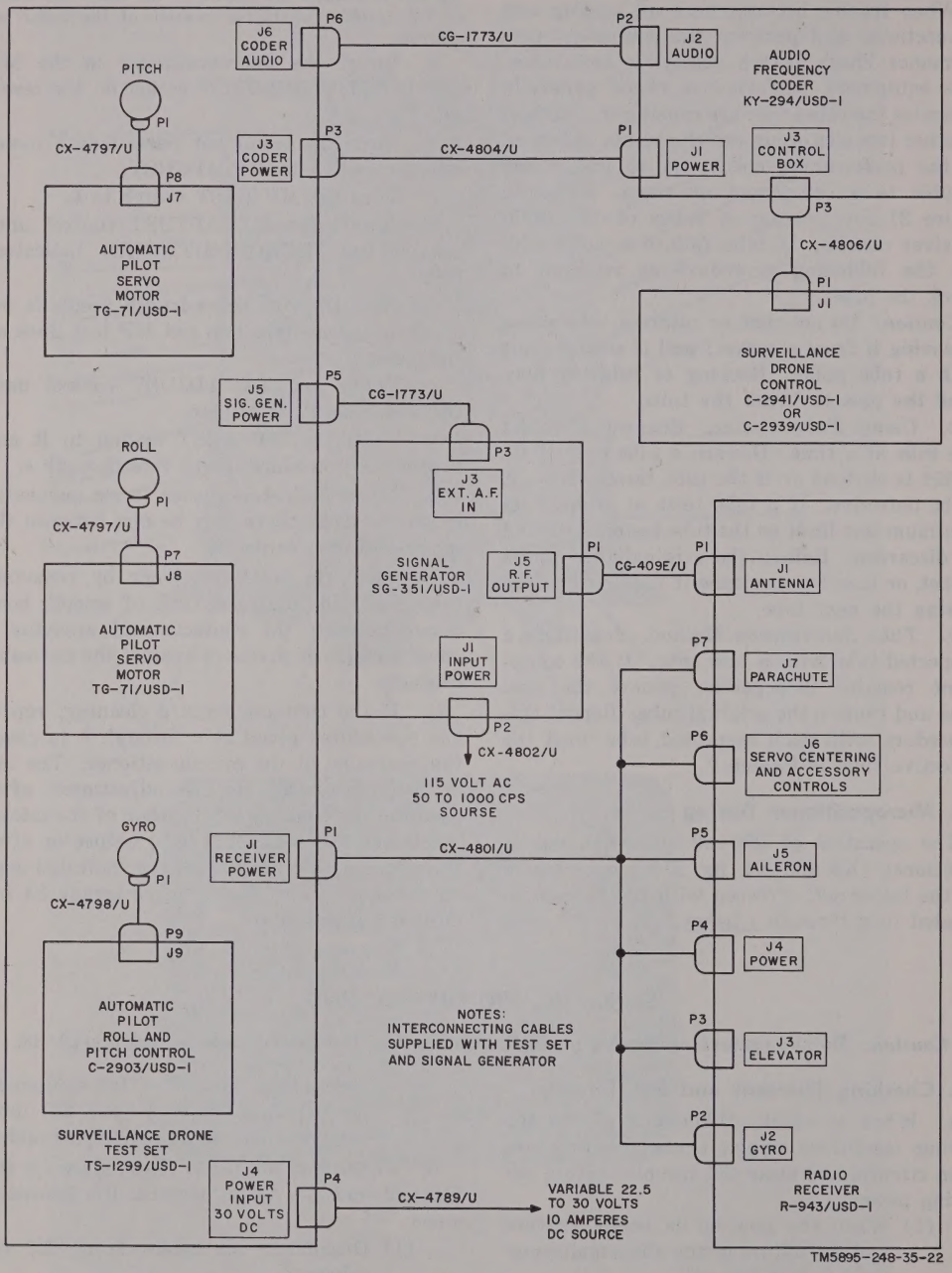


Figure 22. Test setup for troubleshooting.

(3) Remove all tubes, relays, and micropositioners.

c. Measurements. Use the multimeter to make the resistance measurements indicated in the following chart. If abnormal indications are obtained, make the additional isolating checks outlined. When the faulty part is found, repair the trouble before applying power to the unit.

Note. Make all connections to tube sockets for resistance checks (*d* below) from the top of the receiver chassis.

d. Filament and B+ Tests.

Point of measurement	Normal indication	Isolating procedure
Power connector J4–D to ground	300 ohms resistance	Zero resistance indicates a shorted C35, C47, C49, C56, C57, C63, C65, C79, C84, C102, or C107 (fig. 23, 24, and 25). Infinite resistance measurement indicates an open R84 or R85 (fig. 26).
Junction of resistor R40 and capacitor C58 to ground.	400 ohms resistance	Zero resistance indicates a shorted C34, C36 or C58 (fig. 25). High resistance indicates an open R40 (fig. 26).
Junction of resistor R13 and capacitor C38 to ground.	570 ohms resistance	Zero resistance indicates a shorted capacitor C38 (fig. 25). High resistance indicates an open R13 (fig. 26).
Crystal oscillator tube V12, pin 9	305 ohms resistance	Zero resistance measurement indicates a shorted C56 or C57 (fig. 25). High resistance indicates an open R39 (fig. 26).
Crystal oscillator and doubler tube V12, pin 4, to ground.	Infinite resistance	Zero resistance measurement indicates a shorted C55 (fig. 25).
Mixer tube V1, pin 3, to V1, pin 4.	82 ohms resistance	High resistance measurement indicates an open L22, L23 (fig. 25), or R38 (fig. 26).
Mixer tube V1, pin 3 to ground	Infinite resistance	Low resistance indicates a shorted capacitor C53 or C54 (fig. 25).
Discriminator V13, pin 3, to ground.	300 ohms	High resistance indicates an open R41 (fig. 26).

26. Test Setup for Troubleshooting

Bench tests of the receiver require connections to various test equipments (fig. 22). The dc power for the receiver under test is supplied by an external power source through the test equipment connections. The dc power is applied to the receiver for all dynamic-servicing procedures but the test equipment connections will vary from test to test. To perform the bench tests, remove the receiver from its case, and connect the test equipment to the receiver as outlined below.

a. Place the receiver to be tested with the test set, the coder, the master flight control box, and the signal generator, on a suitable workbench having 30-volt dc, and 115-volt ac power sources.

b. When using the cable assemblies included with the test set, connect the receiver, the test set, the coder, and the master flight control box (fig. 22). Each of the individual cable ends on the multiple cable which connects the receiver to the test set is tagged to indicate its proper receiver connector.

c. Install the roll servo on the test set servo test mount and attach a pointer to the servo shaft. Position the roll servo so that its connector lines up with the cutout under the ROLL scale. Insert the servo connector into the cutout from the rear of the panel. Line up the two servo mounting holes with the test mount captive screws, and then insert the captive screws into the servo mounting holes, and tighten the captive screws.

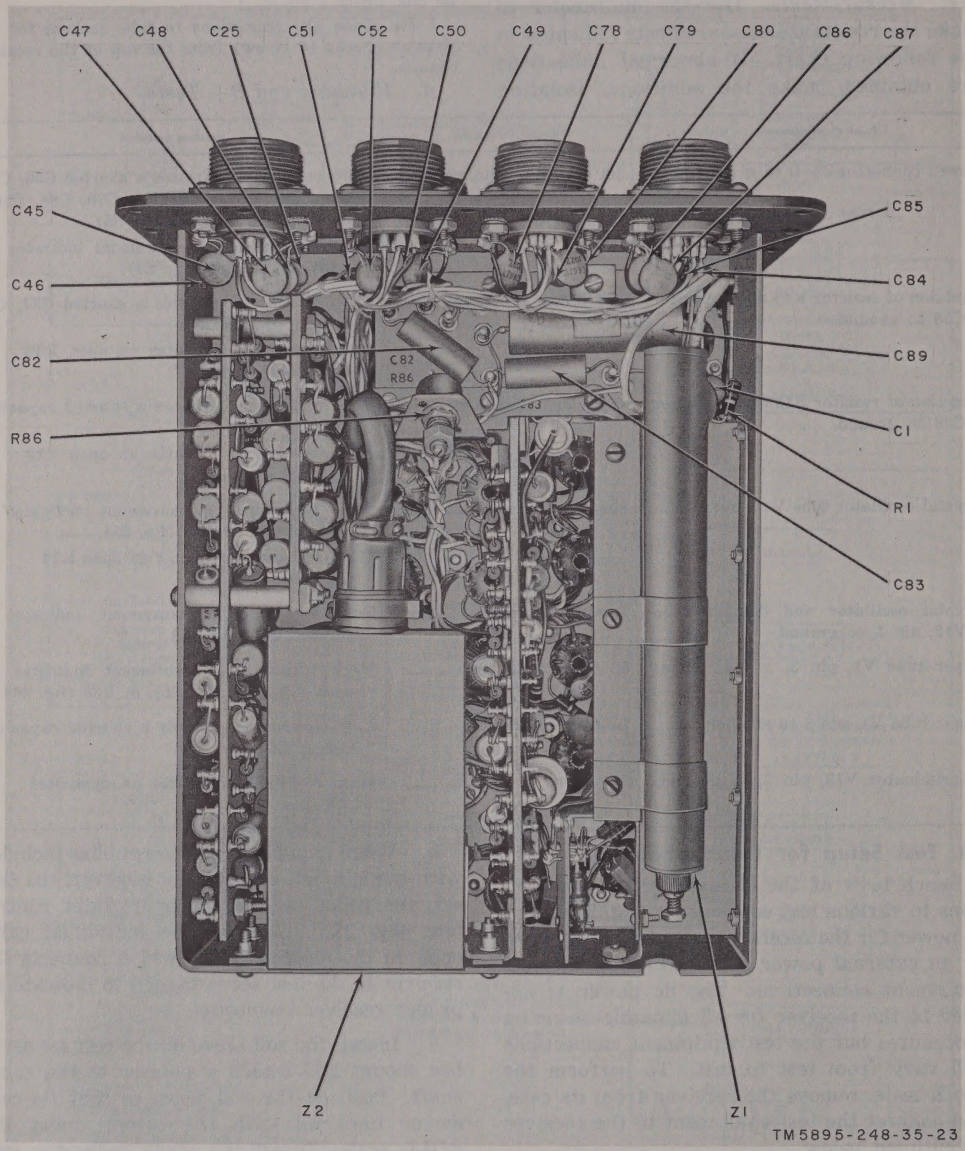


Figure 23. Receiver bottom view, component location.

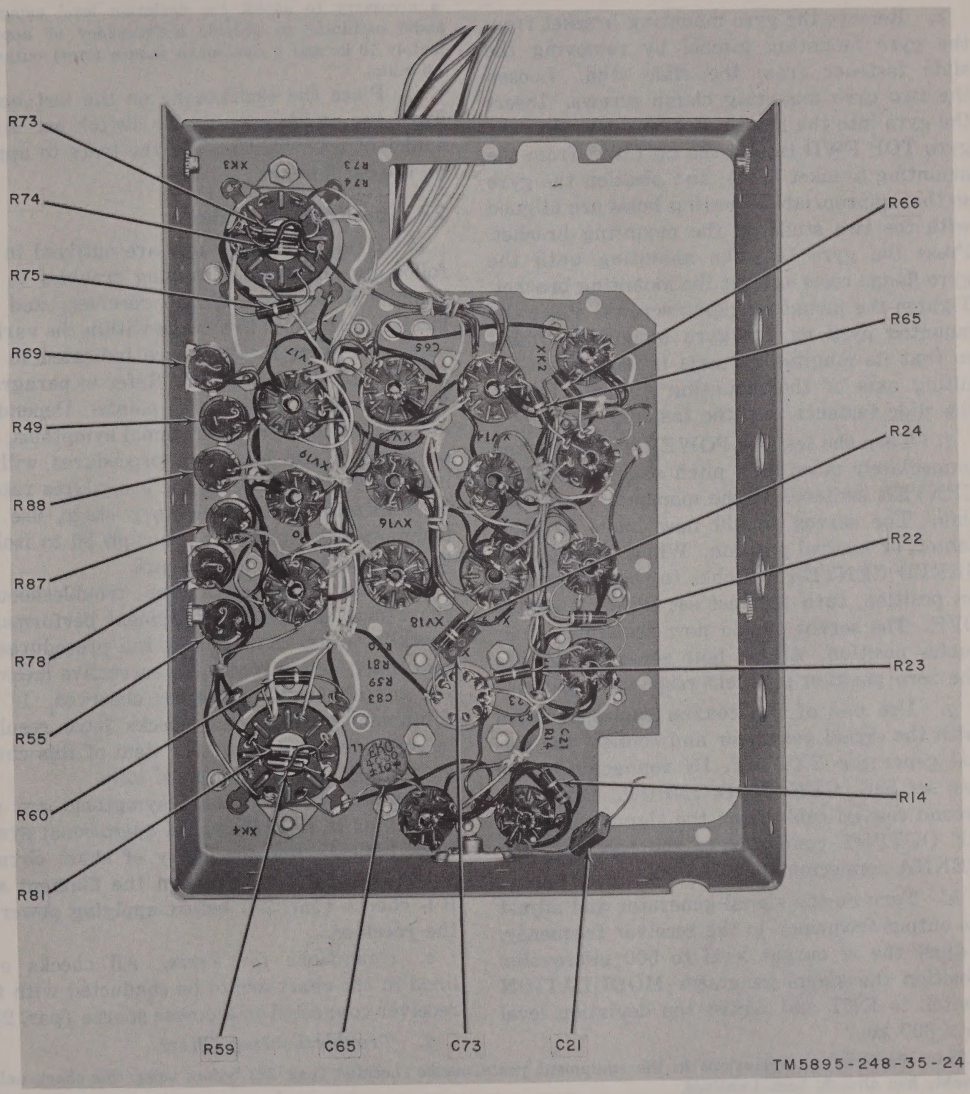


Figure 24. Receiver main chassis bottom view, component location.

d. Install the pitch servo on the test set servo test mount in the same manner as the roll servo.

e. Remove the gyro mounting bracket from the gyro mounting gimbal by removing the slide fastener from the slide stud. Loosen the two gyro mounting clamp screws. Insert the gyro into the mounting bracket so that the gyro TOP FWD label faces up (180° from the mounting bracket base), and position the gyro so that appropriate mounting holes are aligned with the two studs on the mounting bracket. Press the gyro into the mounting until the gyro flange rests against the mounting bracket. Tighten the mounting clamp screws. Place the mounted gyro on the gyro mounting gimbal so that its longitudinal axis is parallel to the tilting axis of the mounting gimbal. Fasten the slide fastener into the fastener stud.

f. Turn the test set POWER switch on and immediately move both pitch and roll SERVO CENTER switches to the momentary *on* position. The servos should now move to their center, or neutral position. While holding both SERVO CENTER switches to the momentary *on* position, turn the test set POWER switch OFF. The servos should now remain in their center position. Adjust both servo pointers to the zero position on their respective scales.

g. Use one of the coaxial cables supplied with the signal generator and connect the signal generator EXT.A.F. IN connector to the test set SIG. GEN. MOD. INPUT. Connect a second coaxial cable from the signal generator RF OUTPUT connector to the receiver ANTENNA connector J1.

h. Turn on the signal generator and adjust its output frequency to the receiver frequency. Adjust the rf output level to 500 microvolts. Position the signal generator MODULATION switch to EXT and adjust the deviation level to ±300 kc.

Note. The deviation indicator is an average reading device, and will not indicate ±300 kc when the pulsing output of the coder is being monitored. Therefore, it is necessary to adjust the deviation level using the audio oscillator to provide a frequency of approximately 10 kc and a root mean square (rms) output of 1.5 volts.

i. Place the oscilloscope on the test bench. Turn the oscilloscope power switch on. Allow sufficient warmup time for the trace to appear on the oscilloscope.

27. Localizing Troubles

a. General. Procedures are outlined in the following chart for localizing troubles to the functional sections of the receiver, and for localizing troubles to a stage within the various sections. Parts locations are indicated in figures 21, 23, 24, 25, and 26. Refer to paragraph 31 for location of the test points. Depending on the nature of the operational symptoms, one or more of the localizing procedures will be necessary. When use of the procedures results in localization of trouble to a stage, use the techniques outlined in paragraph 30 to isolate the trouble to a particular part.

b. Test Procedure. The troubleshooting chart supplements the equipment performance checklist (par. 22). Follow the procedures in this chart, and perform the corrective measure for any abnormal symptoms observed. If the equipment performance checks have resulted in reference to a particular item of this chart, go directly to the referenced item.

Caution: **If operational symptoms are not known, or if the referenced operational symptoms indicate the possibility of short circuits within the receiver, perform the filament and B+ checks (par. 25) before applying power to the receiver.**

c. Conditions for Tests. All checks outlined in the chart are to be conducted with the receiver connected to a power source (par. 26).

d. Troubleshooting Chart.

Note. Perform the operations in the equipment performance checklist (par. 22) before using this chart, unless trouble has already been localized.

Item	Indication	Probable trouble	Procedure
1	Receiver voltage less than 28 to 30 volts.	Resistive short in plate, screen, or filament supply circuit.	Perform filament and B+ circuit tests (par. 25).
2	Receiver current greater or less than 1.8 to 2.2 amperes dc.	Resistive short or open in voltage supply circuit.	Perform filament and B+ circuit checks (par. 25).



d. Install the pitch servo on the test set servo test mount in the same manner as the roll servo.

e. Remove the gyro mounting bracket from the gyro mounting gimbal by removing the slide fastener from the slide stud. Loosen the two gyro mounting clamp screws. Insert the gyro into the mounting bracket so that the gyro TOP FWD label faces up (180° from the mounting bracket base), and position the gyro so that appropriate mounting holes are aligned with the two studs on the mounting bracket. Press the gyro into the mounting until the gyro flange rests against the mounting bracket. Tighten the mounting clamp screws. Place the mounted gyro on the gyro mounting gimbal so that its longitudinal axis is parallel to the tilting axis of the mounting gimbal. Fasten the slide fastener into the fastener stud.

f. Turn the test set POWER switch on and immediately move both pitch and roll SERVO CENTER switches to the momentary *on* position. The servos should now move to their center, or neutral position. While holding both SERVO CENTER switches to the momentary *on* position, turn the test set POWER switch OFF. The servos should now remain in their center position. Adjust both servo pointers to the zero position on their respective scales.

g. Use one of the coaxial cables supplied with the signal generator and connect the signal generator EXT.A.F. IN connector to the test set SIG. GEN. MOD. INPUT. Connect a second coaxial cable from the signal generator RF OUTPUT connector to the receiver ANTENNA connector J1.

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***Caution:* If operational symptoms are not known, or if the referenced operational symptoms indicate the possibility of short circuits within the receiver, perform the filament and B+ checks (par. 25) before applying power to the receiver.**

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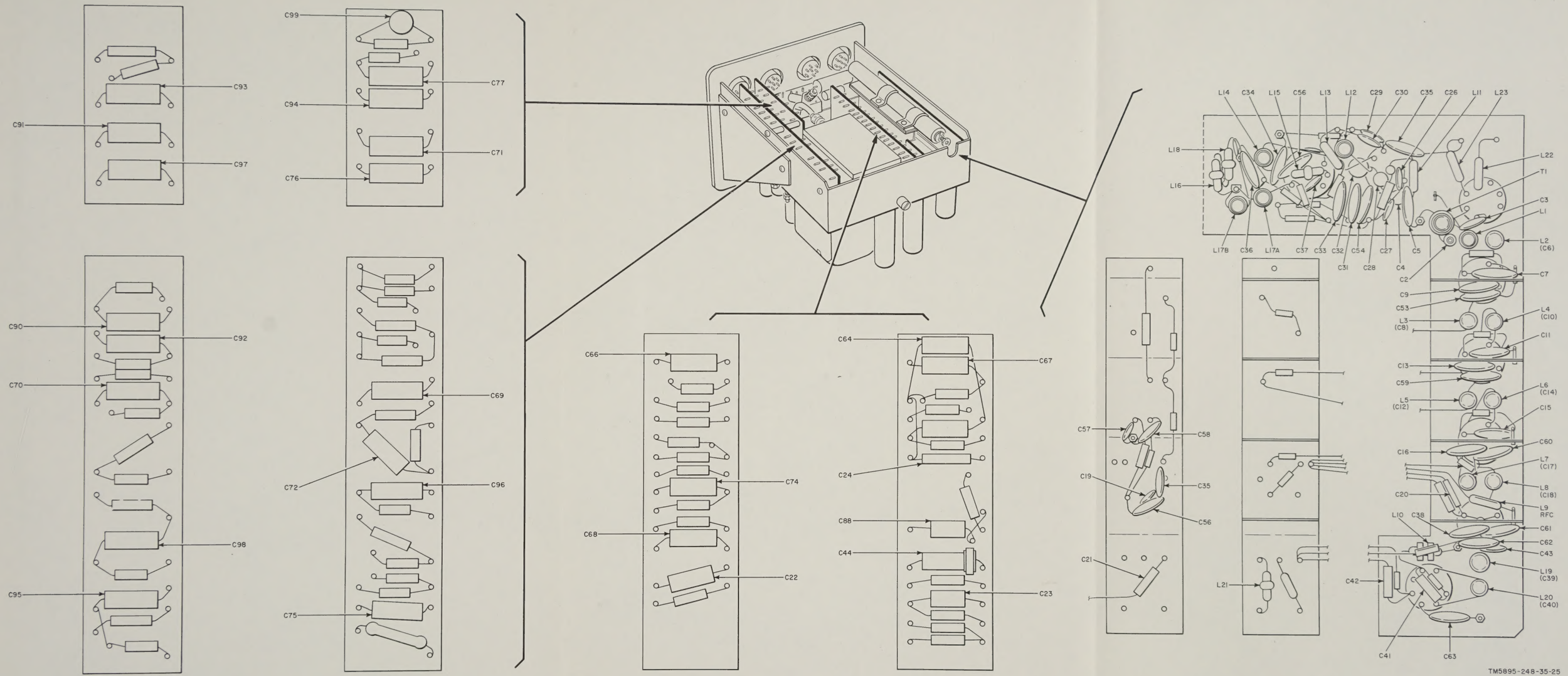


Figure 25. Receiver bottom view, capacitor location.







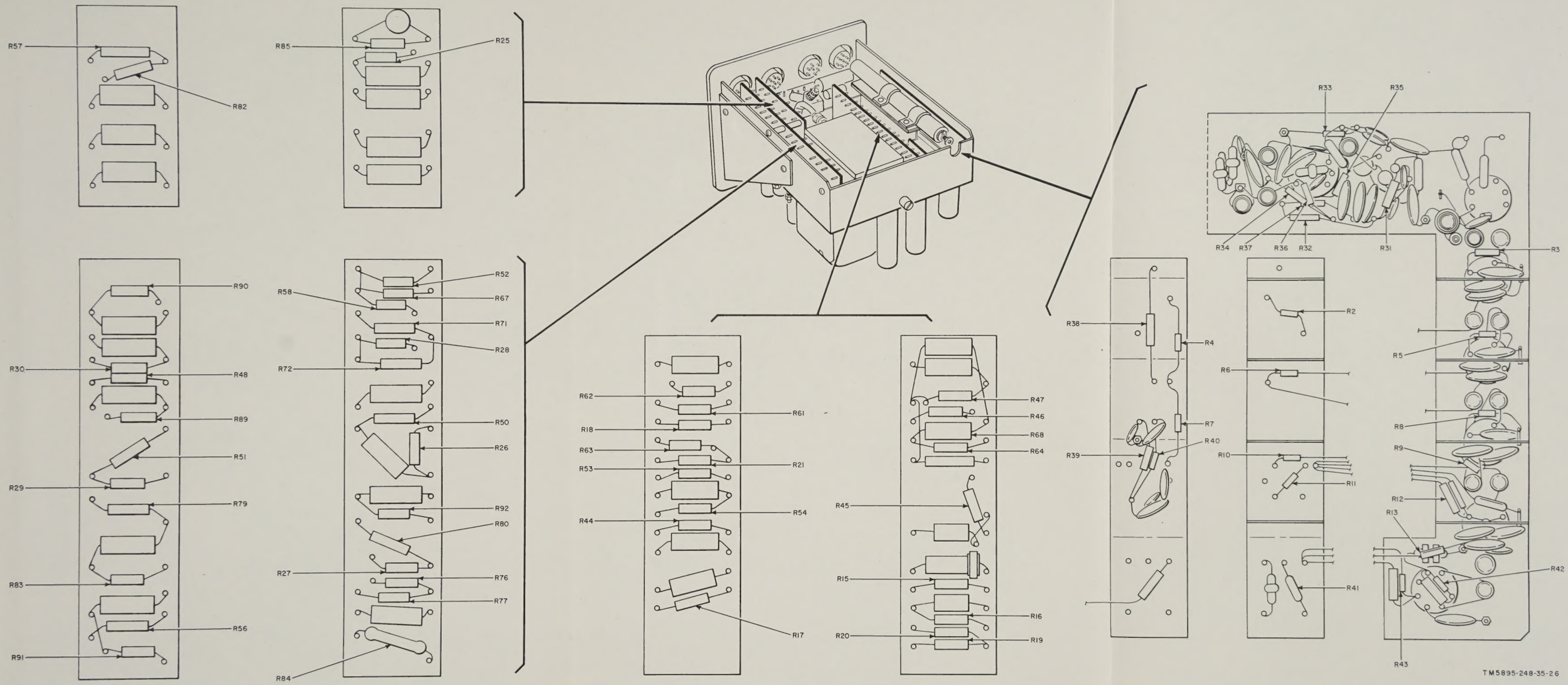
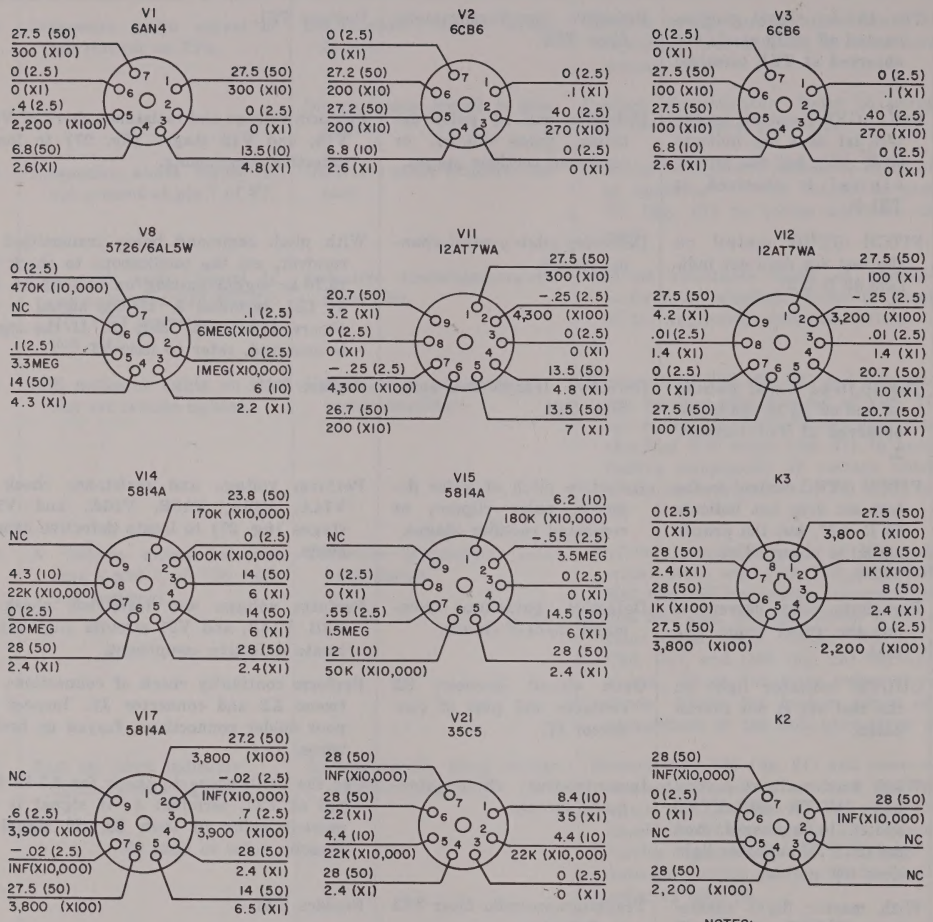


Figure 26. Receiver bottom view, resistor location.

Item	Indication	Probable trouble	Procedure
3	Insufficient output from if amplifiers. (Needle of pulse length meter located on test set should be on right-hand portion of the meter for normal indication.)	Local oscillator stages defective.	Use the multimeter adjusted to measure negative dc voltage and measure the bias voltage at TP5. If no voltage is present, refer to item 4.
		If amplifier stages defective.	Use the oscilloscope with a demodulation probe and check for signals at TP1, TP2, TP3, and TP4. If no signals are present, refer to items 8-11.
			Use the oscilloscope with a direct probe, and check for a signal at TP8. If no signal is present, refer to item 12.
		If amplifier stages or local oscillator and mixer misaligned.	Refer to paragraph 37 for frequency alignment procedure.
4	No bias voltage is present at TP5.	Local oscillator stages defective.	Use the multimeter and check bias voltage at TP7. If no voltage is present, refer to item 5.
			Use the multimeter and check bias voltage at TP6. If no voltage is present, refer to item 6.
5	No bias voltage is present at TP7.	Crystal oscillator or first doubler stage is defective.	Perform voltage and resistance check of crystal oscillator and first doubler stage V12 (fig. 27), to locate defective component. If the measurements are normal, refer to item 6.
6	No bias voltage is present at TP6.	Second doubler stage defective.	Perform voltage and resistance check of second doubler stage V11B (fig. 27) to locate defective component. If the measurements are normal, refer to item 7.
7	No bias voltage is present at TP7.	Third doubler stage defective.	Perform voltage and resistance check of third doubler stage V11A (fig. 27) to locate defective component. If the measurements are normal, refer to item 8.
8	No signal is present at TP1.	Mixer stage defective.	Perform voltage and resistance check of mixer stage V1 (fig. 27) to locate defective component.
9	No signal is present at TP2.	First if amplifier stage is defective.	Perform voltage and resistance check of first if amplifier stage V2 (fig. 27) to locate defective component.
10	No signal is present at TP3.	Second if amplifier stage is defective.	Perform voltage and resistance check of second if amplifier stage V3 (fig. 27) to locate defective component.
11	No signal is present at TP4.	Third if amplifier or limiter stage is defective.	Perform voltage and resistance check of third if amplifier stage V4 or limiter stage V5 (fig. 27) to locate defective component.

Item	Indication	Probable trouble	Procedure
12	Composite audio signal is not present at TP8.	Discriminator circuit is defective.	Perform voltage and resistance check of discriminator V13 (fig. 27) to locate defective component.
		Discriminator circuit is misaligned.	Realign discriminator. Refer to paragraph 37 for alignment procedure.
13	Composite audio signal is not present at pin 7 of V7.	Defective audio amplifier circuit.	Perform voltage and resistance check of first af amplifier V6 and second af amplifier V7 (fig. 27) to locate defective component.
14	Composite audio signal is not present at RECEIVER OUTPUT connector on the test set.	Defective transformer-audio filter TZ1.	Perform resistance check of transformer-audio filter winding. Refer to paragraph 32 for applicable resistance values.
15	Roll indicator lights on the test set remain lighted.	Unbalance in roll bridge detector amplifier.	Remove tube V18 (fig. 21) and measure voltage between pins 2 and 7 of V20. If voltage is zero, perform voltage and resistance check of V20 stage (fig. 27) to locate defective component. If voltage exists between control grids of V20, refer to item 16.
16	A voltage exists between pins 2 and 7 of V20 with V18 removed.	Defective gyro-servo feedback circuit.	Perform resistance check of V20 grid circuits. Make sure that R25, R27, R82, and R83 (fig. 26) are within 5 percent and R57 and R80 (fig. 26) are within 1 percent of their rated value. Check C75, C76, C77, C96, C97, and C98 (fig. 25) for opens or shorts. Check for rated value of capacitance. Check for broken wires or poor connections of the roll gyro-servo circuit.
17	Test set pitch indicator lights remain lighted.	Unbalance in pitch bridge amplifier stage.	Remove tube V15 (fig. 21) and measure voltage between pins 2 and 7 of V17. If voltage is zero, perform voltage and resistance check of V17 circuit (fig. 27) to locate defective component. If a voltage exists between control grids of V17A and V17B, refer to item 18.
18	A voltage exists between pins 2 and 7 of V17 with V15 removed.	Defective gyro-servo feedback circuit.	Perform resistance check of V17 grid circuit. Make sure that R26, R28, R29, and R30 (fig. 26) are within 5 percent, and R51 and R72 (fig. 26) are within 1 percent of their rated values. Check C70, C71, C72, C90, C91, and C92 (fig. 25) for opens or shorts. Check for rated value of capacitance. Check for broken wires or poor connections in the pitch gyro-servo feedback circuit.
19	ROLL GYRO control on the test set does not indicate 50 R ±5°.	Defective roll control channel circuit.	With roll command being transmitted to receiver, use oscilloscope to check for 13.7-kc signal pulsing on and off 15 cps at TZ1, terminal 2. If this signal is not observed, refer to item 20. If the signal is observed, refer to item 21.

Item	Indication	Probable trouble	Procedure
20	The 13.7-kc signal pulsing on and off at 15 cps is not observed at TZ1, terminal 2.	Defective transformer-audio filter TZ1.	Replace TZ1.
21	ROLL GYRO control on the test set does not indicate 50 R ±5°, but the proper signal is observed at TZ1-2.	Defective roll af pulse detector, pulse clipper, or command rectifier stages.	Perform voltage and resistance check of V9B, V18, and V19 stages (fig. 27) to locate defective components.
22	PITCH GYRO control on the test set does not indicate 30 D ±3°.	Defective pitch control channel circuit.	With pitch command being transmitted to receiver, use the oscilloscope to check for 10.76-kc signal pulsing on and off 15 cps at TZ1, terminal 3. If this signal is not observed, refer to item 23. If the signal is observed, refer to item 24.
23	The 10.76-kc signal pulsing on and off at 15 cps is not observed at TZ1 terminal 3.	Defective transformer-audio filter TZ1.	Replace TZ1.
24	PITCH GYRO control on the test set does not indicate 30 D ±3°, but the proper signal is observed at TZI-3.	Defective pitch af pulse detector, pulse clipper, or command rectifier stages.	Perform voltage and resistance check of V14A, V15A, V15B, V16A, and V16B stages (fig. 27) to locate defective components.
25	Parachute relay current is not the rated value (4.5 ma).	Defective parachute command channel circuit.	Perform voltage and resistance check of V8B, V14B, and V21 circuits (fig. 27) to locate defective component.
26	CHUTE indicator light on the test set is not illuminated.	Open circuit between K2 contacts and pins of connector J7.	Perform continuity check of connections between K2 and connector J7. Inspect for poor solder connections, frayed or broken wires.
27	When master flight control box CHUTE DELAYED switch is depressed, test set CHUTE indicator light does not go out.	Instantaneous chute command circuit.	Use the oscilloscope to check for 7.5-kc signal at TZ1, terminal 4. If signal is not present refer to item 28. If signal is present, refer to item 29.
28	With master flight control box CHUTE INSTANT switch depressed, 7.5-kc signal is not present at TZ1-4.	Transformer-audio filter TZ1 is defective.	Replace TZ1.
29	With master flight control box CHUTE INSTANT switch depressed, 7.5-kc signal is present at TZ1-4.	Defective instantaneous chute command circuit.	Perform voltage and resistance check of V8A, V9A, and V10 circuits (fig. 27) to locate defective part.
30	With master flight control box CAMERA, NITE LITE, and SPARE switch buttons depressed, the test set CAMERA, NITE LITE, and SPARE indicator lights do not light.	Defective audio filter Z2. Defective voltage supply to Z2.	Replace Z2. Check for +28 vdc at pin A of Z2 connector. Check the +0.25-volt bias at the junction of R84 and R85 (fig. 28).



NOTES:

1. ALL VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND.
2. ALL VOLTAGES ARE ABOVE THE LINE AND ARE MEASURED USING A 20,000 OHM-PER-VOLT METER, WITH 28 V DC INPUT.
3. ALL RESISTANCES ARE BELOW THE LINE, AND UNLESS OTHERWISE INDICATED, ARE IN OHMS.
4. RESISTANCE MEASUREMENTS ARE MADE WITH ALL EXTERNAL PLUGS DISCONNECTED.
5. NC INDICATES NO CONNECTION.
6. K INDICATES 1,000 OHMS.
7. MEG INDICATES 1,000,000 OHMS.
8. * READING SUBJECT TO VARIATION CAUSED BY FEEDBACK REACTION FROM TEST LEADS.

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Figure 27 (1). Tube-socket voltage and resistance diagram.

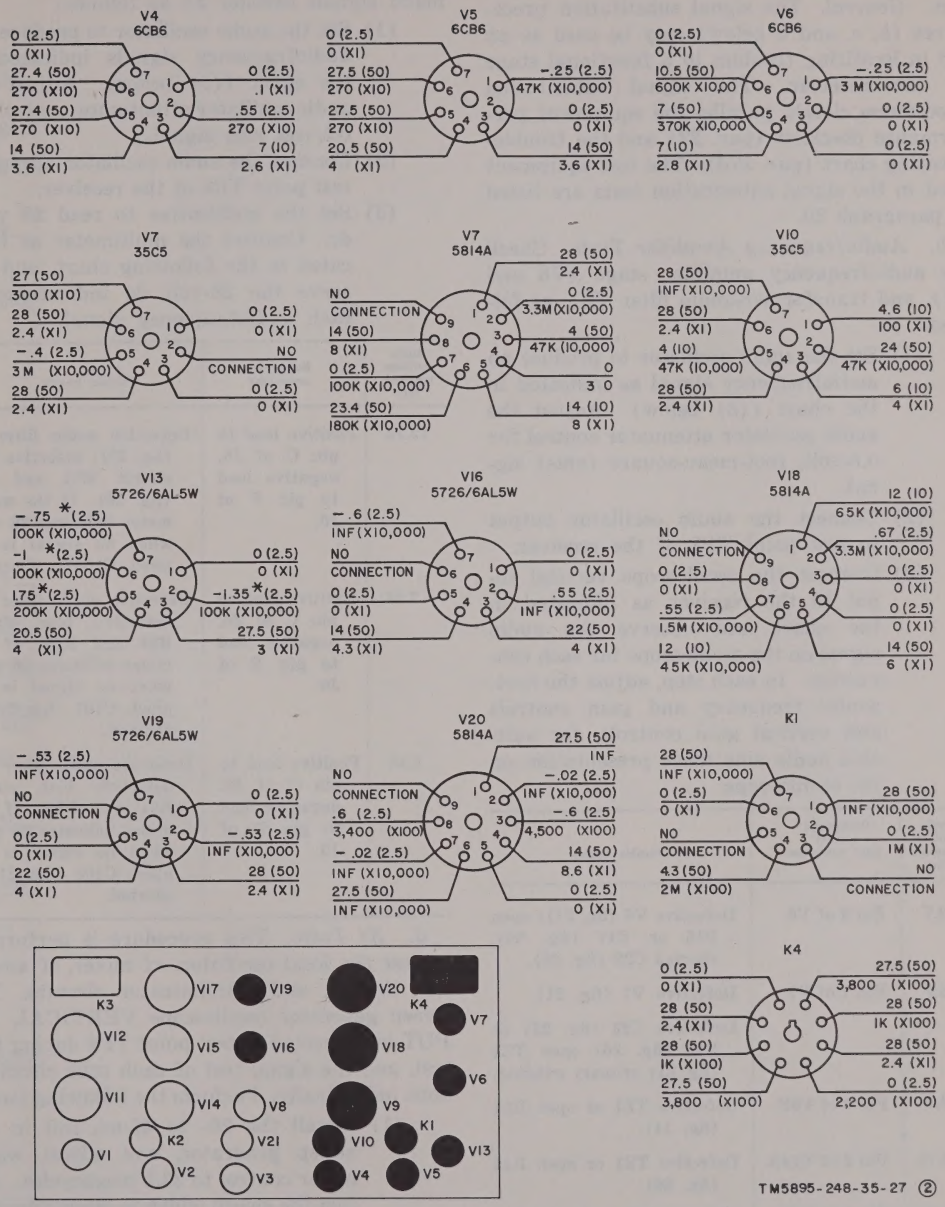


Figure 27 (2) — Continued.

28. Signal Substitution

a. General. The signal substitution procedures (*b*, *c*, and *d* below) may be used as an aid in localizing troubles to a functional stage of the receiver. The signal substitution procedures closely parallel the equipment performance checklist (par. 22) and the trouble-shooting chart (par. 27*d*). The test equipment used in the signal substitution tests are listed in paragraph 20.

b. Audiofrequency Amplifier Tests. Check the audiofrequency amplifier stage (V6 and V7), and transformer-audio filter TZ1, as follows:

(1) Set the audio oscillator to produce an audiofrequency signal as indicated in the chart ((3) below). Adjust the audio oscillator attenuator control for 0.5-volt, root-mean-square (rms) signal.

(2) Connect the audio oscillator output to test point TP8 of the receiver.

(3) Connect the oscilloscope vertical input to the receiver as indicated in the chart and observe the audio signal on the oscilloscope for each connection. In each step, adjust the horizontal frequency and gain controls and vertical gain controls, for suitable audio sine wave presentation on the oscilloscope.

Audio oscillator frequency (kc)	Oscilloscope vertical input connection	Possible trouble
13.7	Pin 5 of V6	Defective V6 (fig. 21); open R15 or R17 (fig. 26), shorted C22 (fig. 25).
13.7	Pin 7 of V7	Defective V7 (fig. 21). Defective C23 (fig. 25) or R16 (fig. 26) open TZ1 (fig. 21) primary winding.
13.7	Pin 7 of V9B	Defective TZ1 or open R24 (fig. 14).
10.76	Pin 2 of V14A	Defective TZ1 or open R45 (fig. 26).
10.76	Pin 7 of V8B	Defective TZ1 or open R44 (fig. 26).
7.5	Pin 2 of V8A	Defective TZ1 or open R23 (fig. 24).

c. Command Signals Decoder. Check command signals decoder Z2 as follows:

(1) Set the audio oscillator to produce the audiofrequency signals indicated in the chart ((3) below). Adjust the audio oscillator attentuator control for 0.5-volt rms signal.

(2) Connect the audio oscillator output to test point TP8 of the receiver.

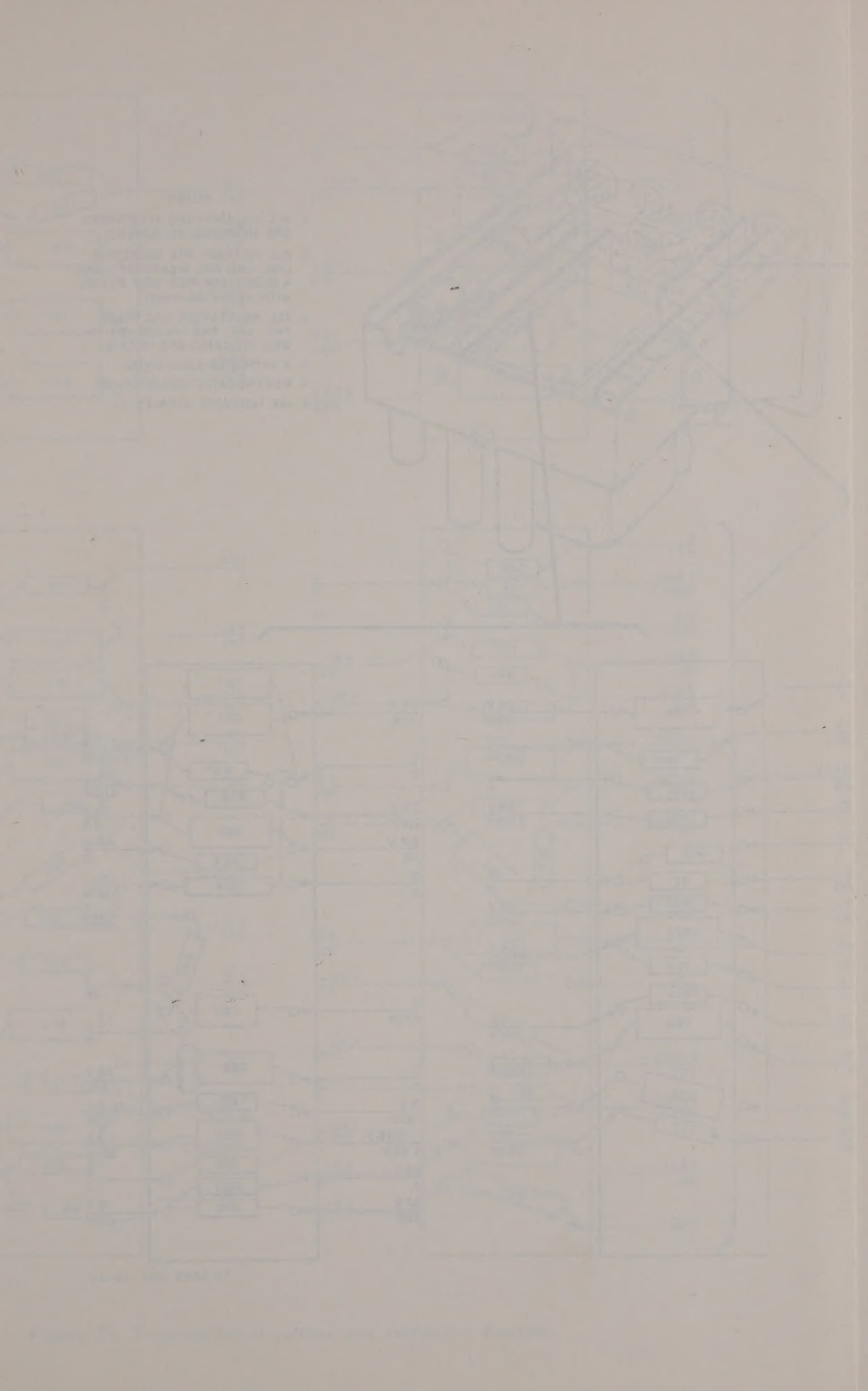
(3) Set the multimeter to read 28 volts dc. Connect the multimeter as indicated in the following chart, and observe the 28-volt dc indication for each audiofrequency signal.

Audio oscillator frequency (kc)	Multimeter connections	Possible trouble
12.14	Positive lead to pin C of J6, negative lead to pin F of J6.	Defective audio filter Z2 (fig. 23); defective bias circuit R84 and R85 (fig. 26). If the multimeter indicates 28 volts when no signal is applied, C100 is shorted.
9.54	Positive lead to pin C of J6, negative lead to pin E of J6.	Defective audio filter Z2; defective bias circuit R84 and R85. If the meter indicates 28 volts when no signal is applied, C101 (fig. 21) is shorted.
8.46	Positive lead to pin C of J6, negative lead to pin D of J6.	Defective audio filter Z2; defective bias circuit R84 and R85. If the meter indicates 28 volts when no signal is applied, C103 (fig. 21) is shorted.

d. Rf Tests. This procedure is performed to test the local oscillator, rf mixer, if amplifier, limiter, and discriminator circuits. The sweep generator oscilloscope VERTICAL INPUT is connected to test point TP8 during this test, and the signal test of each tube circuit is done individually. Perform the following steps:

(1) Install the 20- to 42-mc coil in the sweep generator, and adjust wavemeter control to 33.5 megacycles. Adjust the sweep width to approximately 4 megacycles.

(2) Connect the sweep generator oscilloscope VERTICAL INPUT to test point TP8. Observe the oscilloscope



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a. General. The signal substitution procedures (*b*, *c*, and *d* below) may be used as an aid in localizing troubles to a functional stage of the receiver. The signal substitution procedures closely parallel the equipment performance checklist (par. 22) and the trouble-shooting chart (par. 27*d*). The test equipment used in the signal substitution tests are listed in paragraph 20.

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13.7	Pin 7 of V7	Defective V7 (fig. 21). Defective C23 (fig. 25) or R16 (fig. 26) open TZ1 (fig. 21) primary winding.
13.7	Pin 7 of V9B	Defective TZ1 or open R24 (fig. 14).
10.76	Pin 2 of V14A	Defective TZ1 or open R45 (fig. 26).
10.76	Pin 7 of V8B	Defective TZ1 or open R44 (fig. 26).
7.5	Pin 2 of V8A	Defective TZ1 or open R23 (fig. 24).

c. Command Signals Decoder. Check command signals decoder Z2 as follows:

(1) Set the audio oscillator to produce the audiofrequency signals indicated in the chart ((3) below). Adjust the audio oscillator attentuator control for 0.5-volt rms signal.

(2) Connect the audio oscillator output to test point TP8 of the receiver.

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8.46	Positive lead to pin C of J6, negative lead to pin D of J6.	Defective audio filter Z2; defective bias circuit R84 and R85. If the meter indicates 28 volts when no signal is applied, C103 (fig. 21) is shorted.

d. Rf Tests. This procedure is performed to test the local oscillator, rf mixer, if amplifier, limiter, and discriminator circuits. The sweep generator oscilloscope VERTICAL INPUT is connected to test point TP8 during this test, and the signal test of each tube circuit is done individually. Perform the following steps:

(1) Install the 20- to 42-mc coil in the sweep generator, and adjust wavemeter control to 33.5 megacycles. Adjust the sweep width to approximately 4 megacycles.

(2) Connect the sweep generator oscilloscope VERTICAL INPUT to test point TP8. Observe the oscilloscope

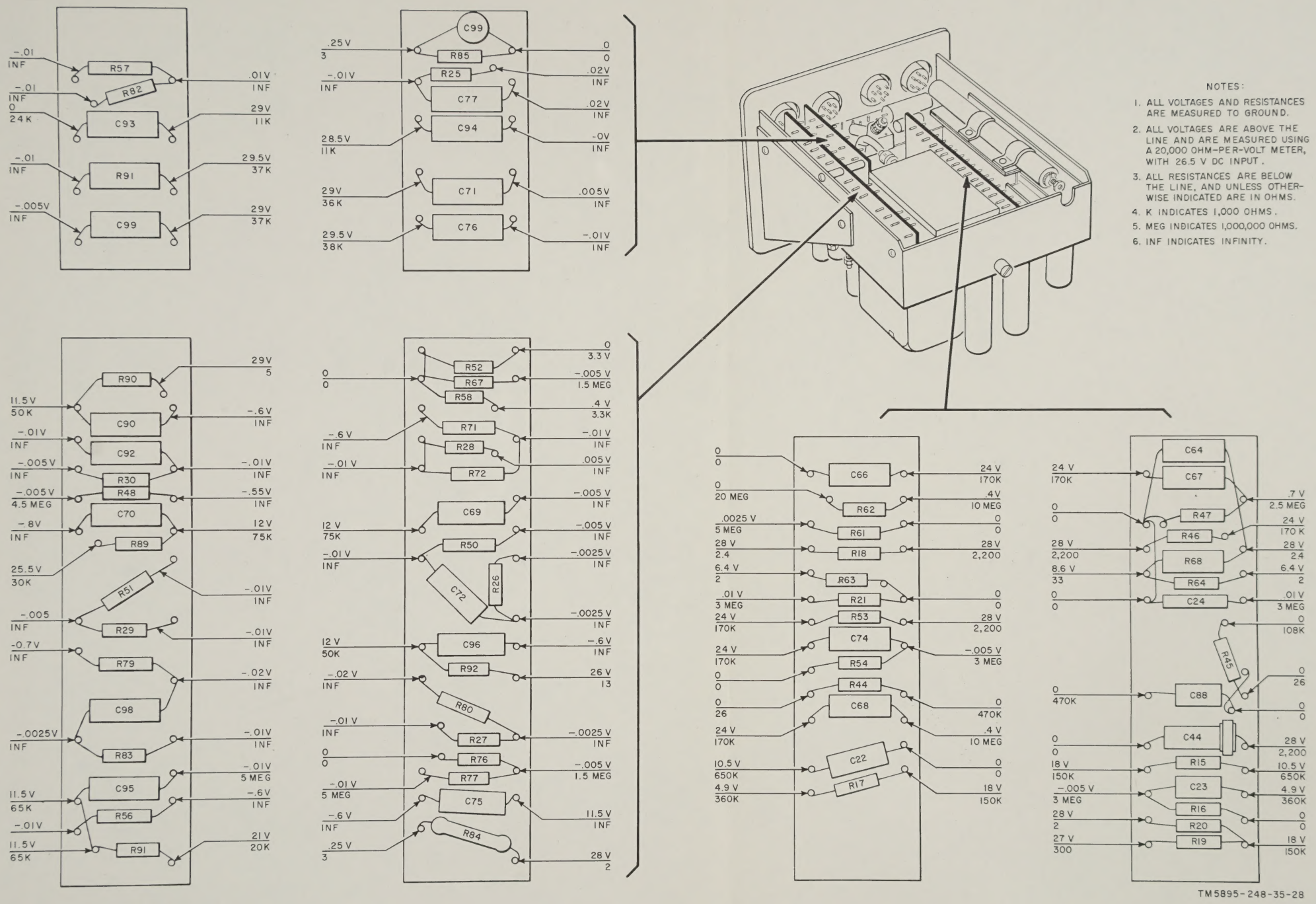
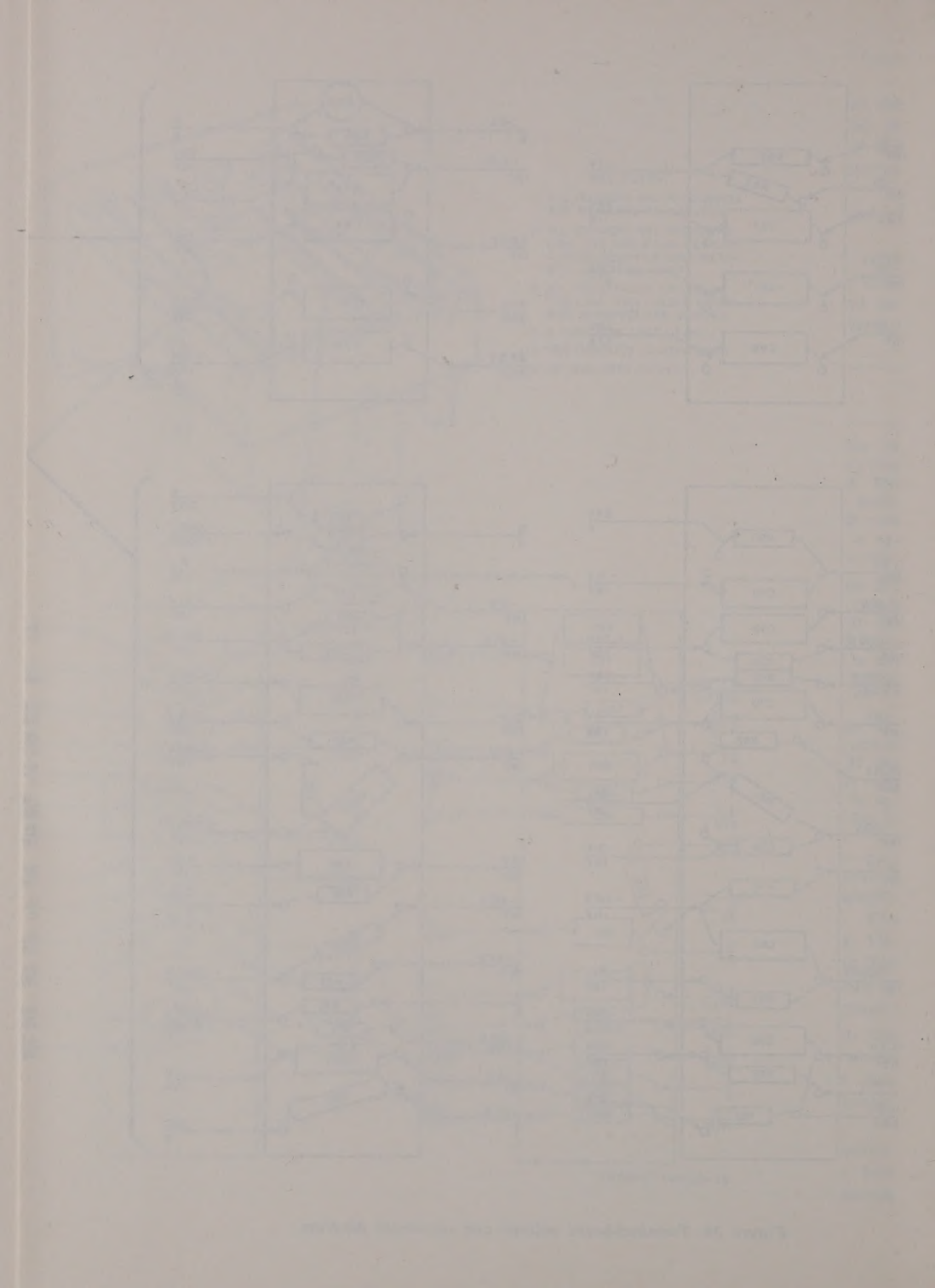


Figure 28. Terminal-board voltage and resistance diagram.



waveform indication for each position of the sweep generator rf output connection as indicated.

Sweep generator if output connection	Possible trouble
Pin 5 of V5	Defective tube V13. Open coil L19 or L20. Defective components in V13 circuit. Out of frequency alignment.
Pin 5 of V4	Defective tube V5. Open coil L7 or L8. Defective components in V5 circuit. Out of frequency alignment.
Test point TP3	Defective V4 tube. Defective components in V4 circuit. Out of frequency alignment.
Test point TP2	Defective tube V3. Defective components in V3 circuit. Out of frequency alignment.
Test point TP1	Defective tube V2. Defective components in V2 circuit. Out of frequency alignment.
Junction of R1 and C1	Defective tube V1 (fig. 21). Defective components in V1 circuit. Out of frequency alignment.

29. Stage-Gain Measurements

Use the techniques outlined in *a*, *b*, and *c* below when the output of the receiver is abnormally low or distorted; see the equipment performance checklist (par. 22) and the troubleshooting chart (par. 27).

a. General Instructions. Connect the receiver to a 28-volt dc power source. Turn the dc power on. Record the output level of the generator for each of the tests (*b* and *c* below), and determine the gain of each stage. Stage gains are shown in the charts (*b* and *c* below).

b. Af Stages. Connect the verticle amplifier input of the oscilloscope to pin G of POWER connector. Apply a signal from the audio oscillator to the points indicated in the chart below. Adjust the oscilloscope vertical amplitude control for visual indication of sufficient amplitude and compare the oscillator readings and computed stage gains with those listed below. Gain indications within 10 percent indicate normal operation. If the gain is abnormally low, use further isolating techniques (par. 30) to determine the defective part within the stage.

Test connection	Input voltage (volts rms)	Stage gain
Pin 5 of V6	3.5	7
Test point TP8	3.5	7

c. Mixer and If Stages. Connect pin G of POWER receptacle J4 to the vertical amplifier of the oscilloscope. Apply a signal from the sweep generator through a 100- to 1,000-micromicrofarad capacitor to the points indicated in the chart below. Adjust the sweep generator to provide a center frequency of 33.5 mc with a sweep frequency of approximately 4-mc total. Adjust the oscilloscope vertical amplitude for visual indication of sufficient amplitude and compare the gain measurements with those listed below. These gain measurements are obtained from the amount of added attentuation in the sweep generator output required to maintain the same signal amplitude on the oscilloscope when applying the sweep generator output through each additional stage. If the measurements are within 10 percent, the receiver mixer and if gain is normal. If the gain is abnormally low, use further isolating techniques (par. 30) or check the alignment (par. 37).

Test connection	Stage	Stage gain
TP3	V4 and V5	23
TP2	V3	10
TP1	V2	20
Pin 1 of V1	V1	3

30. Isolating Trouble Within Stage

When trouble has been localized to a stage, use the following techniques to isolate the defective part:

a. Test the tube involved, either using a tube tester or by substituting a known good tube.

b. Take voltage measurements at the tube sockets (fig. 27) and other points related to the stage in question (fig. 28).

Note. When making voltage measurements at the tube sockets, use test socket adapters so that the measurements can be made from the top of the chassis.

c. If voltage readings are abnormal, take resistance readings (fig. 27 and 28) to isolate open and short circuits. Refer also to the dc resistance of transformers and to the relay solenoids (fig. 32).

d. If signals are weak and all checks fail to indicate a defective part, check the alignment of the receiver (par. 37).

e. Use the schematic (fig. 38) and the wiring (fig. 39) diagrams to circuit trace and isolate the faulty component.

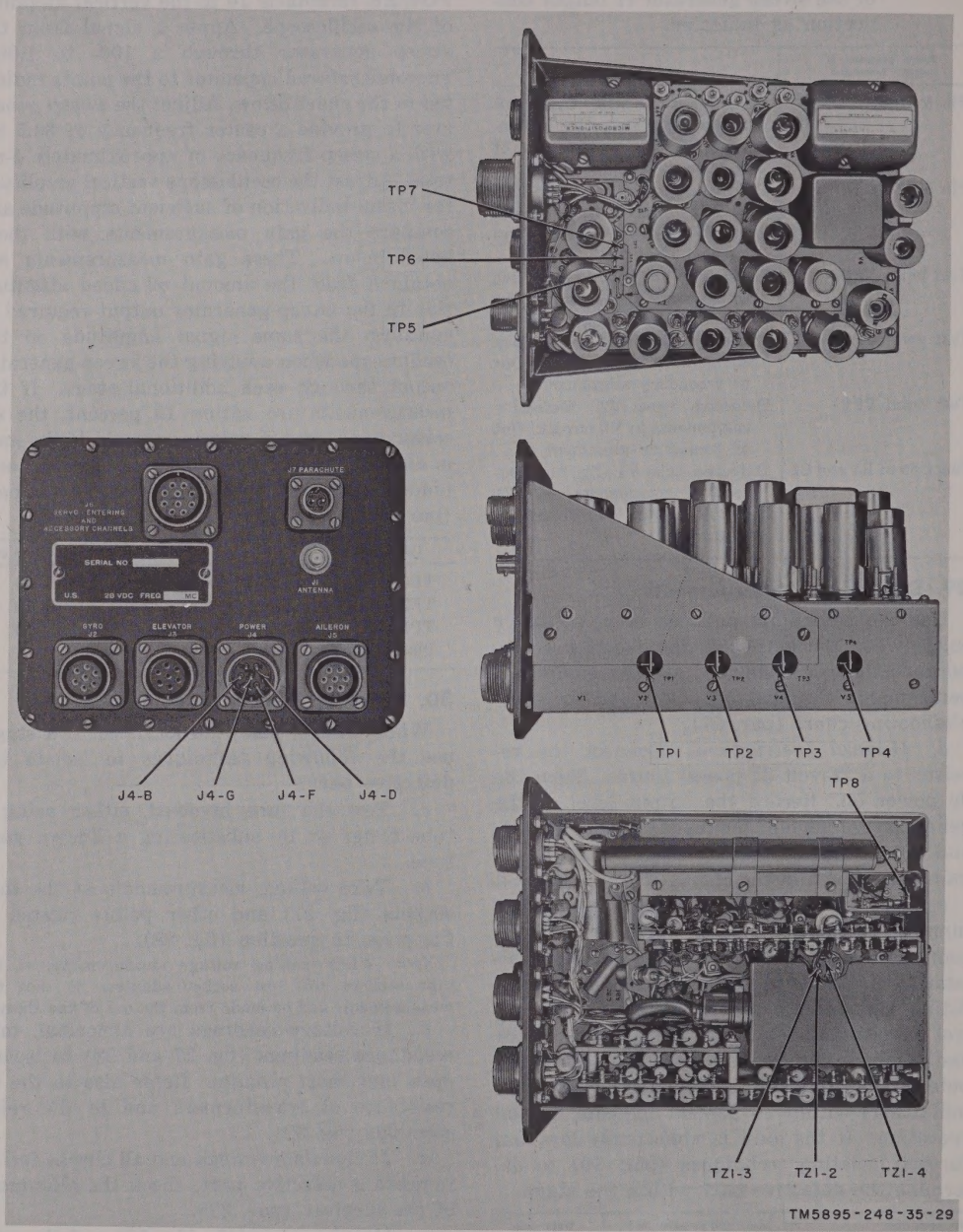


Figure 29. Location of test points.

31. Test Points
(fig. 29)

Several test points and connections are available in the receiver circuit to facilitate troubleshooting and alignment. The test points listed below are used throughout the troubleshooting (par. 27 through 29) and alignment (par. 37) procedures.

a. Test points TP1 through TP8 are associated with the rf, if, local oscillator, and discriminator circuits of the receiver. The function and location of these test points are given in the following chart:

Test point	Circuit location	Testing function
TP1	Control grid V2	Output of first if transformer consisting of L1 and L2.
TP2	Control grid V3	Output of second if transformer consisting of L3 and L4.
TP3	Control grid V4	Output of third if transformer consisting of L5 and L6.
TP4	Low signal end of coil L8.	Grid current of limiter V5.
TP5	Grid circuit of V11A	Grid current of third doubler.
TP6	Grid circuit of V11B	Grid current of second doubler.
TP7	Grid circuit of V12A	Grid current of first doubler.
TP8	Discriminator output	Audio signal output of discriminator V13.

b. The plate supply voltage for parachute relay control V21 and instantaneous chute control V10 is obtained from the 28-volt dc source through pin F of connector J4. When the receiver is connected to the drone wiring, a jumper connects the 28-volt dc supply from pin E of J4 to pin F of J4. During testing, the jumper is removed and an ammeter is connected between pins E and F to measure the combined plate currents of V10 and V21.

c. Two additional circuits can be tested by using pins on POWER connector J4. The limiter bias voltage can be measured by connecting a vacuum tube voltmeter between pin B of J4 and ground. The auxiliary audio output of TZ1 can be observed by connecting the oscilloscope vertical input between pin G of J4 and ground.

32. Dc Resistances of Transformers, Coils, and Relays

The dc resistances of the transformers, coils, and relays in the receiver are listed in the following chart:

Transformer, coil, or relay	Terminals	Resistance (ohms)
K1	1 and 7	2,000
K2	1 and 7	2,000
K3	1 and 3	3,500
	5 and 7	3,500
K4	1 and 3	3,500
	5 and 7	3,500
L1		Less than 1
L2		Less than 1
L3		Less than 1
L4		Less than 1
L5		Less than 1
L6		Less than 1
L7		Less than 1
L8		Less than 1
L9		1
L10		2.5
L11		Less than 1
L12		Less than 1
L13		Less than 1
L14		Less than 1
L15		2.4
L16		2.4
L17A		Less than 1
L17B		4.8
L18		2.4
L19		Less than 1
L20		Less than 1
L21		13.5
L22		Less than 1
L23		Less than 1
T1	Primary	Less than 1
	Secondary	Less than 1
TZ1	5 and 6	250 to 300
	1 and 9	0

CHAPTER 4
REPAIRS AND ALIGNMENT

Section I. REPAIRS

33. Parts Replacement

a. General. The receiver has three major parts: the front panel, the rf chassis, and the main chassis. All the connectors and the individual bypass capacitors associated with each connector pin are mounted on the front panel (fig. 21). The connectors are interconnected with the rf chassis and the main chassis by wiring harnesses. The local oscillator, rf mixer, if amplifier, limiter, and discriminator circuit components are on the rf chassis. Cavity resonator Z1 (fig. 23) and two shielding plates are mounted below the rf chassis. The roll, pitch, parachute, and instantaneous control channels and the af amplifier circuit components are mounted on the main chassis. The front panel and rf chassis are attached to the main chassis (fig. 24).

b. Removal and Replacement Precautions. When removing and replacing a receiver part, observe the following precautions:

(1) Tag and identify all interconnecting wires and cables that are to be disconnected.

(2) Observe the position and length of all wires that are disconnected. If necessary, mark the wires on the wiring diagram (fig. 39).

(3) During the disassembly and reassembly procedures, do not disturb any adjustments. Refer to the adjustment and alignment procedures (par. 34 through 37) before performing the readjustments or realignment.

(4) Use identical replacement parts. Be sure to replace all parts as originally placed.

(5) Be careful when soldering wires and parts to their respective mountings. Excessive heat can change values or physically distort many of the parts. Hold the wires or leads with a pair of long-nosed pliers to dissipate excessive heat.

c. Parts Removal. Follow the procedures below for removing the major components from the receiver. Refer to figures 21 and 23 through 26 for location of parts within the receiver.

(1) To remove the front panel, remove the mounting hardware on both sides of the main chassis and unsolder all interconnecting wiring harness leads.

(2) To remove rf transformers Z1, unsolder the two coaxial cables and remove the two screws securing Z1 to the rf chassis shielding plates.

(3) To remove the rf chassis shielding plates, remove rf transformer Z1 ((2) above); then remove the seven screws that secure the shielding plates to the chassis and unsolder all interconnecting wires.

(4) To remove the rf chassis, remove the rf chassis shielding plates ((3) above); then remove the two screws that secure the rf chassis to the main chassis and unsolder the two coaxial cables.

(5) To remove command signal decoder Z2, disconnect the miniature multipin connector; then remove the four screws and the mounting stud that secure Z2 to the main chassis.

(6) To remove the terminal boards, first unsolder all interconnecting wires; then remove the terminal board mounting screws.

Note. Many parts on the terminal boards can be replaced without removal of the terminal boards from the main chassis.

34. Micropositioner Adjustment (fig. 30 and 31)

The two adjusting arms (fig. 30) on the micropositioner are used to adjust the contact closure sensitivity. Throughout the adjustment, the sensitivity is checked on the test set. When the test set is used for micropositioner testing or adjustment, its pulse length meter indicates the current flowing through the micropositioner coil under test, and the

appropriate MICROPOSITIONER indicator lights when a set of micropositioner contacts close. The two red lines on the test set pulse length meter indicate minimum and maximum currents that should close the contact. To increase the sensitivity, move the adjusting arms toward the top of the micropositioner. Note that each adjusting arm will also affect the sensitivity of the opposite set of contacts. Proceed with the adjustment as follows:

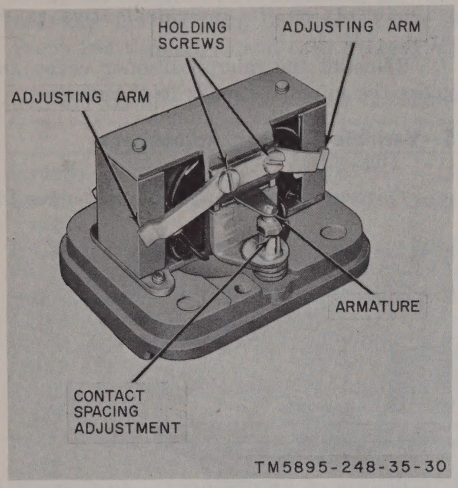


Figure 30. Micropositioner, showing location of adjusting parts.

Note. By varying the micropositioner sensitivity adjustment within the limits of the two red lines, the micropositioner may be used to compensate for variations in the drone flight control system which affect the *dead zone* width. Increasing the sensitivity of the micropositioner by adjusting for contact closure at low readings will decrease the *dead zone* width. Decreasing the sensitivity by adjusting for contact closure at high readings will increase the *dead zone* width. In general, it is desirable to maintain the minimum *dead zone* width at the highest anticipated dc supply. The *dead zone* width should not be so small as to result in servo hunting.

a. Remove the micropositioner from the receiver, remove the micropositioner cover, and plug the micropositioner into the MICROPOSITIONER TEST socket on the test set.

b. Rotate the pulse length meter selector switch to MP ADJUST.

c. Turn the MP TEST switch to R.

d. Rotate the MP ADJUST control until the MICROPOSITIONER R indicator lights. Note the position of the pulse length meter needle in relation to the two red lines.

e. Rotate the MP ADJUST control until the pulse length meter needle is centered between the two red lines.

f. Fabricate or obtain an adjusting tool similar to the one in figure 31. Use this tool to move the adjusting arms (fig. 30) until the left-hand indicator light flickers. In making this adjustment, move both the left and the right arms approximately the same distance. Tap lightly on top of the coil to relieve frictional effects.

Note. If it is impossible to adjust the micropositioner within the required limits, replace the micropositioner with a new one. Check the replacement micropositioner (par. 24) for proper operation.

g. While varying the MP ADJUST control,

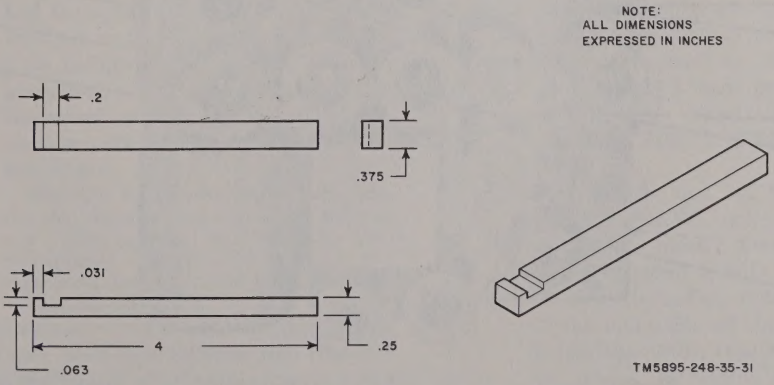


Figure 31. Suggested tool for adjusting micropositioner.

observe the pulse length meter needle position at the instant the MICROPOSITIONER R indicator lights and also when it goes out. The pulse length meter needle must indicate between the red lines when the MICROPOSITIONER R indicator lights and should not move more than three divisions before the indicator goes out.

h. Position the MP TEST switch to L.

i. Rotate the MP ADJUST control until the MICROPOSITIONER L indicator lights. Note the position of the meter needle in relation to the two red lines.

j. Repeat the procedure in *e* through *g* while observing the MICROPOSITIONER L indicator.

k. Recheck both contact closures by repeating the procedure in *c* through *j* above. Make readjustments on the individual arms as required.

l. Reinstall the micropositioner cover and replace the micropositioner in the receiver.

35. Variable Resistor Adjustments
(fig. 32)

a. General. The adjustment procedues for

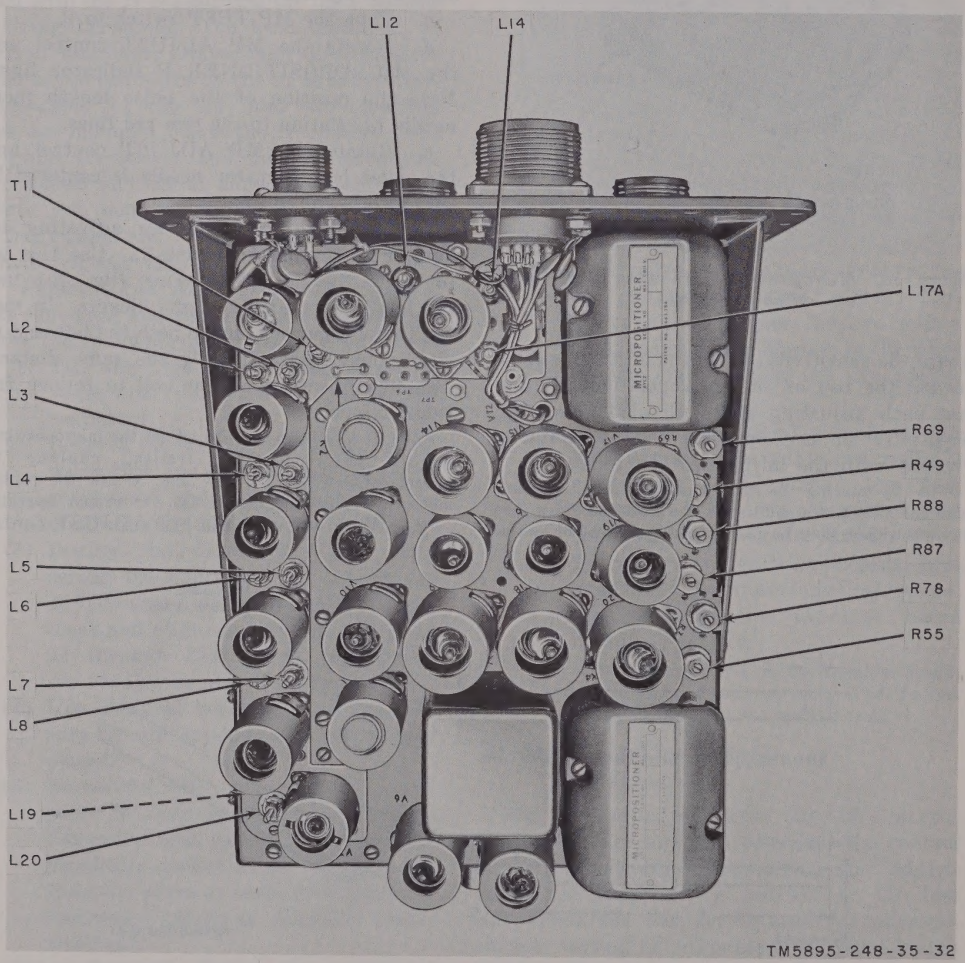


Figure 32. Location of adjustments.

variable resistors R49, R55, R69, R78, R87, and R88 are given in *b* through *d* below, and for R86 (fig. 23) *e* below.

b. Equipment Setup for Adjustments. To set up the equipment for adjusting the variable resistors, first perform the procedure in paragraph 26*a* through *h*, and then proceed as follows:

(1) Set the test set controls as follows:

Control	Position
POWER switch	ON.
RECEIVER meter selector switch.	30 VOLT SCALE.
Pulse length selector switch	(As noted in *c*, *d*, and *e* below).
ROLL AUTOPILOT TEST-GYRO TEST switch.	AUTOPILOT TEST.
PITCH AUTOPILOT TEST-GYRO TEST switch.	AUTOPILOT TEST.
SIMULATED GYRO SENSITIVITY switch.	NORMAL.
ROLL SIMULATED-SERVO switch.	SIMULATED.
PITCH SIMULATED-SERVO switch.	SIMULATED.
ROLL SERVO control	0
PITCH SERVO control	0
ROLL GYRO control	0
PITCH GYRO control	0
VOLTAGE control	(As indicated in (2) below)
SENSITIVE GYRO control	0
SERVO CENTER roll switch	Down position
SERVO CENTER pitch switch	Down position

(2) Adjust the test set VOLTAGE control for a 27-volt dc indication on the receiver meter.

(3) This completes the equipment setup procedure except for specified changes in control settings and equipment connection noted during the adjustment procedure.

Note. Use a test socket adapter when taking the voltage measurements at the tube pins (*c* through *e* below). Using this adapter eliminates extensive disassembly procedures to provide access for making the voltage measurements.

c. Adjustment of Variable Resistors R49, R69, and R88. Resistors R49 and R69 (fig. 32), in the plate circuit of pitch pulse clippers V15A and V15B respectively, must be adjusted to provide identical output signal amplitudes. Variable resistor R88, in the common cathode circuit of pitch bridge detector amplifier V17, is adjusted for equal outputs of both sections of this tube. Proceed as follows:

(1) Adjust the test set pulse length meter selector switch to PITCH CH.

(2) Adjust the PITCH control knob on the master flight control box to 0.

(3) Connect the vtvm, adjusted to read negative voltage, between pin 7 of V16 and ground.

(4) Adjust variable resistor R49 for a negative 8.5-volt indication on the vtvm.

(5) Connect the vtvm, adjusted to read negative voltage, between pin 2 of V16 and ground.

(6) Adjust variable resistor R69 for a negative 8.5-volt indication.

(7) Remove the vtvm.

(8) Observe the PITCH U and D indicators on the test set for illumination. Adjust variable resistor R88 as required until both lights go out.

(9) Position the test set PITCH SIMULATED-SERVO switch to SERVO.

(10) Rotate the master flight control box PITCH control to 30U.

(11) Observe the action of the pitch servo. If the indication of the servo pointer is less than 30U, repeat (2), (3), and (4) above, increasing the voltage at pin 7 of V16. If the indication of the servo pointer is greater than 30U, repeat (2), (3), and (4) above, decreasing the voltage at pin 7 of V16.

(12) If variable resistor R49 was readjusted ((11) above) position the test set PITCH SIMULATED-SERVO switch to SIMULATED; then repeat (8) above.

(13) Position the test set PITCH SIMULATED-SERVO switch to SERVO.

(14) Rotate the master flight control box PITCH control to 30D.

(15) Observe the action of the pitch servo. If the indication of the servo pointer is less than 30D, repeat (2), (5), and (6) above, increasing the voltage at pin 2 of V16. If the indication of the servo pointer is greater than 30D,

repeat (2), (5), and (6) above, decreasing the voltage at pin 2 of V16.

(16) If variable resistor R69 was readjusted ((15) above) position the test set PITCH SIMULATED-SERVO switch to SIMULATED position; then repeat (8) above.

d. Adjustment of Variable Resistors R55, R78, and R87. Variable Resistors R55, and R78 (fig. 32), in the plate circuit of roll pulse clippers V18A and V18B, must be adjusted to provide identical output signal amplitudes. Variable resistor R87, in the common cathode circuit of roll bridge detector amplifier V20, is adjusted for equal outputs of both sections of this tube. Proceed as follows:

(1) Adjust the test set pulse length meter selector switch to ROLL CH.

(2) Connect the vtvm, adjusted to measure negative voltage between pin 7 of V19 and ground.

(3) Adjust variable resistor R55 for a negative 8.5-volt indication on the vtvm.

(4) Connect the vtvm, adjusted to read a negative voltage, between pin 2 of V19 and ground.

(5) Adjust variable resistor R78 for a negative 8.5-volt indication on the vtvm.

(6) Remove the vtvm.

(7) Observe ROLL L and R indicators on the test set for illumination. Adjust variable resistor R87 as required until the indicators go out.

(8) Position the test set ROLL SIMULATED-SERVO switch to SERVO.

(9) Rotate the master flight control box ROLL control to 50L.

(10) Observe the action of the roll servo. If the indication of the servo pointer is less than 50L, repeat (2) and (3) above, increasing the voltage at pin 7 of V18. If the indication of the servo pointer is greater than 50R, repeat (2) and (3) above, decreasing the voltage at pin 7 of V18.

(11) If variable resistor R55 is readjusted ((10) above), position the test set ROLL SIMULATED-SERVO switch to SIMULATED and repeat (7) above.

(12) Position the test set ROLL SIMULATED-SERVO switch to SERVO position.

(13) Rotate the master flight control box ROLL control to 50R.

(14) Observe the action of the roll servo. If the indication of the servo pointer is less than 50R, repeat (4) and (5) above, increasing the voltage at pin 2 of V18. If the indication of the servo pointer is greater than 50R, repeat (4) and (5) above, decreasing the voltage at pin 2 of V18.

(15) If variable resistor R78 is readjusted ((14) above), position the test set ROLL SIMULATED-SERVO switch to SIMULATED position and repeat (7) above.

e. Adjustment of Variable Resistor R86. Variable resistor R86, in the cathode circuit of parachute command rectifier V8B, varies the delay time in the parachute command circuit.

(1) Depress the CHUTE DELAYED switch button on the master flight control box.

(2) Observe the CHUTE indicator on the test set and determine the time that is required for the indicator to light after the CHUTE DELAYED switch button is pushed.

(3) The time required to illuminate the indicator ((2) above) should be between 10 and 11 seconds. If the time delay is less than that required, turn R86 counterclockwise. If the time delay is greater than that required, turn R86 clockwise.

(4) After each adjustment of R86, repeat (1) through (3) above until the required time delay is obtained.

f. Adjustment Procedure Check. Prior to disconnecting and removing the equipment, perform the equipment performance checks (par. 22*e*) to make sure that the adjustments have been properly made.

36. Test Equipment Required

Following is a list of test equipment required for receiver alignment, the associated technical manuals, and the assigned common names.

Test equipment	Technical manual	Common name
Multimeter AN/URM-105	TM 11-6625-203-12	Multimeter
Signal Generator SG-351/USD-1	TM 11-6625-322-12	Signal generator
Signal Generator TS-452/U	TM 11-2695	Sweep generator
Surveillance Drone Test Set TS-1299/USD-1	TM 11-5895-249-12	Test set

37. Alignment Procedure

The complete alignment procedures for the receiver are given below. The procedures include alignment of the mixer, if amplifier, discriminator, and local oscillator stages. The if amplifier and discriminator stages are aligned when the receiver is shipped from the factory, and should not require realignment unless parts have been replaced in the if amplifier or troubleshooting procedures indicate misalignment. The mixer and local oscillator stages must be realigned each time oscillator crystal Y1 is changed to obtain a different operating frequency.

a. If Amplifier Alignment. The if amplifier stages amplify wide-band (±300 kilocycles) frequency-modulated signals transmitted from the ground station. To pass this wide band of frequencies without attenuation, overcoupled, wide-band coupling circuits are used between the if stages. The if center frequency must be adjusted to exactly 33.5 mc to insure proper reception of the crystal-controlled transmitter signals. The sweep generator has a tunable wavemeter that applies a marker to the oscilloscope display. The RF OUTPUT of the sweep generator is connected to the input of the if stage to be aligned. The output of this if stage is connected to the VERTICAL INPUT of the sweep generator oscilloscope (fig. 33). With this arrangement, the sweep frequency response curve and a marker are displayed on the oscilloscope screen. Proceed with the alignment as indicated below.

Note. During the alignment procedure, refer to figures 29 and 32 for location of all test points and adjustments.

(1) Place the test set, sweep generator, and receiver on a bench large enough to allow accessibility to all controls and observation of the oscilloscope screen on the sweep generator.

Note. The test set is used during the alignment procedure to supply dc voltages for the receiver operation and to measure the limiter (V5) grid current.

(2) Interconnect the receiver and the test equipment (fig. 33).

(3) Remove receiver mixer tube V1.

(4) Turn the test set POWER switch on. Turn on the MAIN POWER switch on the sweep generator and allow the sweep generator to warm up for approximately 10 minutes.

(5) Adjust the receiver input dc voltage to 26.5 volts.

(6) Connect a capacitor to the end of the sweep generator rf output cable. This capacitor should have a value between 100 and 1,000 micromicrofarads.

(7) Plug the 20- to 42-mc coil into the operating coil socket on top of the sweep generator. Adjust the sweep width to approximately 4 mc total. Connect the sweep generator RF OUTPUT to test point TP3 (fig. 29).

(8) Connect the sweep generator VERTICAL INPUT to test point TP4; use the demodulator probe. Set the sweep generator signal attenuator controls and vertical gain control to obtain approximately a 1-inch-high pattern on the sweep generator oscilloscope.

Note. Throughout the alignment procedure, maintain the pattern height approximately one inch by readjusting the sweep generator attenuators as required. Keep the sweep generator output as low as possible to eliminate any possibility of overdriving the circuits being aligned.

(9) Adjust the WAVEMETER TUNING control of the sweep generator to 33.5

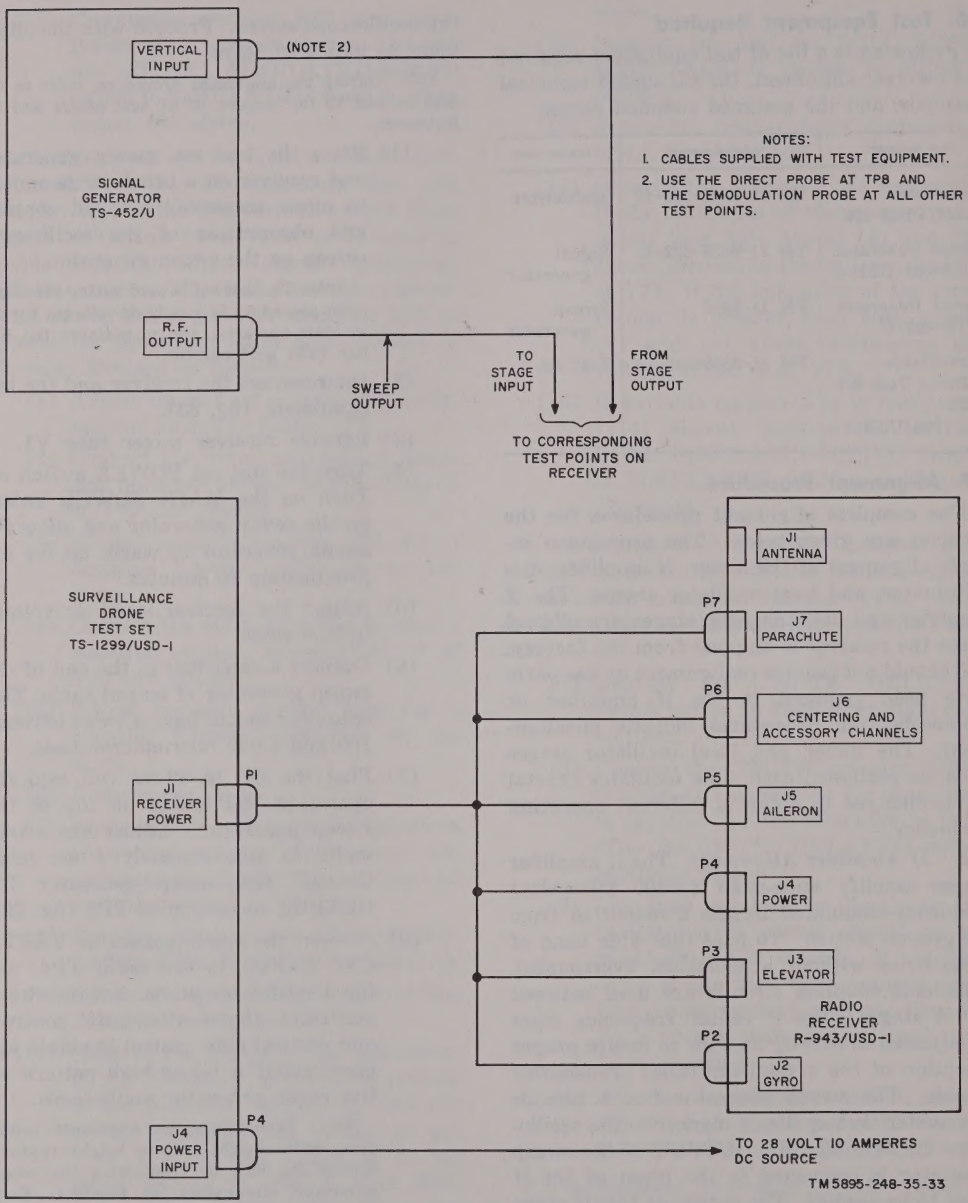


Figure 33. Test setup for if alignment.

mc. Observe the position of the marker on the oscilloscope display.

Note. To increase the resonant frequency of the coils, turn the adjusting screws counterclockwise. To decrease the frequency, turn the screws clockwise.

(10) Adjust L7 and L8 to obtain frequency bandpass output as illustrated in A, figure 34. Alternately adjust the coils to obtain a symmetrical pattern, as indicated, with maximum amplitude.

(11) Adjust the WAVEMETER TUNING control of the sweep generator to 32.8 mc and then 34.2 mc, and observe the positions of the marker on the oscilloscope pattern. In both cases, the marker should coincide with the maximum points on either side of the center valley.

(12) Readjust L7 and L8 as required to obtain the condition noted ((11) above).

(13) Disconnect the demodulation probe from TP4 and connect the sweep generator VERTICAL INPUT to test point TP8; use the direct probe and cable.

(14) Alternately adjust L19 and L20 to obtain the waveform in B, figure 34. Note that by adjusting L20 the relative position of the marker on the S-curve can be moved. Adjust L20 until the 33.5-mc marker coincides with the center of the S-curve.

(15) Adjust the sweep generator control WAVEMETER TUNING to 33 mc. Observe that the marker on the oscilloscope display coincides with one of the maximum points on the S-curve. Adjust the WAVEMETER TUNING to 34 megacycles. Observe that the marker now coincides with the other maximum point on the S-curve.

(16) Readjust L19 and L20 as required to obtain the condition given in (15) above. Be certain that the center of the S-curve remains at 33.5 mc.

(17) Disconnect the sweep generator RF OUTPUT from TP3 and connect it to test point TP2. Disconnect the VERTICAL INPUT cable from TP8 and connect it to test point TP4; use the demodulation probe.

(18) Adjust L5 and L6 to obtain a symmetrical waveform as illustrated in C, figure 34. Readjust L7 and L8 as necessary to maintain proper balance of waveform maximum points.

(19) Disconnect the sweep generator rf cable from TP2 and connect it to TP1.

(20) Adjust L3 and L4 to obtain a symmetrical waveform as illustrated in D, figure 34. Readjust L5, L6, L7, and L8 as required to maintain a proper balance of waveform maximum points.

(21) Insert electron tube V1 into its socket. Allow enough time for the tube to warm up.

Note. For the procedure in (22) below, it is assumed that crystal Y1 has been inserted into its socket, and that the rf and local oscillator stages have been properly aligned. Refer to *b* below for the rf and oscillator alignment procedure.

(22) Disconnect the sweep generator rf cable from TP1 and connect it to ANTENNA connector J1.

(23) Adjust L1 and L2 to obtain the waveform illustrated in E, figure 34. Check to insure that the 33.5-mc marker is located exactly in the center of the waveform, and that the waveform is symmetrical about the 33.5-mc marker.

Note. It may be desirable at this point to slightly retune all of the if adjustments to provide the best waveforms as shown on the oscilloscope screen. Be very careful not to detune the center frequency of the individual tuned circuits from 33.5 mc.

(24) This completes the if alignment; turn off and disconnect the test equipment.

b. Mixer and Local Oscillator Alignment. The mixer and local oscillator stages are aligned by adjusting the tuned circuits in each stage for maximum grid current. This procedure uses Surveillance Drone Test Set TS-1299/USD-1, Signal Generator SG-351/USD-1, and Multimeter AN/URM-105. Proceed with the mixer and local oscillator alignment as follows:

(1) Place the test equipment and the receiver on a bench large enough so that all controls can be reached.

(2) Connect the receiver to the test set

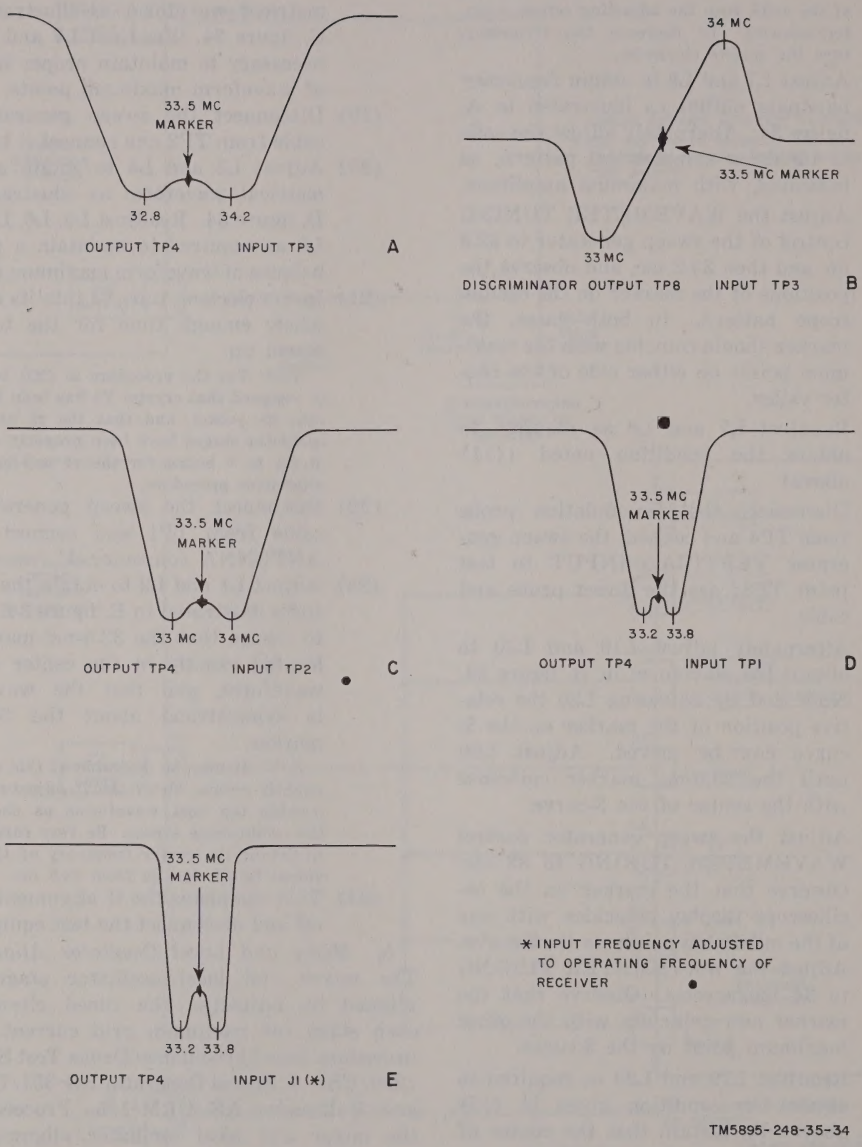


Figure 34. Frequency response waveforms.

as shown in figure 33, and the signal generator RF OUTPUT 52 OHMS to the receiver ANTENNA input.

(3) Turn the test set and signal generator POWER switches on. Allow the signal generator to warm up for approximately 10 minutes. Turn the signal generator CARRIER switch to ON.

(4) Adjust the receiver input dc voltage to 26.5 volts.

(5) Insert a type CR-23/U crystal of the correct frequency in the Y1 crystal socket. To obtain the correct crystal for a desired receiver frequency, refer to the following chart.

Receiver frequency (mc)	Crystal frequency (mc)	Crystal part No.
406	46.5625	68422-1
407	46.6875	68422-3
408	46.8125	68422-5
409	46.9375	68422-7
410	47.0625	68422-9
411	47.1875	68422-11
412	47.3125	68422-13
413	47.4375	68422-15
414	47.5625	68422-17
415	47.6875	68422-19
416	47.8125	68422-21
417	47.9375	68422-23
418	48.0625	68422-25
419	48.1875	68422-27
420	48.3125	68422-29

(6) Connect the multimeter positive lead to the receiver chassis and the negative lead to test point TP7 (fig. 29). Set the multimeter controls to the 10-ma scale.

(7) Adjust oscillator coil L17A for a maximum indication on the multimeter.

(8) Disconnect the multimeter negative lead from TP7 and connect it to TP6.

(9) Adjust doubler coil L14 for a maximum indication on the multimeter.

(10) Disconnect the multimeter negative lead from TP6 and connect it to TP5.

(11) Adjust doubler coil L12 for a maximum indication on the multimeter.

(12) Repeat the procedure in (6) through (11) above to insure peak readings.

(13) Connect the negative multimeter lead to the receiver chassis. Connect the positive multimeter lead to the junction of R1 and C1, located on coaxial resonator Z1 (fig. 23). Set the multimeter to the 2.5-volt dc scale. Adjust doubler transformer T1 for a maximum indication on the multimeter. Disconnect the multimeter.

(14) Turn the signal generator POWER switch and CARRIER switch on and allow the signal generator to warm up for 10 minutes. Adjust the signal generator to the desired rf carrier frequency with 7,500-cycle (recovery) frequency modulation and ±300-kc deviation.

(15) Turn the pulse length meter selector switch on the test set to RCVR TUNE. Adjust the attenuator control on the signal generator for a reading between 60 and 80 on the test set pulse length meter.

(16) Adjust the coaxial resonator Z1 tuning screw for a maximum indication on the test set pulse length meter. It may be necessary to reduce the signal generator output while making this adjustment to maintain the reading on the test set meter scale.

Note. The Z1 tuning screw is accessible from the rear of the chassis. Adjusting this screw tunes the capacitor inside the coaxial resonator.

(17) This completes the mixer and local oscillator alignment; turn off and disconnect the test equipment.

CHAPTER 5
FINAL TESTING

38. Purpose of Final Testing

The purpose of final testing is to determine receiver performance after fourth or fifth echelon overhaul or repair and alignment. A receiver that meets the minimum standards stated in these tests will furnish satisfactory operation equivalent to that of new equipment.

39. Test Equipment Required

The following chart lists the test equipment required for final testing the receiver and gives its associated technical manuals, and the assigned common names.

Test equipment	Technical manual	Common name
Audio Frequency Coder KY–294/USD–1	TM 11–5821–215–12	Coder.
Audio Oscillator TS–382E/U	TM 11–2684A	Audio oscillator.
Automatic Pilot Servometer TG–71/USD–1		Servo.
Automatic Roll and Pitch Control C–2903/USD–1.		Gyro.
Signal Generator SG–351/USD–1	TM 11–6625–322–12	Signal generator.
Surveillance Drone Control C–2941/USD–1	TM 11–5821–215–12	Master flight control box.
Surveillance Drone Test Set TS–1299/USD–1.	TM 11–5895–249–12	Test set.
Stop watch		Stop watch.

40. Test Setup and Preliminary Checks

To set up the equipment for final testing, follow the procedures in paragraph 26*a* through *h* and then proceed as follows:

a. Turn the RECEIVER meter selector switch on the test set to 30 VOLT SCALE. Adjust the VOLTAGE control until the receiver meter reads 27.0 volts.

b. Turn the RECEIVER meter selector switch on the test set to the INPUT 3 AMP SCALE position. The receiver meter should indicate 2 amperes ±10 percent.

c. Turn the test set pulse length meter selector switch to the RCVR TUNE position. The pulse length meter should now indicate in the upper half of its scale.

d. Set the ROLL and PITCH AUTOPILOT TEST-GYRO TEST switches to their AUTOPILOT TEST positions. Set the ROLL and PITCH SIMULATED-SERVO switches to their SIMULATED positions.

e. Adjust the signal generator OUTPUT SIGNAL ATTENUATOR for an indication of 50 microvolts on the RF OUTPUT meter.

f. Adjust the ROLL and PITCH control knobs on the master flight control box and the ROLL GYRO, PITCH GYRO, ROLL SERVO, and PITCH SERVO simulated controls on the test set to zero.

g. Adjust the ROLL TRIM and PITCH TRIM controls on the master flight control box until the ROLL L and R and the PITCH U and D indicators on the test set go out.

h. Set the RECEIVER meter selector switch to 30 VOLT SCALE, and adjust the VOLTAGE control until the receiver meter reads 22.5 volts.

41. Roll and Pitch Channel Testing

After the equipment has been set up (par. 40), follow the procedures in *a*, *b*, and *c* below to test the roll and pitch channels.

a. Dead Zone. Turn the ROLL GYRO control to the right and then to the left until the ROLL L and R indicators light. At the point where an indicator lights, observe the reading on the ROLL GYRO knob scale. The readings should not exceed ±5°. Turn the PITCH GYRO control on the test set as to the right and then to the left while observing the PITCH U and D indicators. The PITCH GYRO knob scale reading also should not exceed ±5° to the point where the indicators light. Adjust the input voltage to 29 volts dc,

with the ROLL GYRO and PITCH GYRO controls set to zero. The roll and pitch servos should not hunt.

b. Roll and Pitch Command Test.

(1) Adjust the input voltage to 27 volts dc. Set the ROLL and PITCH controls on the master flight control box and test set to zero.

(2) Set the pulse length meter selector switch on the test set to ROLL CH. Rotate the ROLL on the master flight control box to 50R.

(3) Rotate the ROLL GYRO control on the test set until the R indicator goes out. The ROLL GYRO knob should indicate 50° R ±5°.

(4) Rotate the ROLL control on the master flight control box to 50L. Rotate the ROLL GYRO knob on the test set until the L indicator goes out. The ROLL GYRO knob should indicate 50° L ±5°. Return all ROLL controls to zero.

(5) Set the pulse length meter selector switch on the test set to PITCH CH.

(6) Rotate the PITCH control on the master flight control box to 30U. Rotate the PITCH GYRO knob on the test set until the U indicator goes out. The PITCH GYRO knob should indicate 30° U ±5°.

(7) Rotate the PITCH control on the master flight control box to 30D. Rotate the PITCH GYRO control on the tester set until the D indicator goes out. The PITCH GYRO control knob should indicate 30° D ±5°. Return all PITCH controls to zero.

c. Roll and Pitch Servo Followup Test. All controls and indicators referred to in this portion of the test are on the tester set.

(1) Set the pulse length meter selector switch to ROLL CH. Make sure the ROLL GYRO and ROLL SERVO controls are at zero. Both the R and L indicator lamps should be out.

(2) Rotate the ROLL GYRO simulator control to 40° R. Rotate the ROLL SERVO simulator control until the R indicator goes out. The ROLL SERVO simulator knob should indicate 20° L ±5°.

(3) Rotate the ROLL GYRO simulator control to 40° L. Rotate the ROLL SERVO simulator control until the L indicator goes out. The ROLL SERVO simulator knob should indicate 20° R ±5°. Return all ROLL controls to zero.

(4) Set the pulse length meter selector switch to PITCH CH. Make sure the PITCH SERVO and PITCH GYRO controls are at zero. Both the U and D indicator lamps should be out.

(5) Rotate the PITCH GYRO control to 30° D. Rotate the PITCH SERVO simulator control until the D indicator goes out. The PITCH SERVO knob indicator should indicate 18° U ±5°.

(6) Rotate the PITCH GYRO simulator control to 30° U. Rotate the PITCH SERVO simulator control until the U indicator goes out. The PITCH SERVO knob should indicate 18° D ±5°. Return all PITCH controls to zero.

42. Parachute Channel Testing

After the equipment has been set up (par. 40), follow the procedures in *a* through *d* below to test the parachute channel.

a. With the RECEIVER meter selector switch on the test set at the 30 VOLT SCALE position, adjust the VOLTAGE control for an indication of 22.5 volts on the receiver meter.

b. Depress and hold the CHUTE INSTANT button on the master flight control box and observe the CHUTE indicator on the test set. The CHUTE indicator should go out within 0.5 seconds after the CHUTE INSTANT button is depressed. Release the CHUTE INSTANT button and allow the CHUTE indicator to light.

c. Depress and hold the CHUTE DELAYED button on the master flight control box while timing the CHUTE indicator on the test set. The CHUTE indicator should go out 10 ±4 seconds after the CHUTE DELAYED button is depressed. Release the CHUTE DELAYED button.

d. Adjust the input voltage as in *a* above to 29 volts and repeat *b* and *c* above. Readjust the input voltage to 27 volts.

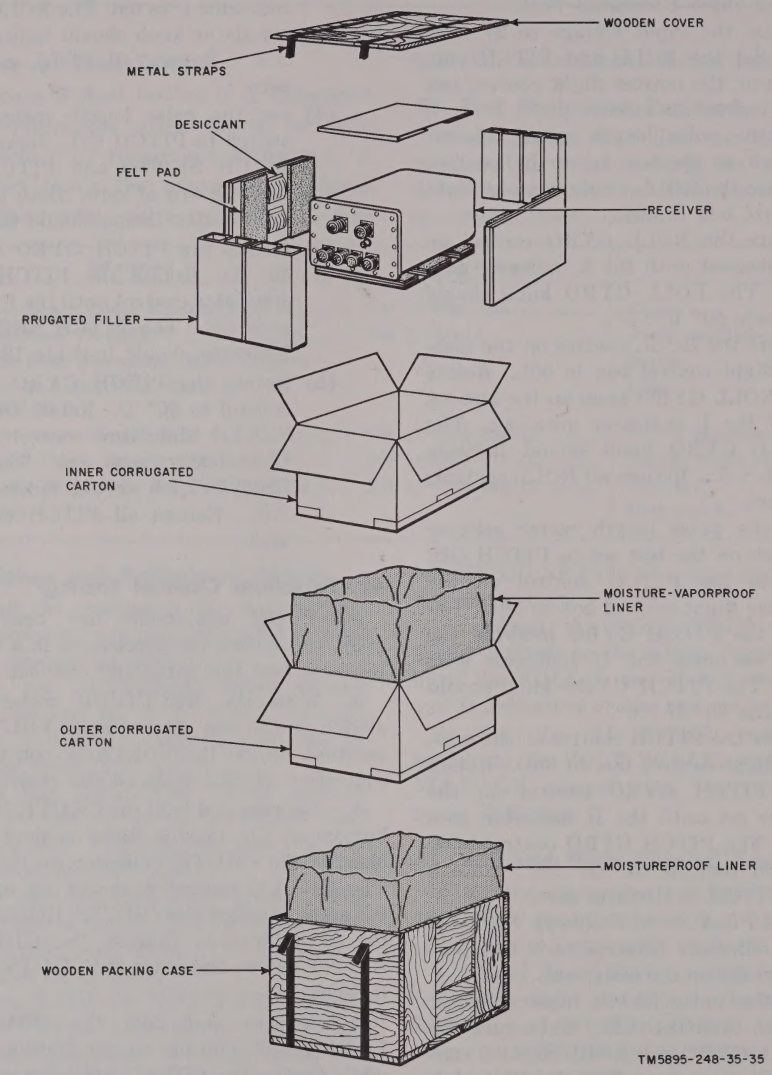


Figure 35. Repackaging diagram.

CHAPTER 6
SHIPMENT AND LIMITED STORAGE, AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

43. General

The receiver is a completely self-contained unit, housed in a rectangular metal case. If all the parts within the case are tightly secured against their respective mounting surfaces, and the panel-chassis assembly is secured against the flange on the metal case, this unit is capable of withstanding normal handling without damage.

44. Shipment and Storage Instructions

a. Disassembly of Equipment. No disassembly of the equipment for shipment or storage is required; however, prior to packaging the equipment, proceed as follows:

(1) Remove the 20 screws around the edge of the front panel.

(2) Remove the panel-chassis assembly from the case.

(3) Inspect the equipment to make sure that all plug-in components are securely mounted.

(4) Inspect all other components for secure mounting.

(5) After determining that all components are properly mounted, reinstall the panel-chassis assembly into the case and secure it with the 20 screws.

b. Materials Required. The materials below are required for packaging the receiver. For stock numbers, consult SB 38-100.

Material	Quantity
Waterproof paper	4 sq ft
Waterproof tape	7 ft
Filler material (felt padding or equivalent).	½ lb
Corrugated cardboard	6 sq ft
Desiccant	4 bags
Dust caps:	
½′ dia.	1
⅜′ dia.	1
¾′ dia.	4
1′ dia.	1
Lumber	6 board ft

c. Packing Instructions. Pack the receiver as given below, and illustrated in figure 35.

(1) Install dust caps on all the connectors.

(2) Install desiccant against one side of the receiver case. Cushion all surfaces of the receiver with felt pads.

(3) Place the receiver in the inner corrugated carton. Place the technical manuals on top of the receiver and seal the inner corrugated carton with gummed tape.

(4) Place the sealed carton into the outer corrugated carton that contains a moisture-vaporproof liner; then seal this carton with gummed tape.

(5) Place the package into a wooden packing case that contains a moistureproof liner.

(6) Place the wooden cover on the wooden packing case and secure it with nails and metal straps.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

45. Authority for Demolition

Demolition of the equipment will be accomplished only upon the order of the commander. The destruction procedures outlined in paragraph 46 will prevent further use of the equipment.

46. Methods of Destruction

Use the following methods to destroy the equipment:

a. Smash. Smash the tubes, coils, switches, capacitors, relays, micropositioners, resistors,

and chassis; use sledges, axes, handaxes, pickaxes, hammers, or crowbars.

b. Burn. Burn technical manuals; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

c. Bend. Bend cover and case.

d. Dispose. Bury or scatter the destroyed parts in slit trenches, foxholes, or throw them into waterways.

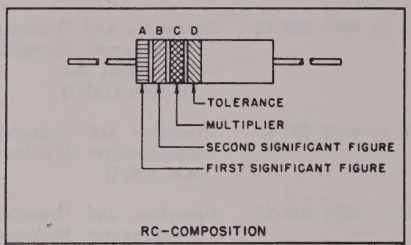
APPENDIX
REFERENCES

Following is a list of references applicable and available to the field and depot maintenance repairman of the receiver.

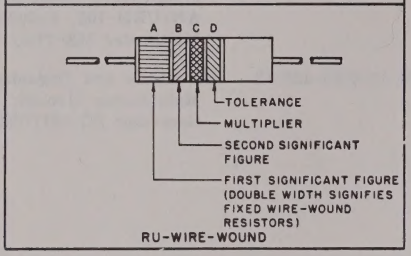
SB 38-100	Preservation, Packaging, and Packing Materials, Supplies, and Equipment Used in the Army.
TM 11-2684A	Audio Oscillator TS-382E/U
TM 11-2695	Signal Generator TS-452/U
TM 11-5083-1	Electron Tube Test Sets TV-7/U
TM 11-5131	Oscilloscope OS-46/U and OS-5001/U
TM 11-5132	Voltmeter, Meter ME-30A/U and Voltmeters, Electronic ME-30B/U and ME-30C/U
TM 11-5821-215-12	Flight Control Groups OA-2380/USD-1 and OA-2381/USD-1
TM 11-5895-249-12	Operator's and Organizational Maintenance: Surveillance Drone Test Set TS-1299/USD-1
TM 11-6625-200-12	Operation and Organizational Maintenance: Multimeter ME-26B/U
TM 11-6625-203-12	Operation and Organizational Maintenance: Multimeter AN/URM-105, including Multimeter ME-77/U
TM 11-6625-322-12	Operator's and Organizational Maintenance Manual: Signal Generator SG-351/USD-1

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)

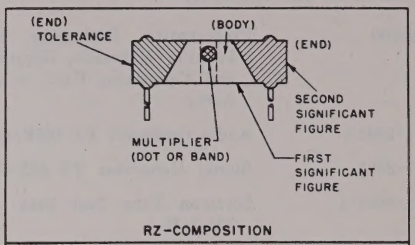


RC-COMPOSITION

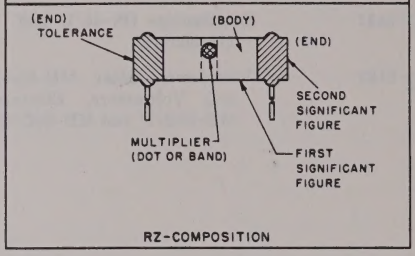


RU-WIRE-WOUND

RADIAL-LEAD RESISTORS (UNINSULATED)



RZ-COMPOSITION



RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

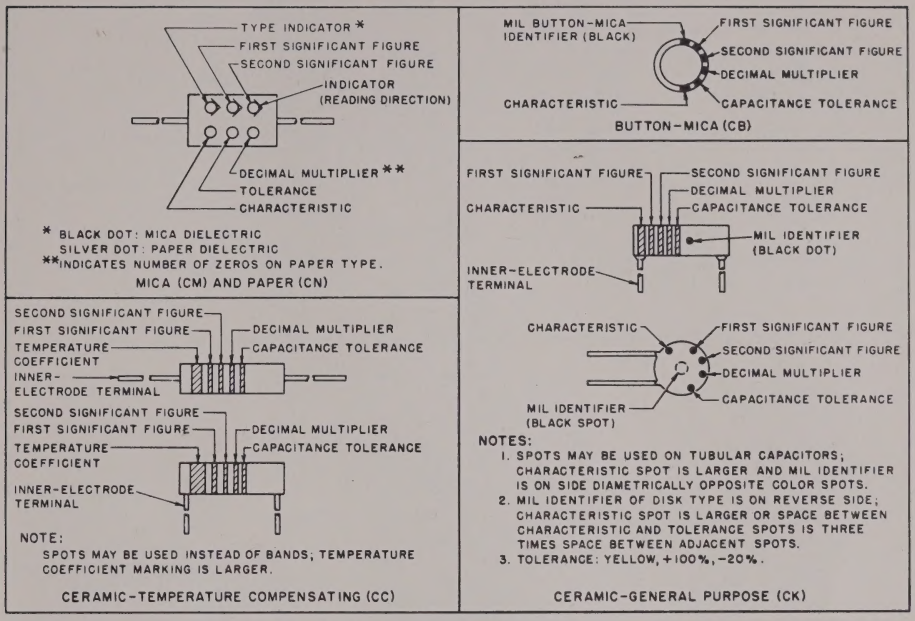
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R1

Figure 36. Resistor color code markings.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



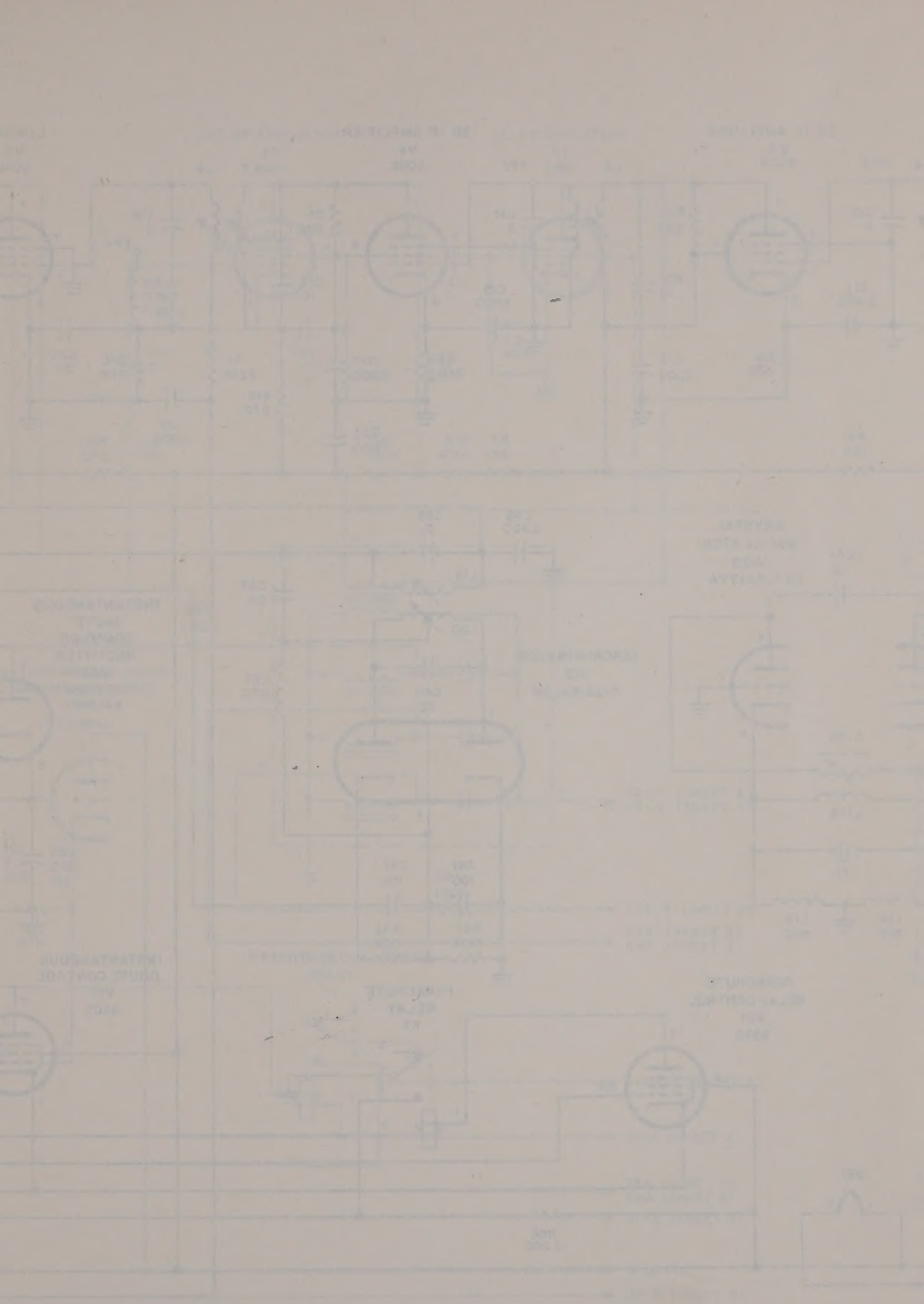
CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

Figure 37. Capacitor color code markings.



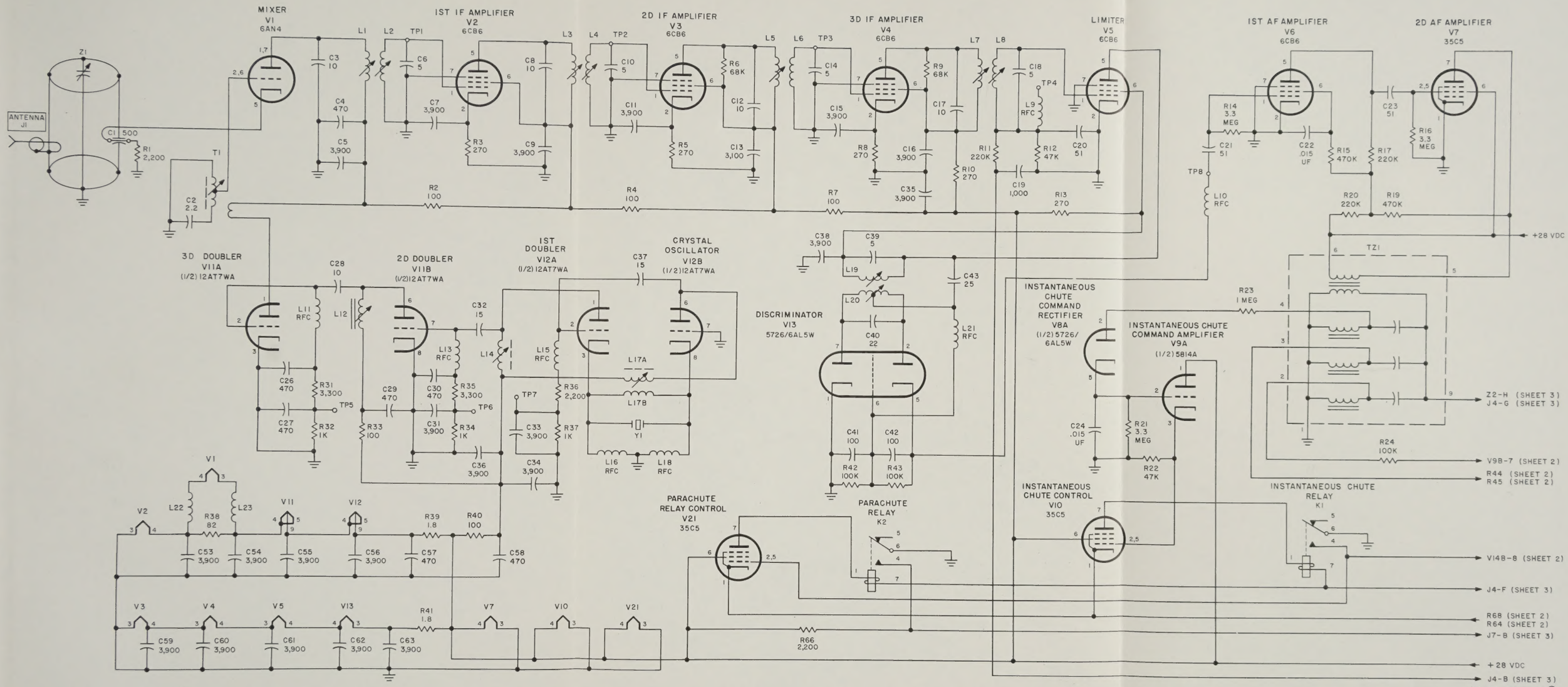
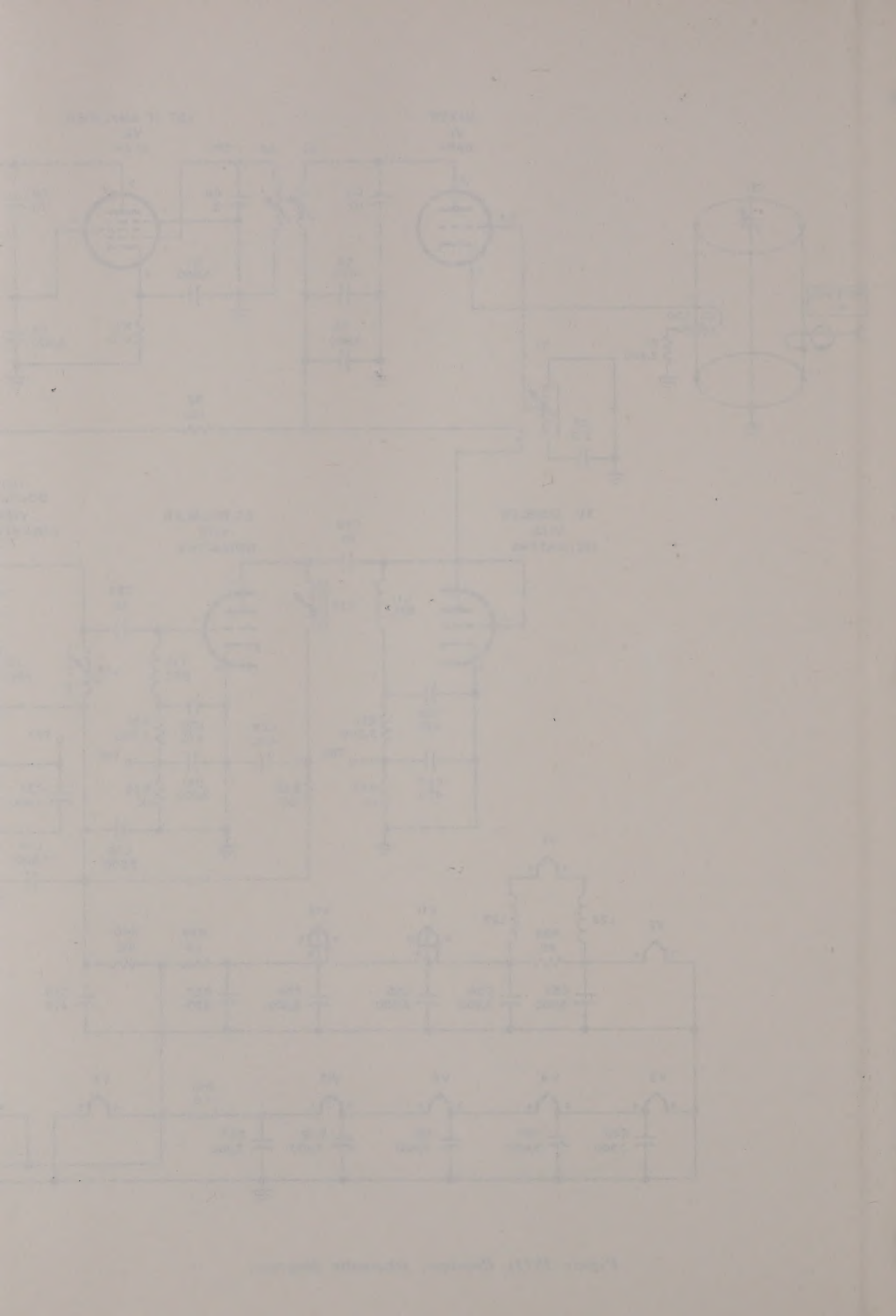
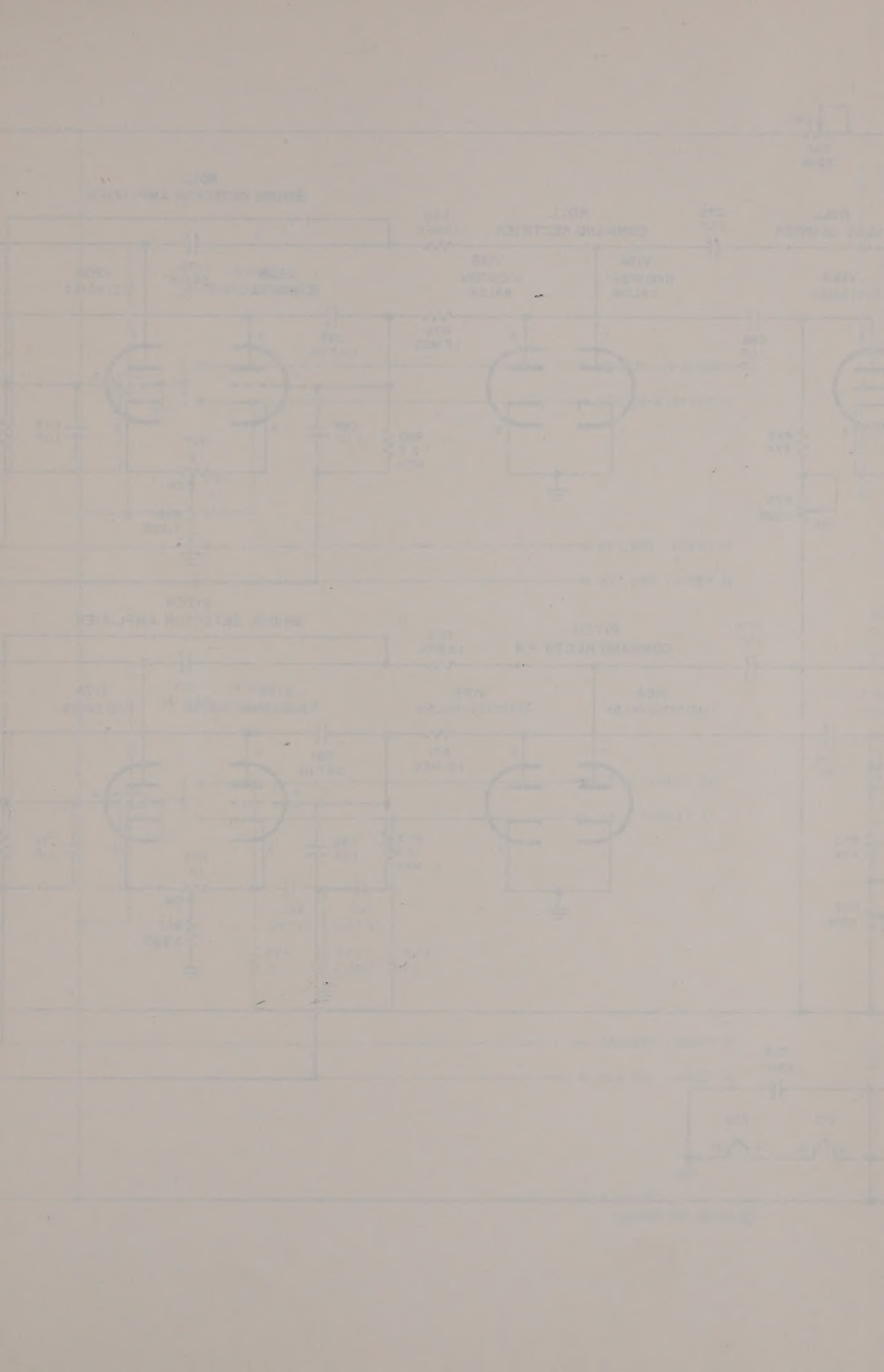
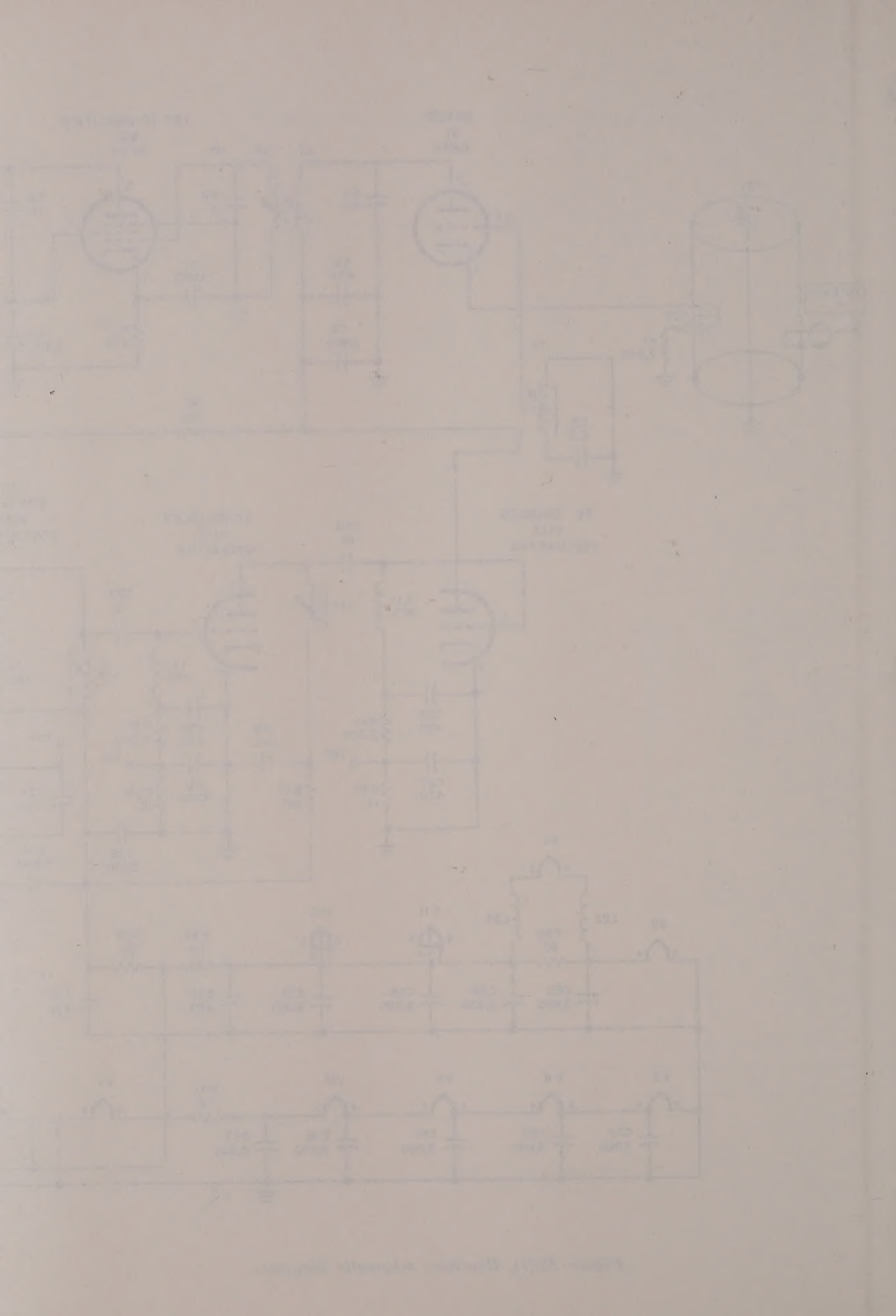


Figure 38 (1). Receiver, schematic diagram.







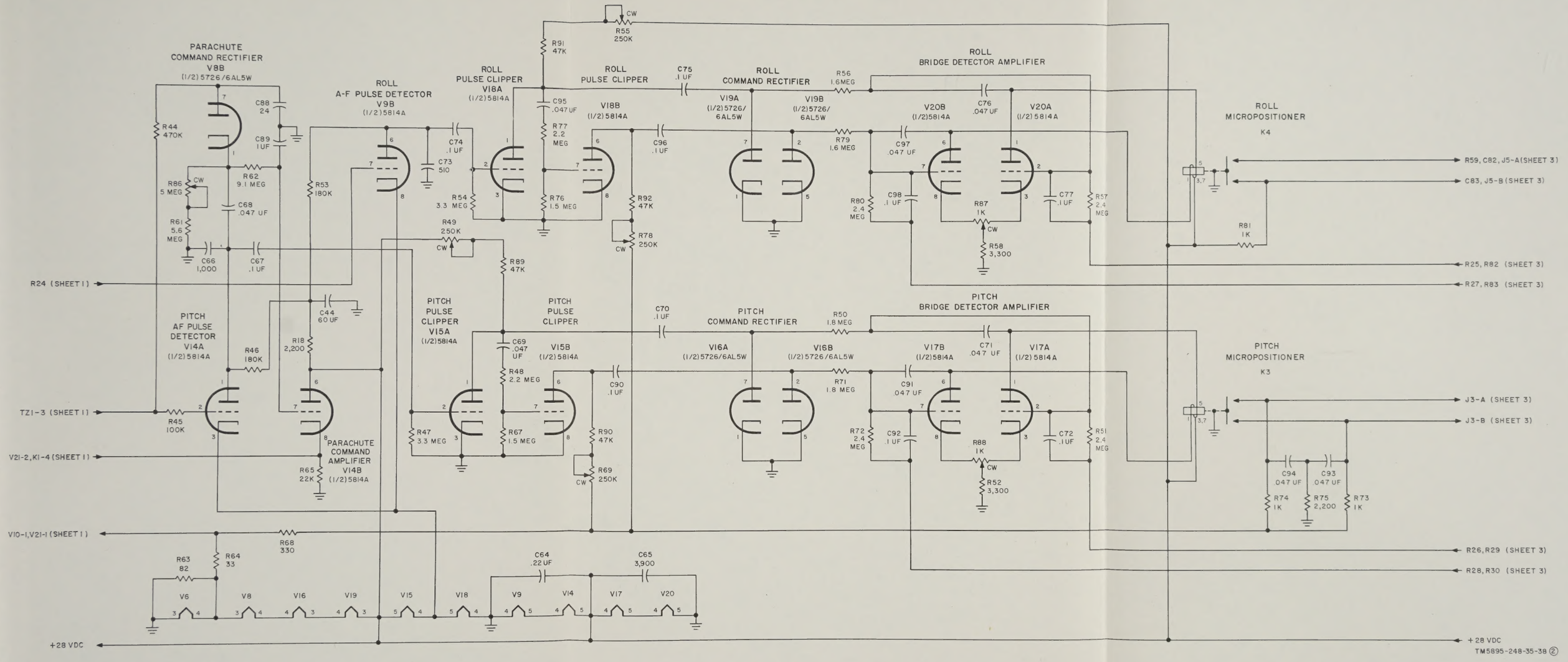
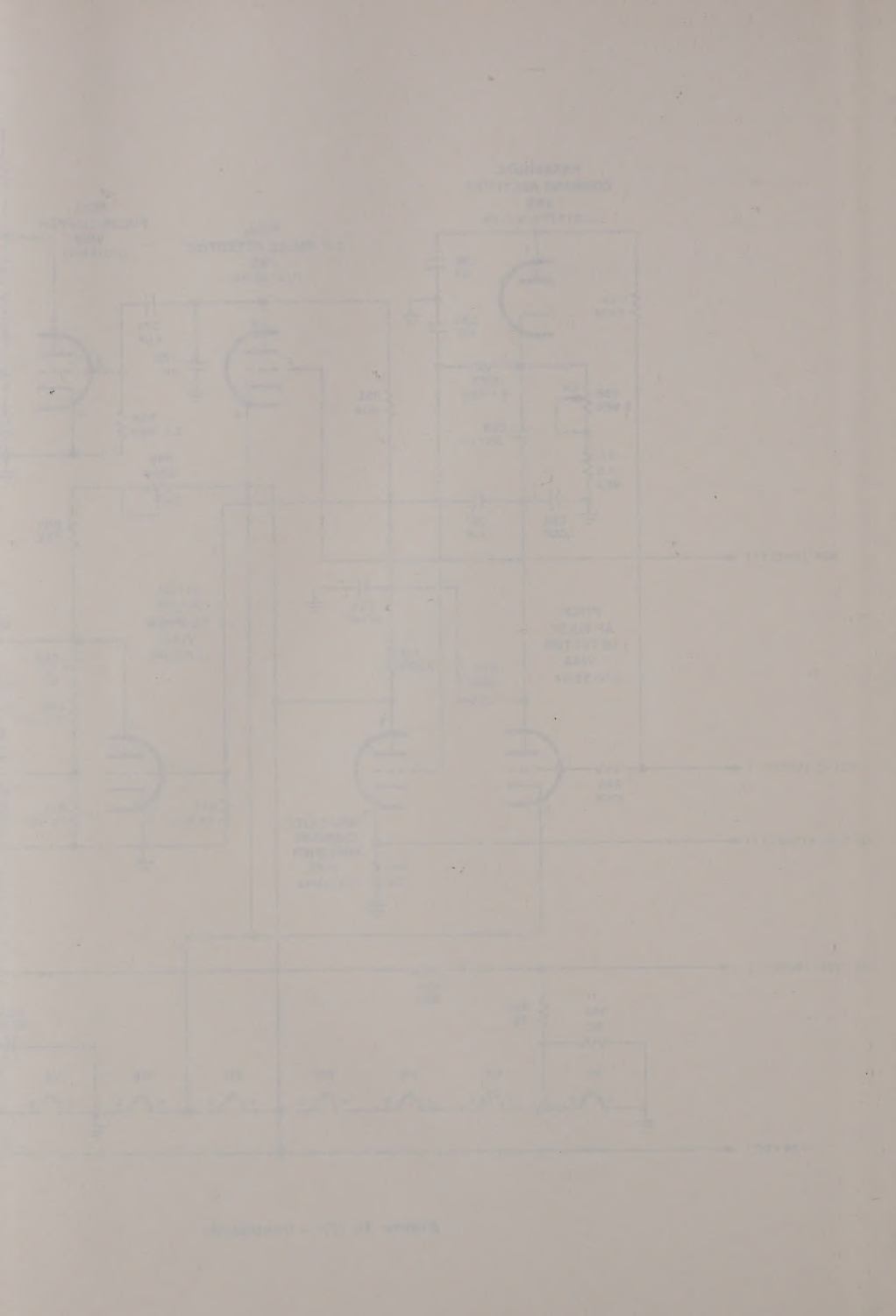
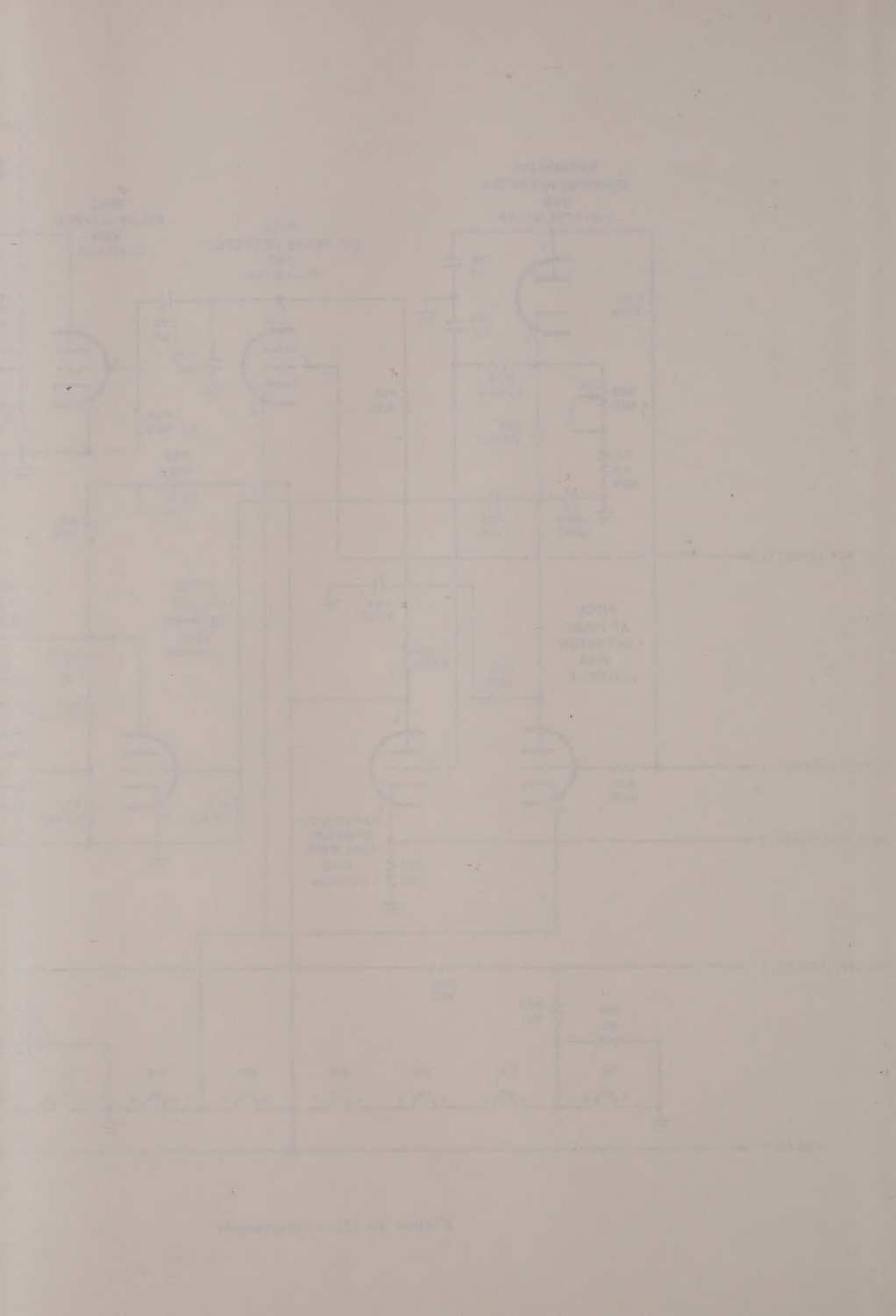
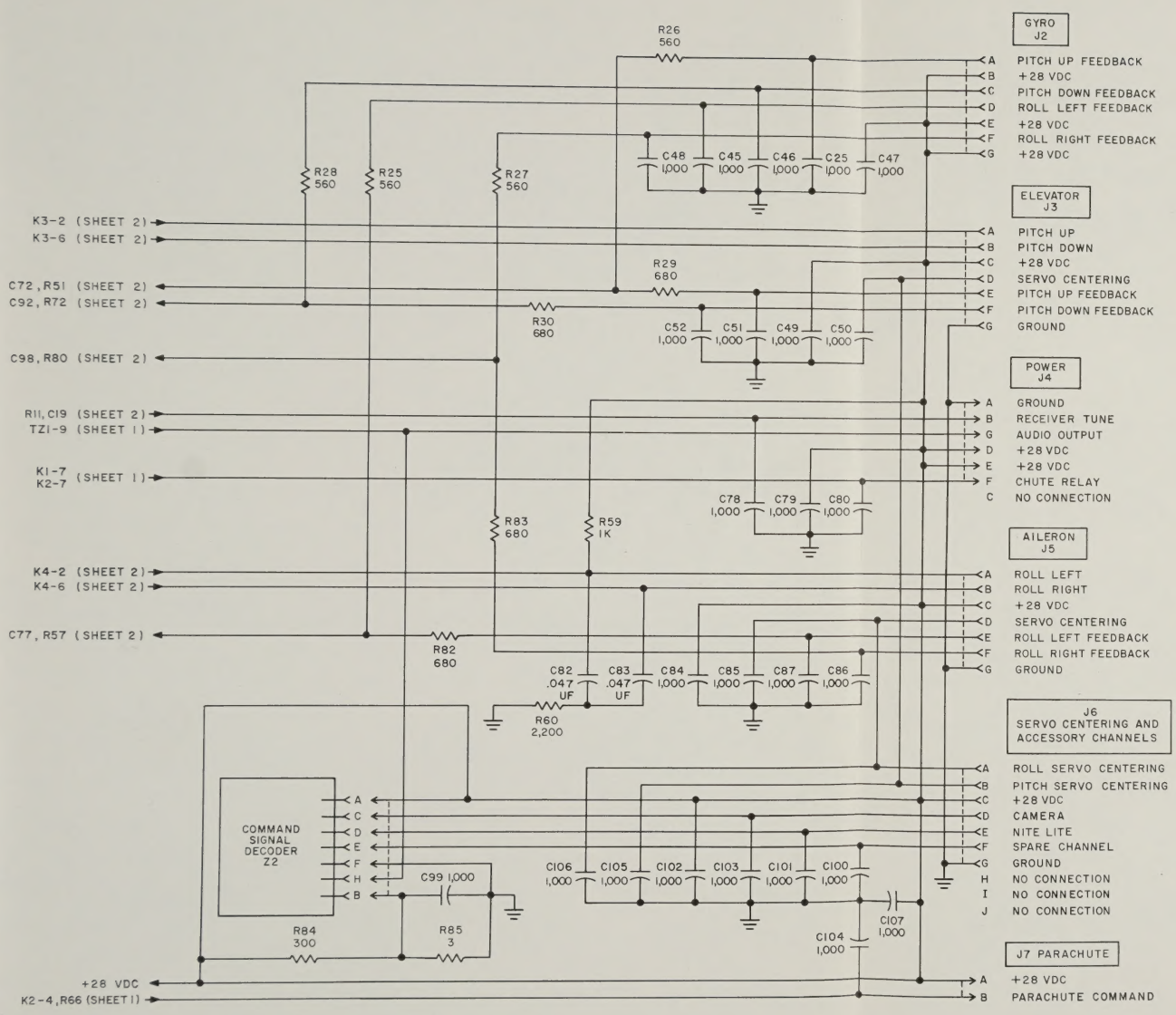


Figure 38 (2) — (continued).



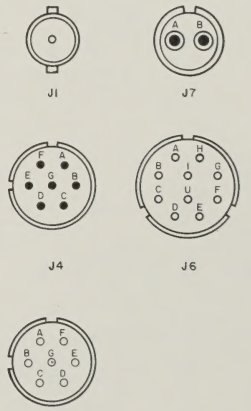






NOTES:

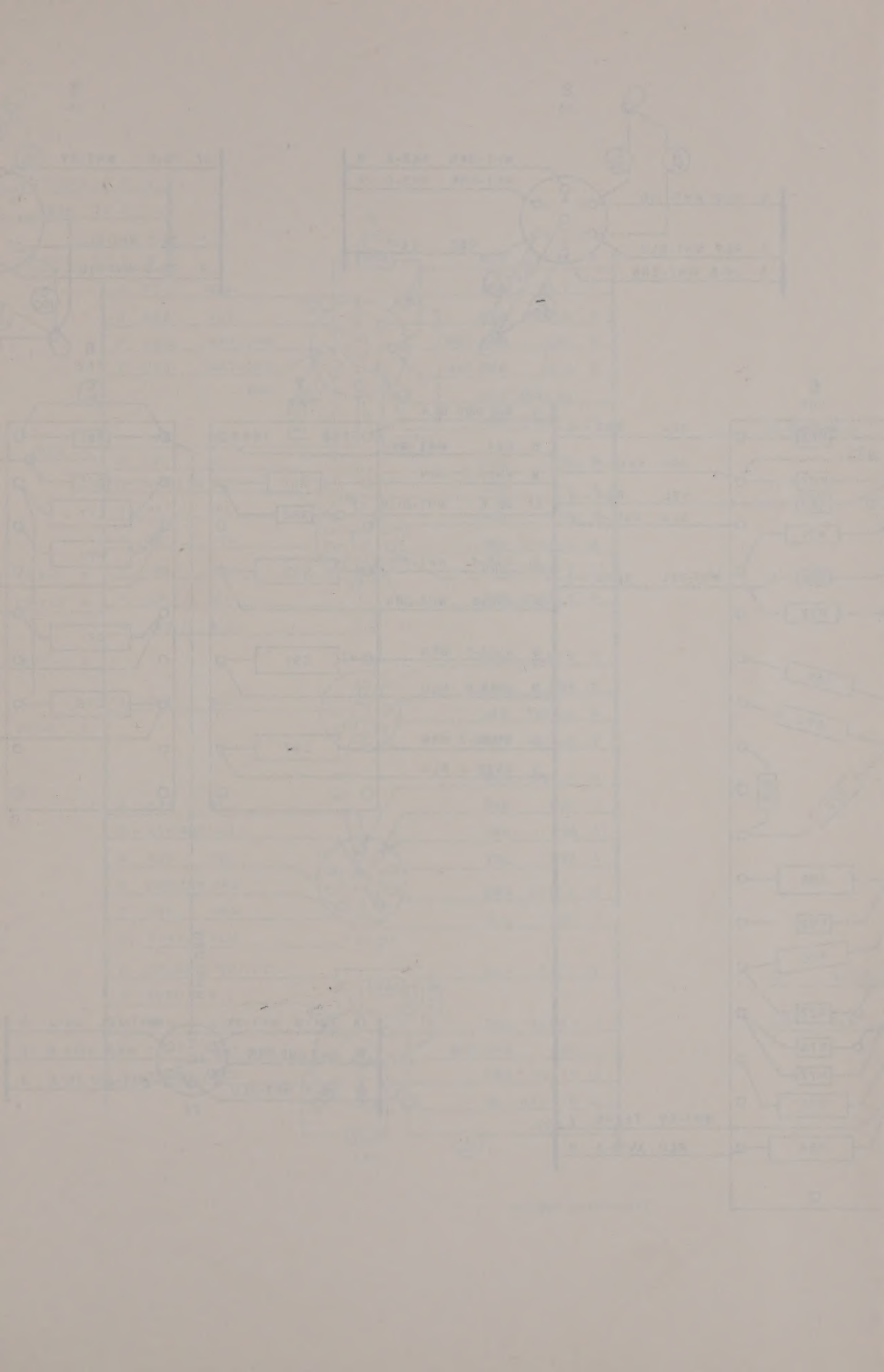
1. UNLESS OTHERWISE INDICATED; ALL RESISTANCES ARE IN OHMS, ALL CAPACITANCES ARE IN MICROMICROFARADS.
2. RELAYS ILLUSTRATED IN DE-ENERGIZED CONDITION.
3. ☐ INDICATES EQUIPMENT MARKING.
4. RECEPTACLES VIEWED FROM PIN OR RECEPTACLE SIDE.
5. K INDICATES 1,000 OHMS.
6. MEG INDICATES 1,000,000 OHMS.
7. UF INDICATES MICROFARADS.

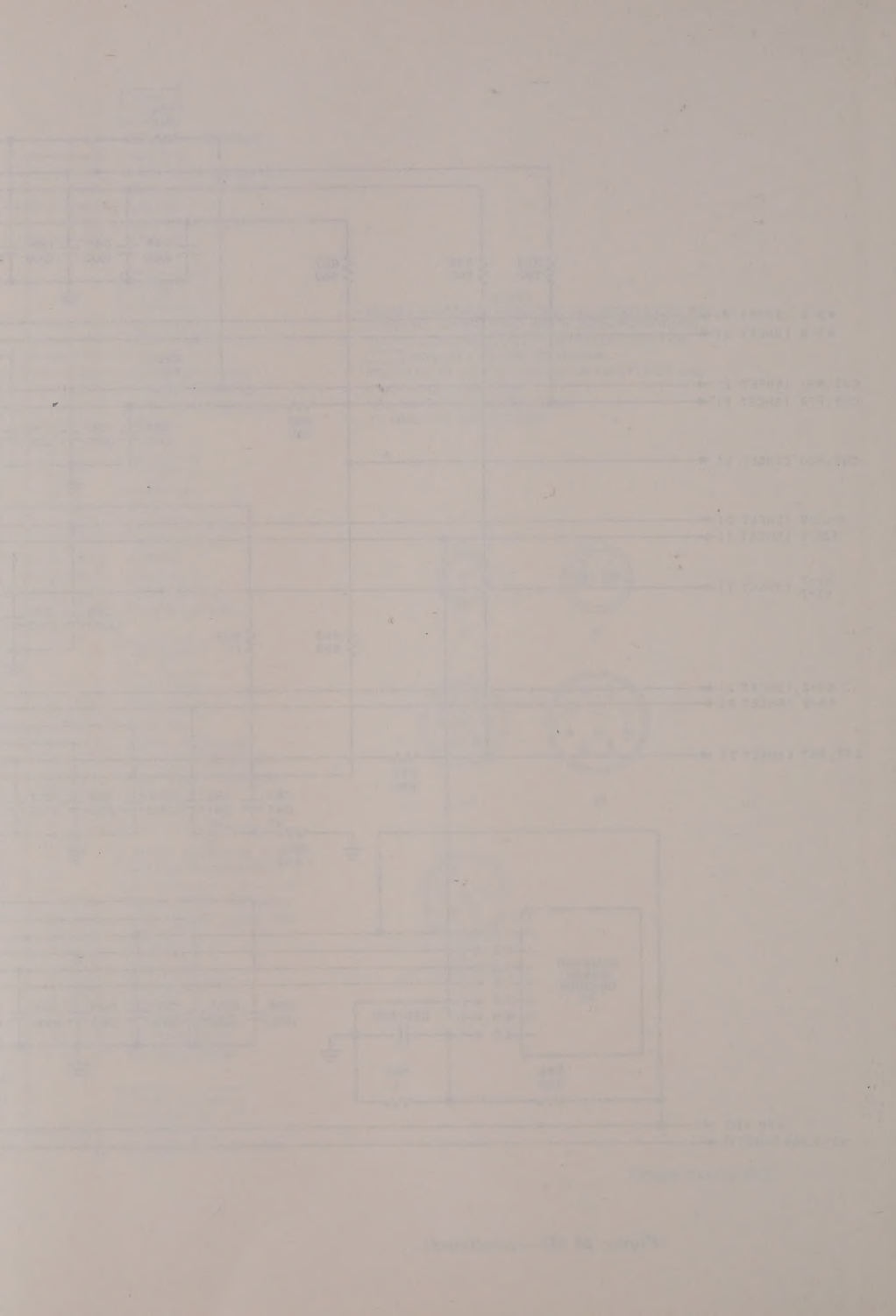


TM5895-248-35-38 ③

Figure 38 (3) — (continued).







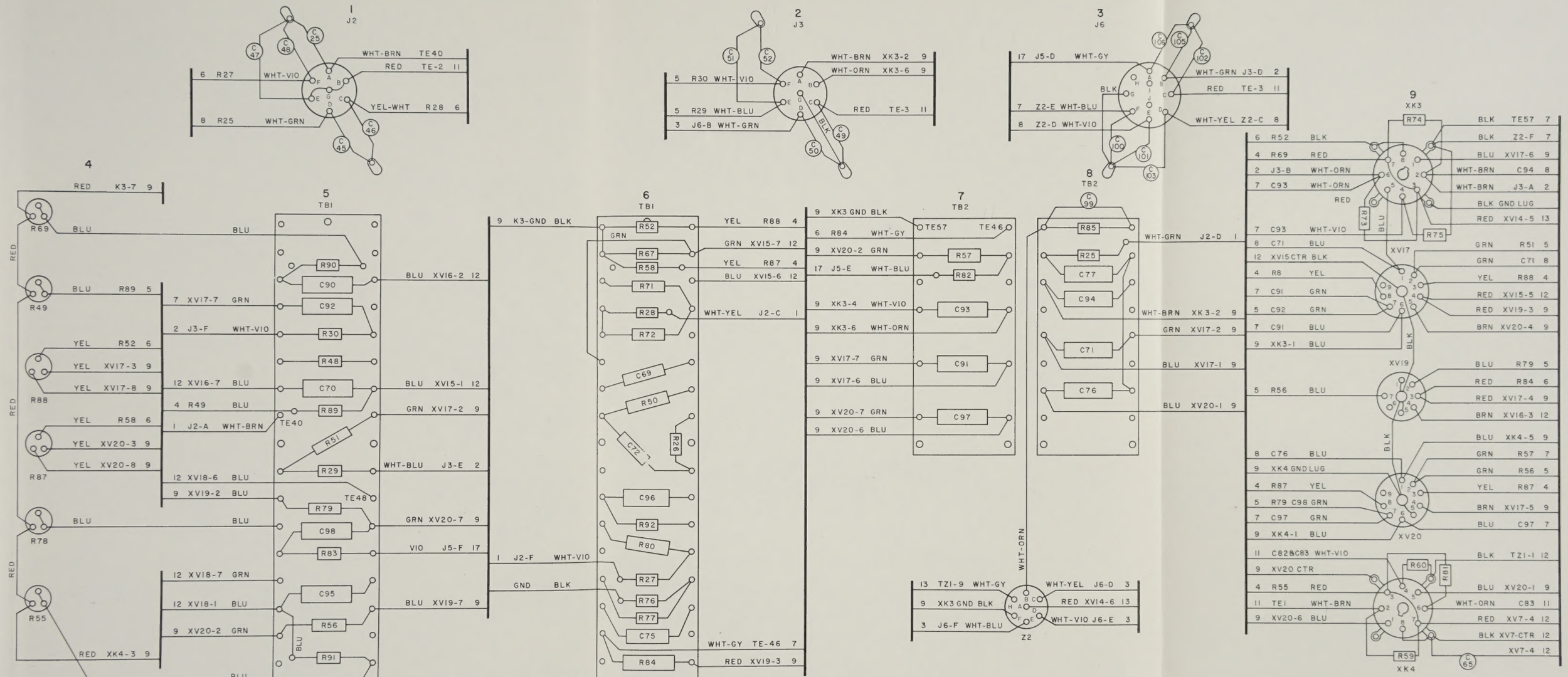
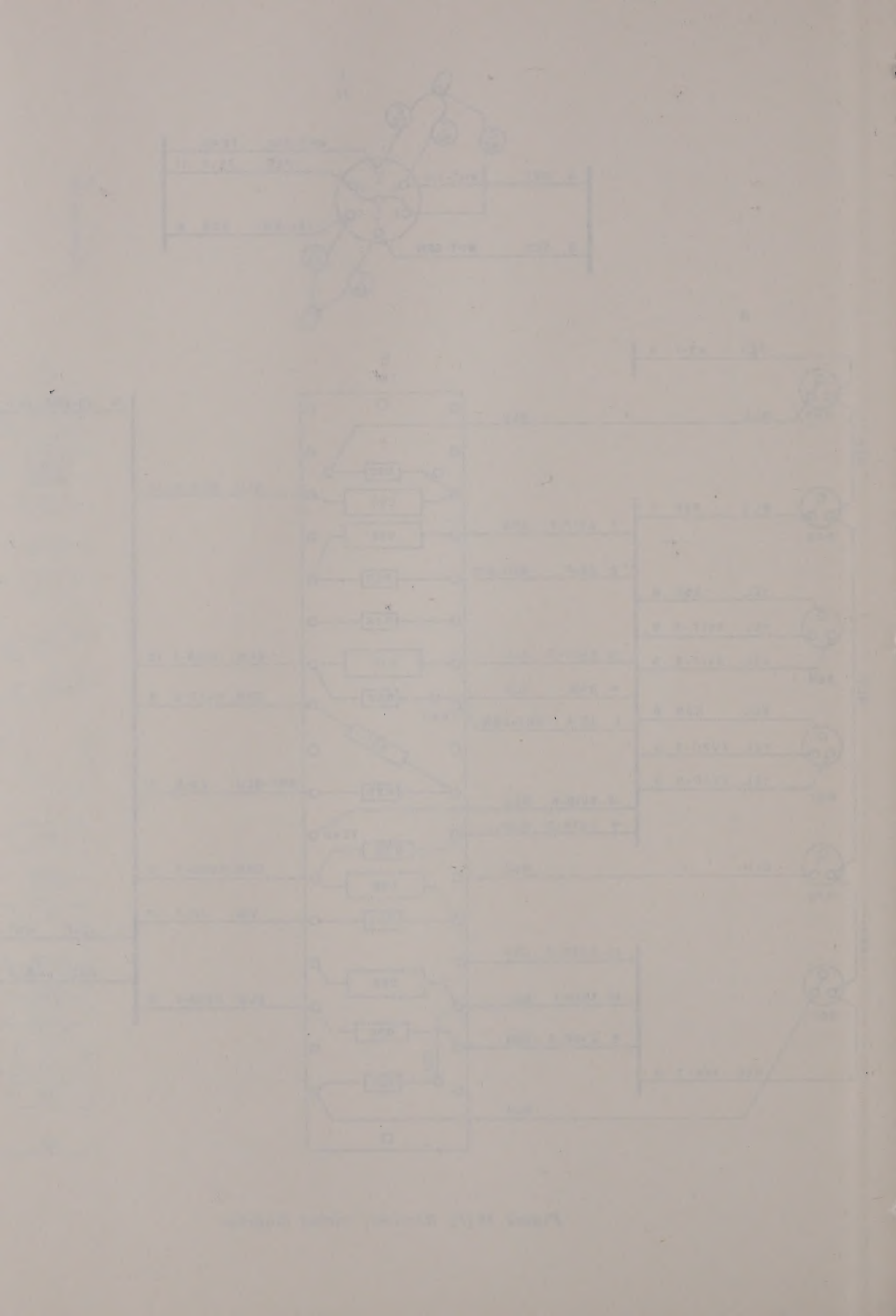
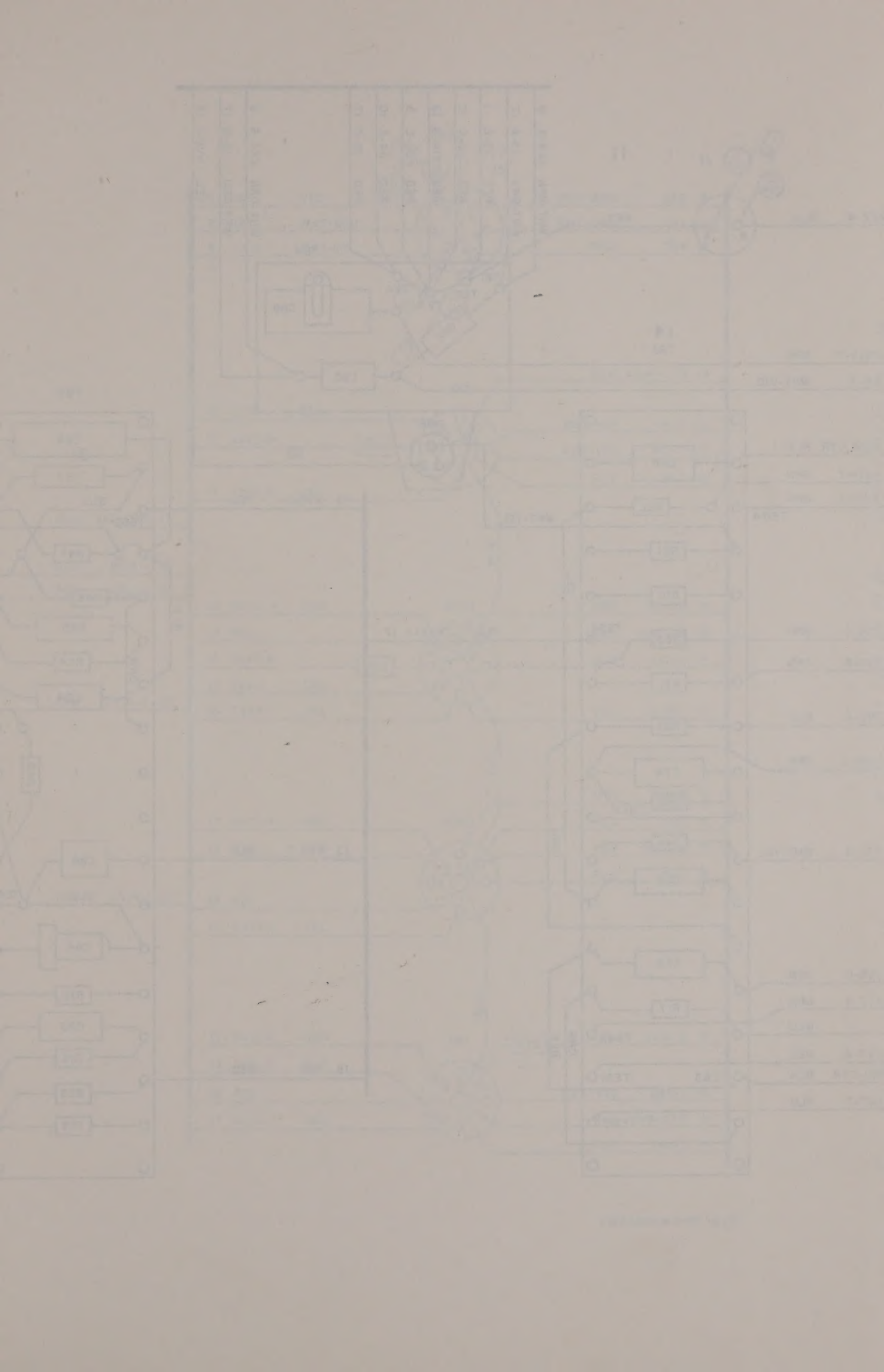
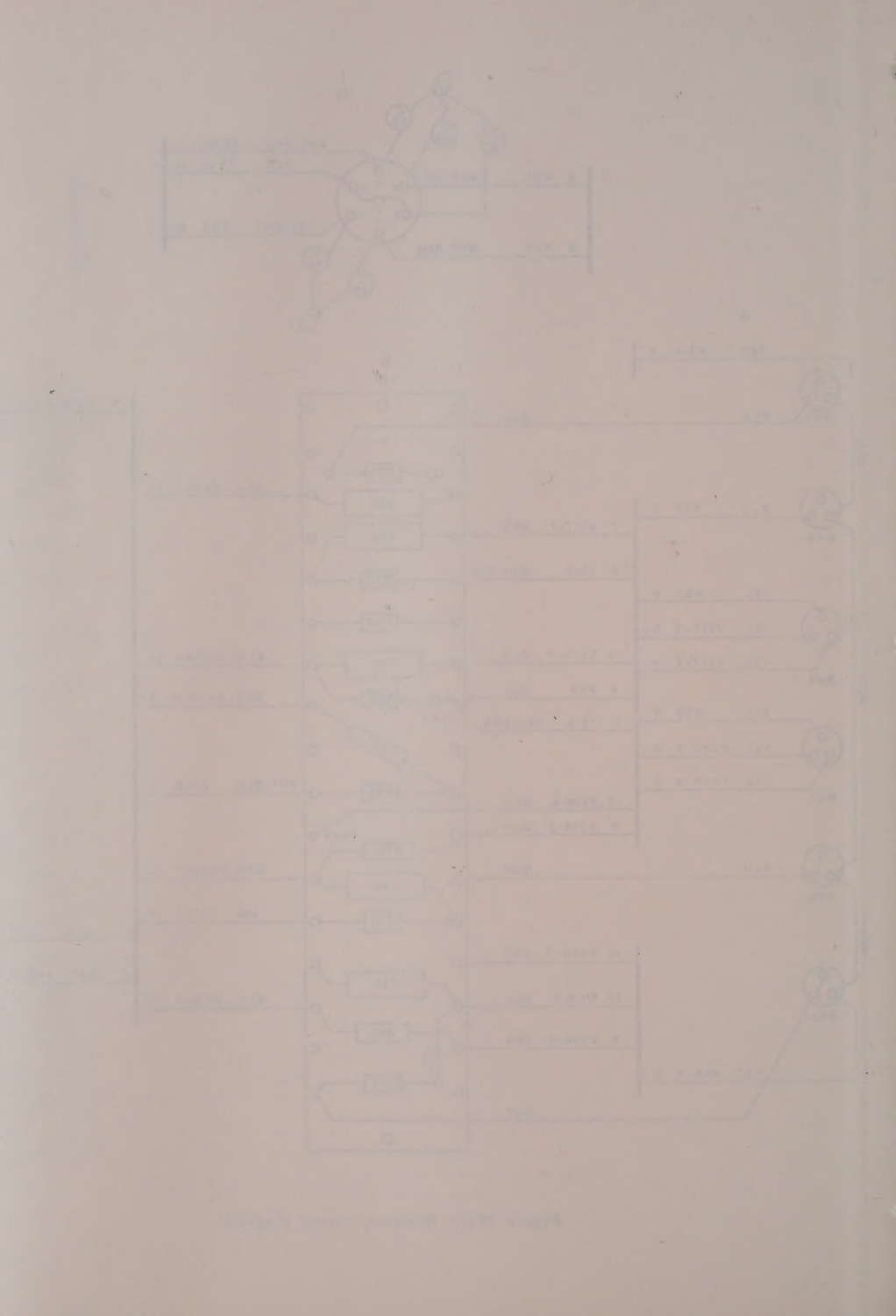


Figure 39 (1). Receiver, wiring diagram.







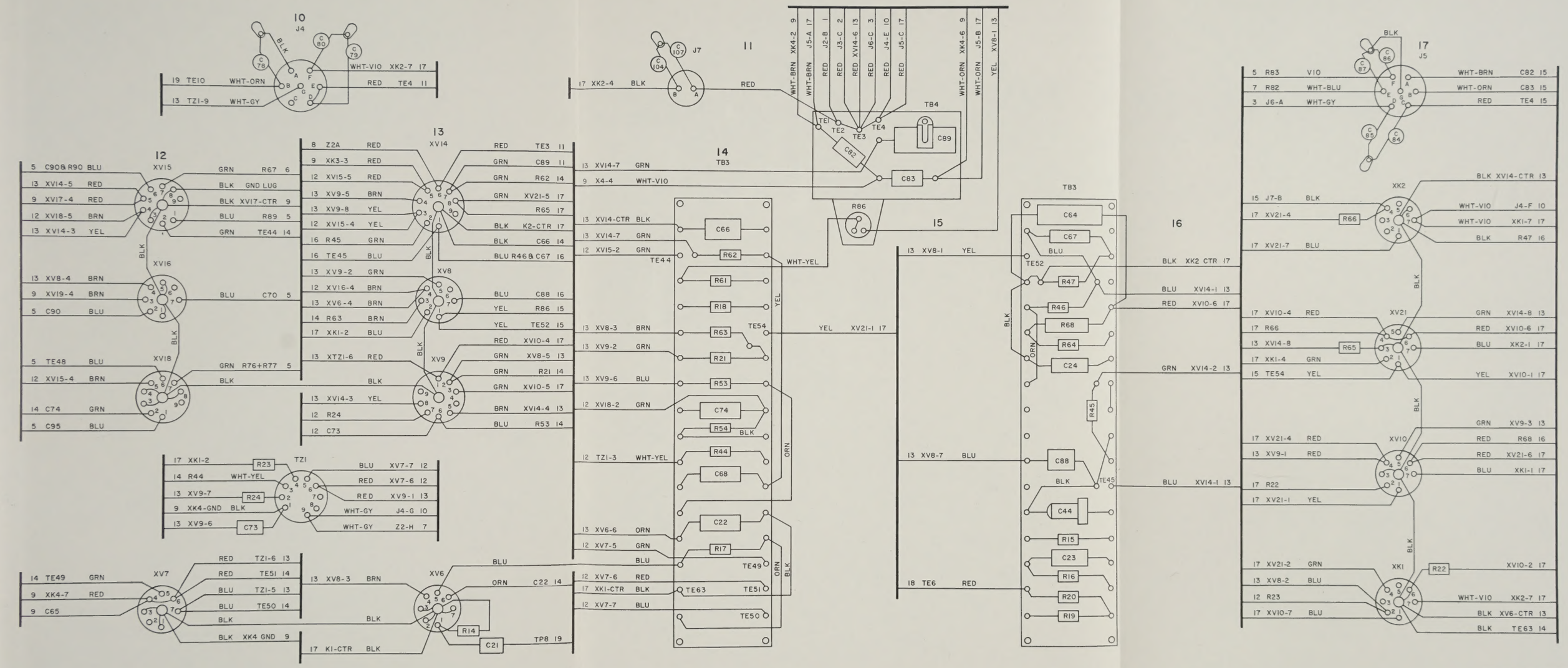
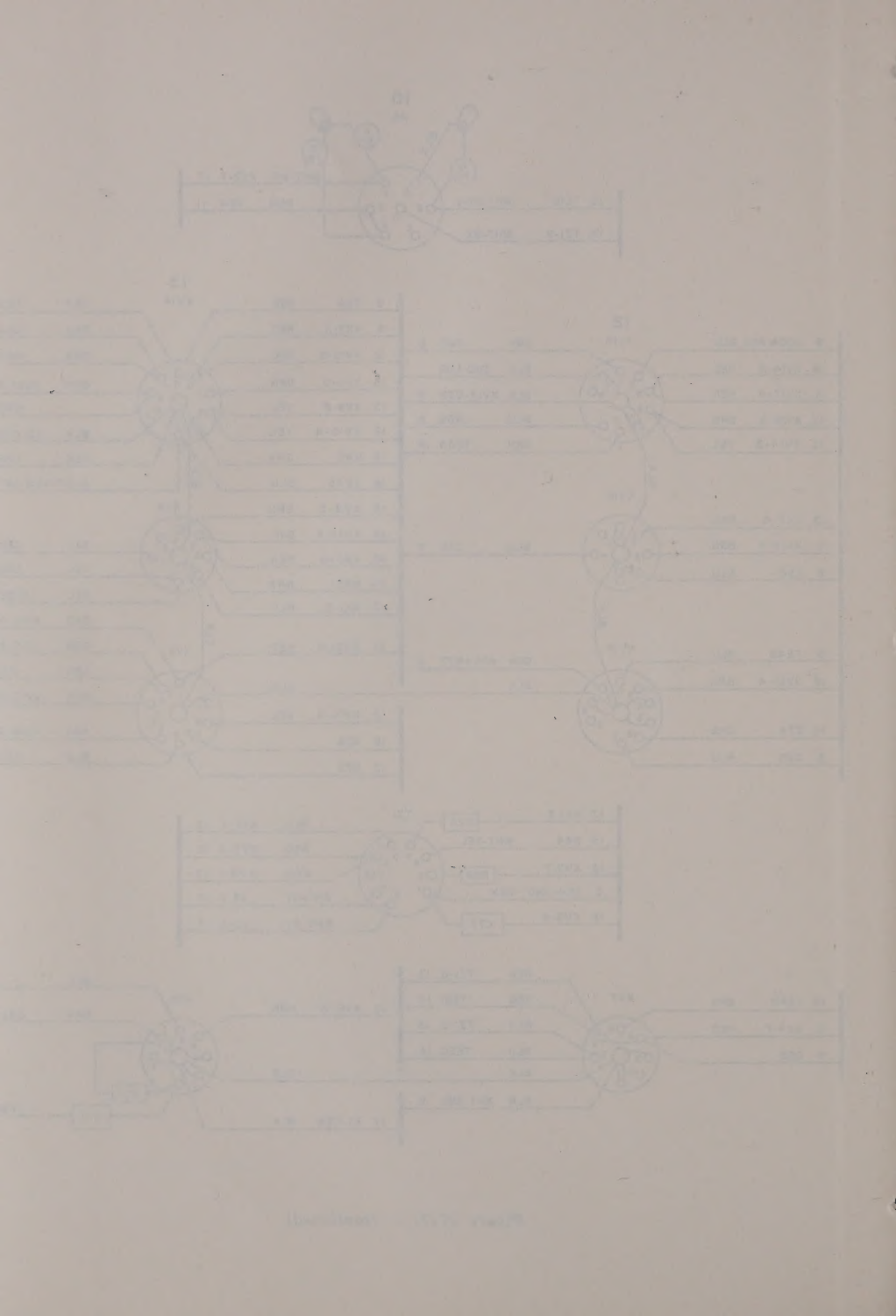
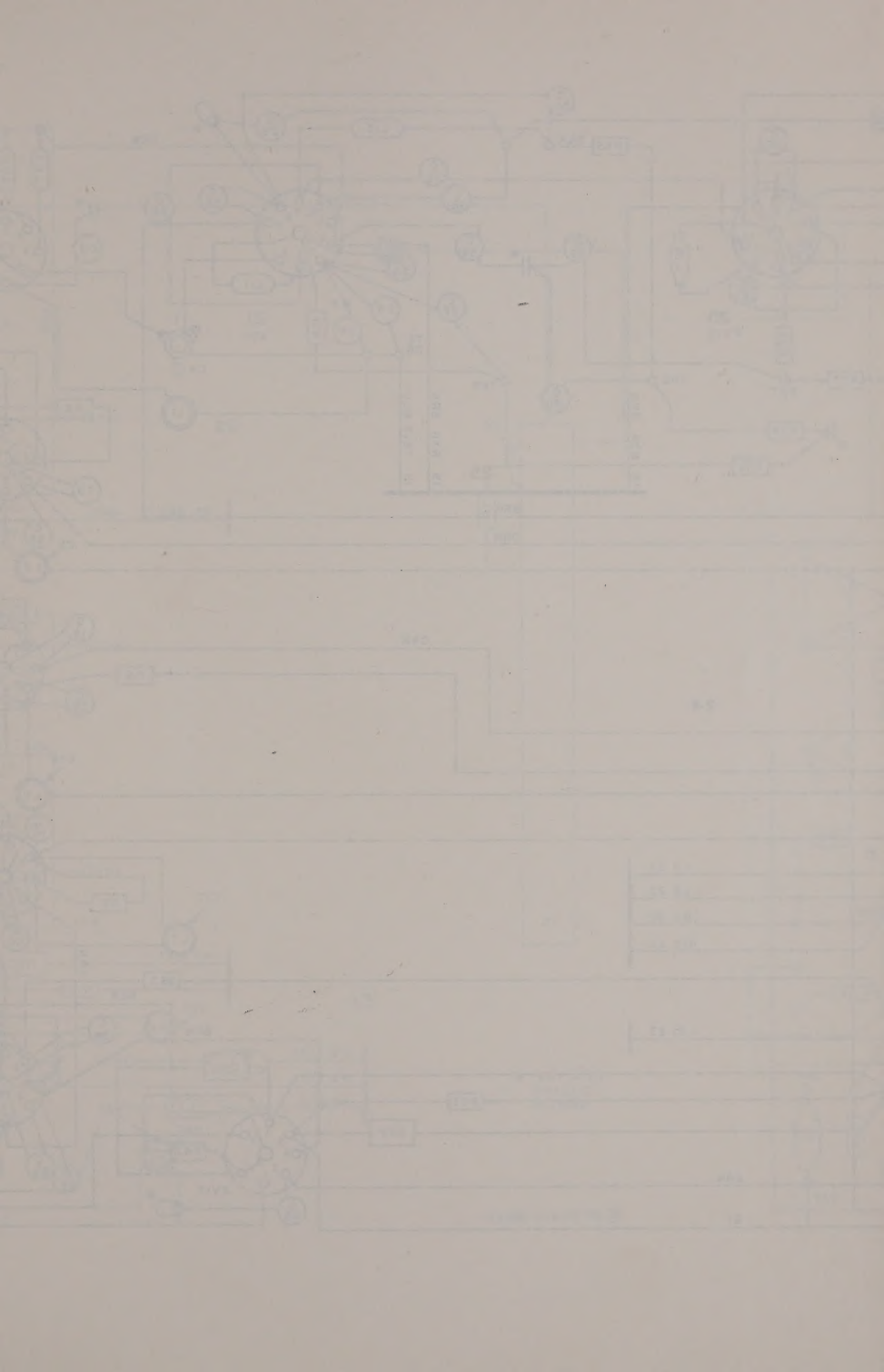


Figure 39 (2) — (continued).







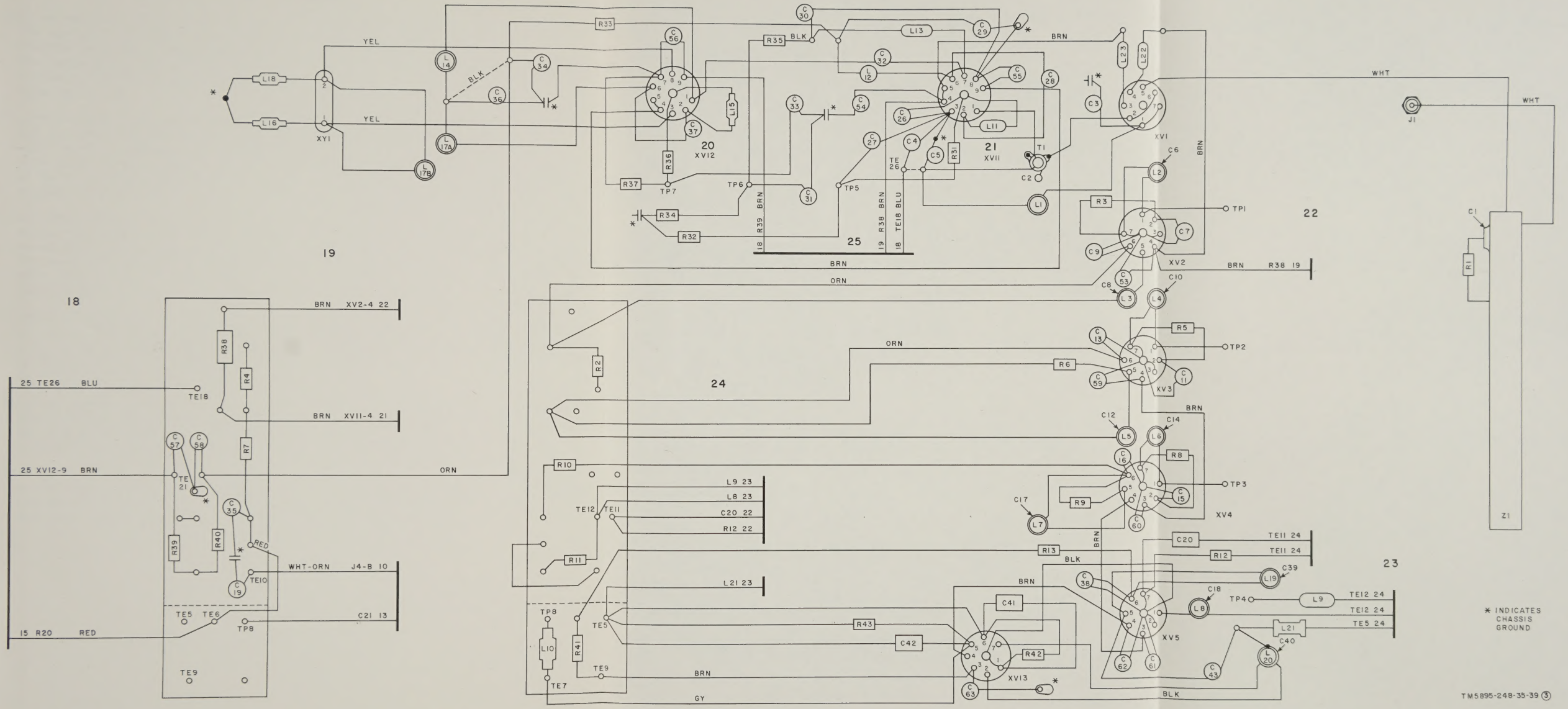
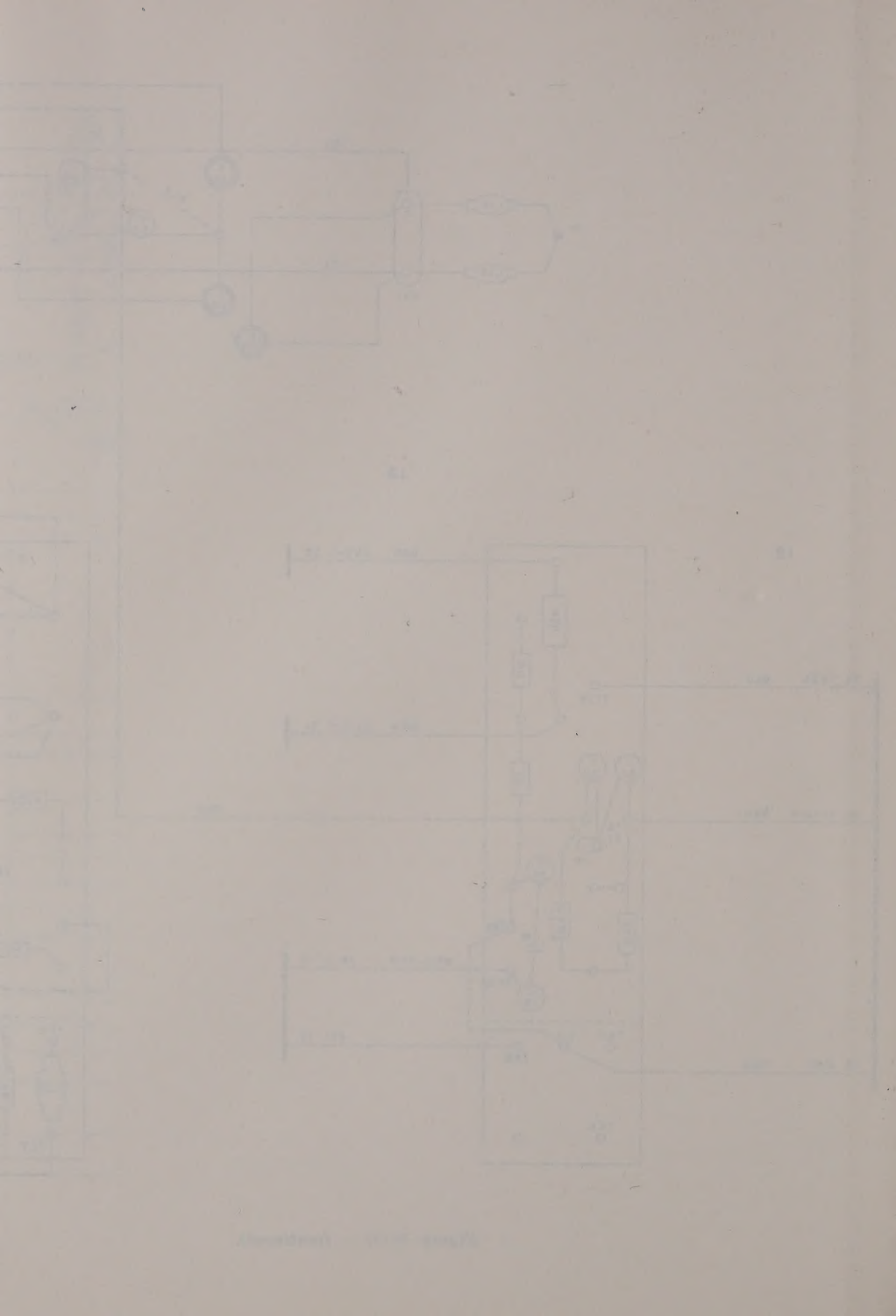


Figure 39 (3) — (continued).



Airborne equipment (flight control systems)—The equipment normallly installed in the drone for the purpose of controlling its flight. The complement of the airborne equipment includes an fm receiver, pitch and roll servo units, and a gyro.

Automatic volume control—The average rectified dc voltage developed by the received signal across a resistance in the discriminator circuit, which is applied as bias to one of the if amplifier stages to automatically regulate the gain of the receiver.

Beam power tube—A power amplifier tube so constructed that the electrons are formed into concentrated beams on their way to the plate. The beam construction makes it possible to draw large plate currents at relatively low plate voltages and increases the power gain.

Decoupling filter—A resistor-capacitor filter, generally installed in series with the plate and screen voltage supply for a vacuum tube, which filters the ac components generated in the tube from the voltage source.

Degenerative feedback—The portion of an amplifier's output signal which is fed back to the input of the amplifier in such a way as to be out of phase with the input signal.

Duty cycle—The ratio of pulse duration time to pulse repetition time. If the pulse duration equals half the pulse repetition time the duty cycle is 50 percent. A 50-percent duty-cycle pulsed signal resembles a square wave with equal, positive portions.

Flight control channel—A signal at a specified audiofrequency that contains flight control information.

Flight control system—Complete complement of ground and airborne equipment required to control the flight of the drone.

Frequency modulation—The superimposing of an intelligence to a radiofrequency signal by varying the carrier frequency of the signal in accordance with the intelligence.

Ground equipment (flight control system)—The equipment normally situated on the ground for the purpose of controlling the flight of the drone. The complement of the ground equipment includes an fm transmitter, audiofrequency coder, control box, and antenna.

Micropositioner—A very sensitive, polarized relay which is actuated by a current differential between two sections of a center-tapped coil.

Regenerative feedback—The portion of an amplifier's output signal which is fed back to the input of the amplifier in such a way as to be in phase with the input signal.

Sensitivity—The ability of an electrical circuit to receive and adequately handle a small input signal. The sensitivity rating and the required amplitude of the input signal are inversely proportional.

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For explanation of abbreviations used, see AR 320–50.

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