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TM 11-1227

WAR DEPARTMENT TECHNICAL MANUAL

U.S. Dept. of army

CALIBRATOR

I-189-A

RESTRICTED. DISSEMINATION OF RESTRICTED MATTER. No person is entitled solely by virtue of his grade or position to knowledge or possession of classified matter. Such matter is entrusted only to those individuals whose official duties require such knowledge or possession. (See also paragraph 23b, AR 380-5, 15 March 1944.)

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WAR DEPARTMENT,
WASHINGTON 25, D. C., 17 MAY 1945.

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(For explanation of symbols see FM 21-6.)

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LIST OF ILLUSTRATIONS

DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — When ordered by your commander.

HOW — 1. Smash — Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

2. Cut — Use axes, handaxes, machetes.

3. Burn — Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

4. Explosives — Use firearms, grenades, TNT.

5. Disposal — Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Smash — Panels, switches, tubes, capacitors, resistors.

2. Cut — Wiring, cables, transformer windings, choke windings.

3. Burn — Manuals, charts, schematic diagrams.

4. Bend — Framework, subpanels..

5. Bury or scatter — All of the above materials after destroying their usefulness.

DESTROY EVERYTHING

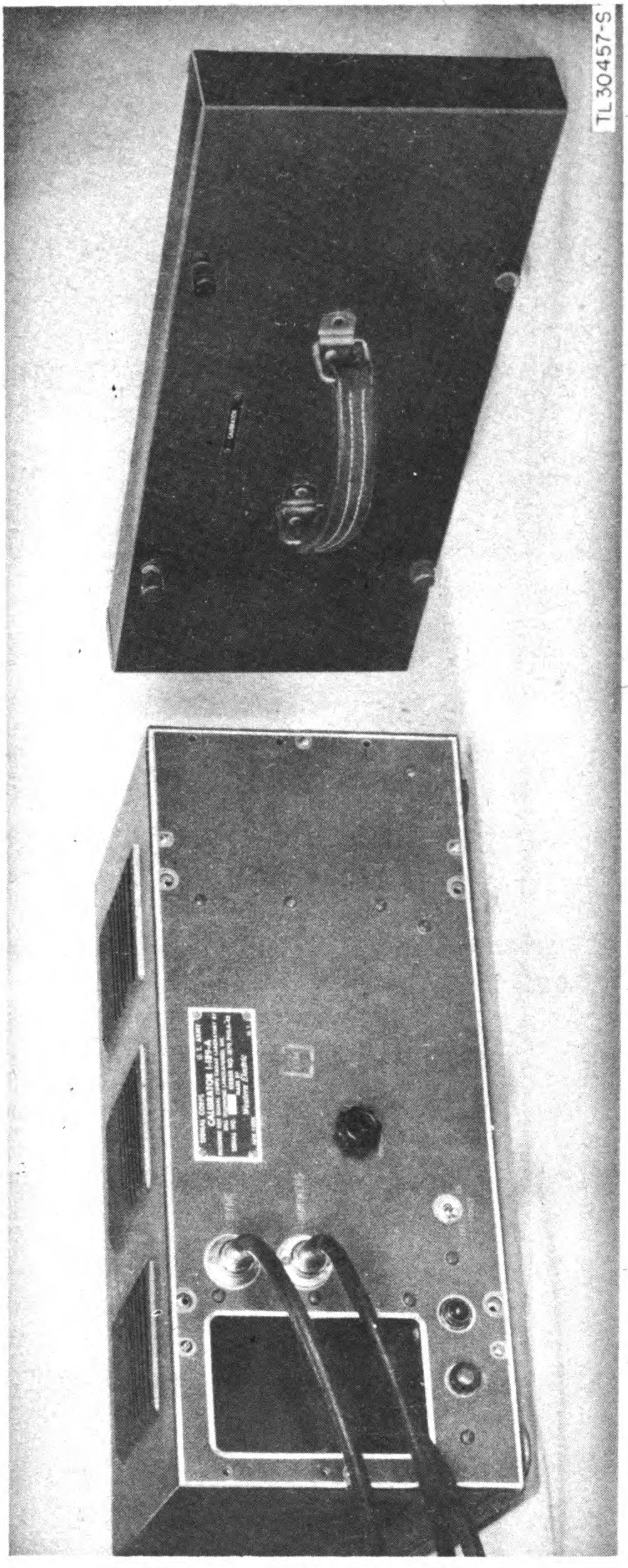


Figure 1. Calibrator I-189-A.

PART ONE
INTRODUCTION

1. GENERAL.

Calibrator I-189-A is a range calibrator for pulse-triggered range oscilloscopes (fig. 1). The oscilloscope sweep is triggered at approximately 480 cycles per second (cps), and the range is calibrated by direct comparison with 500-yard calibration markers. The unit is a portable, self-contained instrument. It contains a crystal-controlled, 327.80-kilocycle (kc) oscillator which furnishes the 500-yard markers and the 480-cps synchronizing pulse outputs. Two coaxial cables for connecting the instrument to the set to be calibrated are provided.

2. TECHNICAL CHARACTERISTICS.

Synchronizing pulse output:

Frequency	Approximately 480 cycles per second.
Amplitude	16 volts minimum across 72 ohms.
Polarity	Negative.

Marker pulse output:

Frequency	327,800 ±50 cycles per second at 20°C.
Variation of frequency with temperature	±40 cycles per second for a temperature variation of ±55°C.
Amplitude	1 to 25 volts across 72 ohms.
Polarity	Negative.
Phase	Continuously variable from 0° to 360° with respect to synchronizing pulse.

Power input:

Potential	115 volts.
Frequency	60 cycles per second.
Fuse protection	2 amperes.

Number of tubes	10.

3. PHYSICAL DESCRIPTION.

The calibrator is mounted in a steel case painted olive drab (fig. 1). When the instrument is not in use, the front panel is covered by a lid on which the carrying handle is mounted. The controls, fuse, pilot light, and output jacks are mounted on the front panel (fig. 2). The power cord is permanently attached to the chassis and is stored in the cord box on the left side of the panel when not

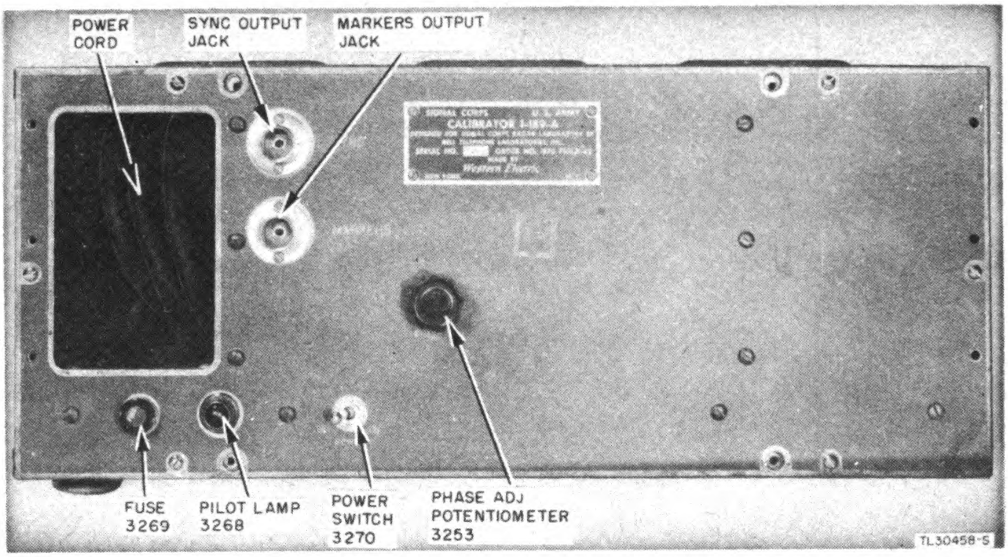


Figure 2. Calibrator I-189-A, front view.

in use. The inside of the unit may be reached by removing the six screws which hold the front panel to the case and slipping the chassis and front panel out. Over-all dimensions including the carrying handle and feet are: length, 20¼ inches; height, 14½ inches; depth, 8½ inches. The weight is approximately 45 pounds.

4. UNPACKING.

Unpack the instrument carefully. After unpacking, inspect the case for any external evidence of damage.

> **CAUTION: If the chassis has received moistureproofing and fungiproofing treatment, *do not remove* any of the protective coating.**

5. INSTALLATION.

The equipment is shipped with a set of tubes installed; check the tubes to see that each one is in the correct socket. The calibrator is ready for use as delivered without any internal adjustments or alignment procedures.

PART TWO
OPERATING INSTRUCTIONS

6. INITIAL ADJUSTMENTS.

a. Set the calibrator in position where it is to be used and remove the lid by loosening the four thumbscrews which hold it to the chassis (fig. 1).

b. Plug the line cord into the a-c line and turn on the POWER switch (fig. 2).

c. Connect the SYNC output connector (fig. 2) to the sync input of the range oscilloscope using one of the coaxial cables provided.

d. Connect the MARKERS output connector (fig. 2) to the video input of the range oscilloscope using one of the coaxial cables provided.

7. RANGE CALIBRATION.

With the calibrator connected as explained in paragraph 6, 500-yard precisely spaced range markers appear on the range oscilloscope of the radar set. The range is calibrated by adjusting the sweep or gating circuits in the range unit so that the range indications on the radar set agree with the standard calibration markers. The PHASE ADJ control on the calibrator (fig. 2) is used to adjust the phase of the markers so that one of them coincides with the range notch, the beginning of the range sweep, or some other reference point on the range oscilloscope. For detailed information on calibration of a radar range circuit see the service manual for the particular set.

PART THREE

PREVENTIVE MAINTENANCE

8. MEANING OF PREVENTIVE MAINTENANCE.

Preventive maintenance is a systematic series of operations performed at regular intervals on equipment, when turned off, to eliminate major break-downs and unwanted interruptions in service, and to keep the equipment operating at top efficiency. To understand what is meant by preventive maintenance, it is necessary to distinguish preventive maintenance from trouble shooting and repair. The prime function of preventive maintenance is to *prevent* break-downs and, therefore, the need for repair. On the other hand, the prime function of trouble shooting and repair is to locate and correct *existing* defects. The importance of preventive maintenance cannot be overemphasized. The entire system of radar operations depends upon the readiness and operating efficiency of each item of equipment when it is needed. The test equipment by which this condition of readiness is realized must therefore be kept in excellent operating condition at all times.

NOTE: All of the operations in this section are user maintenance.

9. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES.

a. General. Most of the electrical parts used in Calibrator I-189-A require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because hit-or-miss maintenance techniques cannot be applied, definite and specific instructions are needed. This part of the manual contains these specific instructions and serves as a guide for personnel assigned to perform the six basic maintenance operations, namely: Feel, Inspect, Tighten, Clean, Adjust, and Lubricate. Throughout this manual the lettering system for the six operations will be as follows:

F—Feel.*
I—Inspect.
T—Tighten.
C—Clean.
A—Adjust.*
L—Lubricate.*

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field needs. For example, the dust encountered on dirt roads during cross-country travel filters into the equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat) excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections

* The Feel, Adjust, and Lubricate operations are inapplicable to Calibrator I-189-A.

and the necessary performance of tightening, cleaning, and lubricating operations, equipment becomes undependable and subject to break-down when it is most needed.

b. Inspect. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Although these defects may not interfere with the performance of the equipment, valuable time and effort can be saved if they are corrected before they lead to major break-downs. Make every effort to become thoroughly familiar with the indications of normal functioning in order to be able to recognize the signs of a defective set. Inspection consists of carefully observing all parts of the equipment, noticing their color, placement, state of cleanliness, etc. Inspect for the following conditions:

(1) Overheating, as indicated by discoloration, blistering, or bulging of the parts or surface of the container; leakage of insulating compounds; and oxidation of metal contact surfaces.

(2) Placement, by observing that all leads and cabling are in their original positions.

(3) Cleanliness, by carefully examining all recesses in the unit for accumulation of dust, especially between connecting terminals. Parts, connections, and joints should be free of dust, corrosion, and other foreign matter. In tropical and high-humidity locations look for fungus growth and mildew.

(4) Tightness, by testing any connection or mounting which appears to be loose.

c. Tighten and Clean. These operations are self-explanatory. Specific procedures to be followed in performing them are given wherever necessary throughout this section.

CAUTION: Screws, bolts, and nuts should not be tightened carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken. Whenever a loose connection is tightened, it should be moistureproofed and fungiproofed again by applying the varnish with a small brush. See paragraph 13 for details of moistureproofing and fungiproofing.

10. COMMON MATERIALS NEEDED.

The following materials will be needed in performing preventive maintenance:

Common hand tools (TE-41 or equivalent).
Clean cloth.
Sandpaper #0000.
Crocus cloth.
Paint brush, small.
Solvent, Dry-Cleaning, Federal Specification P-S-661a.

NOTE: Gasoline must not be used as a cleaning fluid for any purpose. Sol-

vent, Dry-Cleaning, Federal Specification P-S-661a, is available as a cleaning fluid through established supply channels. Oil, Fuel, Diesel, US Army Specification 2-102B, may be used for cleaning purposes when dry-cleaning solvent is not at hand.

11. PREVENTIVE MAINTENANCE OF CALIBRATOR I-189-A.

a. Inspect (I). Examine all parts of the equipment, noting the general condition of the instrument and the state of cleanliness. Inspect all tubes, tube sockets, resistors, capacitors, terminal boards, chokes, transformers, and wiring. Look for accumulations of dirt and for corrosion. Press the tubes down in their sockets and inspect them for firmness. Examine all wiring for placement and for defective insulation. Inspect all terminals and mounting screws for tightness. Examine the insulation of cables.

b. Tighten (T). All loose terminals, mountings, and connections (par. 9d).

c. Clean (C). Keep the instrument thoroughly clean. All corrosion must be removed from metal parts and connections, using crocus cloth or fine sandpaper if necessary. Dust, dirt, and other foreign matter can be removed by using a small paint brush or a cleaning cloth moistened with a cleaning solvent. When it is necessary to use cleaning solvent, always wipe the surfaces dry with a clean cloth. Clean the tubes only if inspection shows cleaning to be necessary.

12. LUBRICATION.

No lubrication is required on Calibrator I-189-A.

13. MOISTUREPROOFING AND FUNGIPROOFING.

a. General. Signal Corps equipment requires special attention in tropical areas where temperature and relative humidity are extremely high. The following are some of the problems met:

(1) Resistors, capacitators, coils, chokes, transformer windings, etc., fail because of the effects of fungus growth and excessive moisture.

(2) Electrolytic action, often visible in the form of corrosion, takes place in resistors, coils, chokes, transformer windings, etc., causing eventual breakdown.

(3) Moisture forms electrical leakage paths on terminal boards and insulating strips, causing flash-overs.

(4) Hook-up wire insulation and cable insulation break down. Fungus growth accelerates deterioration.

b. Treatment. A moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection against fungus growth, insects, salt spray, corrosion, and moisture. The treatment involves the use of a moisture- and fungi-resistant lacquer or varnish applied with a spray gun or brush. Refer to TB SIG 13, Moistureproofing and Fungiproofing Signal Corps Equipment, for a detailed description of the varnish and lacquer spray method of moistureproofing and fungiproofing and the supplies and equipment required in this treatment.

CAUTION: Varnish or lacquer spray may have poisonous effects if inhaled. To avoid inhaling spray, use a respirator if available; otherwise, fasten cheesecloth or other cloth material over the nose and mouth. Never spray varnish or lacquer near an open flame. Do not smoke in a room where varnish or lacquer is being sprayed. The spray may be highly explosive.

c. Step-by-Step Instructions for Treating Calibrator I-189-A.

(1) Preparation. Make all repairs and adjustments necessary for proper operation of the equipment.

(2) Disassembly.

(a) Loosen the four captive thumbscrews in the cover and remove the cover (fig. 1).

(b) Remove the screws around the edges of the front panel (fig. 2) and slide the chassis carefully out of the case.

(c) Remove crystal 3265 (fig. 12).

(d) Loosen the cable clamps on the under side of the chassis and pull the wiring away from the chassis.

(3) Cleaning. Clean all dirt, dust, rust, fungus, oil, and grease from the surface of the equipment to be varnished.

(4) Masking.

(a) Mask the following on the under side of the chassis (fig. 3):

1. The bottoms of all octal base tube sockets (A).
2. The variable capacitor 3245 (B).
3. Rubber-covered wire (C).

(b) Mask the following on the top of the chassis (fig. 4):

1. Variable capacitor 3245 (A).
2. All test jack holes (B).
3. Rubber-covered wire (C).
4. Crystal socket (D).

(5) Drying. Dry the equipment in an oven or under heat lamps for 6 hours at 140°F.

(6) Varnishing.

(a) Apply three coats of moistureproofing and fungiproofing varnish (Lacquer, Fungus-resistant, Spec No. 71-2202, stock No. 6G1005.3, or equal).

(b) The varnish must be applied immediately after the equipment is

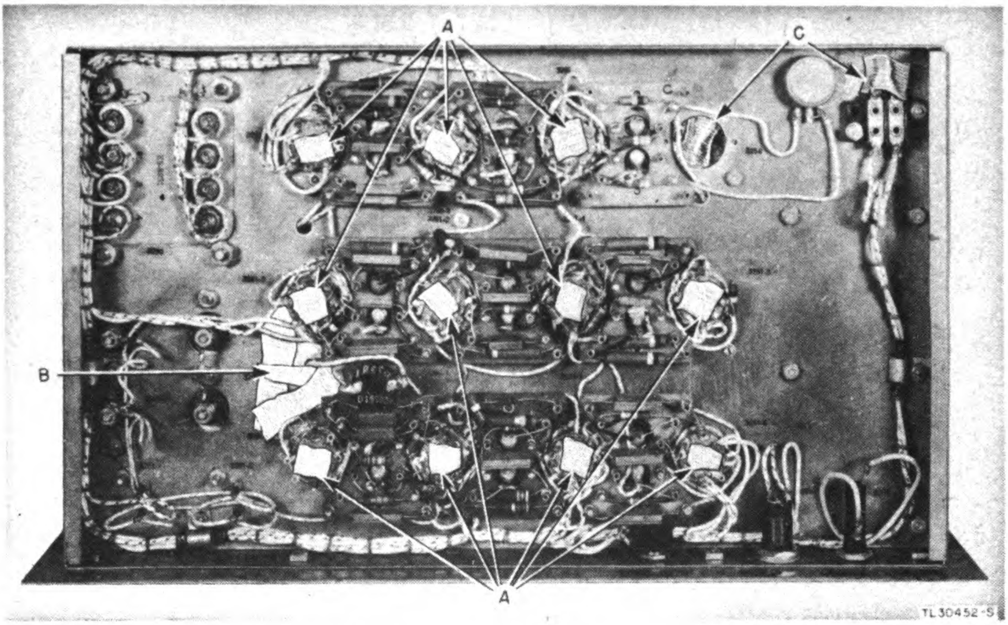


Figure 3. Bottom of chassis, masked.

removed from the oven. Otherwise, moisture condenses on the equipment. Varnish applied over the moisture peels off readily after the varnish has dried.

(c) Spray everything on the top and under side of the chassis.

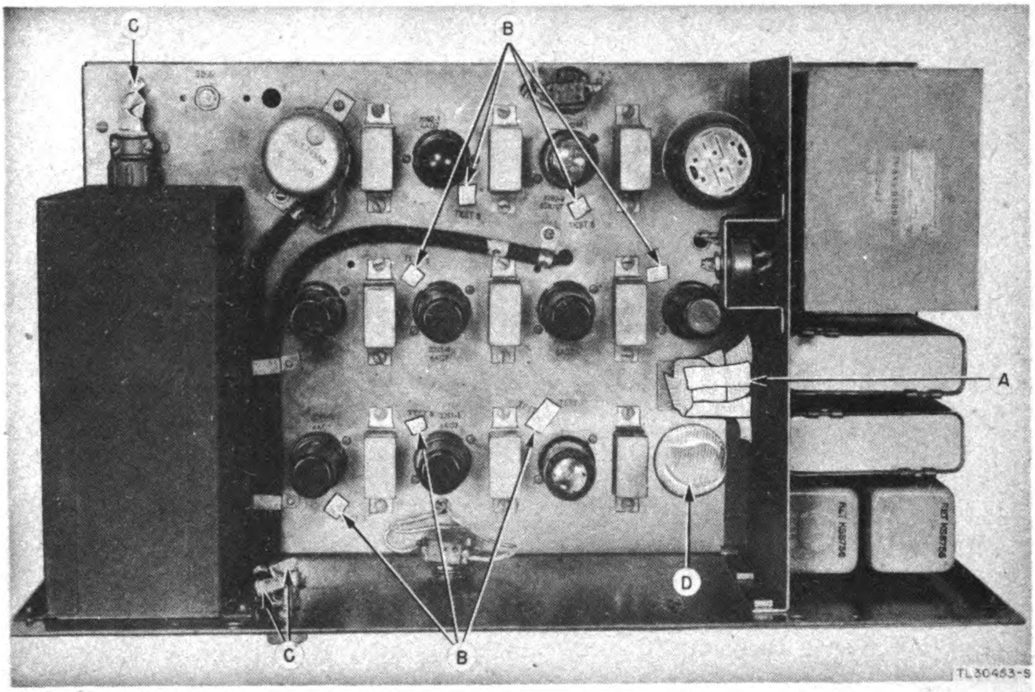


Figure 4. Top of chassis, masked.

(7) *Reassembly.*

(*a*) Remove all masking and touch up with a brush where necessary.

(*b*) Clean and burnish all contacts.

(*c*) Reassemble the equipment and test its operation.

(8) *Marking.* Mark the letters MFP and the date of treatment in a convenient place on the front panel near the nameplate.

EXAMPLE: MFP—5 May 45.

NOTE: When replacing defective parts after the set has been moisture-proofed and fungiproofed, use a brush to touch up exposed surfaces of new parts with fungus-resistant lacquer.

PART FOUR

AUXILIARY EQUIPMENT

(Not Used)

PART FIVE

REPAIR INSTRUCTIONS

NOTE: Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on W.D., A.G.O. Form No. 468 (Unsatisfactory Equipment Report); by Army Air Forces, on Army Air Forces Form No. 54 (Unsatisfactory Report). If either form is not available, prepare the data according to the sample form reproduced in figure 15.

14. GENERAL THEORY.

Calibrator I-189-A produces two outputs: a sync pulse at 480 cycles per second and a 500-yard marker pulse. The interrelation of the various stages in the calibrator circuit which accomplish this is shown in the block diagram (fig. 5).

a. Crystal-controlled Oscillator. Crystal-controlled oscillator 3260-1 is the master oscillator of the unit. It produces a sine-wave output of 327.80 kc frequency. This output goes to the phase inverter.

b. Phase Inverter. Three sine-wave outputs of the same frequency as the input to the stage are taken from phase inverter 3261-1. One of the outputs, in phase with the input, is applied to the synchronizing pulse generator circuit. Two other outputs, one in phase and the other 180° out of phase, are applied to the 360° phase shifter in the marker pulse generator circuit.

c. Synchronizing Pulse Generator. The sine-wave input to the synchronizing pulse generator circuit is amplified and squared in stages 3161-2 and 3161-3. One output from the amplifier-squarer is differentiated into positive and negative pips, and the other triggers the 480-cycle multivibrator circuit, tube 3260-2. The 327.80-kc pips from the differentiating circuit are superimposed on the pedestal from the multivibrator and applied to the Class C amplifier tube 3262. The output from the Class C amplifier is the synchronizing pulse output from the calibrator. It is a negative pulse corresponding to the positive pulse on top of the pedestal at the input to the Class C amplifier.

d. 500-yard Marker Pulse Generator. The output from the 360° phase shifter is a 327.80-kc sine wave shifted from 0° to 350° in phase with respect to the output from the crystal oscillator. The phase shift is adjusted by the PHASE ADJ control. This output is amplified and squared by tubes 3261-6 and 3261-5. The square-wave output from these stages is differentiated into positive and negative pips and applied to Class C amplifier 3261-4. The output from this amplifier is the 500-yard marker pulses. These pulses are negative pulses at 327.80-kc frequency corresponding to the positive pulses at the input to the Class C amplifier.

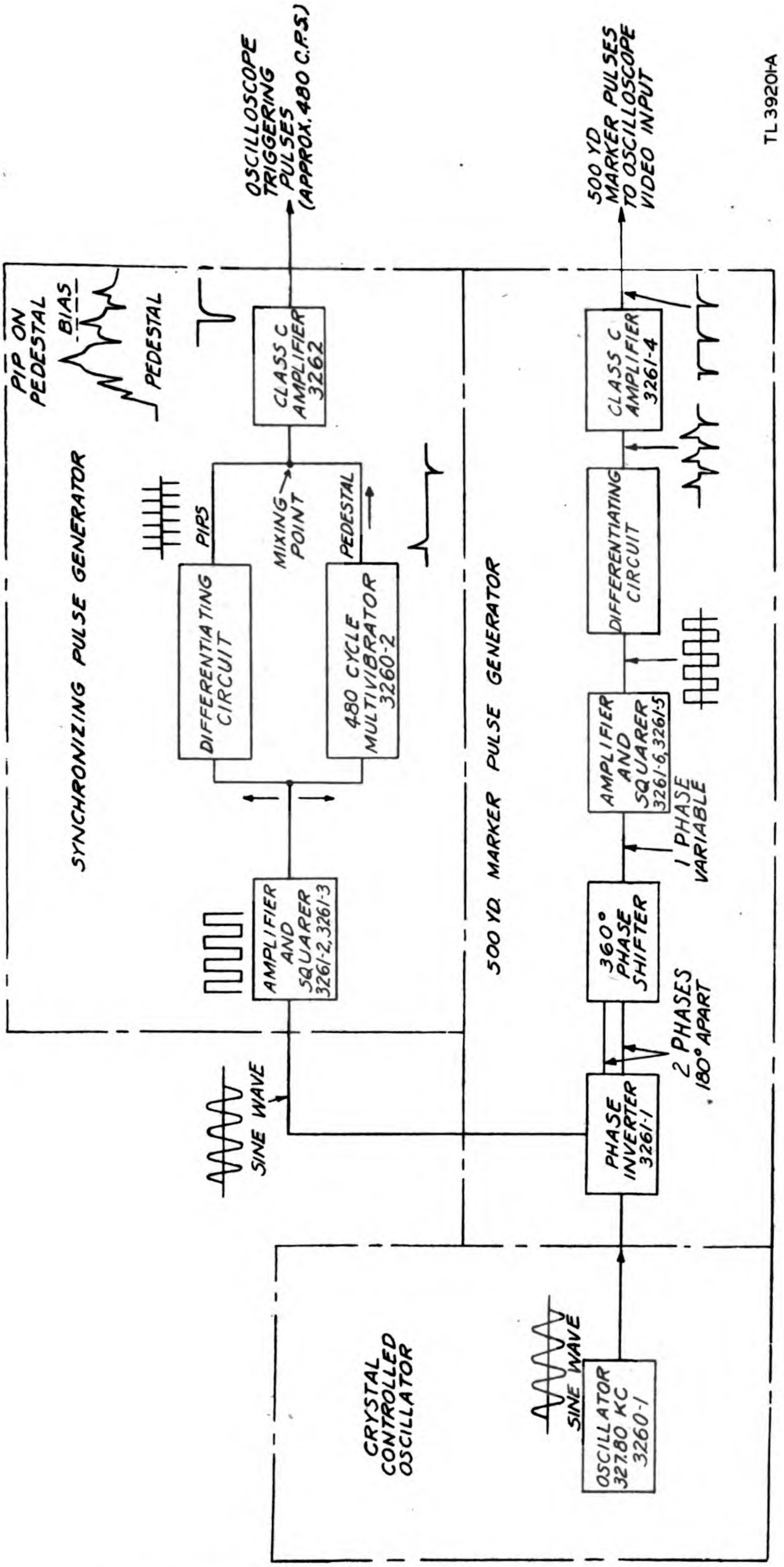


Figure 5. Calibrator I-189-A, block diagram.

15. CRYSTAL-CONTROLLED OSCILLATOR CIRCUIT.

The master oscillator of the calibrator is oscillator 3260-1 controlled by crystal 3265 (fig. 8).

a. Tube 3260-1 is a two-stage amplifier with feedback from the second plate to the first grid. Since a phase inversion of 180° takes place in each stage, the output of the second section is shifted 360° and is in phase with the input of the first stage. Therefore oscillations take place in the circuit.

b. The second plate circuit is tuned by the parallel resonant circuit consisting of inductor 3248 and capacitors 3247 and 3238 in series. The output of the stage is therefore sinusoidal. Capacitors 3247 and 3238 act as a voltage divider so that only a small portion of the a-c plate voltage is fed back through the crystal to grid 1.

c. Crystal 3265 acts as a highly selective series resonant circuit in series with the feedback path to the grid of the first section, and fixed frequency is thus obtained. The crystal appears as a low impedance (a few hundred ohms) at its natural frequency of mechanical vibration and as a very high impedance at other frequencies. It is cut for 327,800 ±30 cycles. Trimmer capacitor 3245 is adjusted at the factory for maximum output from the oscillator, and the frequency is checked at 327,800 ±50 cycles.

d. The output to the following stages is tapped from the capacitive voltage divider which feeds the crystal. The wave is sinusoidal and has an amplitude of approximately 30 volts peak to peak.

16. PHASE INVERTER CIRCUIT.

Tube 3261-1 is connected as a phase inverter (fig. 8). The sine wave from the oscillator is applied to the grid. Sine waves 180° out of phase with each other are taken from the plate and cathode circuits. The signal from the plate is coupled through capacitor 3242-2 to one side of the 360° phase shifter. The wave from the junction of resistors 3223 and 3224 in the cathode circuit is applied directly to the other side of the phase-shifter circuit and is coupled through capacitor 3234-1 to the input of the synchronizing pulse circuit.

17. SYNCHRONIZING PULSE GENERATOR CIRCUIT.

a. Amplifier and Squarer. The sine-wave input to the synchronizing pulse generator circuit is squared and amplified in the two-stage resistance-coupled amplifier consisting of the two 6AC7 tubes, 3261-2 and 3261-3 (fig. 8).

(1) Tube 3261-2 acts as a triode limiter. The amplitude of the sine wave at the grid is sufficient to drive the tube to plate current saturation during part of each positive half-cycle and below cut-off on part of each negative half-cycle. The resulting signal at the plate of tube 3261-2 is flattened on both positive and

negative half-cycles and is of large amplitude due to the large load resistor, 3211-1. Screen voltage for the stage is taken from the voltage divider 3220-1 and 3220-2 and is held constant by bypass capacitor 3243-3. The only bias on the stage is due to grid current flowing in resistor 3209-2.

(2) The output from tube 3261-2 is approximately a square wave, but the rise is not steep enough for good peaking. Tube 3261-3 squares the wave further and steepens the sides. The input signal at the grid of tube 3261-3 is of such high amplitude that only a small portion of the middle of the wave is amplified. The tube is quickly driven to plate current saturation on positive swings and is quickly driven below cut-off on negative swings. The output at the plate is thus a square wave with very straight sides. This stage also has zero fixed bias and is biased by grid current flowing through resistor 3210-2. Two parallel outputs are taken from this stage; one is coupled to the multivibrator by capacitor 3224-2; the other is differentiated by capacitor 3255 and resistors 3203-1 and 3203-2 in series and is applied to the grid of the Class C amplifier.

b. 480-CPS Multivibrator Circuit. The multivibrator 6SN7 tube 3260-2 (fig. 8) is triggered by the square-wave input from the previous stage and produces a positive pedestal voltage for mixing with the differentiating pips from capacitor 3255.

(1) Assume that the circuit is opened at points X, Y, and Z (fig. 6) The circuit now appears as a conventional multivibrator with feedback from each plate to the opposite grid. The free-running frequency depends mainly on the time constants of the two grid circuits: capacitor 3246-2 and resistors 3225-2 and 3225-3 in parallel; and capacitor 3246-1 and resistor 3225-1 in parallel with 3210-1, and 3252. Variable resistor 3252 permits setting this frequency at approximately 480 cycles at the factory. The voltage across cathode resistor 3203-1 from this free-running multivibrator should appear as shown at (1) in figure 6, the voltage at cathode terminal 3 being positive with respect to ground during the half-cycle when T1 the left half of the triode, is conducting.

(2) If the parallel tuned circuit formed by capacitor 3236 and inductor 3249 is now connected by closing point Y, damped oscillations are produced, as shown at (2) in figure 6.

(3) If point X is closed, some voltage from the squarer, tube 3261-3, will be fed to the grid of T1. Therefore, when T1 is ready to start conducting because of relaxed grid bias, the next positive pulse will trigger T1. This insures that the positive pulses or pedestals, shown at (3), always start in phase with a positive voltage swing at test point 4, the squarer output.

(4) When point Z is closed, the pips shown at (5) (fig. 6) and the pedestal from the cathode of T1 are combined, and the pips are superimposed on the pedestal, as shown at (6).

c. Class C Amplifier. The 480-cps pedestal with the pips superimposed on it (test point 6, fig. 9) is coupled directly to the following Class C amplifier stage (fig. 8). A 6AG7 tube (3262) is used with high cathode bias to cut off all but the pip on top of the pedestal. When this pip overcomes the bias, a 1-microsecond negative pulse is delivered to the SYNC output jack (test point 7, fig. 9) to trigger the range oscilloscope. Transformer 3258 steps down the tube impedance and delivers a sufficiently high-voltage pulse to the 72-ohm load. Potentiometer 3256 permits adjusting the 6AG7 bias for the maximum undistorted output pulse.

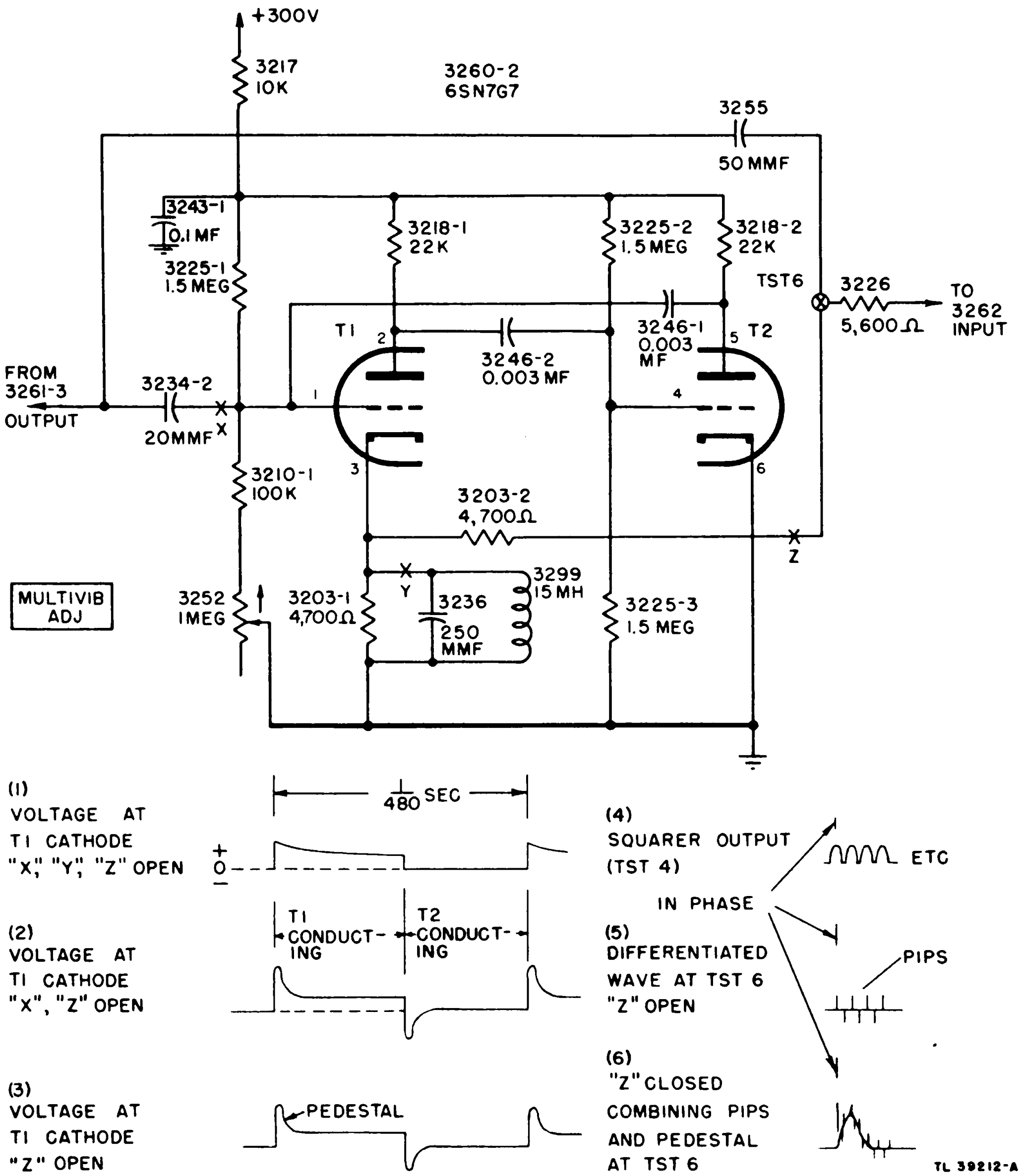


Figure 6. 480-cycle multivibrator, simplified schematic diagram.

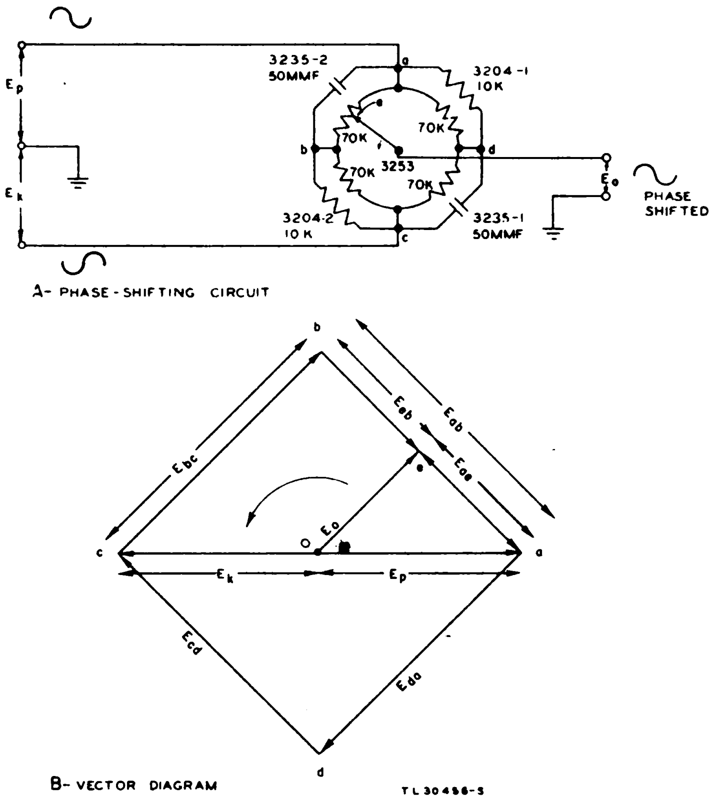


Figure 7. 360° phase shifter, simplified schematic diagram.

18. 500-YARD MARKER PULSE GENERATOR CIRCUIT.

a. 360° Phase Shifter. Phase shifter 3253 (fig. 8), operated by the PHASE ADJ control, shifts the phase of the input to the 500-yard marker circuits.

(1) Two input voltages 180° out of phase with each other are applied to the phase shifter; E_p (fig. 7-A) is taken from the plate of phase inverter 3261-1, and E_k is taken from the cathode circuit. In the vector diagram (fig. 7-B) these two input voltages are represented by the vectors E_p and E_k, equal in magnitude and pointing in opposite directions from the point of ground voltage, O.

NOTE: The amplitudes of the two input voltages are not exactly equal. The operation of the circuit is essentially the same, however, and the explanation is simplified by assuming that they are equal.

(2) Phase-shift potentiometer 3253 is continuously rotatable through 360°. Taps are provided at four equally spaced points around the potentiometer, each section being 70,000 ohms. This potentiometer acts merely as a voltage divider for the voltage applied across it. The phase shift is caused by capacitors 3235-1 and -2 and resistors 3204-1 and -2 connected in parallel with the sections of the potentiometer.

(3) The total voltage applied across the phase shifter equals the sum of the two vectors E_p and E_k. Vector E_o (fig. 7-B) represents the output voltage

taken between the movable tap of the potentiometer and ground. With the tap at point *a* (fig. 7-A) the output voltage is the same as the input from the plate of 3261-1, and vector E_o coincides with E_p in direction (phase) and magnitude. When the tap is turned to position *c*, the output voltage is the same as the input from the cathode of 3261-1, and E_o coincides with E_k, 180° out of phase with E_p.

(4) Since capacitor 3235-2 and resistor 3204-2 are connected in series with each other across the whole phase shifter, the voltage across them must be the same as the total input voltage to the phase shifter, and also must be the sum of the individual voltages across the resistor and the capacitor. The current in a capacitor, however, always leads the voltage applied to the capacitor by a phase angle of 90°. Since this leading current flows through resistor 3204-2, the voltage drop across the resistor leads the voltage drop across the capacitor by 90°. These conditions are shown in figure 7-B, where E_{bc} (the voltage across resistor 3204-2) leads E_{ab} (the voltage across capacitor 3235-2) by 90°, and the sum of these two vectors is equal to the total input voltage, E_p plus E_k.

(5) If the center tap of the potentiometer is turned to point *b* (fig. 7-A) (the junction of resistor 3204-2 and capacitor 3235-2), the output voltage is equal to either one of two parallel voltages; E_p minus E_{ab} or E_k minus E_{bc}. On the vector diagram this places E_o in the position O_b, still equal in magnitude to E_p (or E_k) but leading E_p in phase by 90°.

(6) Each section of potentiometer 3253 acts as a voltage divider for the voltage across the capacitor or resistor in parallel with it. If the movable tap is set at *e* between points *a* and *b* (fig. 7-A), the ouput voltage is equal to the difference between E_p and E_{ae}. This condition is represented by the position of E_o in figure 7-B. Capacitor voltage E_{ab} is divided in the ratio E_{ae} to E_{eb}, and E_o plus E_{ae} equals E_p. As the potentiometer tap is moved from *a* to *b*, the proportion of E_{ae} to E_{eb} changes, and the vector E_o rotates from the position O_a to O_b. When the tap moves past *b* into the section of the potentiometer in parallel with resistor 3204-2, E_{bc} is divided in the same manner. Thus, a continuously variable phase shift of 0° to 180° with respect to E_p is obtained.

(7) The parallel voltage divider consisting of resistor 3204-1 and capacitor 3235-1 operates in the same manner except that the positions of the resistor and capacitor are reversed. This changes the direction of the two vectors E_{cd} and E_{da} so that the output voltage at *d* leads E_k instead of E_p. Thus the full 360° phase shift is obtained.

(8) It can be seen from the vector diagram that the magnitude of the output voltage is not constant. It is equal to E_p or E_k at the four stationary taps of the potentiometer and decreases to approximately 70 percent of each input voltage at the midpoints of each one of the voltage divider sections. This variation in amplitude is permissible, however, since the output voltage at its minimum is still large enough to overdrive the squarer stage and produce a square-wave output (subpar. b below).

b. Squarer and Amplifier. The phased voltage from the phase shifter is coupled to the input of the squarer and amplifier stage (tubes 3261-6 and 3261-5) by capacitor 3240. The operation of this circuit is the same as the squarer-amplifier circuit in the synchronizing pulse generator (par. 15a). The squarer output is differentiated by capacitor 3237-2 and resistor 3201-1, resulting in the pips shown at test point 9 (fig. 9).

c. Class C Amplifier. The differentiated pips are fed into a Class C amplifier, 6AC7 pentode 3261-4 (fig. 8). Positive cathode bias, provided by resistors 3221 and 3202, keeps the tube cut off except on positive pips. The latter produce negative pulses in the plate circuit as shown at test point 10 (fig. 9). These pips are coupled to the MARKERS output jack as the 500-yard marker pulses.

19. POWER SUPPLY CIRCUIT.

All of the d-c voltages for the circuits are supplied from rectifier 3263, a 5U4G tube connected as a full-wave rectifier (fig. 8). A positive output of approximately 300 volts is taken from the filament circuit of the rectifier and is filtered by filter chokes 3251-1 and -2 and capacitors 3244-1 and -2. One filament winding on power transformer 3250 supplies the rectifier tube, and a second one supplies the filament power for all the other tubes on the chassis and the pilot light. Power from the input cable passes through a 2-ampere fuse, 3269, and POWER switch 3270 to the primary of the power transformer.

20. SERVICING.

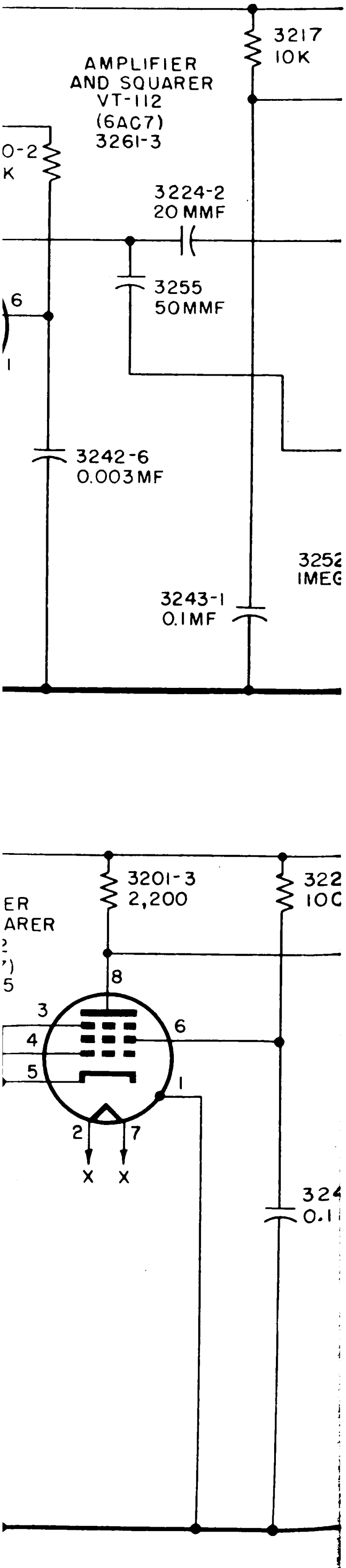
Servicing and repair other than the replacement of tubes should be performed only by competent personnel supplied with adequate tools and instruments. An inexperienced operator attempting to locate and repair troubles may damage the equipment to such an extent that shipment to a higher repair echelon will be necessary. This precaution cannot be overemphasized.

21. GENERAL REPAIR.

Removal and replacement of defective parts or circuit elements in this equipment are very critical; great care must be taken to avoid further damage to the equipment or to the part being replaced. Before attempting repairs, make every effort to obtain the proper tools for the job.

a. identification of Leads. Often it may be necessary to remove other circuit elements to gain access to the defective part. To insure proper reinstallation, make a record of the connections to each removed element and of the position of the element in the equipment.

b. Electrical Connections. When renewing leads, clip them as short as possible for satisfactory connection. Use only sufficient solder to make a secure


3217
10K
AMPLIFIER
AND SQUARER
VT-112
(6AC7)
3261-3
3224-2
20 MMF
3255
50 MMF
3242-6
0.003 MF
3243-1
0.1 MF
3201-3
2,200

'tic diagram.

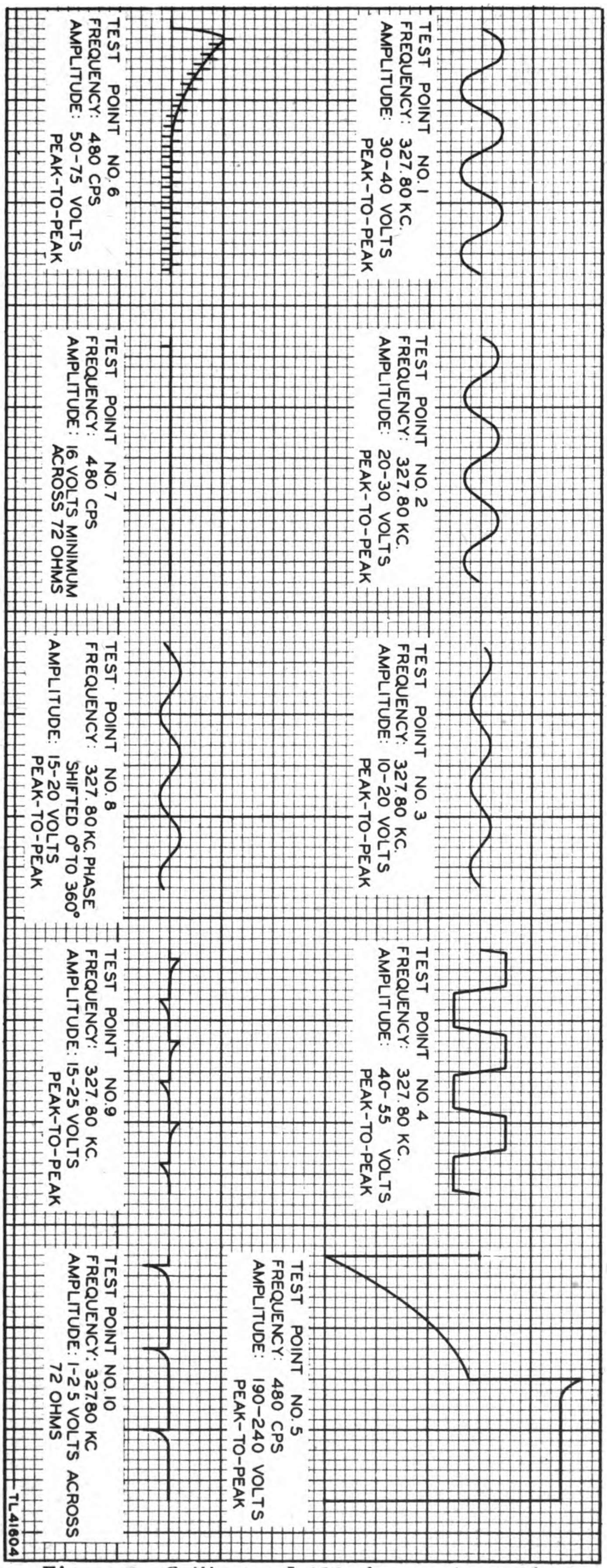


Figure 9. Calibrator I-189-A, waveform chart.

connection. A slight amount of excess solder dropped accidentally inside the equipment may cause other circuits or circuit elements to become short-circuited. Some clearances inside the instrument are very small, and extreme care must be exercised when soldering. Do not heat the lug or connection more than is absolutely necessary because of possible damage to near-by elements. When a wire is connected to a tube socket, the connecting wire should be long enough to prevent pull on the socket. Save time and trouble by making a thorough electrical check of any part that appears to be defective *before* removing it from the circuit.

22. GENERAL TROUBLE-SHOOTING NOTES.

a. Reference Data. The block diagram, the simplified and complete schematic diagrams, and the waveform chart will be of assistance to maintenance personnel in trouble shooting in the calibrator. In addition figures identifying all the parts on the chassis and tube socket voltage and resistance diagrams are included at the end of the trouble-shooting chart (par. 23). The waveforms shown in figure 9 are not test scope waveforms. Most of the waveforms at the test points are too high in frequency for the shape of individual cycles to be seen on an ordinary test oscilloscope. The waveforms viewed at the various test points on the chassis, however, will give an indication of how the circuits are operating.

b. Trouble-shooting Chart. The trouble-shooting chart in paragraph 23 gives a systematic procedure for locating and eliminating trouble in the circuits of the calibrator. Symptoms of abnormal operation are given together with probable causes of the fault and procedure for clearing the fault. As in most electronic equipment, defective tubes are the most common cause of trouble. When trouble is indicated in a certain stage, the tube should be checked first. Then the circuits connected with the tube should be checked. The voltage and resistance data given in figures 13 and 14 is helpful in checking circuits.

23. TROUBLE-SHOOTING CHART.

A. SYMPTOM:
Pilot light does not glow when calibrator is turned on.

Probable Location of Fault	Procedure
1. Fuse 3269.	1. Replace fuse.
2. Power cord.	2. Check power cord for continuity.
3. POWER switch 3270.	3. Check contacts of switch.
4. Power transformer 3250	4. Check continuity of windings 1-2 and 7-8 of transformer (fig. 10).
5. Pilot light 3268.	5. Replace pilot light.

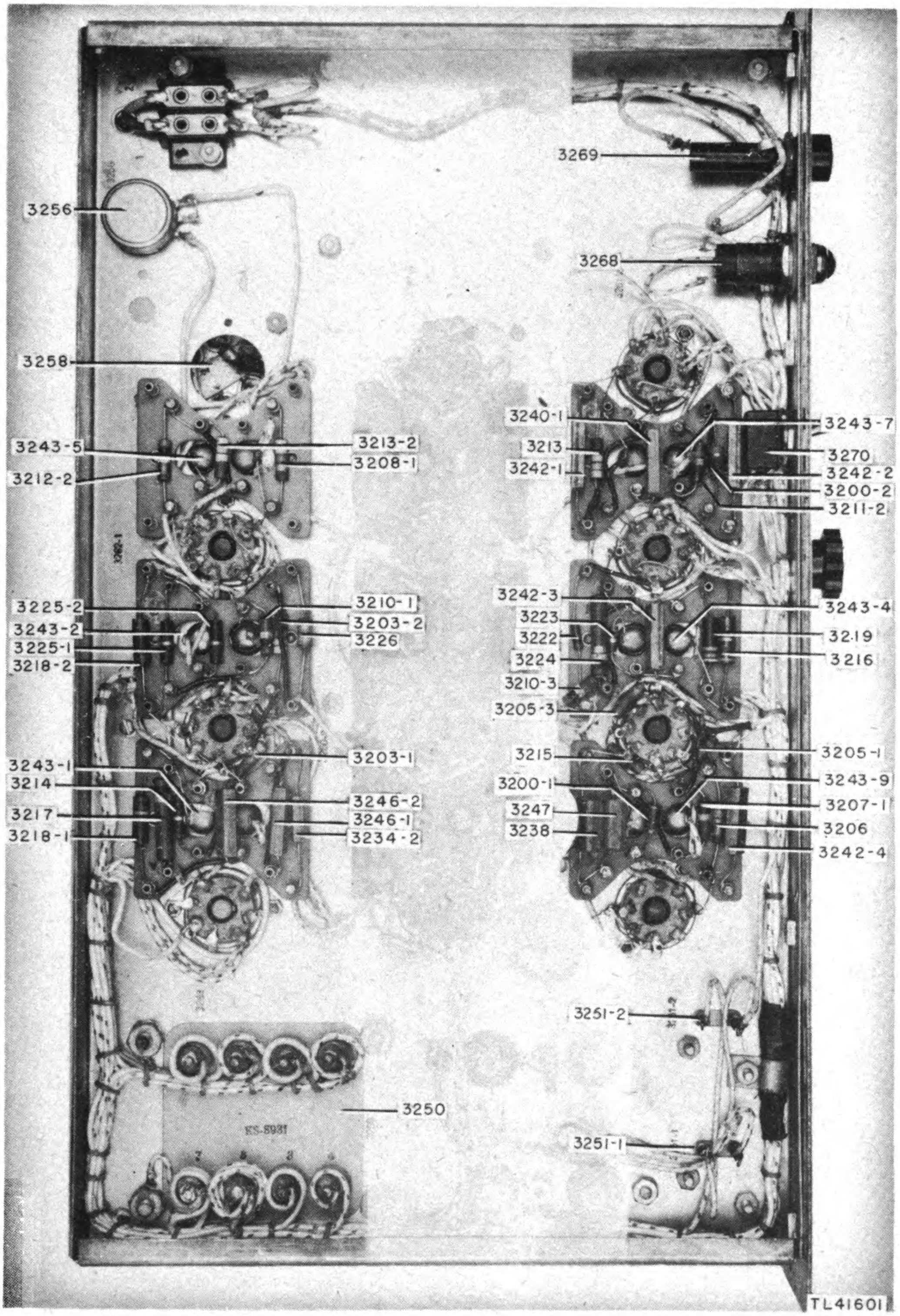


Figure 10. Calibrator I-189-A, bottom of chassis (1).

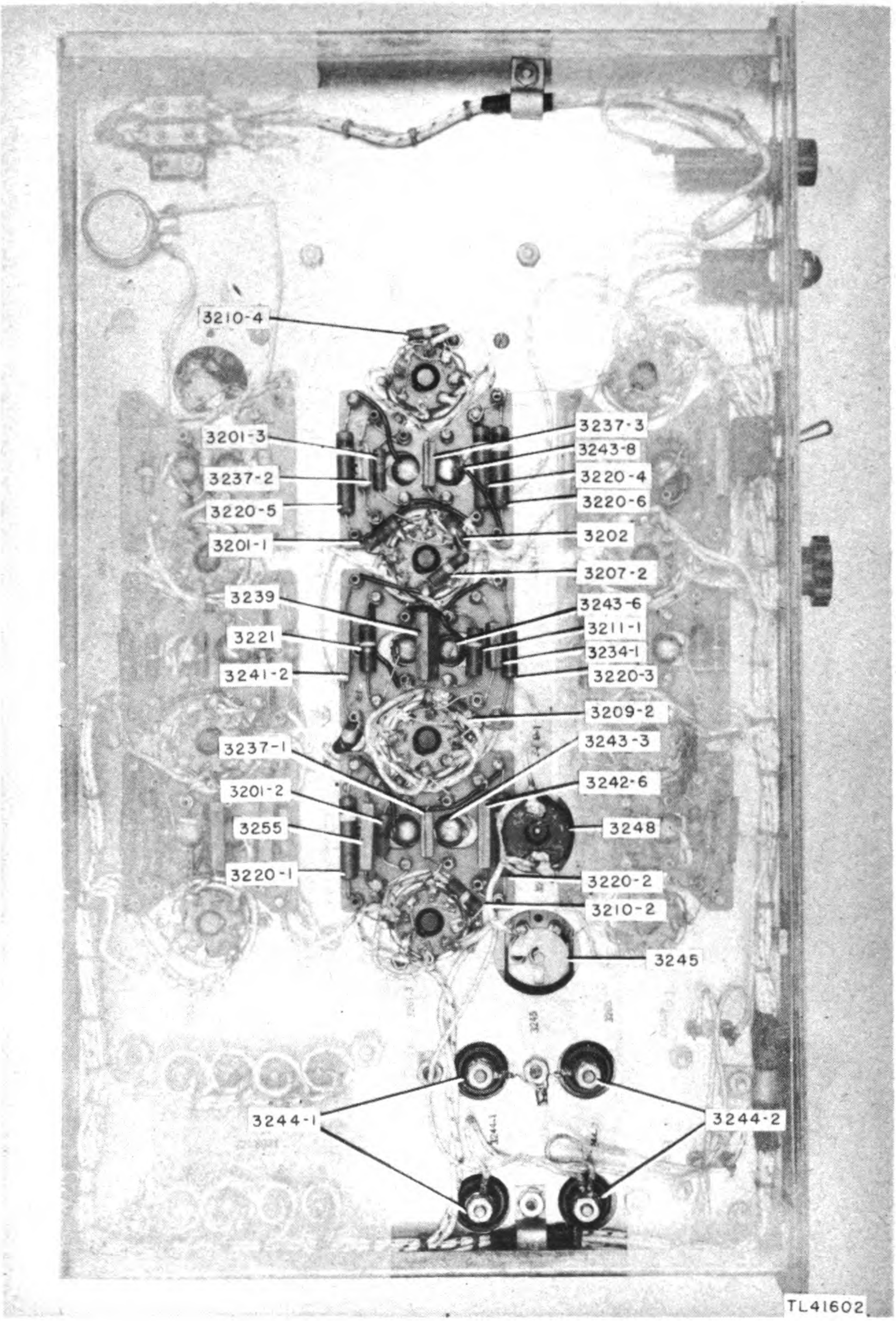


Figure 11. Calibrator I-189-A, bottom of chassis (2).

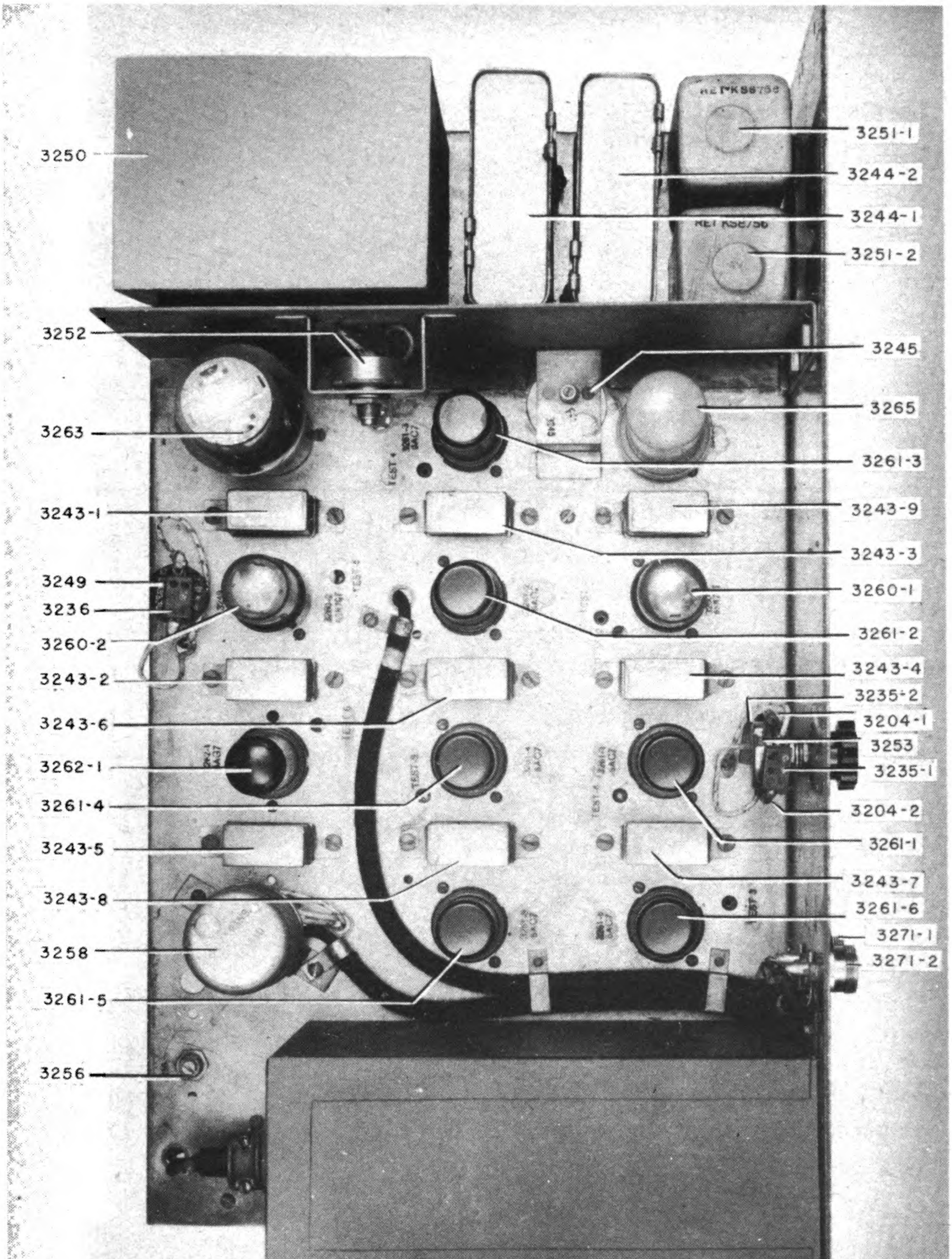


Figure 12. Calibrator I-189-A, top of chassis.

B. SYMPTOM:

No sweep or 500-yard markers on range oscilloscope.

Probable Location of Fault	Procedure
1. Rectifier.	1. Check the circuit of tube 3263 (figs. 10 and 12).
2. Power transformer 3250.	2. Check continuity of windings 3-4 and 5-6 of transformer (fig. 10).
3. Crystal 3265.	3. Check by replacing crystal (fig. 12).
4. 327.8-kc oscillator circuit.	4. Check circuits of tubes 3260-1 and 3261-1 (figs. 10 and 12).

C. SYMPTOM:

No sweep, or sweep is jittery on range oscilloscope. (Trouble indicated in calibrator.)

Probable Location of Fault	Procedure
1. Incorrect bias of sync pulse Class C amplifier 3262.	1. Vary resistor 3256 (fig. 12) for maximum output with waveshape as shown at test point 7 (fig. 9 and par. 25).
2. Synchronizing pulse generator circuit.	2. Check the circuits of tubes 3261-2, 3261-3, 3260-2, and 3262 (figs. 10, 11, and 12).
3. Output transformer 3258.	3. Check transformer windings for open and short circuits (fig. 12).
4. Faulty connection between SYNC output jack and range oscilloscope sync input.	4*a*. Check continuity of coaxial cable. *b*. Check jack 3271-2 (fig. 12).

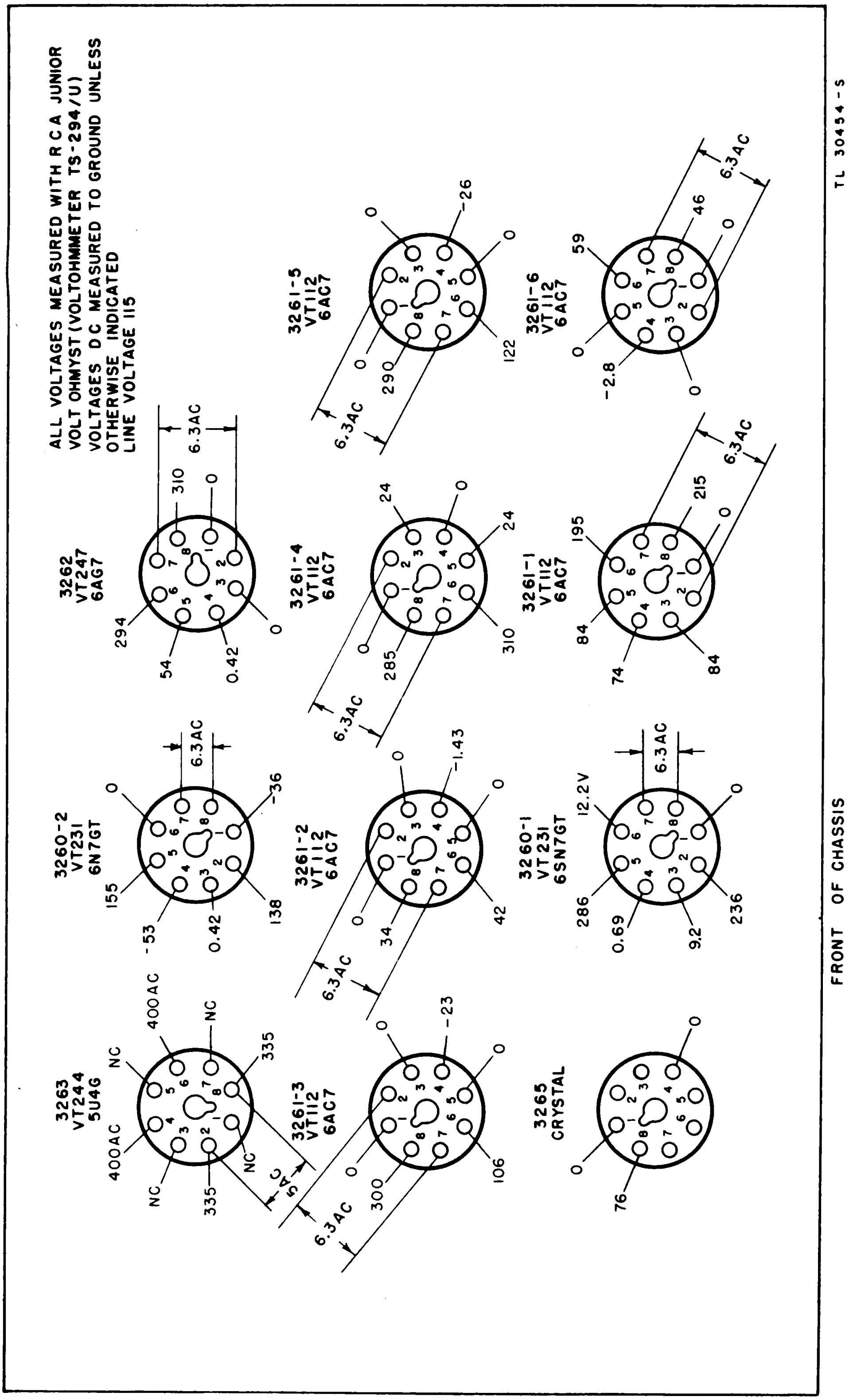


Figure 13. Tube socket voltage diagram.

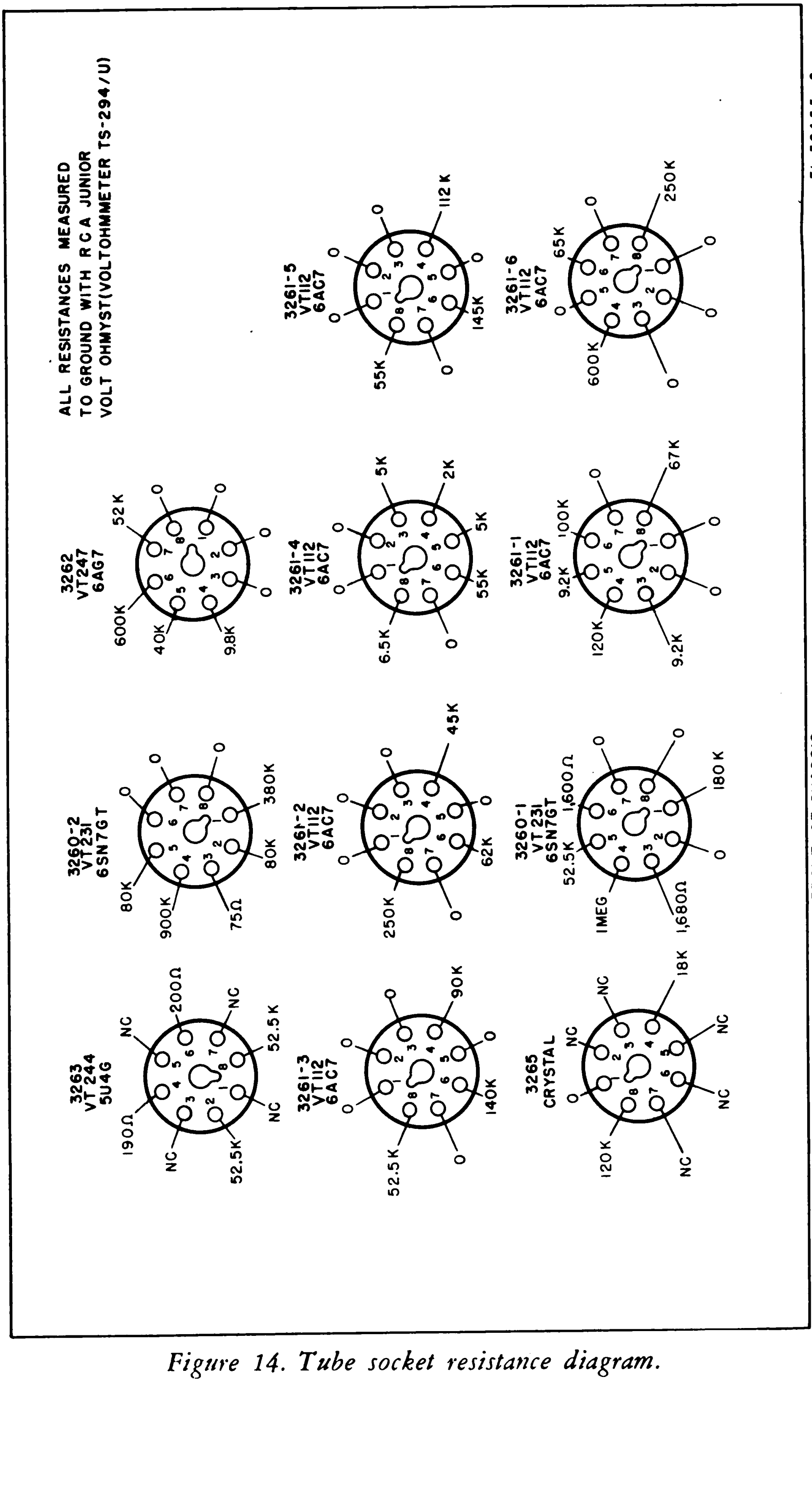


Figure 14. Tube socket resistance diagram.

D. SYMPTOM:

No 500-yard markers, or weak and jittery 500-yard markers on range oscilloscope. (Trouble indicated in calibrator.)

Probable Location of Fault	Procedure
1. Marker pulse generator circuits.	1. Check the circuits of tubes 3261-6, 3261-5, and 3261-4 (figs. 10, 11, and 12).
2. Phase-shifter circuit.	2. Check potentiometer 3253 and associated circuit (fig. 12).
3. Faulty connection between MARKERS output jack and video input on range oscilloscope.	3*a*. Check continuity of coaxial cable. *b*. Check jack 3271-1 (fig. 12).

E. SYMPTOM:

360° phase shift is not obtained when PHASE ADJ control is rotated.

Probable Location of Fault	Procedure
1. Phase-shifter circuit.	1. Check potentiometer 3253 and associated circuit (fig. 12).

24. MULTIVIBRATOR FREQUENCY ADJUSTMENT.

Multivibrator potentiometer 3252 is set at the factory and usually need not be changed thereafter. If it has been disturbed, it may be reset by synchronizing the voltage at test point 7 against the 60-cycle line voltage, using a test oscilloscope.

a. Set up the test oscilloscope and connect a 60-cycle voltage from the power line to the Y or vertical input.

b. Adjust the oscilloscope sweep frequency controls until one cycle of the 60-cycle voltage is seen on the screen. Adjust the frequency as closely as possible with the fine frequency control using no synchronizing voltage.

c. Disconnect the 60-cycle signal and connect the Y input of the oscilloscope to test point 6 on the calibrator.

d. Adjust potentiometer 3252 (fig. 12) until eight cycles of the pedestal from the multivibrator are seen on the screen.

25. ADJUSTMENT OF TUBE 3262 CLASS C BIAS.

If the output pulses at the SYNC output jack are insufficient, the bias of the 6AG7 vacuum tube 3262 may need to be adjusted.

a. Set up the test oscilloscope and connect the Y signal input to test point 7 on the calibrator.

b. Adjust the oscilloscope controls until one or more cycles of the output pulse are seen on the screen.

c. Adjust resistor 3256 (fig. 12) for maximum clean output as seen on the oscilloscope screen.

26. ADJUSTMENT OF 327.8-KC OSCILLATOR.

If the oscillator does not operate properly, the fault may be in the crystal. If the crystal is replaced, the oscillator-adjustment trimmer capacitor 3245 must be readjusted.

a. Set up the test oscilloscope and connect the Y signal input to test point 2 on the calibrator.

b. Turn the frequency controls to the highest frequency at which the pattern on the screen can be seen. It may not be possible to see the shape of individual cycles of the signal or to synchronize the pattern. For this test, however, it is necessary to observe only the amplitude of vertical deflection produced.

c. Adjust capacitor 3245 (fig. 12) for maximum output as observed on the test oscilloscope.

27. UNSATISFACTORY EQUIPMENT REPORT.

a. When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report, W.D., A.G.O. Form No. 468, should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C.

b. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form No. 54 should be filled out and forwarded through channels.

c. If either form is not available, prepare the data according to the sample form reproduced in figure 15.

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps	MATERIEL	DATE: 20 Mar. 1945
FROM	ORGANIZATION: 885 Signal Repair Co.		STATION: APO 258, New York
TO	NEXT SUPERIOR HEADQUARTERS: Signal Officer	STATION: Army	TECHNICAL SERVICE

COMPLETE MAJOR ITEM

NOMENCLATURE: Calibrator I-189-A	TYPE		MODEL
MANUFACTURER: Western Electric	U. S. A. REG. No.: Order No. 817-MPD44	SERIAL NO.: 89	DATE RECEIVED: 20 Dec. 1944
EQUIPMENT WITH WHICH USED (*if applicable*)			

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART No. (3256) 2Z7270.3	TYPE: Potentiometer	MANUFACTURER: Allen Bradley.	DATE INSTALLED: 15 Jan. 1945

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (*If additional space is required, use back of form*)
Potentiometer burned out - too low wattage rating.

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
15 Mar. 1945	—	2	—			5	15		

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN
High operating temperature.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (*If additional space is required, use back of form*)
POOR	FAIR	GOOD	Potentiometer 3256 should have a higher power rating.
		✓	

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION: HAROLD T. MASON, CAPT., SIG. C. 885 SIG. REPAIR CO.	SIGNATURE: Harold T. Mason

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

1. It is imperative that the chief of technical service concerned be advised at the earliest practical moment of any constructional, design, or operational defect in matériel. This form is designed to facilitate such reports and to provide a uniform method of submitting the required data.
2. This form will be used for reporting manufacturing, design, or operational defects in matériel, petroleum fuels, lubricants, and preserving materials with a view to improving and correcting such defects, and for use in recommending modifications of matériel.
3. This form will not be used for reporting failures, isolated material defects or malfunctions of matériel resulting from fair-wear-and-tear or accidental damage nor for the replacement, repair or the issue of parts and equipment. It does not replace currently authorized operational or performance records.
4. Reports of malfunctions and accidents involving ammunition will continue to be submitted as directed in the manner described in AR 750-10 (change No. 3).
5. It will not be practicable or desirable in all cases to fill all blank spaces of the report. However, the report should be as complete as possible in order to expedite necessary corrective action. Additional pertinent information not provided for in the blank spaces should be submitted as inclosures to the form. Photographs, sketches, or other illustrative material are highly desirable.
6. When cases arise where it is necessary to communicate with a chief of service in order to assure safety to personnel, more expeditious means of communication are authorized. This form should be used to confirm reports made by more expeditious means.
7. This form will be made out in triplicate by using or service organization. Two copies will be forwarded direct to the technical service; one copy will be forwarded through command channels.
8. Necessity for using this form will be determined by the using or service troops.

W. D., A. G. O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted

TL 41605

U. S. GOVERNMENT PRINTING OFFICE 16—41546-1

Figure 15. Unsatisfactory Equipment Report.

APPENDIX

28. MAINTENANCE PARTS FOR CALIBRATOR I-189-A.

Ref. symbol	*Signal Corps stock No.*	*Name of part and description*
3243-6 3243-7 3243-8 3243-9	3DA100-170	CAPACITOR, paper: 0.1 mf ±20%; 600 vdcw; Aerovox 616M-14842.
3244-1 3244-2	3DB8-69	CAPACITOR, paper: 8.0 mf ±20%; 600 vdcw; Dubilier TJH-6080.
3245	3D9075V-14	CAPACITOR, variable: 75 mmf (max), 4.5 mmf (min); screwdriver adjustment; ESO-682070-17; Hammarlund APC-75 (modified).
3246-1 3246-2	3DKA3-23.2	CAPACITOR, mica: 0.003 mf ±10%; 500 vdcw; Dubilier 3WLS.
3247	3K3030232	CAPACITOR, mica: 0.003 mf ±5%; 500 vdcw; Dubilier IR.
3248	3C1987-33	COIL: 0.5 mh (approx); d-c resistance 12.0 ohms (max); WECo D-163333.
3249	3C1987-34.2	COIL: 15 mh (approx); d-c resistance 95 ohms (max); WECo D-163334.
3250	2Z9613.45	TRANSFORMER, power: 120 va; pri (1-2) 115v, 50-65 cyc; secd (3-4) 585v at 0.086 amp; secd (5-6) 5v at 3 amp; secd (7-8) 6.3v at 6 amp; WECo KS-8931.
3251-1 3251-2	3C198756.1	COIL, filter: 4.5 hy w/0.075 amp DC in winding, max voltage to case 2,000v, 60 cyc, 186 ohms (max), d-c resistance; WECo KS-8756.
3252	2Z7273-2	POTENTIOMETER, composition: linear taper; 1.0 meg ±20%; ½" shaft w/screwdriver slot; ESO-691122-25; Allen-Bradley J.
3253	2Z7271-10	POTENTIOMETER, composition: linear taper; resistance between terminals (1-2) (2-3) (3-4) (4-1) 70,000 ohms ±20%; shaft ⅞" lg, bushing ⅜", 360° rotation; ESO-695581-1; Clarostat 1-824-AW control.

28. MAINTENANCE PARTS FOR CALIBRATOR I-189-A (contd).

Ref. symbol	*Signal Corps stock No.*	*Name of part and description*
3200-1 3200-2	3Z6100-73	RESISTOR, composition: 1,000 ohms ±20%; ½w; IRC BT-½.
3201-1 3201-2 3201-3	3Z6220-10	RESISTOR, composition: 2,200 ohms ±20%; ½w; IRC BT-½.
3202	3Z6506	RESISTOR, composition: 5,600 ohms ±5%; ½w; IRC BT-½.
3203-1 3203-2	3Z6470-16	RESISTOR, composition: 4,700 ohms ±20%; ½w; IRC BT-½.
3204-1 3204-2	3Z4529	RESISTOR, composition: 10,000 ohms ±10%; ½w; IRC BT-½.
3210-3 3210-4	3Z6700-72	RESISTOR, composition: 0.1 meg ±20%; ½w; IRC BT-½.
3211-1 3211-2	3Z6715-28	RESISTOR, composition: 0.15 meg ±20%; ½w; IRC BT-½.
3212-1 3212-2	3Z6720-1	RESISTOR, composition: 0.2 meg ±5%; ½w; IRC BT-½.
3213-1 3213-2	3Z6747-14	RESISTOR, composition: 0.47 meg ±20%; ½w; IRC BT-½.
3214	3Z6782	RESISTOR, composition: 0.82 meg ±10%; ½w; IRC BT-½.
3215	3Z6801-16	RESISTOR, composition: 1 meg ±20%; ½w; IRC BT-½.
3205-1 3205-2	3Z6180-11	RESISTOR, composition: 1,800 ohms ±20%; ½w; IRC BT-½.
3206	3Z6618-15	RESISTOR, composition: 18,000 ohms ±5%; ½w; IRC BT-½.
3207-1 3207-2	3Z6610-76	RESISTOR, composition: 10,000 ohms ±20%; ½w; IRC BT-½.
3208-1 3208-2	3Z6470-2	RESISTOR, composition: 4,700 ohms ±10%; ½w; IRC BT-½.
3209-1 3209-2	3Z6647-12	RESISTOR, composition: 47,000 ohms ±20%; ½w; IRC BT-½.
3210-1 3210-2	3Z6700-72	RESISTOR, composition: 0.1 meg ±20%; ½w; IRC BT-½.
3216	3Z6582-6	RESISTOR, composition: 8,200 ohms ±10%; 1w; IRC BT-1.
3217	3Z6610-118	RESISTOR, composition: 10,000 ohms ±20%; 1w; IRC BT-1.

28. MAINTENANCE PARTS FOR CALIBRATOR I-189-A (contd).

Ref. symbol	*Signal Corps stock No.*	*Name of part and description*
3218-1 3218-2	3Z6622-16	RESISTOR, composition: 22,000 ohms ±20%; 1w; IRC BT-1.
3219	3Z6647-24	RESISTOR, composition: 47,000 ohms ±20%; 1w; IRC BT-1.
3220-1 3220-2 3220-3 3220-4 3220-5 3220-6	3Z6700-94	RESISTOR, composition: 0.1 meg ±20%; 1w; IRC BT-1.
3221	3Z6720-23	RESISTOR, composition: 0.2 meg ±5%; 1w; IRC BT-1.
3222	3Z6010-76	RESISTOR, composition: 100 ohms ±20%; 2w; IRC EB-1012.
3223	3ZK6018-4	RESISTOR, composition: 180 ohms ±10%; ½w; IRC EB-1811.
3224	3Z6610-11	RESISTOR, composition: 10,000 ohms ±10%; 1w; IRC BT-1.
3225-1 3225-2 3225-3	3Z6801A5	RESISTOR, composition: 1.5 meg ±10%; ½w; IRC BT-½.
3226	3ZK6506-9	RESISTOR, composition: 5,600 ohms ±10%; ½w; IRC BT-½.
3234-1 3234-2	3D9020-17	CAPACITOR, mica: 20 mmf ±20%; 500 vdcw; Dubilier 3WLS.
3235-1 3235-2	3K2051022	CAPACITOR, mica: 50 mmf ±10%; 500 vdcw; Dubilier 5WLS.
3236	3D9250-47.1	CAPACITOR, mica: 250 mmf ±10%; 500 vdcw; Dubilier 3WLS.
3237-1 3237-2 3237-3	3D9100-107	CAPACITOR, mica: 100 mmf ±20%; 500 vdcw; Dubilier 3WLS.
3238	3D9400-23	CAPACITOR, mica: 400 mmf ±5%; 500 vdcw; Dubilier IR.
3239	3D9500-95.1	CAPACITOR, mica: 500 mmf ±20%; 500 vdcw; Dubilier 3WLS.
3240	3DKA1-120	CAPACITOR, mica: 0.001 mf ±20%; 500 vdcw; Dubilier 3WLS.

28. MAINTENANCE PARTS FOR CALIBRATOR I-189-A (contd).

Ref. symbol	*Signal Corps stock No.*	*Name of part and description*
3241-1 3241-2	3DA2-114.1	CAPACITOR, mica: 0.002 mf ±20%; 500 vdcw; Dubilier 3WLS.
3242-1 3242-2 3242-3 3242-4 3242-5 3242-6	3DA3-23.2	CAPACITOR, mica: 0.003 mf ±20%; 500 vdcw; Dubilier 3WLS.
3243-1 3243-2 3243-3 3243-4 3243-5	3DA100-170	CAPACITOR, paper: 0.1 mf ±20%; 600 vdcw; Aerovox 616M-14842.
3255	3D9050-77.1	CAPACITOR, mica: 50 mf ±20%; 500 vdcw; Dubilier 3WLS.
3256-1 3256-2	2Z7270.3	POTENTIOMETER, composition: linear taper; 50,000 ohms ±20%; ½″ shaft w/screwdriver slot; ESO-691122-3; Allen-Bradley J.
3258	2Z9632.39	TRANSFORMER: impedance ratio 120: 2,350 ohms between windings (1-2) & (3-4); frequency range 50 kc to 4,000 kc; winding (1-2) 2.5 mh (min), winding (3-4) 60 mh (min), 105 mh (max), turns ratio 4:16:1 (min) 4:40:1 (max); WECo D-161310.
3260-1 3260-2	2J6SN7GT	TUBE, vacuum: twin triode amplifier 6SN7-GT (VT-231); RCA.
3261-1 3261-2 3261-3 3261-4 3261-5 3261-6	2J6AC7	TUBE, vacuum: amplifier; pentode; RCA (VT-112).
3262-1 3262-2	2J6AG7	TUBE, vacuum: video power amplifier; pentode; RCA (VT-247).
3263	2J5U4G	TUBE, vacuum: full-wave high-vacuum rectifier; RCA (VT-224).

28. MAINTENANCE PARTS FOR CALIBRATOR I-189-A (contd).

Ref. symbol	*Signal Corps stock No.*	*Name of part and description*
3265	2Z3566	CRYSTAL: quartz plate; GT cut; sealed metal container; WECo D-163526.
	2Z8678.16	SOCKET: type 9881 (1) for crystal; Cinch.
3268A	2Z5927	LAMP: 6-8v, 0.25 amp; miniature bayonet base; T-3¼″ bulb; GE Mazda 44.
3268B	2Z5883-16	LAMP: green; frosted; indicator; Dialco AV-722.
3269A	3Z1927	FUSE: cartridge type; 2 amp; 250v; Littelfuse 1042.
3269B	3Z3275	CLIP, fuse: Littelfuse 1075.
3270	3Z9859-8.15	SWITCH, toggle: SPST, rated 250v at 3 amp; 125v at 6 amp; molded case light duty; ESO-676800; AH&H.
3271-1 3271-2	2Z8671.16	JACK: socket; Jones HB S-201-D-⅜″.
3272	2Z3010.10	PLUG: 2-wire polarized; AH&H 4469.
	1F4W1-1.62	CORD, coaxial: #13, single cond (D-163480); Jones P-201-D-⅜″; coaxial plug at end, 60⅛″ lg; ESO-689301; WECo.
	1F4W1-1.17.75A	CORD, coaxial: single cond; shielded (KS-8086); both ends terminated in special term; 16½″; ESO-685682-6; WECo.
	2Z9412.5	STRIP, terminal: 12 cont; mounting assembly; phenolic ESO-690179-3; WECo.
	2Z5783-1	KNOB: phenolic; without pointer; GR 637-A.
	3Z12072-17	TERMINAL: 0.188″ stud hole; Zierick 7.
	3Z12072-20	TERMINAL: 0.265″ stud hole; Zierick 112.
	2Z940.2.44	BOARD, terminal: 2 term; Jones HB 2-141.
	3E4036-65	CORD: 2 cond; #16 rubber extension; 2 wire polarized plug at one end and soldered connection at other end; 62″ lg; ESO-685682-5; WECo.

Order Nos. 1874-MPD-44 and 2408-MPD-45; 16,452 copies; 17 May 1945.