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TM 11-1048

WAR DEPARTMENT

TECHNICAL MANUAL

CALIBRATOR BC-725-A

NOVEMBER 14, 1942

SAFETY NOTICE

PARTS OF THIS EQUIPMENT, WITHIN THE COVER, OPERATE AT DANGEROUS VOLTAGES. PROTECTION TO THE OPERATOR IS AFFORDED BY AN INTERLOCK SWITCH, ARRANGED TO OPEN THE POWER SUPPLY UPON REMOVAL OF THE COVER. BEFORE REMOVING THE COVER FOR TUBE REPLACEMENTS, ADJUSTMENT, ETC., DISCONNECT THE POWER SUPPLY; DO NOT DEPEND ON THE INTERLOCK SWITCH. SHOULD IT BE NECESSARY TO APPLY POWER WHILE THE COVER IS REMOVED, EXERCISE ALL PRECAUTIONS AGAINST CONTACT WITH LIVE PARTS.

TECHNICAL MANUAL
FOR
CALIBRATOR BC-725-A

Prepared under the direction of the
Chief Signal Officer

CLASSIFICA... WD Cir. 3... ...OVED

[redacted]

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WAR DEPARTMENT
Washington, November 14, 1942

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For explanation of symbols, see FM 21–6.

[redacted]

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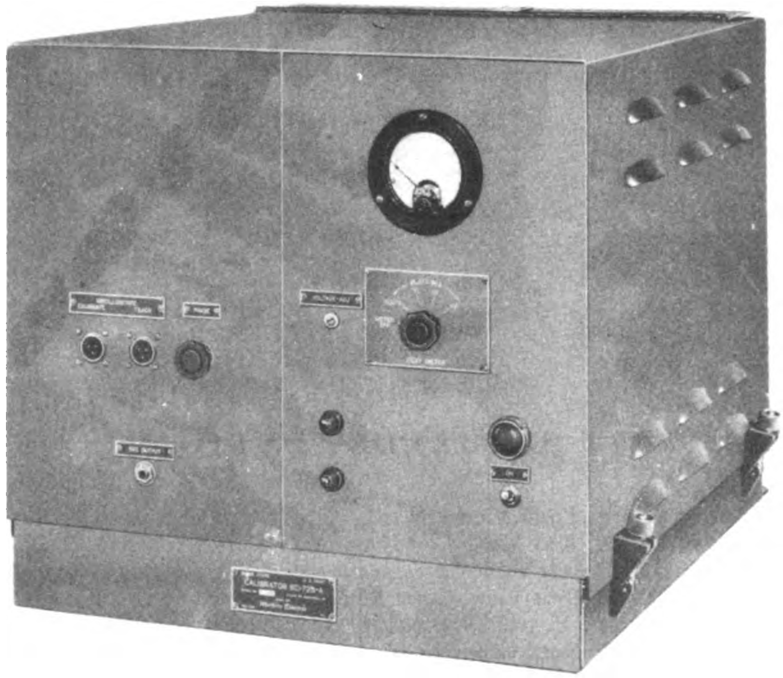

Fig. 1. Calibrator BC-725-A, Front View

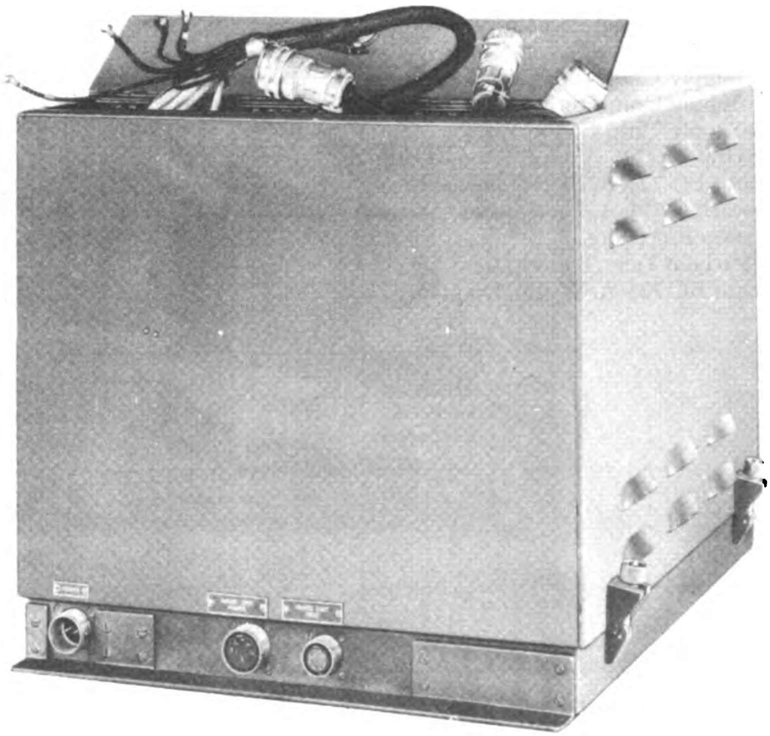

Fig. 2. Calibrator BC-725-A, Rear View

SECTION I. GENERAL DESCRIPTION

1. GENERAL (Figs. 1, 2, 3, 4, 5)

a. Range Unit BC-723-A of Radio Set SCR-296-A is essentially a 360-degree phase shifter indicating its angular position in yards range. Calibrator BC-725-A provides a means for checking and calibrating the range unit, i.e., determining the amount by which the actual range (as fixed by the actual phase shift) may deviate from the indicated range. A cathode-ray oscilloscope (RCA 155B or an equivalent providing direct access to the deflection plates) is required for use with the calibrator. Otherwise the latter is complete and self-contained. It operates from a 115-volt, 60-cycle, a-c power supply, and, including the range unit under test, requires about 190 watts. The calibrator measures 18¾ inches wide, 17 inches high, and 23 inches deep, and weighs 175 pounds.

b. In the range unit, 360-degree phase shift at a frequency of 1.64 kilocycles per second is accomplished by two phase shifters geared together in a 1:18 ratio and operating in separate circuits of 1.64 kc and 29.5 kc respectively. The calibrator provides:

(1) means for setting the 29.5-kc shifter to twenty positions, eighteen electrical degrees apart,—the range unit calibration error for each position being the difference between the actual range unit dial reading and the nominal dial reading for that phase condition;

(2) means for checking the accuracy of the 1:18 phase shift relationship, or the tracking, between the two phase shifters of the range unit;

(3) a source of voltage at frequencies of 1.64, 29.5, and 295 kc for other test purposes.

c. The calibrator is in four circuit sections: an oscillator circuit, two harmonic producer or multiplier circuits, and a power-supply circuit. The assembly consists of a base on which are mounted two subassemblies each having a front panel and a double shelf chassis, the upper shelf of which is hinged for accessibility.

d. A removable cover protects all apparatus. This cover contains a compartment (Fig. 2) accessible through a hinged lid for storing the following component interconnecting cords and plugs (Fig. 4):

NOTE: Designation markings appearing on the apparatus are written herein in capital letters.

(1) The power cord, for connecting the POWER receptacle in the calibrator base to the 115-volt, 60-cycle, a-c power source.

(2) The test cord, which is a multiconductor cable used to connect the RANGE UNIT POWER and RANGE UNIT TEST jacks in the base to the range unit under test.

(3) The oscilloscope cord, for connecting the OSCILLOSCOPE jacks on the front panel of the calibrator to the oscilloscope.

(4) Two test plugs, to replace the test cord for certain uses of the calibrator without a range unit.

2. OSCILLATOR AND FREQUENCY MULTIPLIERS (Figs. 3, 4, 5)

a. Facing the front of the calibrator the left panel and its attached two-shelf chassis house the oscillator circuit on the lower shelf and the two multiplier circuits on the hinged upper shelf. Both shelves are shock-mounted. The circuits are brought out to a terminal strip at the rear of the chassis, from which they extend to the RANGE UNIT TEST jack on the base, and to the power supply circuit, by a local cable.

b. In the *oscillator* circuit, none of the circuit components are adjustable. The initial frequency of 1639.3 ±0.3 cycles is established by the Crystal Unit D-161647. There are two outputs at 1.64 kc and 29.5 kc respectively, both of which are connected to the RANGE UNIT TEST jack. The 1.64-kc output is also available at the OSC OUTPUT jack on the front panel.

c. The two *frequency multiplier* circuits are identical, each serving to multiply an input frequency of 29.5 kc to an output frequency of 295 kc. Each multiplier has four tuned circuits (within cylindrical shields on top of shelf), three of which are adjustable by inserting a screwdriver

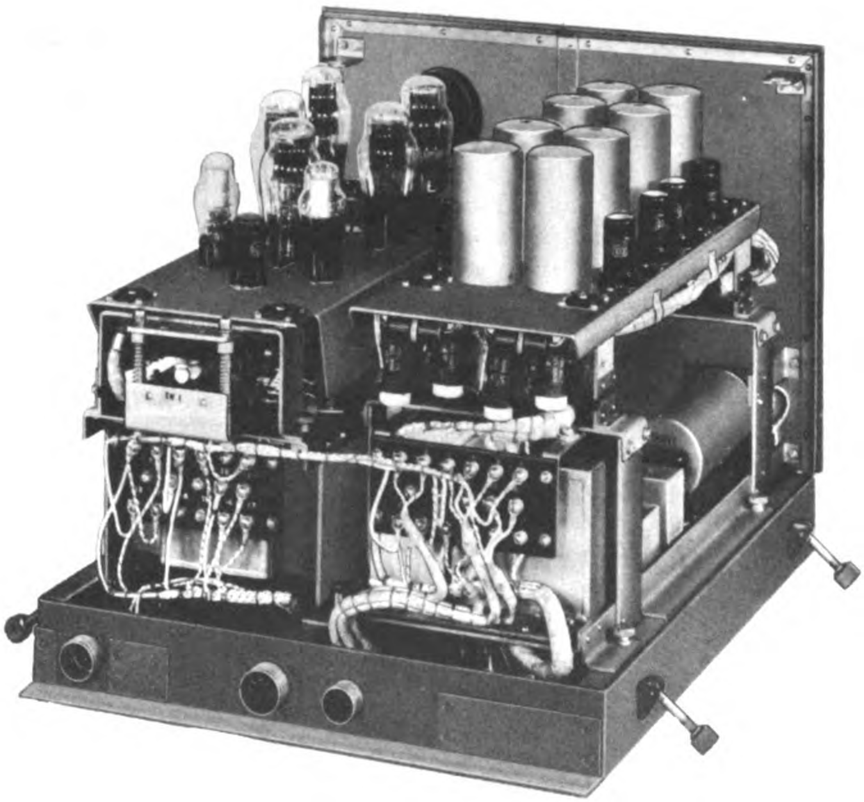

FIG. 3. CALIBRATOR BC-725-A, REAR VIEW, COVER REMOVED

through the holes in the tops of the shields. The 295-kc output of each multiplier is connected to the OSCILLOSCOPE CALIBRATE jack on the panel.

3. POWER SUPPLY UNIT (Figs. 3, 4, 5)

This unit is a full-wave regulated voltage rectifier and forms the right half of the calibrator assembly including the front panel and associated chassis. The vacuum tubes, resistors, and small capacitors are mounted on the shock-mounted hinged shelf and the coils and larger capacitors on the lower shelf. A safety switch which disconnects the power supply when the calibrator cover is removed, is also mounted on this chassis. The front panel mounts a power switch and associated indicating lamp, a TEST METER with associated switch, a screwdriver adjustment for setting the d-c output voltage, and two fuses. The circuits are brought out to a terminal strip at the rear of the chassis, from which they extend to the POWER and RANGE UNIT POWER jacks, and to the oscillator-multiplier terminal strip, by a local cable.

4. VACUUM TUBES

a. The following tubes are used in the Calibrator BC-725-A:

No.	*Type*	*Signal Corps No.*	*Function*
Oscillator:			
1	6K6-GT	VT-152	Amplifier
1	6SJ7	VT-116	Oscillator
1	6SJ7	VT-116	Amplifier
1	6SJ7	VT-116	Output Amplifier
Multiplier A:			
1	6AC7	VT-112	Amplifier
1	6AC7	VT-112	Harmonic Producer
1	6SF5	—	Harmonic Producer
1	6SK7	VT-117	Amplifier
Multiplier B:			
1	6AC7	VT-112	Amplifier
1	6AC7	VT-112	Harmonic Producer
1	6SF5	—	Harmonic Producer
1	6SK7	VT-117	Amplifier
Power Supply Unit:			
2	274B	—	Rectifiers
3	2A3	VT-95	Regulators
1	6SJ7	VT-116	Regulator Control
1	VR105-30	VT-200	Voltage Regulator
1	VR150-30	VT-139	Voltage Regulator

b. A total of twenty tubes are used, the quantity of each type being as follows:

Type	*Signal Corps No.*
2—274B	—
3—2A3	VT-95
4—6AC7	VT-112
1—6K6-GT	VT-152
2—6SF5	—
4—6SJ7	VT-116
2—6SK7	VT-117
1—VR105-30	VT-200
1—VR150-30	VT-139

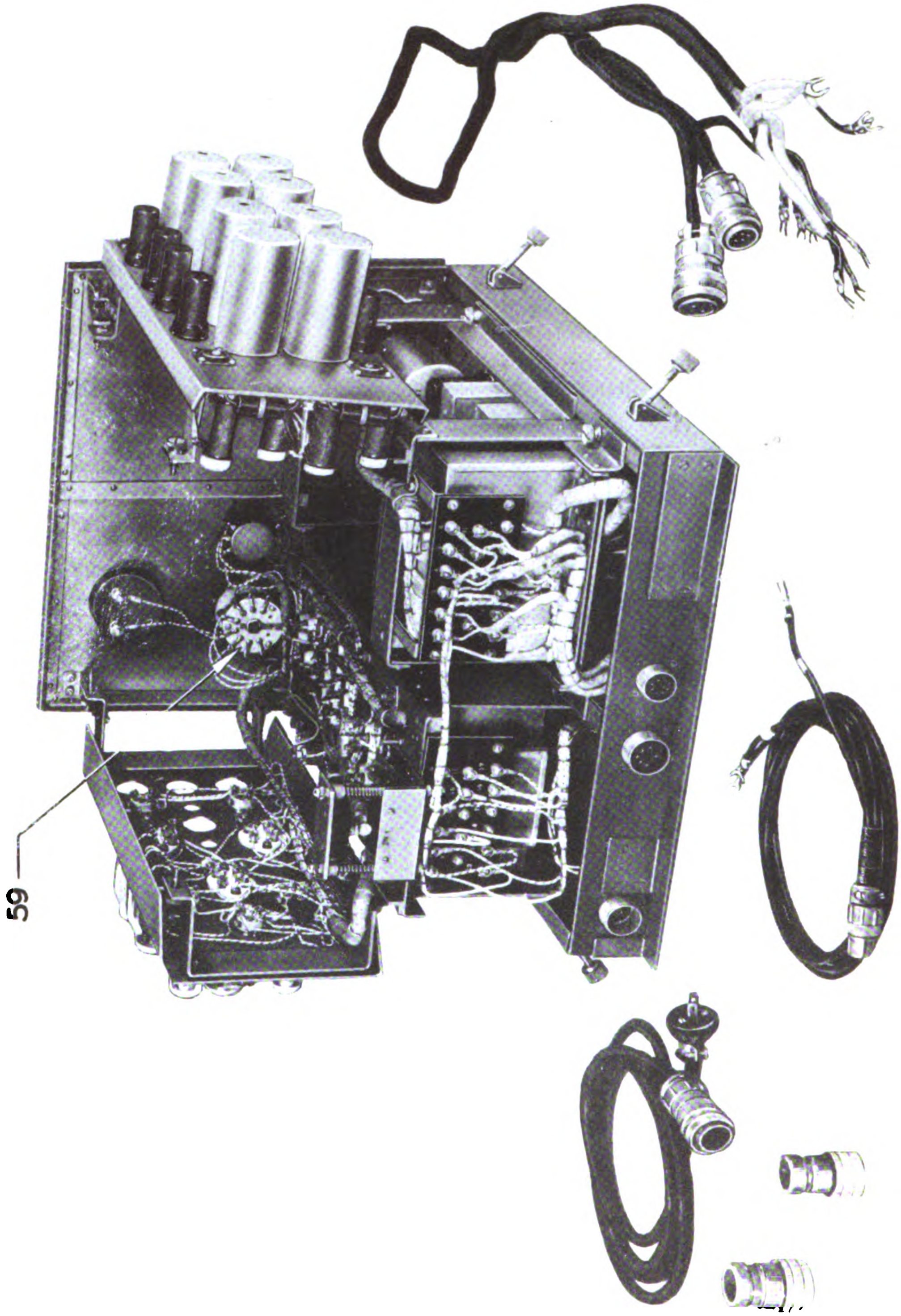

FIG. 4. CALIBRATOR BC-725-A, REAR VIEW, COVER REMOVED, HINGED CHASSIS RAISED

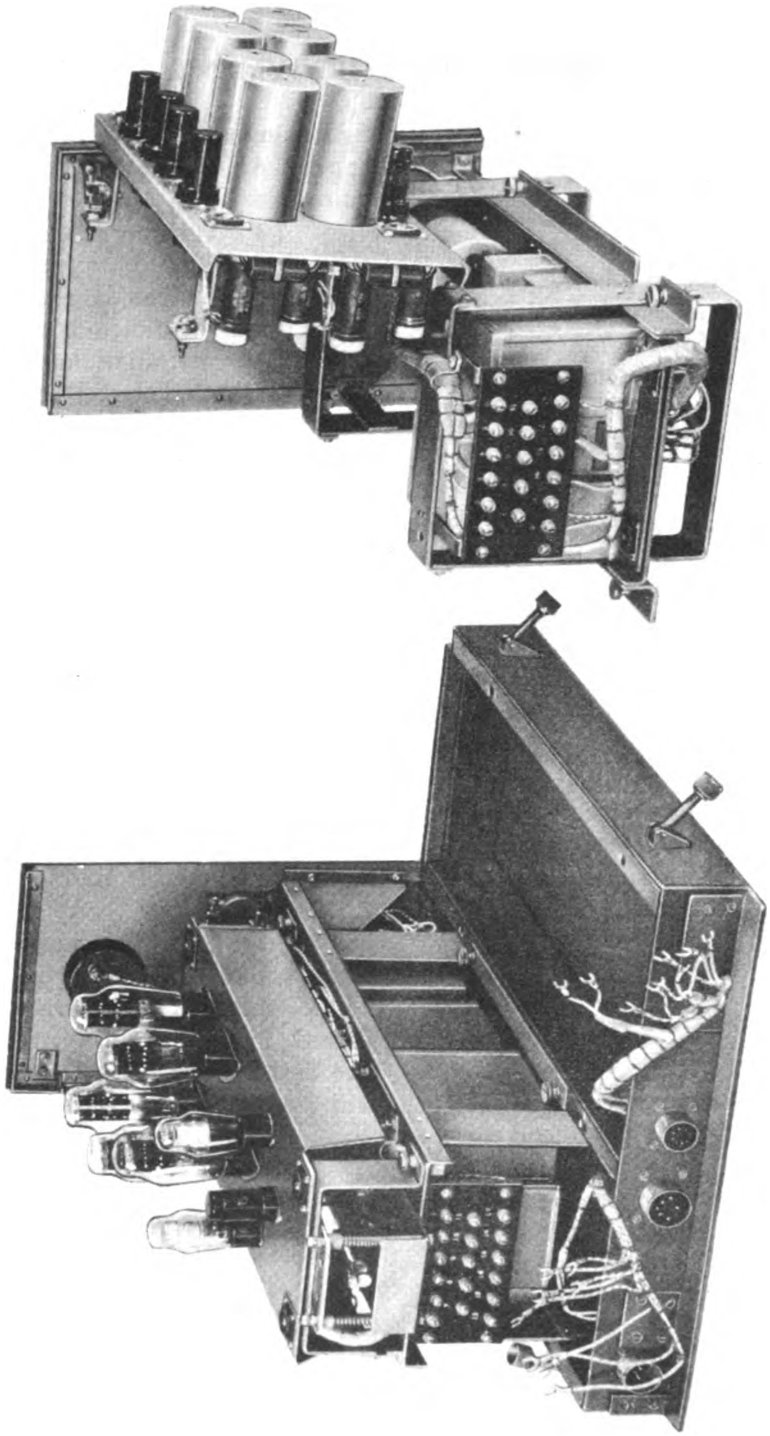

Fig. 5. Calibrator BC-725-A, Partial Disassembly

SECTION II. EMPLOYMENT

5. INSTALLATION

a. As shipped, the calibrator is ready for operation with vacuum tubes in place and circuits tuned and adjusted.

b. Set the calibrator on a bench convenient to a 115-volt, 60-cycle, a-c supply, with space immediately to the left for the range unit to be tested and for the test oscilloscope. Remove the power, test, and oscilloscope cords from their storage compartment, and connect them as indicated on Fig. 6. Do not install the two test plugs.

6. PREPARATION FOR USE

a. All of the information in this instruction book should be carefully read and understood before proceeding with the actual use of the calibrator.

b. While no initial adjustments of the calibrator circuit are ordinarily necessary, the checks described in Section IV, particularly the tuning and output voltage checks covered in paragraph 16, may be made if circumstances warrant.

c. Copies of a form, similar to Table I, should be available for noting down the data as taken.

7. OPERATION

a. Calibration Check

(1) Close the power supply switch, lighting the associated indicating lamp, and energizing all calibrator and range unit circuits. After about three minutes, turn the TEST METER switch to the V1, V2, and V3 positions successively and observe the meter readings, which should be between 30 and 45 milliamperes. If not, replace the corresponding REG tube 83-1, 83-2, or 83-3. Then turn the switch to VOLTS, and set the VOLTAGE ADJ control for 250 volts on the TEST METER. *Wait for about fifteen minutes to permit the circuit elements to approach stable operating temperature.* The oscilloscope cord should be in the OSCILLOSCOPE CALIBRATE jack.

(2) On the oscilloscope, turn the amplifier switches OFF and the power switch ON. A figure similar to one of those in Fig. 7A should appear. Adjust the focus and intensity as required.

(3) Turn the range unit crank and observe that the figure progresses from a straight slanting line on one side, to an approximate circle in the middle and then to a straight line on the other side. The straight line or "collapsed circle" condition sloping up to the right (at left end of Fig. 7A) is the reference condition; with the pattern in this position, set the range unit by releasing the range unit clutch, turning the crank until the dials read 0000 yards, while holding the pattern to the reference position by means of the knurled ZERO ADJ collar. Then reset the clutch.

(4) Turn the range unit crank clockwise to make the pattern go through nine "collapses" alternating left and right, and ending with a line sloping up to the left. Read the indicated range to the nearest 5 yards, noting it on the form referred to in paragraph 6 opposite Test Point 1 under "Dial Scale—Yards" in the "Indicated" column. It should be approximately 2,500 yards.

(5) Operate the range unit through nine more "collapses," ending with a line sloping up to the right. Note the reading opposite Test Point 2. Proceed in this manner through successive Test Points to Test Point 20, corresponding with a nominal dial reading of 50,000 yards.

NOTES:

(a) To reduce "backlash" error, approach the reference "collapsed circle" position by turning the crank clockwise each time.

(b) The range unit 29.5-kc phase shifter positions are respectively the same from 50,000 to 100,000 yards, as from 0000 to 50,000 yards, and further observations to 100,000 yards would merely repeat those already made. Accordingly, the test may be considered complete at 50,000 yards unless a check on the readings is desired.

(6) On the form (Table I) obtain the deviation for each Test Point by subtracting the

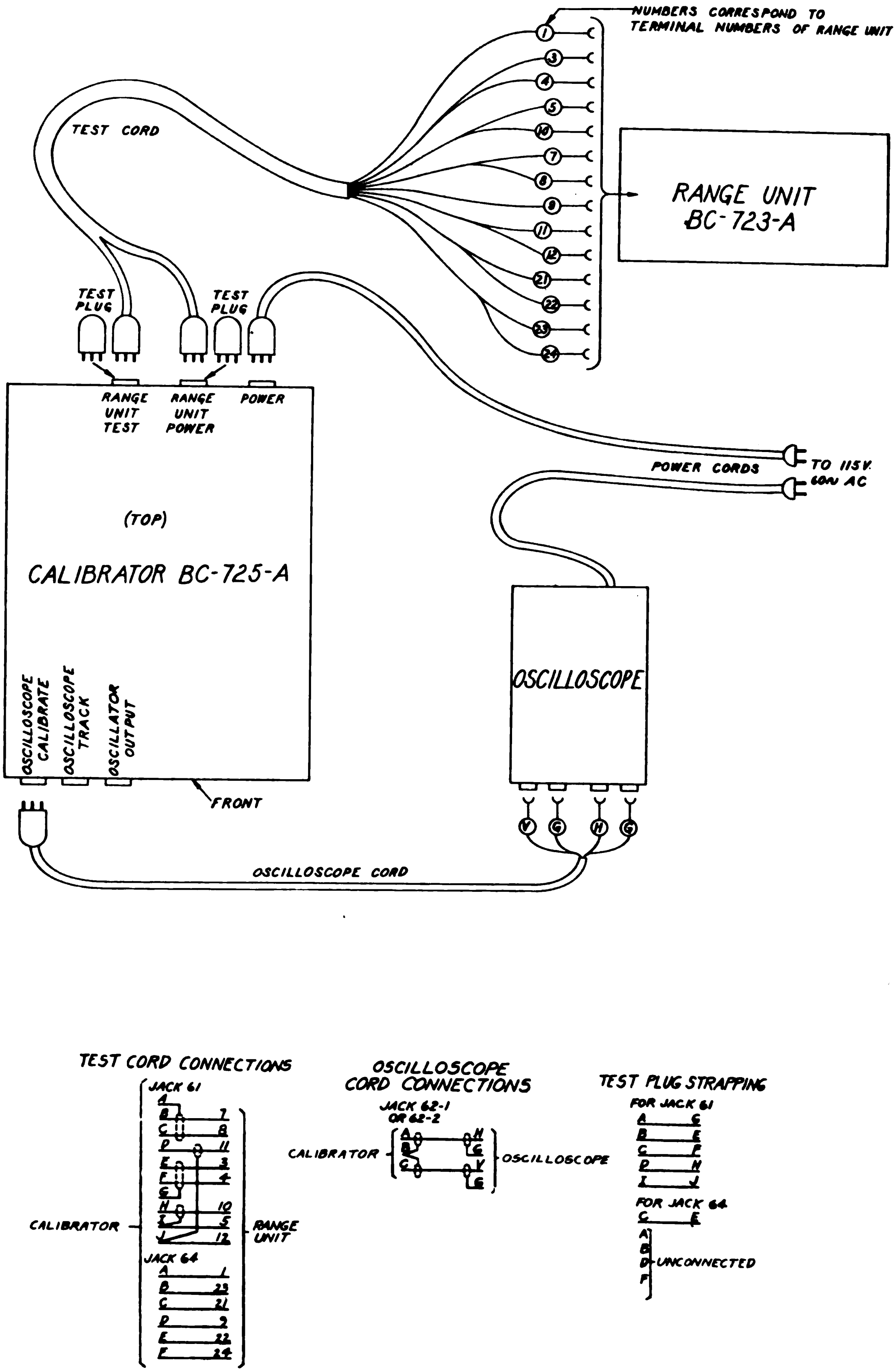

Fig. 6. Calibrator BC-725-A, Cord Connections

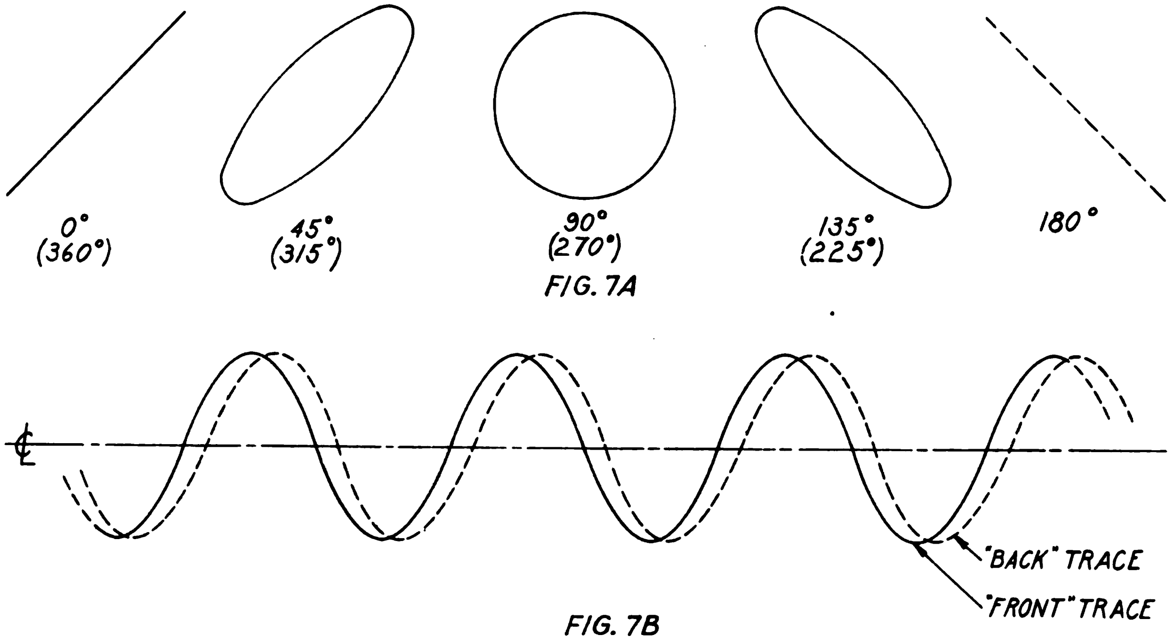

FIG. 7. OSCILLOSCOPE PATTERNS

figure in the "Nominal" column from the figure in the "Indicated" column. Note it in the "Deviation" column, as *plus* if the indicated reading exceeds the nominal value, and *minus* if the indicated reading is less than the nominal value.

(7) The data may be plotted, if desired, as shown on Fig. 8. It will be noted that the data is plotted thereon not in the order of the "Test Point Number," but in the sequence of angular positions occupied by the 29.5-kc range unit phase shifting capacitor at the Test Points. This will be clear when it is remembered that the capacitor goes through nine revolutions for a dial change of 50,000 yards, and the significance of any deviation for a particular capacitor position is best shown in relation to deviations for adjacent positions, thus giving a continuous deviation picture for a complete revolution. This is explained further in Section III.

(8) If the arithmetic sum of the maximum minus deviation and the maximum plus deviation is less than 100 yards, the range unit calibration may be considered satisfactory.

NOTE: In using the calibration test data it must be remembered that the indicated errors are associated with the respective positions of the 29.5-kc phase shifting capacitor only. Any position of the capacitor may be set as 0000 yards on the dials by the range unit ZERO ADJ clutch. For that reason the deviations are significant only in their relation to each other, and not in their relation to either the dial reading or the zero axis as shown in Fig. 8.

b. Tracking Check

(1) Transfer the oscilloscope cord to the OSCILLOSCOPE TRACK jack, turn to ON, and adjust the oscilloscope amplifiers for maximum amplitude. A pattern similar to Fig. 7B should appear, consisting of eighteen cycles, nine in the "front" trace and nine in the "back" trace. Adjust the oscilloscope amplifier controls as required.

(2) As the range unit crank is turned, note that the two traces move somewhat with respect to each other. Turn the crank through a dial change of 100,000 yards, noting on the oscilloscope scale the farthest left (or right) position occupied by a particular point in the pattern, preferably on the horizontal center line of the screen. Then turn the crank back to that position.

NOTE: If the oscilloscope has no ruled screen, one may be made from cross-section paper, fastened in position by an adhesive.

(3) Now set the PHASE control on the calibrator to make the "front" and "back" traces coincide, and note the dial reading for reference purposes. Also carefully note the number of oscilloscope scale divisions covered by one cycle, adjusting the horizontal amplifier of the oscilloscope to an exact number of divisions, say 5.

(4) Again turn the range unit crank through the full range of 100,000 yards, until the "front" and "back" traces depart from coincidence by a maximum amount and note the departure in terms of scale divisions. Each division represents 2 degrees (at 1.64 kc) of relative phase shift (based on one cycle [at 29.5 kc] covering 5 divisions).

NOTE: The 29.5-kc voltage is on the vertical deflecting plates, and one cycle of spacing on the screen at this frequency represents 180-degree phase shift rather than 360 degrees, because of the fact that both "front" and "back" traces move equally in opposite directions, when the relative phase changes. This is equivalent to $\frac{180 \text{ degrees}}{18}$ or 10 degrees at 1.64 kc. The tracking error may be written as

$$E = \frac{10A}{B}$$

where

E = tracking error (or relative phase shift) in degrees at 1.64 kc.

A = departure from coincidence, in scale divisions, of front and back traces, when range unit is operated.

B = width of 1 cycle at 29.5 kc in scale divisions.

(5) Record the tracking error on the form, Table I. If the tracking error is less than 5 degrees, the range unit tracking is satisfactory.

8. CONNECTIONS FOR USE OF CALIBRATOR AS FREQUENCY SOURCE

The calibrator may be used as a source of accurate frequencies of 1.6393 kc, 29.5 kc, or 295 kc for other test purposes, without the range unit and range unit test cord, as follows:

a. 1.6393 kc.—Insert the large test plug in the RANGE UNIT POWER jack, and connect the power cord to 115-volt, a-c supply. The 1.6393-kc voltage (about 50 volts on open circuit) is available at the OSC OUTPUT jack. If the other test plug is plugged into the RANGE UNIT TEST jack and the oscilloscope cord plugged into the OSCILLOSCOPE TRACK jack, the 1.6393-kc voltage is also available, at reduced amplitude, between the H and G terminals of the oscilloscope cord shown in Fig. 6.

b. 29.5 kc.—With both test plugs in circuit, the 29.5-kc frequency is available between terminals V and G of the oscilloscope cord when plugged into the OSCILLOSCOPE TRACK jack, at about 1 volt.

c. 295 kc.—With both test plugs in circuit and with the oscilloscope cord plugged into the OSCILLOSCOPE CALIBRATE jack 62-2, the 295-kc outputs of multipliers A and B are available between the H and G, and V and G, terminals, respectively, of the oscilloscope cord, at about 45 volts, with AMP A and AMP B controls 75-1 and 75-2 at maximum.

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SECTION III. FUNCTIONING OF PARTS

9. CIRCUITS OF THE CALIBRATOR

a. General

(1) The calibration test procedure is to apply a 29.5-kc voltage to the 29.5-kc phase shifter of the range unit, operate the latter to shift the phase of the voltage by a known amount, and then compare the change in dial reading with the theoretical change corresponding with the known shift. Observations at fairly close intervals on the phase shifter capacitor (say 18 degrees) are wanted, and this amount of shift is not conveniently measured on an oscilloscope directly. However, by applying the respective range unit input and output voltages to multiplier circuits and observing the tenth harmonics (295 kc) instead of the 29.5-kc voltages, the 18-degree intervals at the phase shifter become readily and accurately observable at 180-degree intervals on the oscilloscope.

(2) The tracking test procedure is to apply to the respective range unit phase shifters 1.64-kc and 29.5-kc voltages of fixed frequency ratio, and with the range unit output voltages connected to the plates of an oscilloscope, observe and measure on the screen the amount by which the relative phase of the voltages changes, as the range unit crank is turned.

(3) The oscillator circuit provides directly the above-mentioned 1.64-kc and 29.5-kc voltages, the latter being also the input source for the two multiplier circuits which provide the two 295-kc voltages.

b. Oscillator Circuit (Figs. 9, 10, 11, 12)

(1) The oscillator circuit consists of four sections: a crystal controlled oscillator, a tuned amplifier, a power amplifier and eighteenth harmonic generator circuit, and a fundamental frequency output amplifier circuit.

(2) The crystal-controlled oscillator circuit includes the oscillator tube 80-1 (6SJ7), the output of which is connected to resistors 12, 13, and 14 in series. A voltage from the junction of resistors 13 and 14 is fed back to the input through quartz crystal 5. The varistor 18, shunted across the plate circuit in series with capacitor 67-1, tends to limit this voltage to about 0.6-volt root mean square. The crystal 5 establishes the frequency of oscillation at 1639.3 ± 0.3 cycle per second. The oscillator frequency is not adjustable.

(3) The amplifier tube 80-2 (6SJ7) is energized from the oscillator output. The plate circuit of this stage is tuned to 1.64 kc by non-adjustable tuned circuit 8-1. Resistor 43-1 provides cathode bias and a small amount of feedback.

(4) The output of the tuned amplifier stage is applied to the grid circuit of vacuum tube 76 (6K6-GT) where it exceeds the biasing voltage and overloads the tube in order to obtain stability of output with variation of applied grid voltage. The plate circuit includes a step-down transformer 9, tuned on the low side to 1.64 kc by capacitor 72, which supplies current to a harmonic producer circuit and across which is a voltage dividing network composed of resistors 36-4 and 44 from which is derived the input to vacuum tube 80-3 (6SJ7). The current passes through a series-resonant circuit consisting of capacitor 73, retard coil 15, and retard coil 16 (paralleling the output circuit), which offers a low impedance to the fundamental frequency and greater impedance to harmonics. Retard coil 16 is a nonlinear coil which has a high inductance and high impedance for values of current in the fundamental frequency cycle near zero amplitude, and a low inductance and low impedance for the remainder of the cycle.

(5) Nonlinear coil 16 functions to produce sharp positive and negative pulses across capacitor 67-3, varying at the fundamental frequency. The bridge type rectifier 19 rectifies this pulse output, effectively producing a wave rich in even harmonics of the fundamental frequency of 1.64 kc. Repeating coil 17-1 separates the balanced filter circuit from rectifier 19 and provides a low resistance termination for the bridge. Band-pass filter 6 selects the eighteenth harmonic of 1.64 kc or a frequency of 29.5 kc and discriminates against lower and higher harmonics. The

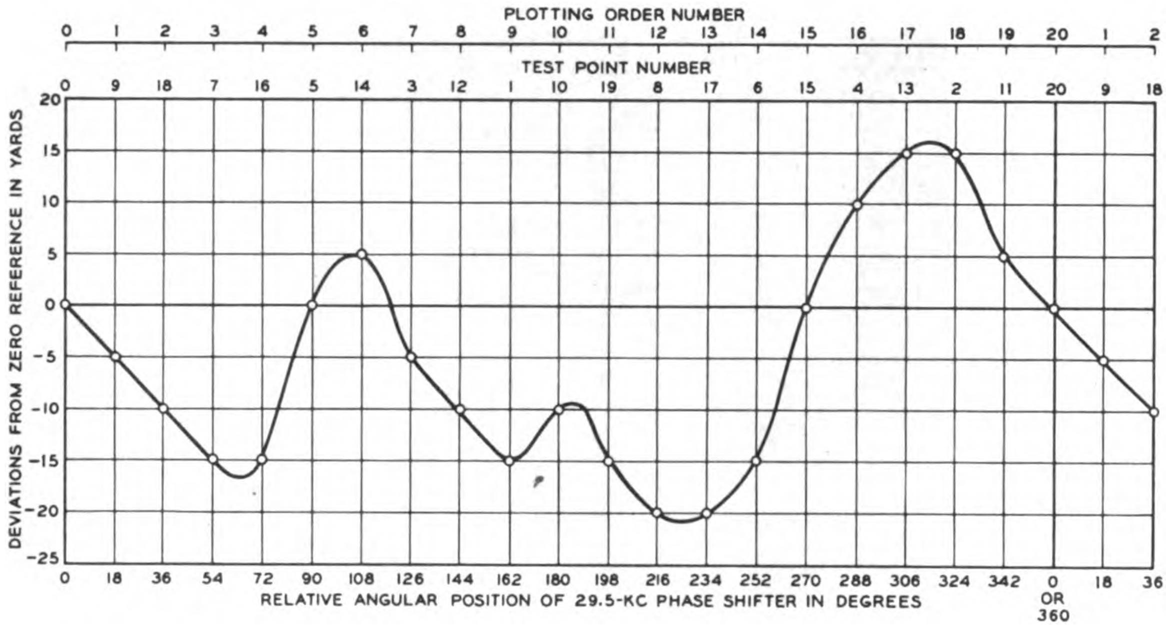


FIG. 8. PLOT OF TYPICAL CALIBRATION DEVIATIONS

output from the filter is connected to pins E and F on RANGE UNIT TEST jack 61. Capacitors 68 and 67-3 form a capacitive voltage divider to provide the desired output of the eighteenth harmonic.

(6) As noted above, tube 80-3 obtains grid voltage from a voltage divider circuit at the low side of the output transformer 9. The plate circuit is the same as that of tube 80-2 and serves to suppress harmonics of the fundamental frequency, in order that the 1.64 kc available at OSC OUTPUT jack 23 and at pins H and I of RANGE UNIT TEST jack 61 will be sinusoidal.

(7) Accordingly, the oscillator circuit supplies a 1.64-kc sinusoidal voltage across pins H and I of jack 61 and a 29.5-kc voltage across pins E and F in parallel with terminals 3 and 4 of multiplier A. As explained further on in this section, these two voltages, after passing through the range unit, return to terminals 15 and 10 of TS2 of the calibrator. From terminal 15, the 1.64-kc voltage is connected to pin A of OSCILLOSCOPE TRACK jack 62-1, after passing through a phase shifter circuit consisting of terminating resistor 40, capacitor 69-2, and PHASE control rheostat 57. From terminal 10 of TS2, the 29.5-kc voltage connects to pin C of jack 62-1.

c. Multiplier Circuits (Figs. 9, 10, 12)

(1) Two identical multiplier or tenth harmonic producer circuits, A and B, are provided, for which the input frequency is 29.5 kc and the output frequency is 295 kc.

(2) The input of circuit A is bridged across the 29.5-kc output of the oscillator. The 29.5-kc voltage is applied to the grid of vacuum tube 79-1 (6AC7), is amplified, and the harmonics are suppressed in the fixed plate circuit impedance, 2-1 and 20-1, tuned to 29.5 kc. The voltage is then applied to the grid of tube 79-2 (6AC7), where a "square" wave is generated.

(3) The "square" wave is applied to the grid circuit of vacuum tube 78-1 (6SF5), which is adjustably tuned to 147.5 kc or the fifth harmonic of 29.5 kc. Resistor 38-1 isolates the tuned circuit across which the fifth harmonic voltage is developed from the square wave voltage in the preceding plate circuit. Tube 78-1, whose grid is biased to cut-off by resistor 47-1, acts as a half-

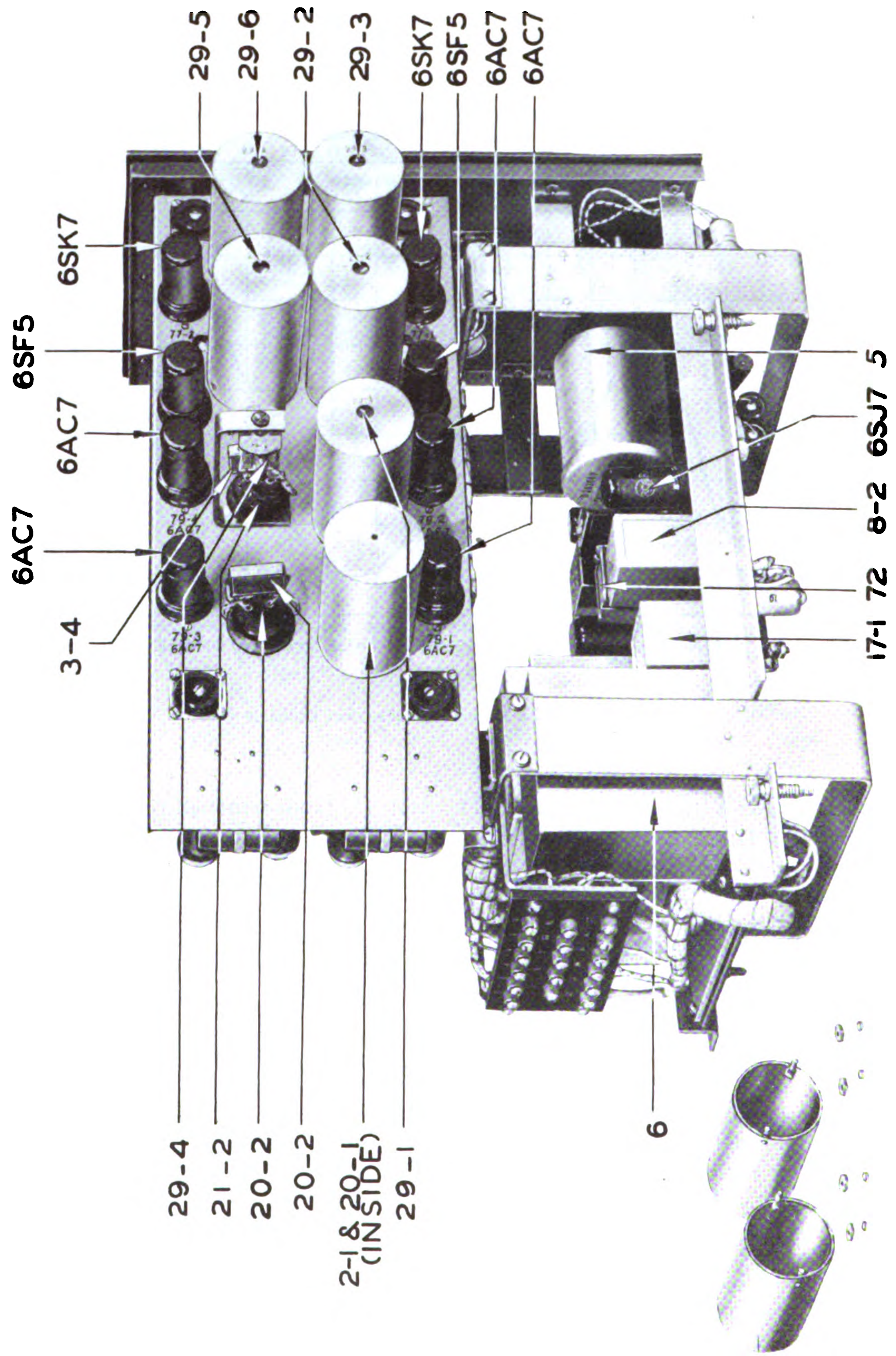


FIG. 9. OSCILLATOR-MULTIPLIFR UNIT, HINGED CHASSIS RAISED

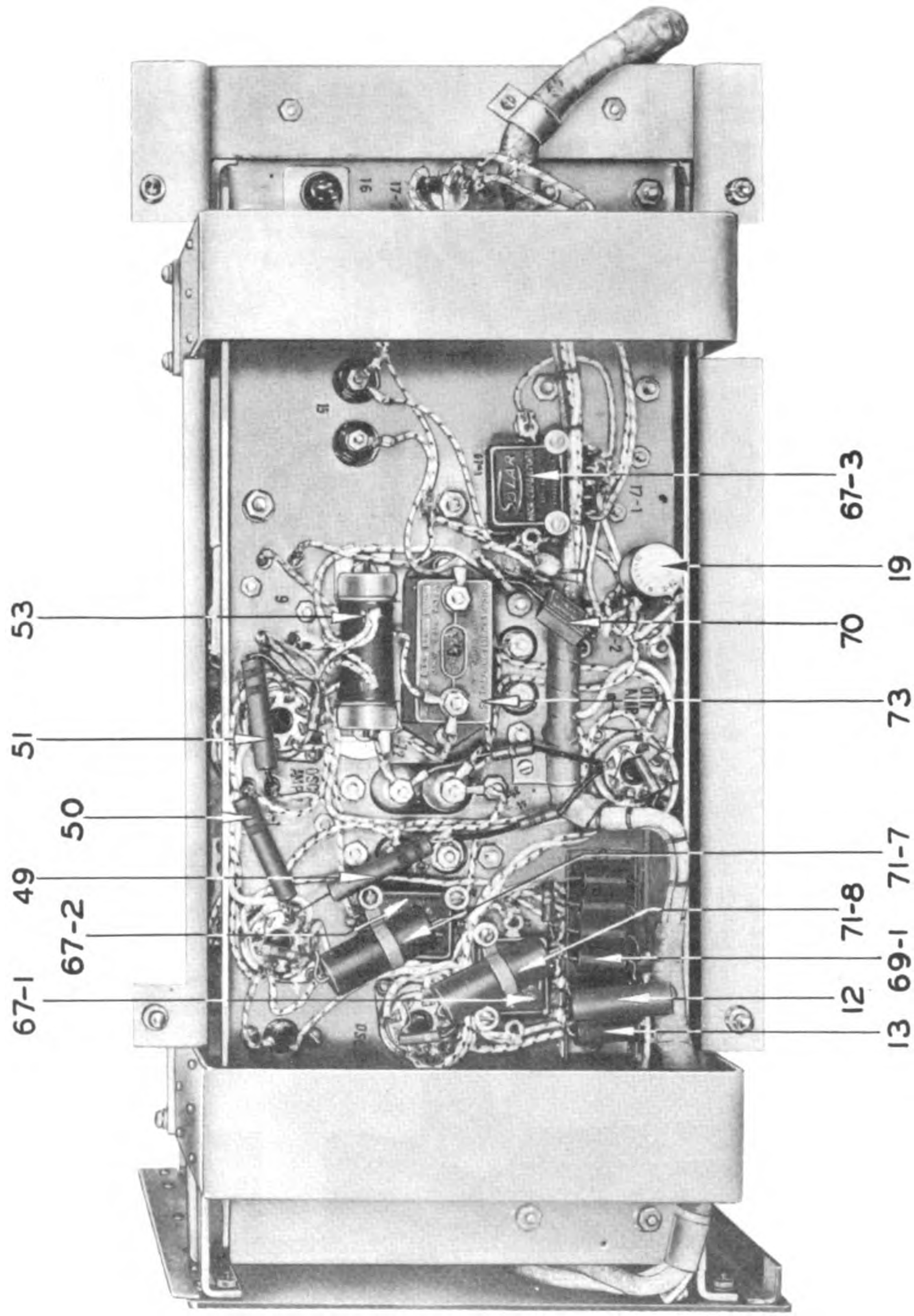


FIG. 10. OSCILLATOR-MULTIPLIER UNIT, SHOWING BOTTOM OF OSCILLATOR CIRCUIT

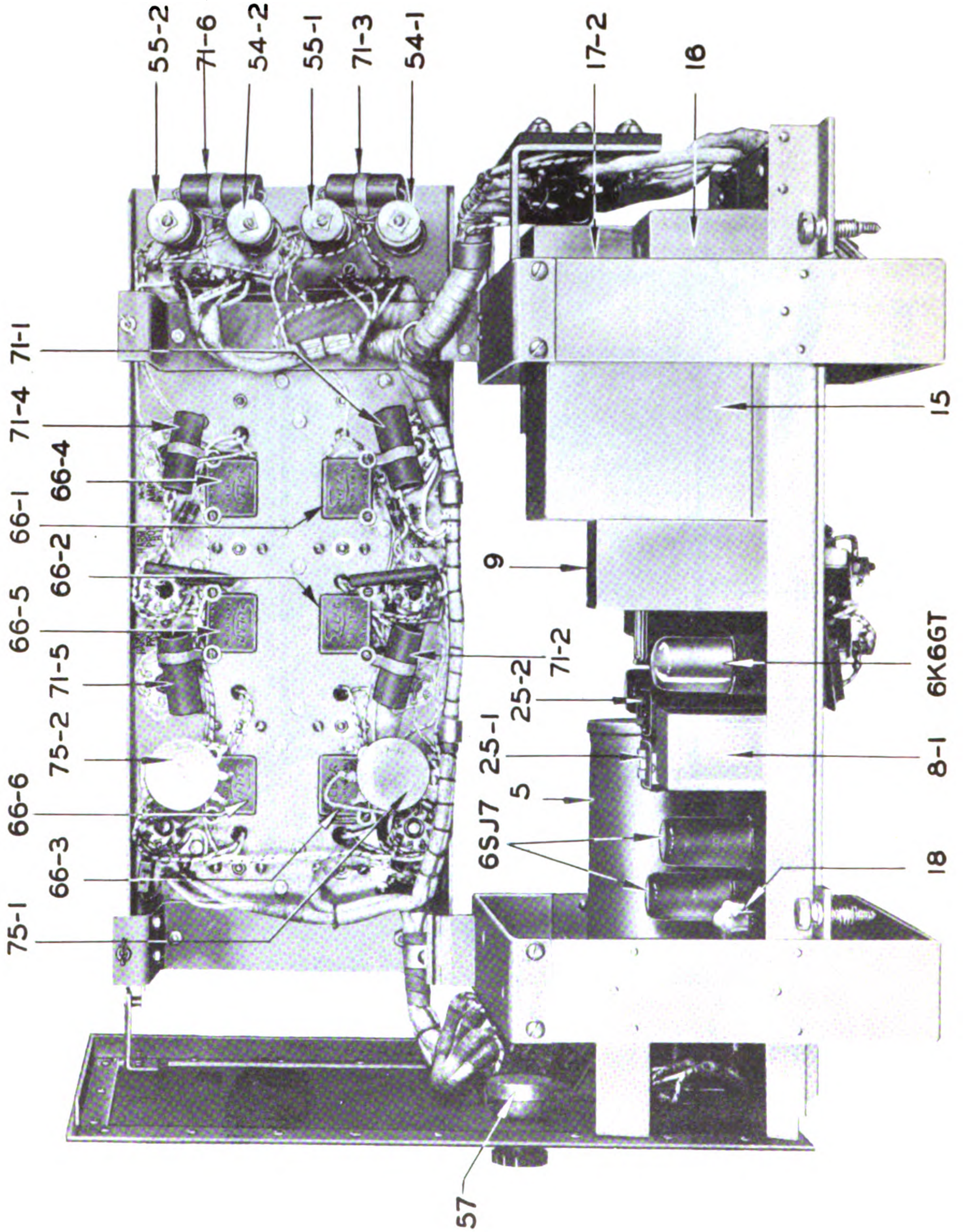
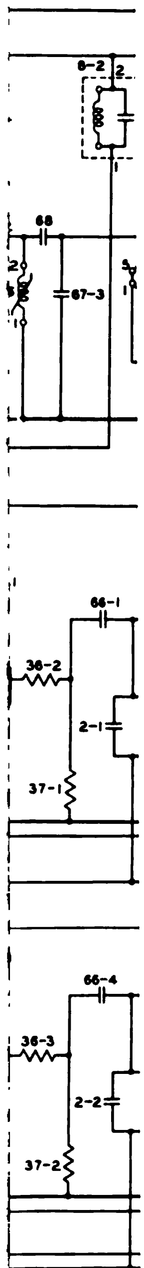


Fig. 11. Oscillator-Multiplier Unit, Showing Bottom of Hinged Chassis



PART NO	
30	24
31-2, 31-3	4
32	15
33	33
2, 34-3, 34-4, -6, 34-7,	6
	16
35	5
-2, 36-3, 36-4, 36-5	5
	37
	17
37-2, 37-3	40
	18
38-2, 38-3	38
	19
-1, 39-2	20
40	37
41	41
42	39
-1, 43-2	34
44	36
45	4
-1, 46-2	6
-1, 47-2	21
-1, 48-2	22
49	44
50	43
51	42
52	34
53	31
-1, 54-2	13
-1, 55-2	14
56	7

wave rectifier whose output contains a large amount of energy at 295 kc, the second harmonic of the input. The output circuit is adjustably tuned to this 295-kc frequency, which is, of course, the tenth harmonic of 29.5 kc. The 295-kc frequency is then amplified by tube 77-1 (6SK7) whose plate circuit impedance is also adjustably tuned to 295 kc, including the external impedance of output leads which connect to OSCILLOSCOPE CALIBRATE jack 62-2, pins A and B. The amplitude of the 295-kc output voltage may be adjusted by potentiometer 75-1.

(4) Circuit B is the same as circuit A, except that the input is terminated in resistor 32 (200 ohms), and is available at RANGE UNIT TEST jack 61, pins B and C. The output appears at the OSCILLOSCOPE CALIBRATE jack 62-2, pins C and B.

(5) Accordingly, multipliers A and B provide at their outputs separate 295-kc sinusoidal voltages, the input to multiplier A being directly energized by the 29.5-kc output of the oscillator circuit, while the input to multiplier B is energized from the same source, but through the range unit.

d. Power Supply Unit
(Figs. 12, 13, 14, 15, 16)

(1) The 115-volt, 60-cycle supply extends from POWER jack 63 through toggle switch 30, fuses 58 (on panel), cover-operated safety switch 60, and pins E-C on the RANGE UNIT POWER jack, which normally connect to the range unit safety switch, to the primaries of power transformers 7 and 10. Transformer 7 supplies the heaters of all tubes in the oscillator and multiplier circuits, and also in the range unit under test. Transformer 10 is the power-supply transformer for the full-wave regulated rectifier circuits. The d-c output voltage of the rectifier is adjustable from about 220 to 275 volts, being set at 250 volts for normal operation. The output current is normally about 125 milliamperes.

(2) Referring to Fig. 12, a full-wave rectifier composed of transformer 10, 274B tubes 84-1 and 84-2, and a filter section composed of choke coil 1-1, capacitors 27-2 and 27-1, choke coil 1-2, and capacitor 26, supplies a high d-c potential to a voltage regulator section. Regulation is obtained by varying the plate impedance of the three paralleled 2A3 vacuum tubes 83-1, 83-2, and 83-3, under control of the output voltage, which is made to change their grid-biasing potential. The plate-to-cathode circuits of the three 2A3 tubes are in series with the rectifier output.

(3) The regulator control tube 80-4 (6SJ7) receives its plate supply from the 250-volt filtered supply, through resistor 35. The cathode voltage to ground is fixed at approximately +105 volts by the voltage regulator tube 82 (VR105-30). Voltage regulator tube 81 (VR150-30) is in series with resistors 56 and 46 across the 250-volt supply and accordingly a small change in this supply voltage causes practically the same change in the voltage across resistor 46, due to the regulator action of the tube. Potentiometer 65 and resistors 36-1 and 46 in series, are connected across the 250-volt supply, the arm of potentiometer 65 being connected to the control grid of tube 80-4, giving it a negative bias. This negative bias is so varied by the voltage drop across resistor 46 referred to above, as to cause the plate current through resistor 35 to increase when the 250-volt supply voltage increases, thereby increasing the bias on the regulator tubes and tending to keep the supply voltage constant. The setting of VOLTAGE ADJ potentiometer 65 (screwdriver control on front of cabinet) determines the supply voltage value at which this regulation takes place.

(4) By means of the TEST METER switch 59, meter 74 may be connected to indicate the output voltage of the rectifier, or the current through each of the regulator tubes 83-1, 83-2, and 83-3.

10. RANGE UNIT BC-723-A (Figs. 17 and 18)

a. Range Unit BC-723-A is described in the Instruction Book on Radio Set SCR-296-A. It consists essentially of two gear-coupled independent phase shifters, one for a frequency of 1.64 kc and the other for the eighteenth harmonic of that frequency, or 29.5 kc. The gear ratio between the phase-shifting capacitors is such that the 29.5-kc shifter is moved through an angle

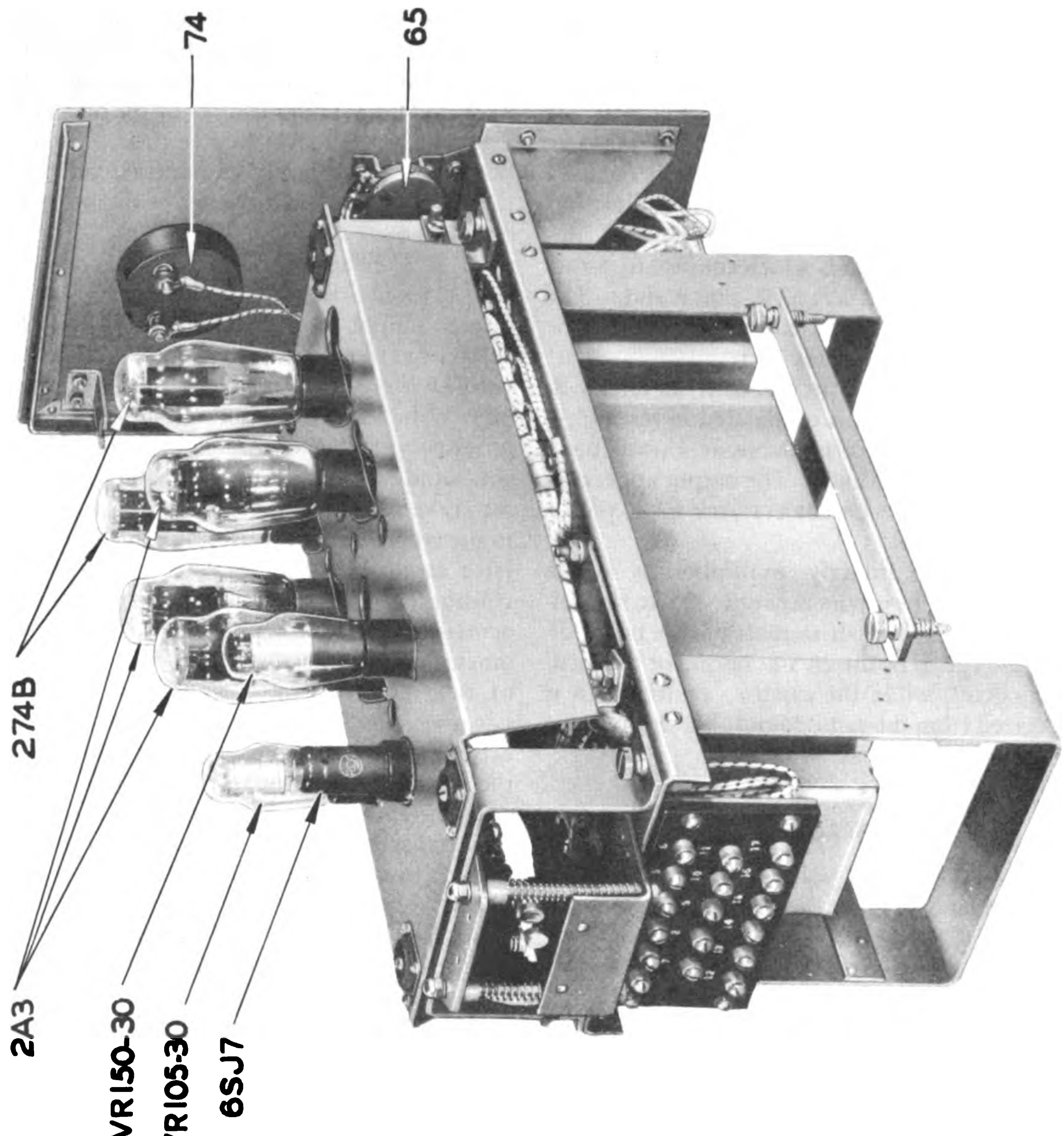


FIG. 13. POWER SUPPLY UNIT

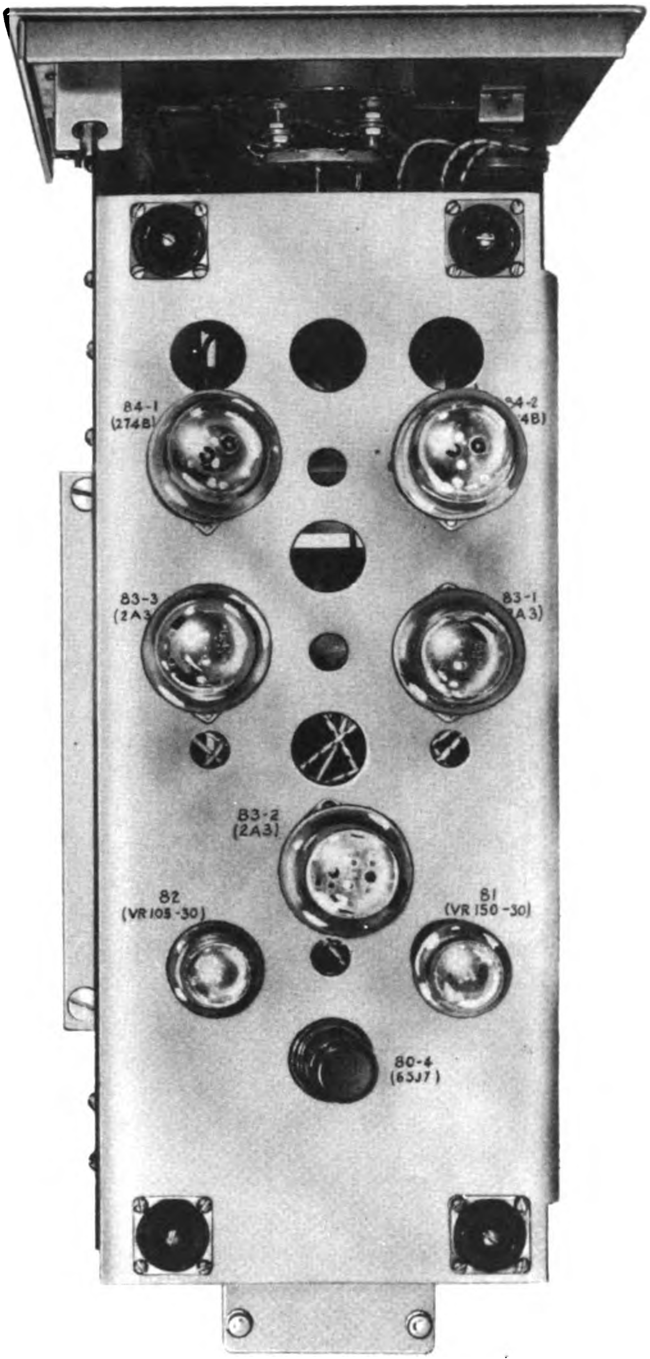


FIG. 14. POWER SUPPLY UNIT, TOP VIEW

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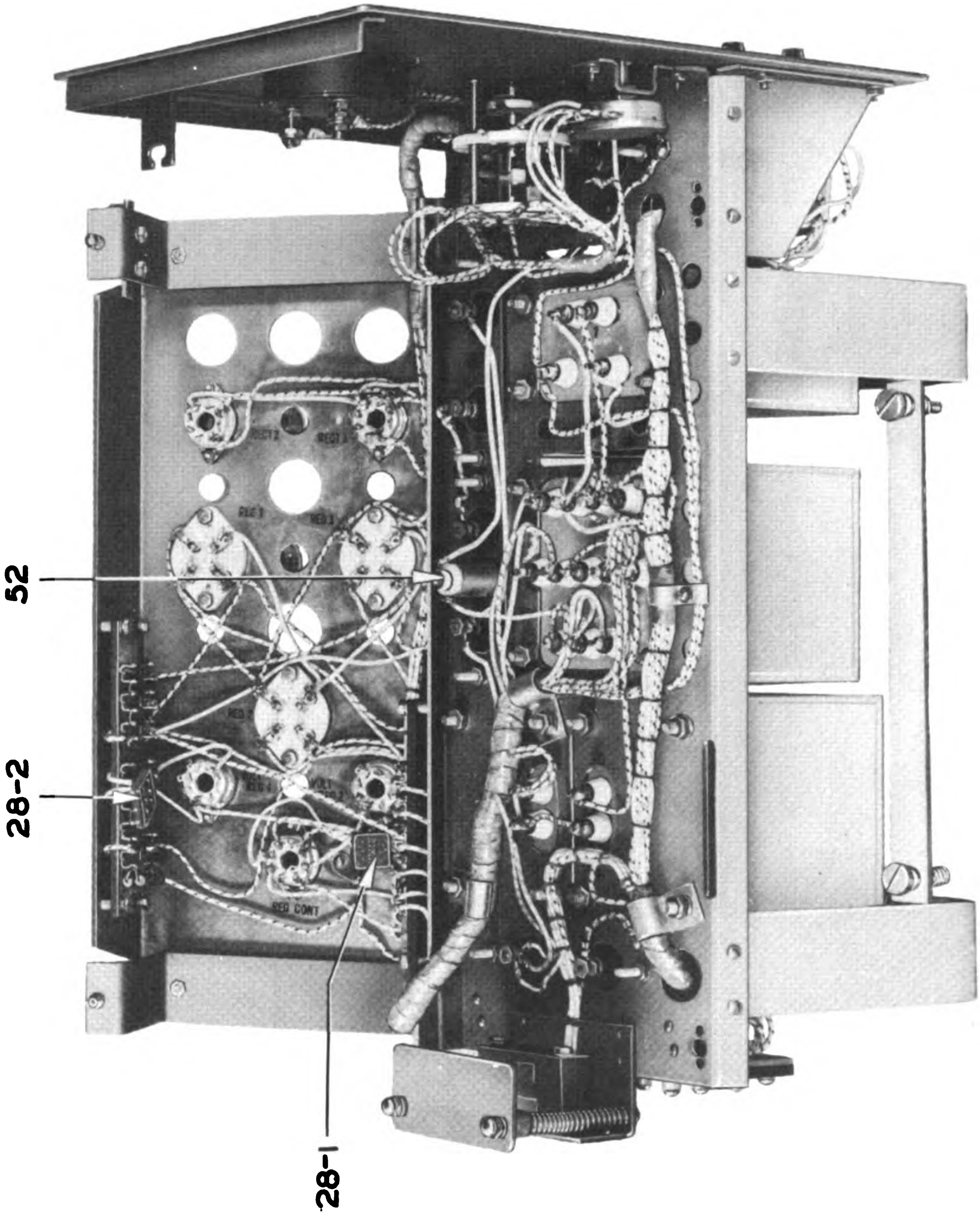


Fig. 15. Power Supply Unit, Hinged Chassis Raised

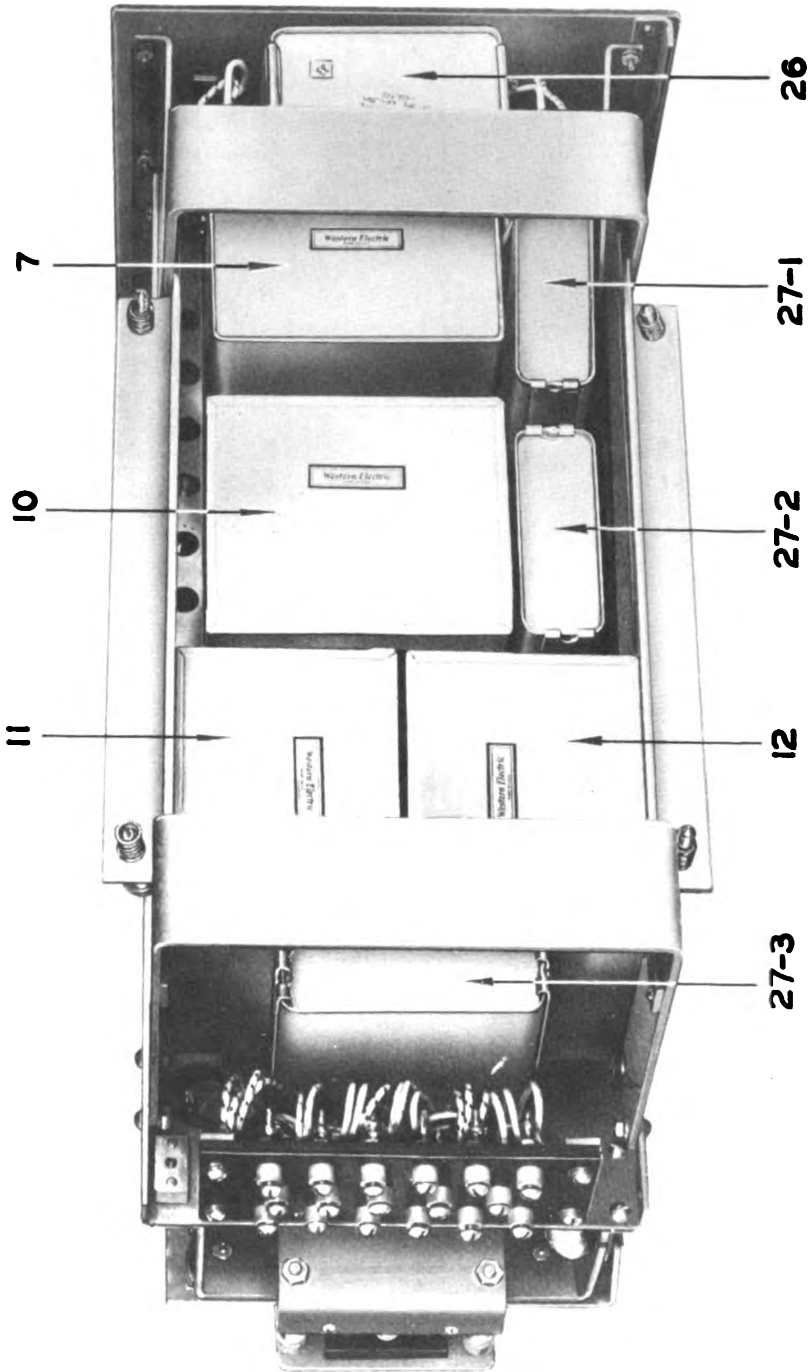


FIG. 16. POWER SUPPLY UNIT, BOTTOM VIEW

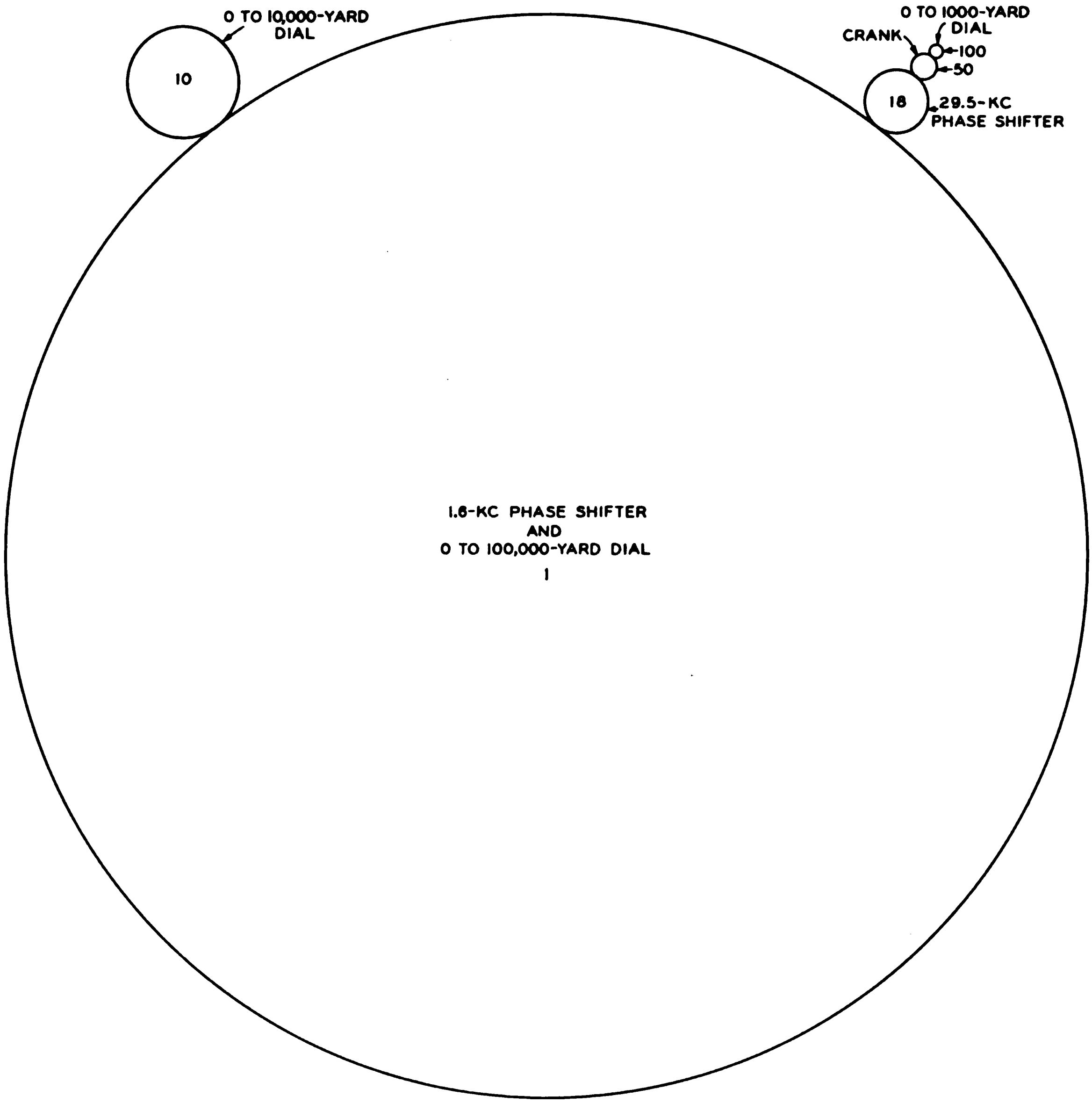


Fig. 17. Range Unit BC-723-A, Gear Ratios, Diagram

eighteen times the angle of movement of the 1.64-kc shifter, so that 29.5-kc and 1.64-kc waves entering their respective shifters are subject to no relative phase shift by the action of the range unit. Otherwise stated, if these two voltages at the input were added and the combined wave observed and then the two output voltages similarly added and observed, the two observations would show identical wave forms.

b. Directly coupled to the 1.64-kc unit is a dial divided over 360 degrees into ten equal steps of 10,000 yards each and coupled to it by a one-to-ten gear ratio is a second dial covering 10,000 yards in 100-yard steps. A vernier dial reading in 20-yard steps is provided on the side of the unit. The dials can be set to read as desired, without changing the phase-shifter positions, by means of a mechanical clutch arrangement. The

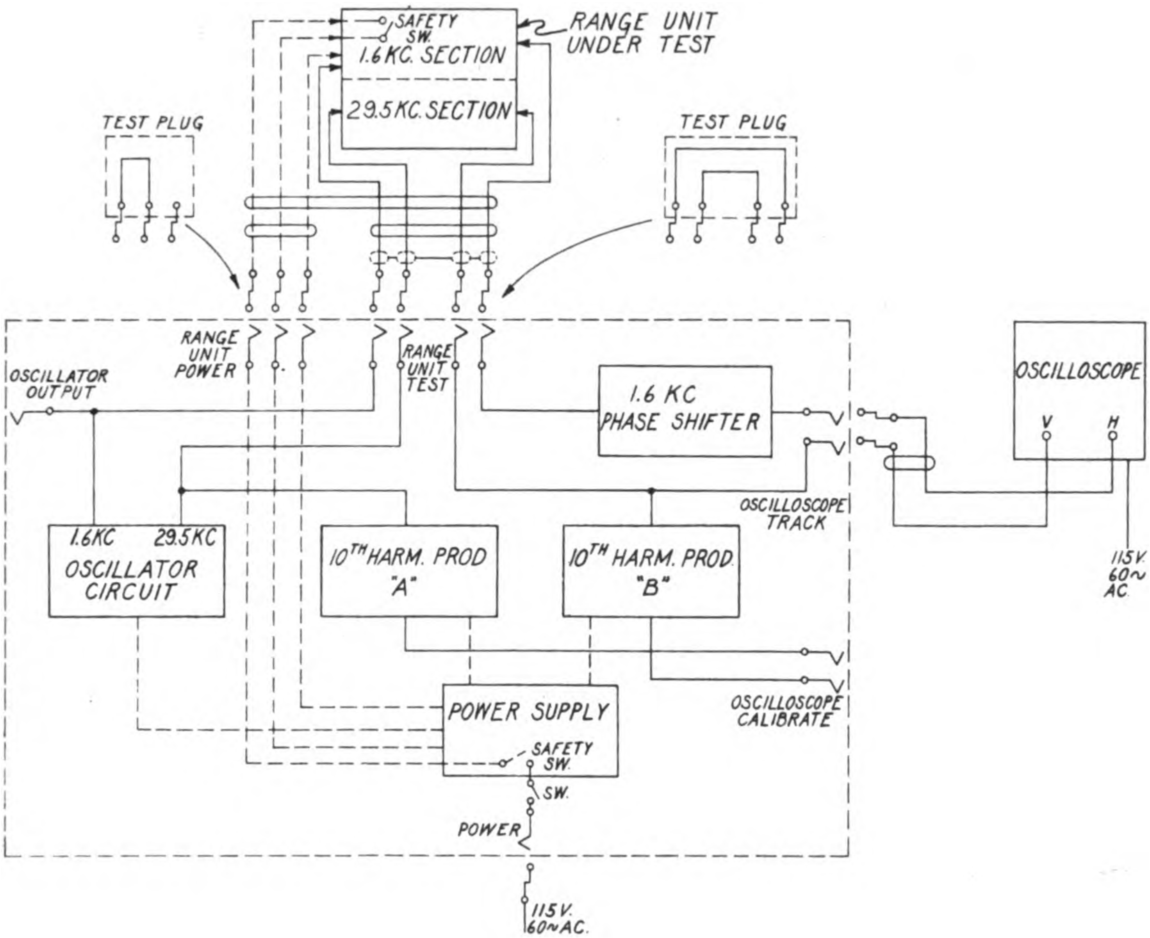


Fig. 18. Calibrator BC-725-A, Block Schematic

system of shifters and dials is driven from a crank which rotates fifty times for one rotation of the 1.64-kc shifter, or one crank shaft rotation is equivalent to changing the dials by 2,000 yards. Fig. 17 illustrates these gear ratios. All of the gearing is of an antibacklash type with the exception of that between the two dials. The parts are continuously rotatory.

c. The variable capacitors employed in the two-phase shifters are identical mechanically and are so built that the electrical degrees shift obtained is held within ± 1.5 degrees of the mechanical angular position. The calibration check procedure is to determine the actual relationship between the electrical position of the 29.5-kc shifter and its mechanical position in terms of yards on the dials; and the tracking check is made to determine the relationship between the 29.5-kc shifter and the 1.64-kc shifter.

11. CALIBRATION TEST (Figs. 18, 19, and 20)

a. Method

(1) For the calibration test the oscilloscope cord is plugged into the OSCILLOSCOPE CALIBRATE jack. Connections are made to the Range Unit by means of a spade-terminal-ended test cable, through which is also supplied heater and plate power for the amplifiers in the range unit circuit (Fig. 18). Covers on the calibrator and range unit must be in place to close the safety switches in the 115-volt, 60-cycle, a-c supply.

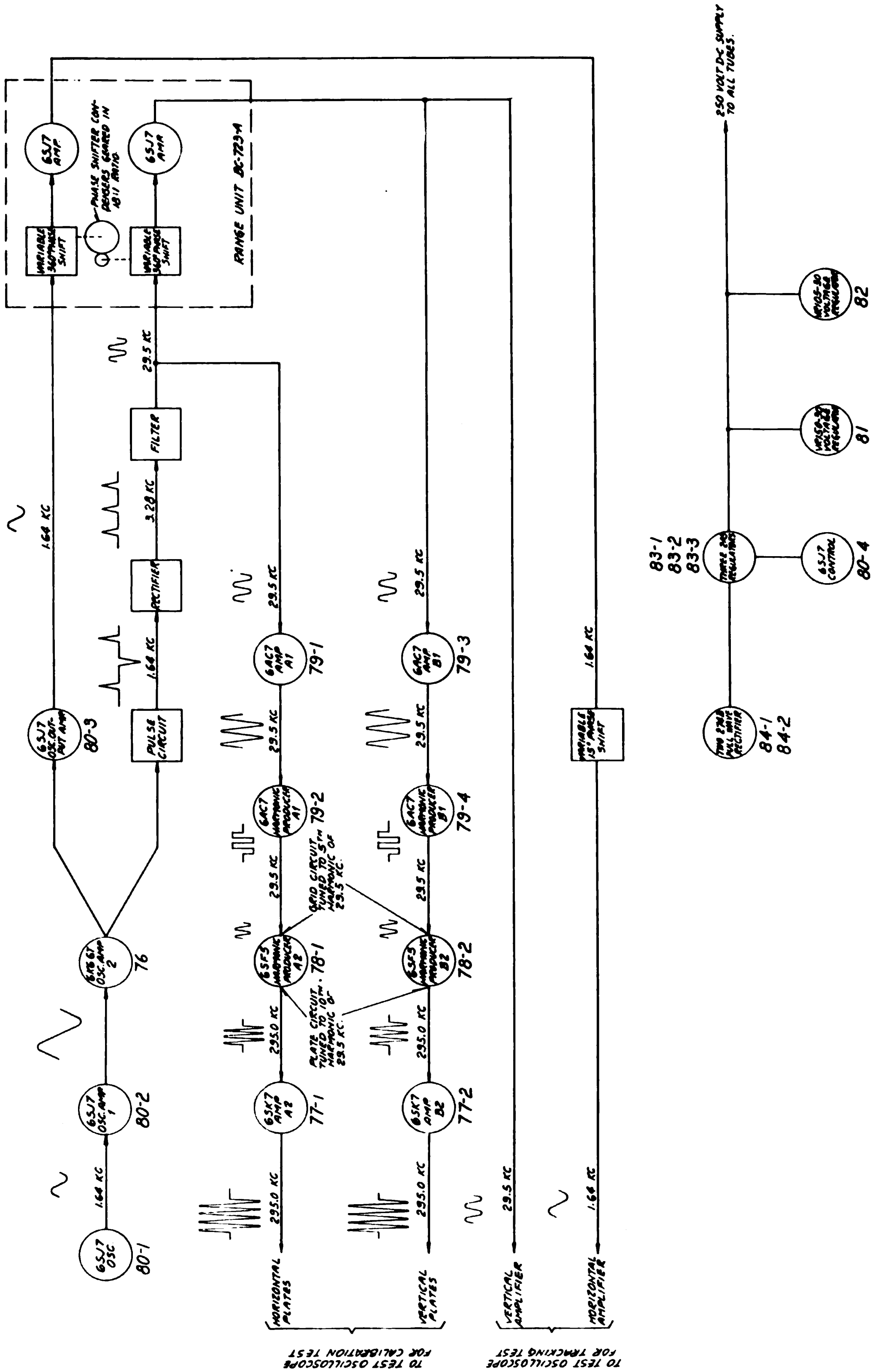


FIG. 19. CALIBRATOR BC-725-A, FUNCTIONAL DIAGRAM

(2) The 29.5-kc output from the oscillator circuit is connected to the input of the range unit and bridged across this connection is the input to multiplier A. The output of the range unit is connected to and is properly terminated by the input to multiplier B. The outputs of multipliers A and B connect through the OSCILLOSCOPE CALIBRATE jack directly to the horizontal and vertical plates, respectively, of the oscilloscope by turning the oscilloscope amplifier switches to the OFF position. The relative phase relation of the 295-kc at the output of multiplier B with respect to that at the output of multiplier A is determined by the position of the 29.5-kc phase shifter of the range unit.

(3) Since both outputs are of the same frequency, the pattern on the oscilloscope screen can vary from a straight line sloping up to the left or to the right, to a circle or ellipse, as shown on Fig. 7A, as the phase relation between them is changed. A shift of 180 degrees from a line sloping up to the right causes the pattern to assume the form of an ellipse, a circle (if both voltages have the same amplitude), an ellipse, and then a line sloping up to the left.

(4) The period for one cycle of 29.5 kc is the same as that for ten cycles of the tenth harmonic or 295 kc which forms the pattern. For example, an angular shift of 36 degrees at 29.5 kc is the same as 360-degrees shift at 295 kc, or a shift of 18 degrees is the same as a shift of 180 degrees at the tenth harmonic. Summarizing, if the 29.5-kc phase shifter is moved so that the pattern changes from a line sloping up to the right to a line sloping up to the left, the phase of the 295 kc has shifted 180 degrees, or the phase shifter has shifted the 29.5-kc voltage 18 electrical degrees. By this relationship, the 360 degrees of electrical shift producible by the phase shifter can be divided into twenty equal parts of 18 degrees each.

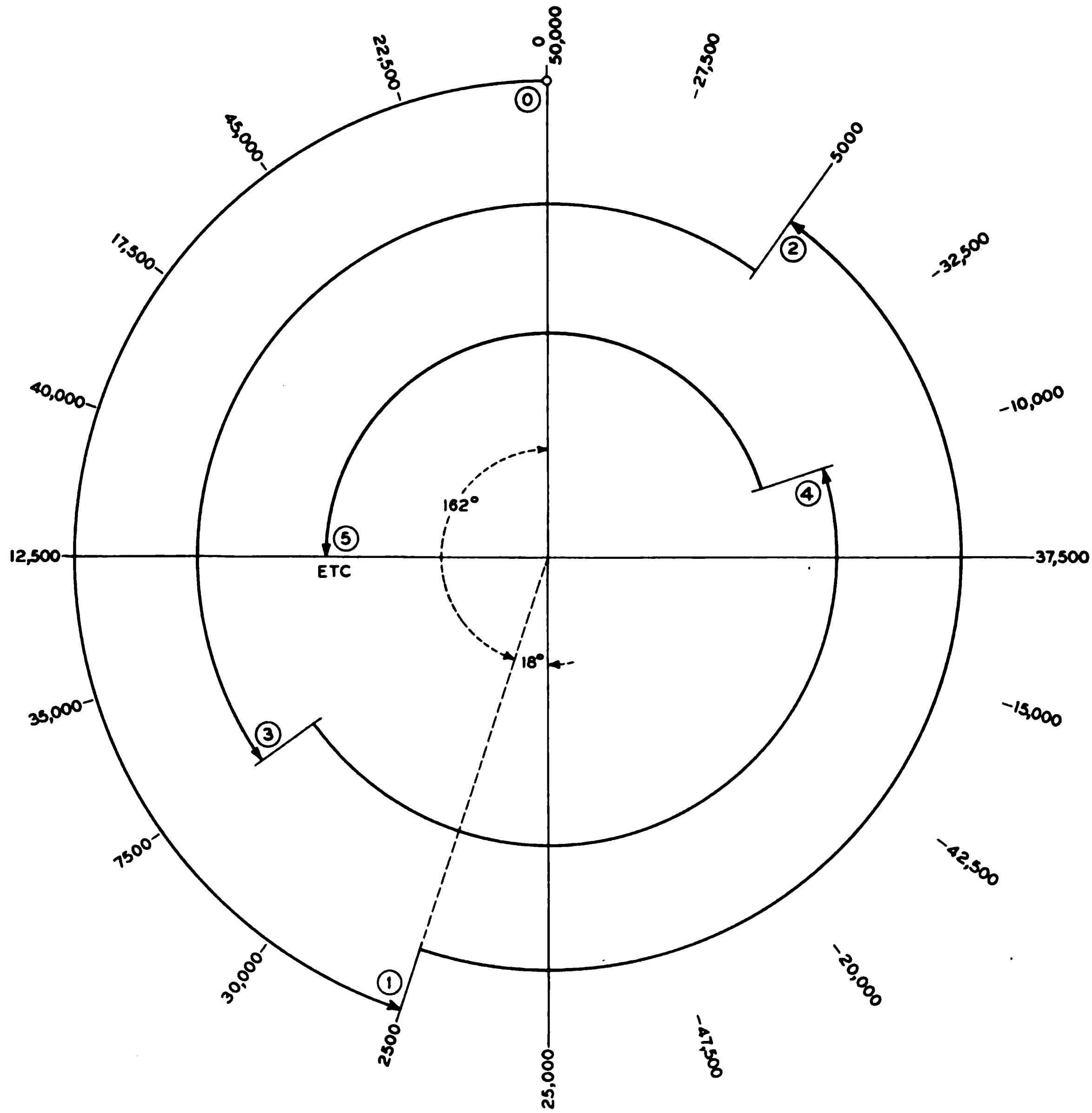
(5) The dial system of the range unit, as described above, is such that eighteen rotations of the 29.5-kc phase shifter represents 100,000 yards, or one rotation 5555.55 yards, and 18 degrees represents 277.77 yards. Accordingly, a dial change of 2,500 yards corresponds to 162-degrees rotation of the phase shifter, or 18 degrees less than 180 degrees. It is desirable to read the dials at scale graduations, so that a system of calibration at 18-degree intervals is used, employing 2,500-yard dial steps, or 162 degrees phase shift steps. 162 degrees is nine steps of 18 degrees or, in terms of the oscilloscope pattern, is nine 180-degree changes of pattern. The "collapsed circle" or straight-line pattern is used as a reference, so that if a start were made with a line sloping up to the right and the range unit dials were set to zero by means of the mechanical clutch provided, nine "collapses" from that pattern would result in a straight line sloping up to the left with the dial reading 2,500 plus or minus an error. The next ninth "collapsed circle" would slope up to the right, as at the start, and would correspond to a shift of 324 degrees and the dial would read 5,000 plus or minus an error from the starting point and so on. At the 50,000-yard point, the phase-shifter capacitor would have returned to its starting position, after having occupied twenty positions at 18-degree intervals, not consecutively.

(6) Covering the dial range from 50,000 to 100,000 yards would recheck the points determined in the calibration from 0 to 50,000 yards.

(7) The above procedure is diagrammed in Fig. 20 and listed in Table I, where the "Test Point" number refers to the order of successive ninth "collapses"; the "Dial Scale" column indicates the nominal and indicated readings, and the deviations, for the test points; the "Total Angular Movement of Phase Shifter" is the angular travel required to reach the test point; the "Relative Angular Position" is the position occupied with respect to the starting position, being the "Total Angular Movement" less the whole rotations in multiples of 360 degrees; and the "Order of Angular Progression" indicates the sequence of test points if data for consecutive angular positions is to be inspected or plotted. Fig. 8 illustrates the plotting of calibration data.

b. Calibration Accuracy

(1) It has been determined experimentally that with a clean-cut oscilloscope trace



OUTER FIGURES ARE DIAL SETTINGS CORRESPONDING TO INDICATED ANGULAR POSITIONS OF PHASE SHIFTER

FIGURES IN CIRCLES INDICATE ORDER OF MOVEMENTS AND RELATIVE POSITIONS OF 29.5-KC PHASE SHIFTER

FIG. 20. CALIBRATION PROCEDURE

with a line width of less than $\frac{1}{32}$ of an inch, the straight-line patterns or "collapsed circles" can be set to about 1 degree at 295 kc and often better on repetition of a calibration. This represents 0.1 degree or less at 29.5 kc or a setting to plus or minus 1½ yard. On the oscilloscope screen 1 degree of phase difference for a 2-inch diameter circle separates the lines of the "collapsed circle" by about 0.025-inch and this departure from coincidence is observable.

(2) The straight-line patterns, which have been assumed to occur at intervals of 180 electrical degrees, can depart from that ideal. Coupling from one set of deflecting plates to the other (including all circuits involved) will cause,

on each pair of plates, a certain amount of "crosstalk" voltage from the other pair and this disturbing voltage will not, in general, have a phase relation of either 0 degrees or 180 degrees with either of the original voltages. Each observed voltage will then be the resultant of its original combined with "crosstalk" from the other, rather than the original and the two observed voltages will be set to the straight-line reference pattern. Then, a consideration of the vector relationships will show that when one of the resultant voltages is shifted to the opposite straight-line pattern, the shift will not be exactly 180 degrees unless the original voltages are equal, making the "crosstalk" voltages symmetrical both in amplitude and phase.

Therefore, in order for "crosstalk" to have no effect the two multiplier output voltages should be made equal before they are *both* connected to the oscilloscope. The method for doing this is described in paragraph 16.

(3) The accuracy of electrical position determination is dependent also upon the relative phase stabilities of the various parts of the calibrator system. Possible variations due to change of plate voltage are eliminated by use of the regulated plate power supply circuit. Circuit changes caused by vacuum tube variations have been reduced by operating the heaters at 6.7 volts, at which voltage the variations cause less change in cathode emission than at the usual heater voltage of 6.3 volts. The most susceptible portions of the system to heater voltage change are the two multiplier circuits and here the tubes in the square-wave generators are the controlling factors. A change in voltage from 6.7 to 6.0 (−10 per cent) causes the greatest shift, which may be about 5 yards, or roughly 1/3 degree at 29.5 kc, while a change from 6.7 to 7.4 volts (+10 per cent) may result in a shift of possibly 1 yard or about 1/16 degree at 29.5 kc. It is possible to "match" tubes such that the whole shift, which is indicated above to be about 6 yards for a ± 10 per cent voltage change, can be reduced to possibly 2 or 3 yards.

(4) Transmission through the range unit is not necessarily constant for various positions of the phase shifter but may vary up to possibly 1 db. This change in transmission means that the voltage applied to the input of multiplier B will vary. A 0.3-db input change may cause about 3 yards resultant error, a drop in voltage causing a decrease in range reading. The reason for this is that the phase shift through the multiplier is affected by input voltage change.

(5) Unbalances and unwanted coupling in the calibrator circuits which connect to the input and output of the range unit under test may introduce errors of as much as 4 yards for some positions of the range unit. The average of two deviation measurements, made (a) under normal circuit conditions, and (b) with the input leads to the range unit reverse, may be used where an especially exact approach to the "true deviation" of the range unit is required.

(6) Neglecting errors caused by instability in the circuits, a calibration should indicate deviations to within about 7 yards of the actual deviation summarized as follows:

(a) Error caused by phase shift in multiplier B because the output voltage of the range unit is not constant with phase shifter position ± 1½ yards.

(b) Error in setting the tracing to a line ± 1½ yards.

(c) Error caused by unbalances ± 4 yards.

Not all points in a calibration would be subject to the same error. Error (a) is relative, as is the whole calibration, and depends upon the relation between the voltage variation and the phase shifter position. Error (b) is more or less random, depending somewhat on the operator. Error (c) varies with the position of the phase shifter, usually being zero for two points; this error can be reduced, as indicated above, by using the average of measurements with the normal and reversed connections.

In addition to the above sources of error, unless the phase shifter is made to approach a setting always from one direction, a backlash error may be introduced. This may amount to as much as 4 yards for some dial positions.

A complete calibration can probably be completed in from twenty to thirty minutes, and after an initial warm-up time of fifteen minutes or more, the above indications of accuracy should apply. The range unit 1000-yard dial scale divisions are spaced at 20-yard intervals and the dial may be read to within about 5 yards.

12. TRACKING TEST

a. The purpose of the tracking check is to determine the departure of relative phase shifts of the 1.64-kc and 29.5-kc sections of the range unit from the required 1:18 relationship.

b. Referring again to Figs. 18 and 19 the calibrator circuit is set up for a tracking check by plugging the oscilloscope cord into the OSCILLOSCOPE TRACK jack. 1.64 kc from the oscillator circuit is fed to the low-frequency phase shifter section of the range unit under test, whose output connects through the knob-controlled PHASE shifter to the horizontal deflection plate circuit of the oscilloscope. 29.5 kc from the oscillator circuit is supplied to the high-frequency section of the range unit (the same connection employed during calibration) whose output connects to the vertical deflection plate circuit. The horizontal and vertical oscilloscope amplifiers are used in the tracking test.

c. The pattern is represented in Fig. 7B and consists of eighteen waves spread horizontally, nine being in the "front" trace and nine in the "back" trace. The PHASE shifter permits rotating the pattern through a small angle, about 15 degrees at 1.64 kc, so that a reference condition can be readily obtained. The horizontal amplifier of the oscilloscope can be used to spread the pattern as desired, within its range.

d. A phase-shift change of either range unit section which departs from the 1:18 relationship causes a partial rotational movement of the pattern, or the "front" trace moves in one direction, while the "back" trace moves in the opposite direction. A movement from a position where both traces are superimposed through intermediate positions to the next superimposition represents a relative phase shift of 180 degrees at the higher frequency, or a shift of 10 degrees at the lower. The apparent shift is, of course, 360 degrees (one cycle) at the 29.5-kc frequency but this is because *both* traces are moving. The actual movement from one superimposition to the next is one-half cycle.

e. To make a tracking check, the two-phase shifters in the range unit are rotated until an extreme of movement of the trace is obtained. At this point, the PHASE shifter in the calibrator is so set as to make the front and back traces coincide and the dial reading is noted for reference purposes. The horizontal amplifier is adjusted to make one cycle cover in distance a desired number of oscilloscope screen scale divisions, say 5. Then the crank is turned and the greatest departure from coincidence is noted, in terms of the screen scale divisions. If five divisions represent 10 degrees at the 1.64-kc frequency, for the reason noted above, each division of separation represents 2 degrees of relative phase shift. About 10 degrees of shift will not materially affect the accuracy of the SCR-296-A system operation, but the phase-shifter capacitor construction as noted before should not contribute more than 3 degrees. The range unit may be considered as satisfactory if the relative phase shift, as tested above, is less than 5 degrees at 1.64 kc.

f. A simpler tracking check, not giving as close an error determination as that described above, may be made by setting the PHASE shifter so that the "front" and "back" traces on the oscilloscope intersect on the horizontal center line, regardless of the position of the range unit. Then, as the range unit is operated, the traces should never move to coincidence.

13. VACUUM-TUBE CHARACTERISTICS

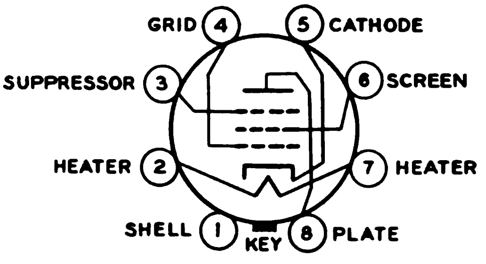


FIG. 21. 6SK7 VACUUM TUBE, BOTTOM VIEW

a. All vacuum tubes used in Calibrator BC-725-A, except type 6SK7, are described and diagrammed in the Instruction Book covering Radio Set SCR-296-A. Accordingly, only the 6SK7 tube is described here.

b. 6SK7 Vacuum Tube

This is a triple-grid super-control amplifier metal vacuum tube with a coated unipotential cathode. Manufacturer's ratings are:

Heater Voltage	6.3 volts
Heater Current	0.3 ampere
Plate Voltage	300 volts max.
Screen Voltage	125 volts min.
Grid Voltage	0 volts min.

Typical Operation and Characteristics, Supressor Connected to Cathode:

Plate Voltage	250 volts
Screen Voltage	100 volts
Grid Voltage	—3 volts
Transconductance	2,000 micromhos
Plate current	9.2 milliamperes
Screen current	2.6 milliamperes

SECTION IV. MAINTENANCE

14. GENERAL

a. Most operating troubles in equipment of this type arise from the use of old or defective tubes and may be avoided by individual tube tests at regular intervals.

b. An occasional inspection should be made for loose connections, loose screws and so forth. Most circuit troubles experienced should be located and corrected without great difficulty, with the aid of the information herein, provided the operator has studied and understood the principles involved.

c. Power voltages at all tube socket terminals may be checked from Tables II and III, which indicate expected voltages under operating conditions. Typical signal voltages are listed in Table IV and a circuit continuity test in Table V. With a line voltage of 115 volts and the power supply unit adjusted for a d-c output voltage of 250 volts, the line current for the calibrator, less the range unit and oscilloscope, is about 1.8 amperes and the power input 175 watts. When the range unit is connected, the line current is about 1.9 amperes and the power input 190 watts.

15. OSCILLATOR FREQUENCY CHECK

a. The 1639.3-cycle oscillator frequency (OSC OUTPUT) jack is controlled by the crystal unit 5 which is manufactured to ± 0.3-cycle tolerance at a room temperature of 70 degrees F. Circuit variations and temperature and tube changes will affect the frequency slightly. The frequency may be checked directly against a standard oscillator whose frequency is 1,694 ± 3 cycles, using an oscilloscope. Any difference between them will be indicated by motion or beats in the figure. However, the direction of the difference would not be indicated. It can also be checked by first setting a test oscillator to 1.64 kc by using a 100-cycle standard frequency. This may be done by connecting the 100-cycle frequency to the horizontal oscilloscope plates and the test oscillator output to the vertical plates (through oscilloscope amplifiers, if necessary) and adjusting the test oscillator frequency for a five-line stationary pattern (ten lines if "back" trace is visible; refer to the instruction book on the oscilloscope for additional information). Then replace the 100-cycle connection to the oscilloscope by the output of the OSC OUTPUT jack. A single-line, single-loop figure should be obtained, as in Fig. 7A, moving at the rate of the frequency difference between the test and calibrator oscillators. Determine the difference by timing the beats, i.e., "x" beats in "y" seconds would be $\frac{x}{y}$ cycles difference. The direction of the difference can be observed by changing the test oscillator frequency slightly; if increasing the test oscillator frequency increases the frequency of the beats, then the calibrator frequency is lower than 1,640 cycles by the amount of the difference. No adjustment of the oscillator frequency is provided in the calibrator and replacement of the crystal unit is the only remedy if after careful check the frequency is found to be at fault.

b. The open-circuit voltage at the OSC OUTPUT jack should be 35 to 65 volts root mean square, measured without any plug in the RANGE UNIT TEST jack. The presence of either the cord plug or the test plug in the RANGE UNIT TEST jack will reduce this voltage somewhat.

16. CALIBRATION TEST CHECK

a. With the range unit or the test plugs connected in circuit, plug the oscilloscope cord into the OSCILLOSCOPE CALIBRATE jack. Turn OFF the amplifier switches on the oscilloscope.

b. Check the tuning of multiplier A separately by connecting its output on the oscilloscope cord (H and G) to the corresponding oscilloscope terminals leaving the multiplier B output unconnected. Then progressively tune the capacitors 29-1, 29-2, and 29-3 of multiplier A for maximum screen deflection. Using screwdriver control 75-1 (AMP A) set the output voltage for a horizontal deflection of 2 inches.

c. Similarly, check the tuning of multiplier B with the output of multiplier A unconnected, adjusting 29-4, 29-5, and 29-6 for maximum deflection, and setting 75-2 (AMP B) control for a vertical deflection of 2.4 inches. The sensitivity of deflection on the horizontal and vertical plates of the Oscilloscope 155B is in the ratio of 2:2.4 so that the respective voltages should now be equal. This may be checked by a vacuum tube voltmeter, if available.

d. Following is a check on the effect of possible line voltage change. With both multiplier outputs connected to their respective oscilloscope terminals, detune either output stage until the oscilloscope figure is a line. Then vary the 115-volt, a-c supply by external means, noting that the line spreads into a flat ellipse. This spread should not, in general, exceed about 1/12 inch for a 2-inch diameter circle (which is equivalent to about 6-yards change, in terms of the calibration procedure), for a line voltage change of ± 10 per cent. If the spread is excessive it may be reduced by installing better matched HARM PROD 2 tubes 78-1 and 78-2. Output stage tuning should be restored after this test.

e. Table IV shows typical signal voltages through the circuit.

17. TRACKING TEST CHECK

With a range unit connected in the circuit, plug the oscilloscope cord into the OSCILLOSCOPE TRACK jack and turn the amplifier switches on the oscilloscope to ON. Adjust the gain of the amplifiers to obtain a figure in which the 29.5-kc waves are visible horizontally across the screen. With the PHASE shifter turned counterclockwise, the 1.64-kc voltage at the horizontal deflection terminals of the oscilloscope should be between 0.4 and 0.5 volt root mean square and the 29.5-kc voltage at the vertical deflection terminals should be between 1.0 and 1.25. The pattern on the screen should appear as sketched on Fig. 7B, though compressed horizontally. As the PHASE control is moved clockwise, the "front" and "back" traces will move with respect to one another, and the relative movement should be equivalent to bringing peaks from coincidence through the intermediate positions to a second coincidence and then a little beyond. In other words, the range of phase control should be about 15 degrees at 1.64 kc.

SECTION V. APPENDIX

ORDERING INFORMATION: Apparatus lists included in this section should be used in ordering replacement parts. Ordering information should include the apparatus circuit designation (such as 70-1), state that the parts are intended for use in Calibrator BC-725-A, and give the serial number. The values of resistance and capacitance and other information in these lists are intended as aids in servicing the equipment. In some cases, procurement difficulties have necessitated the substitution of equivalent, but not identical, parts for those listed. In making field replacements either the parts listed or duplicates of those supplied should be used to assure satisfactory operation. Many substitute parts may be used, however, on a temporary basis.

TABLE I

TEST DATA: RANGE UNIT BC-723-A, SERIAL NO.....................

a. Calibration Test:

Test Point	Dial Scale—Yards: Nominal	Indicated	Deviation	Total Angular Movement of Phase Shifter, Degrees	Relative Angular Positions, Degrees	Order of Angular Progression or Plotting Order
0	0,000			0	0	0
1	2,500			162	162	9
2	5,000			324	324	18
3	7,500			360 + 126	126	7
4	10,000			360 + 288	288	16
5	12,500			2 x 360 + 90	90	5
6	15,000			2 x 360 + 252	252	14
7	17,500			3 x 360 + 54	54	3
8	20,000			3 x 360 + 216	216	12
9	22,500			4 x 360 + 18	18	1
10	25,000			4 x 360 + 180	180	10
11	27,500			4 x 360 + 342	342	19
12	30,000			5 x 360 + 144	144	8
13	32,500			5 x 360 + 306	306	17
14	35,000			6 x 360 + 108	108	6
15	37,500			6 x 360 + 270	270	15
16	40,000			7 x 360 + 72	72	4
17	42,500			7 x 360 + 234	234	13
18	45,000			8 x 360 + 36	36	2
19	47,500			8 x 360 + 198	198	11
20	50,000			9 x 360 + 0	0	0
21	52,500			9 x 360 + 162	162	9
22	55,000			9 x 360 + 324	324	18
	etc.					

b. Tracking Test:

Maximum Tracking Error, ... degrees at 1.64 kc.

Note 1. The progression from 50,000 to 100,000 yards is a repetition of that from 0 to 50,000.

Note 2. A typical set of deviations is plotted on Fig. 8. The test point and plotting order sequences are shown diagrammatically on Fig. 20.

Note 3. The dial scale readings are for convenience in setting the 29.5-kc capacitor at successive 18-degree positions only and are not to be associated with the respective deviations.

TABLE II

TYPICAL D-C VOLTAGES
(OPERATING CIRCUIT POWER SUPPLY SET FOR 250 VOLTS)

Reference No.	*Tube Type*	*Tube Function*	*Socket Terminal to Ground*							
			1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Regulated Rectifier Circuit										
84-1	274B	RECT 1	—	+460	—	0	—	0	—	+460
84-2	274B	RECT 2	—	+460	—	0	—	0	—	+460
83-1	2A3	REG 1	+250	+460	+102 +210	+250	—	—	—	—
83-2	2A3	REG 2	+250	+460	+102 +210	+250	—	—	—	—
83-3	2A3	REG 3	+250	+460	+102 +210	+250	—	—	—	—
81	VR150-30	VOLT REG 1	—	+100	—	—	+250	—	—	—
82	VR105-30	VOLT REG 2	—	0	—	—	+105	—	—	—
80-4	6SJ7	REG CONT	0	0	+105	+100	+105	+250	—	+102 +210
Oscillator Circuit										
80-1	6SJ7	OSC	0	—	+1.0	0	+1.0	+31 +37	—	+18 +23
80-2	6SJ7	OSC AMP 1	0	—	+3.0	0	+3.0	+100 +102	—	+182 +188
76	6K6-GT	OSC AMP 2	—	—	+246	+250	−4 −7	—	—	+14
80-3	6SJ7	OSC OUT AMP	0	—	+2.8	0	+2.8	+100 +102	—	+182 +188
Multiplier Circuit A										
79-1	6AC7	AMP A1	0	—	+3.0	0	+3.0	+116	—	+250
79-2	6AC7	HARM PROD A1	0	—	0	−15 to −30 −30	0	+116	—	+86
78-1	6SF5	HARM PROD A2	0	2.2	0	—	+116 +122	—	—	—
77-1	6SK7	AMP A2	0	—	+6.4	0	+6.4	+116	—	+250

Multiplier Circuit B, as for *A* above, for equivalent tubes in positions 79-3, 79-4, 78-2, and 77-2, respectively.

Note: Upper figures are voltages measured with a 1000 ohm/volt voltmeter.
Lower figures are voltages measured with a Weston 772 Test Set (20,000 ohm/volt).
A single reading indicates that both meters read the same.

TABLE III

TYPICAL 60-CYCLE A-C VOLTAGES FOR 115-VOLT LINE

Tube	*Socket Terminal to Ground* 1	2	3	4	5	6	7	8
Power Supply Circuit								
84-1	—	*	—	540	—	540	—	*
84-2	—	*	—	540	—	540	—	*
83-1	**	—	—	**	—	—	—	—
83-2	**	—	—	**	—	—	—	—
83-3	**	—	—	**	—	—	—	—
81								
82								
80-4	—	0	—	—	—	—	6.7	—
Oscillator Circuit								
80-1	—	6.7	—	—	—	—	0	—
80-2	—	6.7	—	—	—	—	0	—
76	—	6.7	—	—	—	—	0	—
80-3	—	6.7	—	—	—	—	0	—
Harmonic Producer A								
79-1	—	6.7	—	—	—	—	0	—
79-2	—	6.7	—	—	—	—	0	—
78-1	—	—	—	—	—	—	0	6.7
77-1	—	6.7	—	—	—	—	0	—
Harmonic Producer B								
79-3	—	6.7	—	—	—	—	0	—
79-4	—	6.7	—	—	—	—	0	—
78-2	—	—	—	—	—	—	0	6.7
77-2	—	6.7	—	—	—	—	0	—

*The voltage measured between these pins should be approximately 5.2 volts alternating current.

**The voltage measured between these pins should be approximately 2.5 volts alternating current.

TABLE IV

TYPICAL SIGNAL VOLTAGES, RMS

a. Notes

(1) Voltages are measured with a vacuum tube voltmeter between the designated point and ground unless otherwise noted.

(2) Test plug is used in RANGE UNIT TEST jack unless otherwise noted.

(3) The oscilloscope is connected to the OSCILLOSCOPE CALIBRATE jack, and the multiplier circuits are tuned.

b. Oscillator Circuit

1 to 3 of D-161647 Crystal Unit	.55 volt(s)
Tube 80-2, pin 4	.85
Tube 76, pin 5	36.
Tube 80-3, pin 4	1.
OSC OUTPUT jack, open circuit (test plug removed from RANGE UNIT TEST jack)	50.

c. Multiplier Circuit

Designations refer to circuit A, but voltages also apply to similar locations in circuit B.

Across resistors 11-1 plus 11-2	.6 volt(s)
Tube 79-1, pin 4	.3
Junction resistors 36-2 and 37-1	45.
Tube 79-2, pin 4	25.
Junction resistor 38-1 and capacitor 66-2	20.
Tube 78-1, pin 3	2.
Junction resistor 39-1 and capacitor 66-3	12.
Tube 77-1, pin 4, AMP A control max.	3.
Tube 77-1, pin 4, AMP A control min.	0.
Output side capacitor 3-3 AMP A control max.	45.

TABLE V

CONTINUITY MEASUREMENTS

With the lead removed from terminal 8 of TS1, and no power applied to the calibrator, the following continuity measurements may be made (test plugs removed):

a. Terminal 8 of regulated rectifier terminal plate TS1 to ground, 150,000 ± 10,000 ohms.

b. Grid terminal 3 of REG 1, REG 2, and REG 3 tube to ground, 201,000 ± 10,000 ohms greater than the resistance measured in *a.*

c. Terminal 8 of TS2 to ground, 6,240 ± 400 ohms.

d. The following resistances to ground should be measured at the tube socket grid terminals:

Tube	
80-1 (OSC)	Terminal 4, 2 megohms ± 100,000 ohms
80-2 (OSC AMP 1)	Terminal 4, 14,000 ± 140 ohms
76 (OSC AMP 2)	Terminal 4, 500,000 ± 25,000 ohms
80-3 (OSC OUT AMP)	Terminal 4, 6000 ± 300 ohms
79-1 (AMP A1)	Terminal 4, 1000 ± 10 ohms
79-2 (HARM PROD A1)	Terminal 4, 600,000 ± 30,000 ohms
78-1 (HARM PROD A2)	Terminal 3, 14 ± 1.5 ohms
77-1 (AMP A2)	Terminal 4, AMP A control min. 0 ohm
	Terminal 4, AMP A control max. 50,000 ± 5,000 ohms
79-3 (AMP B1)	Terminal 4, 1048 ± 13 ohms
79-4 (HARM PROD B1)	Terminal 4, 600,000 ± 30,000 ohms
78-2 (HARM PROD B2)	Terminal 3, 14 ± 1.5 ohms
77-2 (AMP B2)	Terminal 4, AMP B control min. 0 ohm
	Terminal 4, AMP B control max. 50,000 ± 5,000 ohms

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Sheet 8, Issue 3
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TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
1-1		Inductor	Retard Choke: 3.5 henries, 500 ma; KS-8572	Plate supply filter inductor	29	
1-2		Inductor	Retard Choke: 3.5 henries, 500 ma; KS-8572	Plate supply filter inductor	29	
2-1		Capacitor	Mica: 1550 mmf ± (1% +1 mmf); D-162384	Amp A1 plate circuit capacitor	29	
2-2		Capacitor	Mica: 1550 mmf ± (1% +1 mmf); D-162384	Amp B1 plate circuit capacitor	29	
3-1		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Harm Prod A2 grid circuit capacitor	29	
3-2		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Harm Prod A2 plate circuit capacitor	29	
3-3		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Amp A2 plate stopping capacitor	29	
3-4		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Harm Prod B2 grid circuit capacitor	29	
3-5		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Harm Prod B2 plate circuit capacitor	29	
3-6		Capacitor	Mica: 550 mmf ± (1% +1 mmf); D-162383	Amp B2 plate stopping capacitor	29	
4-1		Capacitor	Mica: 400 mmf ± (1% +1 mmf); D-162383	Amp A2 plate circuit capacitor	29	
4-2		Capacitor	Mica: 400 mmf ± (1% +1 mmf); D-162383	Amp B2 plate circuit capacitor	29	
5		Crystal	1.6393 kc ± 0.3 cycle; D-161647	Frequency stabilizer	29	
6		Filter	Filter: Special band pass; D-160382	29.5-kc selector	29	
7		Transformer	Transformer: 77 va, 75 watts, 60 cps Primary: 115 V at 0.67 ampere Secondary: 6.75 V at 10 amperes Type KS-8604	Supplies all amplifier filaments	29	
8-1		Network	D-162317	Osc Amp 1 plate circuit	29	
8-2		Network	D-162317	Osc Out Amp plate circuit	29	
9		Output Transformer	D-162320	Osc Amp 2 output	29	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
10		Transformer	Transformer: 222 va, 190 watts, 60 cps Primary: 115 V at 1.92 amperes Secondary No. 1: 1,080 V at 0.177 ampere, C.T. Secondary No. 2: 5.13 V at 4 amperes Secondary No. 3: 6.64 V at 1 ampere, insulated for 300 V DC Secondary No. 4: 2.63 V at 7.5 amperes, C.T., insulated for 600 V DC; KS-8606	Rectifier plate and filament supply	29	
11-1		Resistor	2,000 ohms ± 1%; 106A	Amp A1 grid circuit	29	
11-2		Resistor	2,000 ohms ± 1%; 106A	Amp A1 grid circuit	29	
11-3		Resistor	2,000 ohms ± 1%; 106A	Amp B1 grid circuit	29	
11-4		Resistor	2,000 ohms ± 1%; 106A	Amp B1 grid circuit	29	
12		Resistor	50,000 ohms ± 1%; 107A	Oscillator plate circuit voltage divider	29	
13		Resistor	5,000 ohms ± 1%; 106A	Oscillator plate circuit voltage divider	29	
14		Resistor	9,000 ohms ± 1%; 106A	Oscillator plate circuit voltage divider	29	
15		Inductor	Retard: 0.1 henry at 1 ampere, 1,640 cps Average d-c resistance 5 ohms; D-159995	Pulse circuit coil	29	
16		Inductor	Retard: 0.06 to 0.13 henry measured with 0.5 ma, 4,000-cycle current Effective resistance 1,000 ohms at 4,000 cps Average d-c resistance 5 ohms; D-162306	Pulse generating coil	29	
17-1		Transformer	Input Transformer: Primary resonates at 1,640 cps with approximately 0.11 mf, 1:1 ratio Resonant impedance 5,000 ohms Coil Q at 1,640 cycles = 30 Secondary C.T. ± 1% impedance balance Electrostatic shield; SR-1007	Band Pass filter input coil	29	
17-2		Transformer	Input Transformer: Primary resonates at 1,640 cps with approximately 0.11 mf, 1:1 ratio Resonant impedance 5,000 ohms Coil Q at 1,640 cycles = 30 Secondary C.T. ± 1% impedance balance Electrostatic shield; SR-1007	Band Pass filter output coil	29	
18		Varistor	D-162356	Voltage limiter	29	
19		Varistor	D-161870	1.64-kc pulse doubler	29	
20-1		Inductor	20 microhenries ± 1% Min. Q = 50 at 100 kc; Type 400-142	Amp A1 plate circuit inductor	74	ES0-683487-6

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
20-2		Inductor	20 microhenries ± 1% Min. Q = 50 at 100 kc; Type 400-142	Amp B1 plate circuit inductor	74	ESO-683487-6
21-1		Inductor	2 microhenries ± 1% Min. Q = 100 at 300 kc; Type 400-141	Harm Prod A2 grid circuit inductor	74	ESO-683487-5
21-2		Inductor	2 microhenries ± 1% Min. Q = 100 at 300 kc; Type 400-141	Harm Prod B2 grid circuit inductor	74	ESO-683487-5
22-1		Inductor	0.5 microhenry ± 1% Min. Q = 100 at 400 kc; Type 400-140	Harm Prod A2 plate circuit inductor	74	ESO-683487-4
22-2		Inductor	0.5 microhenry ± 1% Min. Q = 100 at 400 kc; Type 400-140	Amp A2 plate circuit inductor	74	ESO-683487-4
22-3		Inductor	0.5 microhenry ± 1% Min. Q = 100 at 400 kc; Type 400-140	Harm Prod B2 plate circuit inductor	74	ESO-683487-4
22-4		Inductor	0.5 microhenry ± 1% Min. Q = 100 at 400 kc; Type 400-140	Amp B2 plate circuit inductor	74	ESO-683487-4
23		Jack	SC-D-1585, JK-44	OSC OUTPUT jack	73	
24		Lamp	110 V, double contact bayonet base; S-6	Indicates "power on"	36	
25-1		Capacitor	Paper: 1.0 mf +14 -6%, 600 V DC working TRS-601	By-Pass Capacitor	48	
25-2		Capacitor	Paper: 1.0 mf +14 -6%, 600 V DC working TRS-601	By-Pass Capacitor	48	
26		Capacitor	Paper: 15 mf +14 -6%, 1,000 V DC working TJH-10150	Plate supply filter capacitor	9	
27-1		Capacitor	Paper: 4 mf +14 -6%, 1,500 V DC working TJH-15040	Plate supply filter capacitor	9	
27-2		Capacitor	Paper: 4 mf +14 -6%, 1,500 V DC working TJH-15040	Plate supply filter capacitor	9	
27-3		Capacitor	Paper: 4 mf +14 -6%, 1,500 V DC working TJH-15040	Plate supply filter capacitor	9	
28-1		Capacitor	Mica: 0.01 mf ± 10%, 300 V DC working; 1WLS	Noise filter capacitor	9	
28-2		Capacitor	Mica: 0.01 mf ± 10%, 300 V DC working; 1WLS	Noise filter capacitor	9	
29-1		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3
29-2		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3
29-3		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
29-4		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3
29-5		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3
29-6		Capacitor	Variable air: 100 mmf; APC-100	Tuning capacitor	15	ES-680214-3
30		Switch	Switch: special DPST	Power supply switch	16	ESO-676800-7
31-1		Resistor	10 ohms ± 5%, wax impregnated; BW-1/2	Voltage dropping resistor	18	
31-2		Resistor	10 ohms ± 5%, wax impregnated; BW-1/2	Voltage dropping resistor	18	
31-3		Resistor	10 ohms ± 5%, wax impregnated; BW-1/2	Voltage dropping resistor	18	
32		Resistor	200 ohms ± 5%, wax impregnated; BW-1/2	Terminating resistor	18	
33		Resistor	1,500 ohms ± 2%, wax impregnated; BW-1	Voltmeter series resistor	18	
34-1		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Reg 1 grid resistor	18	
34-2		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Reg 2 grid resistor	18	
34-3		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Reg 3 grid resistor	18	
34-4		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Amp A1 biasing resistor	18	
34-5		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Amp A2 biasing resistor	18	
34-6		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Amp B1 biasing resistor	18	
34-7		Resistor	1,000 ohms ± 10%, wax impregnated; BT-1/2	Amp B2 biasing resistor	18	
35		Resistor	0.2 megohm ± 10%, wax impregnated; BT-1/2	Regulator tubes biasing resistor	18	
36-1		Resistor	0.1 megohm ± 10%, wax impregnated; BT-1/2	Voltage divider	18	
36-2		Resistor	0.1 megohm ± 10%, wax impregnated; BT-1/2	Harm Prod A1 grid resistor	18	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
36-3		Resistor	0.1 megohm ± 10%, wax impregnated; BT-1/2	Harm Prod B1 grid resistor	18	
36-4		Resistor	0.1 megohm ± 10%, wax impregnated; BT-1/2	Voltage divider resistor	18	
36-5		Resistor	0.1 megohm ± 10%, wax impregnated; BT-1/2	Oscillator circuit resistor	18	
37-1		Resistor	0.5 megohm ± 10%, wax impregnated; BT-1/2	Amp A1 load resistor	18	
37-2		Resistor	0.5 megohm ± 10%, wax impregnated; BT-1/2	Amp B1 load resistor	18	
37-3		Resistor	0.5 megohm ± 10%, wax impregnated; BT-1/2	Osc Amp 1 load resistor	18	
38-1		Resistor	0.15 megohm ± 10%, wax impregnated; BT-1/2	Isolating resistor	18	
38-2		Resistor	0.15 megohm ± 10%, wax impregnated; BT-1/2	Isolating resistor	18	
38-3		Resistor	0.15 megohm ± 10%, wax impregnated; BT-1/2	Voltage dropping resistor	18	
39-1		Resistor	50,000 ohms ± 10%, wax impregnated; BT-1/2	Voltage divider resistor	18	
39-2		Resistor	50,000 ohms ± 10%, wax impregnated; BT-1/2	Voltage divider resistor	18	
40		Resistor	500 ohms ± 5%, wax impregnated; BT-1/2	Terminating resistor	18	
41		Resistor	2 megohms ± 10%, wax impregnated; BT-1/2	Oscillator circuit resistor	18	
42		Resistor	0.25 megohm ± 10%, wax impregnated; BT-1/2	Oscillator screen resistor	18	
43-1		Resistor	750 ohms ± 10%, wax impregnated; BT-1/2	Osc Amp 1 biasing resistor	18	
43-2		Resistor	750 ohms ± 10%, wax impregnated; BT-1/2	Osc Out Amp biasing resistor	18	
44		Resistor	6,000 ohms ± 10%, wax impregnated; BT-1/2	Voltage divider	18	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
45		Resistor	51,000 ohms ± 10%, wax impregnated; BT-1	Current limiter	18	
46-1		Resistor	20,000 ohms ± 10%, wax impregnated; BT-1	Voltage divider	18	
46-2		Resistor	20,000 ohms ± 10%, wax impregnated; BT-1	Voltage divider	18	
47-1		Resistor	5,000 ohms ± 10%, wax impregnated; BT-1	Harm Prod A2 biasing resistor	18	
47-2		Resistor	5,000 ohms ± 10%, wax impregnated; BT-1	Harm Prod B2 biasing resistor	18	
48-1		Resistor	10,000 ohms ± 10%, wax impregnated; BT-2	Harm Prod A1 load resistor	18	
48-2		Resistor	10,000 ohms ± 10%, wax impregnated; BT-2	Harm Prod B1 load resistor	18	
49		Resistor	20,000 ohms ± 10%, wax impregnated; BT-2	Oscillator circuit voltage divider	18	
50		Resistor	12,000 ohms ± 10%, wax impregnated; BT-2	Oscillator circuit voltage divider	18	
51		Resistor	500 ohms ± 10%, wax impregnated; BT-2	Osc Amp 2 biasing resistor	18	
52		Resistor	0.3 megohm ± 1%, 1 watt. wax impregnated; WW-13	Voltmeter series resistor	18	
53		Resistor	5,000 ohms ± 10%, 6 watts, No. 3 terminals; Type EL	Oscillator circuit voltage divider	18	
54-1		Resistor	10,000 ohms ± 10%, 6 watts, No. 3 terminals; Type EL	Voltage divider	18	
54-2		Resistor	10,000 ohms ± 10%, 6 watts, No. 3 terminals; Type EL	Voltage divider	18	
55-1		Resistor	5,000 ohms ± 10%, 10 watts, No. 3 terminals; Type EM	Voltage divider	18	
55-2		Resistor	5,000 ohms ± 10%, 10 watts, No. 3 terminals; Type EM	Voltage divider	18	
56		Resistor	3,300 ohms ± 5%, wax impregnated; BT-1/2	Volt Reg 1 series resistor	18	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
57		Potentiometer	Potentiometer: 25,000 ohms, No. 11-120 taper "A", round shaft, standard type CS without switch, shaft "A" dimension 7/8" with two hex. nuts	PHASE adjuster	18	
58-1		Fuse	Littelfuse: 3-ampere; Type 1043	Power supply fuse	49	
58-2		Fuse	Littelfuse: 3-ampere; Type 1043	Power supply fuse	49	
59		Switch	Special No. 537	TEST METER switch	38	ESO-686165-1
60-1		Switch	No. 6900	Safety interlock	14	
60-2		Switch	No. 6900	Safety interlock	14	
61		Connector	AN-3102-18-1S	RANGE UNIT TEST jack	64	
62-1		Connector	AN-3102-14S-1S	OSCILLOSCOPE TRACK jack	64	
62-2		Connector	AN-3102-14S-1S	OSCILLOSCOPE CALIBRATE jack	64	
63		Connector	AN-3102-20-5P	POWER receptacle	64	
64		Connector	AN-3102-22-711S	RANGE UNIT POWER receptacle	64	
65		Potentiometer	Potentiometer: 40,000 ohms; Type B-115072	Plate VOLTAGE ADJ	22	ESO-679305-1
66-1		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Amp A1 plate stopping capacitor	70	
66-2		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Harm Prod A1 plate stopping capacitor	70	
66-3		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Harm Prod A2 plate stopping capacitor	70	
66-4		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Amp A2 plate stopping capacitor	70	
66-5		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Harm Prod B1 plate stopping capacitor	70	
66-6		Capacitor	Mica: 0.01 mf ± 5%, 600 V; Type XQW .6-11-5	Harm Prod B2 plate stopping capacitor	70	
67-1		Capacitor	Mica: 0.03 mf ± 5%, 600 V; Type XQW .6-13-5	Oscillator circuit stopping capacitor	70	
67-2		Capacitor	Mica: 0.03 mf ± 5%, 600 V; Type XQW .6-13-5	Oscillator circuit stopping capacitor	70	
67-3		Capacitor	Mica: 0.03 mf ± 5%, 600 V; Type XQW .6-13-5	Oscillator circuit rectifier input capacitor	70	
68		Capacitor	Mica: 0.016 mf ± 5%, 600 V; Type XQW .6-116-5	Pulse circuit capacitor	70	
69-1		Capacitor	Mica: 0.001 mf ± 5%, 500 V; Type MWW 1227-5	Oscillator circuit stopping capacitor	70	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
69-2		Capacitor	Mica: 0.001 mf ± 5%, 500 V; Type MWW 1227-5	Phase shifter capacitor	70	
70		Capacitor	Mica: 0.005 mf ± 5%, 375 V; Type MWW 1239-5	Oscillator output stopping capacitor	70	
71-1		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V: oil impregnated Type XTIMW6	By-pass capacitor	70	
71-2		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V; oil impregnated Type XTIMW6	By-pass capacitor	70	
71-3		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V: oil impregnated Type XTIMW6	By-pass capacitor	70	
71-4		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V: oil impregnated Type XTIMW6	By-pass capacitor	70	
71-5		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V; oil impregnated Type XTIMW6	By-pass capacitor	70	
71-6		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V; oil impregnated Type XTIMW6	By-pass capacitor	70	
71-7		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V: oil impregnated Type XTIMW6	By-pass capacitor	70	
71-8		Capacitor	Paper: 0.1 mf - 10% + 20%, 600 V; oil impregnated Type XTIMW6	By-pass capacitor	70	
72		Capacitor	Paper: 0.95 mf ± 5%, 600 V; oil impregnated; Type XLJMW6 .95-5	Osc Amp 2 plate circuit tuning	70	
73		Capacitor	Mica: 0.094 mf ± 5%, 500V; Type XSW .5-194	Pulse circuit capacitor	70	
74		Meter	Milliammeter: Type 301, 0-1 ma DC flush 3-1/2" bakelite case, non-glare glass, for use with external shunts and multipliers for scale range 0-150 ma and 0-300 V; per Navy Spec. 17-I-12	Test meter	28	
75-1		Potentiometer	50,000 ohms, taper 4; Type M50MP	Multiplier A output adjuster	22	
75-2		Potentiometer	50,000 ohms, taper 4; Type M50MP	Multiplier B output adjuster	22	
76		Vacuum Tube	Power amplifier pentode; 6K6-GT	Osc Amp 2	26	
77-1		Vacuum Tube	Triple-grid super-control amplifier; 6SK7	Amp A2	26	

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
77-2		Vacuum Tube	Triple-grid super-control amplifier; 6SK7	Amp B2	26	
78-1		Vacuum Tube	High-mu triode; 6SF5	Harm Prod A2	26	
78-2		Vacuum Tube	High-mu triode; 6SF5	Harm Prod B2	26	
79-1		Vacuum Tube	Television amplifier pentode; 6AC7	Amp A1	26	
79-2		Vacuum Tube	Television amplifier pentode; 6AC7	Harm Prod A1	26	
79-3		Vacuum Tube	Television amplifier pentode; 6AC7	Amp B1	26	
79-4		Vacuum Tube	Television amplifier pentode; 6AC7	Harm Prod B1	26	
80-1		Vacuum Tube	Triple-grid detector amplifier; 6SJ7	Oscillator	26	
80-2		Vacuum Tube	Triple-grid detector amplifier; 6SJ7	Osc Amp 1	26	
80-3		Vacuum Tube	Triple-grid detector amplifier; 6SJ7	Osc Out Amp	26	
80-4		Vacuum Tube	Triple-grid detector amplifier; 6SJ7	Reg Cont Tube	26	
81		Gas Tube	Voltage regulator; VR150-30	Volt Reg 1	26	
82		Gas Tube	Voltage regulator; VR105-30	Volt Reg 2	26	
83-1		Vacuum Tube	Power amplifier triode; 2A3	Reg 1	26	
83-2		Vacuum Tube	Power amplifier triode; 2A3	Reg 2	26	
83-3		Vacuum Tube	Power amplifier triode; 2A3	Reg 3	26	
84-1		Vacuum Tube	Full-wave rectifier; 274B	Rect 1	29	
84-2		Vacuum Tube	Full-wave rectifier; 274B	Rect 2	29	
-		Socket	Special octal socket	For Tube 76	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 77-1	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 77-2	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 78-1	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 78-2	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 79-1	40	ESL-678315-3
-		Socket	Special octal socketq	For Tube 79-2	40	ESL-678315-3

TABLE VI

LIST OF REPLACEABLE PARTS FOR CALIBRATOR BC-725-A

Ap. Desig.	Stock No.	Name of Part	Description	Function	Mfr.	Drawing No.
-		Socket	Special octal socket	For Tube 79-3	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 79-4	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 80-1	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 80-2	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 80-3	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 80-4	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 81	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 82	40	ESL-678315-3
-		Socket	4-contact socket; XC-4	For Tube 83-1	25	
-		Socket	4-contact socket; XC-4	For Tube 83-2	25	
-		Socket	4-contact socket; XC-3	For Tube 83-3	25	
-		Socket	Special octal socket	For Tube 84-1	40	ESL-678315-3
-		Socket	Special octal socket	For Tube 84-2	40	ESL-678315-3
-		Cord	Cord assembly	Power supply cord	29	ESO-686155-1
-		Cord	Cord assembly	Oscilloscope cord	29	ESO-686155-2
-		Cord	Cord assembly	Range Unit cord	29	ESO-686167-2
-		Plug	Plug assembly	Test plug, Range Unit power	29	ESO-686155-3
-		Plug	Plug assembly	Test plug, Range Unit test	29	ESO-686155-4

Note 1. For list of manufacturers of components as indicated by numbers in "Mfr." column above, see BL-10547.

Note 2. In some cases, procurement difficulties may necessitate the substitution of equivalent, but not identical, parts for those listed.

TABLE VII

LIST OF MANUFACTURERS FOR CALIBRATOR BC-725-A

Ref. No.	Manufacturer	Address
9	Cornell-Dubilier Electric Corp.	100 Hamilton Boulevard South Plainfield, N. J.
14	General Electric Co.	Schenectady, N. Y.
15	Hammarlund Manufacturing Co.	460 West 34th Street New York, N. Y.
16	Arrow-Hart & Hegeman Electric Co.	Hartford, Conn.
18	International Resistance Co.	401 North Broad Street Philadelphia, Pa.
22	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
25	The National Company, Inc.	Malden, Mass.
26	RCA Manufacturing Co., Inc.	Camden, N. J.
28	Weston Electrical Instrument Co.	Newark, N. J.
29	Western Electric Co.	New York, N. Y.
36	Westinghouse Electric and Manufacturing Co.	East Pittsburgh, Pa.
38	Shallcross Manufacturing Co.	Collingdale, Pa.
39	Dial Light Company of America, Inc.	90 West Street New York, N. Y.
40	Cinch Manufacturing Corp.	Chicago, Ill.
48	Tobe Deutschmann Corp.	Canton, Mass.
49	Littelfuse, Inc.	Chicago, Ill.
64	American Phenolic Corp.	Chicago, Ill.
70	Solar Manufacturing Corp.	Bayonne, N. J.
73	Telephonics Laboratories of America, Inc.	350 West 31st Street New York, N. Y.
74	Automatic Winding Co.	Harrison, N. J.

TABLE VIII

EQUIPMENT SPARE PARTS LIST FOR CALIBRATOR BC-725-A

Item	Quantity	Symbol Designation	Description	Mfr.	Mfr. Designation	Contractor's Drawing and Part Number
			Capacitors			
1	3	29-1, 29-2, 29-3, 29-4, 29-5, 29-6	Variable air; 100 mmf	15	APC-100	ES-680214-3
2	1	4-1, 4-2	Mica: 400 mmf ± (1% +1 mmf)	29	D-162383	
3	3	3-1, 3-2, 3-3, 3-4, 3-5, 3-6	Mica: 550 mmf ± (1% +1 mmf)	29	D-162383	
4	1	69-1, 69-2	Mica: 0.001 mf ± 5%, 500 V	70	MWW-1227-5	
5	1	2-1, 2-2	Mica: 1,550 mmf ± (1% +1 mmf)	29	D-162384	
6	1	70	Mica: 0.005 mf ± 5%, 375 V	70	MWW-1239-5	
7	1	28-1, 28-2	Mica: 0.01 mf ± 10%, 300 V DC working	9	1WLS	
8	3	66-1, 66-2, 66-3, 66-4 66-5, 66-6	Mica: 0.01 mf ± 5%, 600 V	70	XQW .6-11-5	
9	1	68	Mica: 0.016 mf ± 5%, 600 V	70	XQW .6-116-5	
10	2	67-1, 67-2, 67-3	Mica: 0.03 mf ± 5%, 600 V	70	XQW .6-13-5	
11	1	73	Mica: 0.094 mf ± 5%, 500 V	70	XSW .5-194	
12	4	71-1, 71-2, 71-3, 71-4, 71-5, 71-6, 71-7, 71-8	Paper: 0.1 mf -10% +20%, 600 V; oil impregnated	70	XTIMW6	
13	1	72	Paper: 0.95 mf ± 5%, 600 V; oil impregnated	70	XLJMW6-.95-5	
14	1	25-1, 25-2	Paper: 1.0 mf + 14 -6%, 600 V DC working	48	TRS-601	
15	2	27-1, 27-2, 27-3	Paper: 4 mf +14 -6%, 1,500 V DC working	9	TJH-15040	
16		26	Paper: 15 mf +14 -6%, 1,000 V DC working	9	TJH-10150	

TABLE VIII

EQUIPMENT SPARE PARTS LIST FOR CALIBRATOR BC-725-A

Item	Quantity	Symbol Designation	Description	Mfr.	Mfr. Designation	Contractor's Drawing and Part Number
			Inductors			
17	1	1-1, 1-2	Retard Choke: 3.5 henries, 500 ma	29	KS-8572	
18	1	15	Retard: 0.1 henry at 1 ampere, 1,640 cps Average d-c resistance 5 ohms	29	D-159995	
19	1	16	Retard: 0.06 to 0.13 henries measured with 0.5 ma 4,000 cycle current Effective resistance 1,000 ohms at 4,000 cps Average d-c resistance 5 ohms	29	D-162306	
20	1	20-1, 20-2	20 microhenries ± 1% Min. Q = 50 at 100 kc	74	400-142	ES0-683487-6
21	1	21-1, 21-2	2 microhenries ± 1% Min. Q = 100 at 300 kc	74	400-141	ES0-683487-5
22	2	22-1, 22-2, 22-3, 22-4	0.5 microhenry ± 1% Min. Q = 100 at 400 kc	74	400-140	ES0-683487-4
			Resistors			
23	1	40	500 ohms ± 5%, wax impregnated	18	BT-1/2	
24	1	43-1, 43-2	750 ohms ± 10%, wax impregnated	18	BT-1/2	
25	4	34-1, 34-2, 34-3, 34-4 34-5, 34-6, 34-7,	1,000 ohms ± 10%, wax impregnated	18	BT-1/2	
26		44	6,000 ohms ± 10%, wax impregnated	18	BT-1/2	
27	1	39-1, 39-2	50,000 ohms ± 10%, wax impregnated	18	BT-1/2	
28	3	36-1,36-2,36-3,36-4,36-5	0.1 megohm ± 10%, wax impregnated	18	BT-1/2	
29	1	56	3,300 ohms ± 5%, wax impregnated	18	BT-1/2	
30	2	38-1, 38-2, 38-3	0.15 megohm ± 10%, wax impregnated	18	BT-1/2	
31	1	35	0.2 megohm ± 10%, wax impregnated	18	BT-1/2	
32	1	42	0.25 megohm ± 10%, wax impregnated	18	BT-1/2	
33	2	37-1, 37-2, 37-3	0.5 megohm ± 10%, wax impregnated	18	BT-1/2	
34	1	41	2 megohms ± 10%, wax impregnated	18	BT-1/2	

TABLE VIII

EQUIPMENT SPARE PARTS LIST FOR CALIBRATOR BC-725-A

Item	Quantity	Symbol Designation	Description	Mfr.	Mfr. Designation	Contractor's Drawing and Part Number
			Resistors (Cont'd.)			
35	2	31-1, 31-2, 31-3	10 ohms ± 5%, wax impregnated	18	BW-1/2	
36	1	32	200 ohms ± 5%, wax impregnated	18	BW-1/2	
37	2	47-1, 47-2	5,000 ohms ± 10%, wax impregnated	18	BT-1	
38	1	46-1, 46-2	20,000 ohms ± 10%, wax impregnated	18	BT-1	
39	1	45	51,000 ohms ± 10%, wax impregnated	18	BT-1	
40	1	33	1,500 ohms ± 2%, wax impregnated	18	BW-1	
41	1	51	500 ohms ± 10%, wax impregnated	18	BT-2	
42	1	48-1, 48-2	10,000 ohms ± 10%, wax impregnated	18	BT-2	
43	1	50	12,000 ohms ± 10%, wax impregnated	18	BT-2	
44	1	49	20,000 ohms ± 10%, wax impregnated	18	BT-2	
45	1	53	5,000 ohms 6 watts, No. 3 terminals	18	EL	
46	1	54-1, 54-2	10,000 ohms, 6 watts, No. 3 terminals	18	EL	
47	1	55-1, 55-2	5,000 ohms, 10 watts, No. 3 terminals	18	EM	
48	1	52	0.3 megohm ± 1%, wax impregnated, 1 watt	18	WW-13	
49	2	11-1, 11-2, 11-3, 11-4	2,000 ohms ± 1%	29	106A	
50	1	13	5,000 ohms ± 1%	29	106A	
51	1	14	9,000 ohms ± 1%	29	106A	
52	1	12	50,000 ohms ± 1%	29	107A	
53	1	57	Potentiometer: 25,000 ohms, No. 11-120 taper "A", round shaft, standard type CS without switch, shaft "A" dimension 7/8" with 2 hex. nuts	18	11-120	
54	1	65	Potentiometer: 40,000 ohms	22	B-115072	ESO-679305-1

TABLE VIII

EQUIPMENT SPARE PARTS LIST FOR CALIBRATOR BC-725-A

Item	Quantity	Symbol Designation	Description	Mfr.	Mfr. Designation	Contractor's Drawing and Part Number
55	1	75-1, 75-2	Potentiometer: 50,000 ohms, taper 4	22	M50MP	
			Miscellaneous			
56	1	61	Connector	64	AN-3102-18-1S	
57	1	62-1, 62-2	Connector	64	AN-3102-14S-1S	
58	1	63	Connector	64	AN-3102-20-5P	
59	1	64	Connector	64	AN-3102-22-711S	
60	1	-	Cord assembly	29	ESO-686155-1	ESO-686155-1
61	1	-	Cord assembly	29	ESO-686155-2	ESO-686155-2
62	1	-	Cord assembly	29	ESO-686167-2	ESO-686167-2
63	1	5	Crystal: 1.6393 kc ± 0.3 cycle	29	D-161647	
64	1	6	Filter: special band pass	29	D-160382	
65	1	58-1, 58-2	Littelfuse: 3-ampere	49	1043	
66	1	23	Jack	73	SC-D-1585, JK-44	
67	1	24	Lamp: 110 V, double contact bayonet base	36	S-6	
68	1	74	Meter: milliammeter, 0-1 ma DC, flush 3-1/2" bakelite case, non-glare glass, for use with external shunts and multipliers for scale range 0-150 ma and 0-300 V; per Navy Spec. 17-I-12	28	Type 301	
69	1	8-1, 8-2	Network	29	D-162317	
70	1	-	Plug Assembly	29	ESO-686155-3	ESO-686155-3
71	1	-	Plug Assembly	29	ESO-686155-4	ESO-686155-4
72	8	-	Sockets: special octal	40	ESL-678315-3	ESL-678315-3
73	2	-	Sockets: 4-contact	25	XC-4	
74	1	59	Switch: special meter	38	Spl 537	ESO-686165-1
75	1	60-1, 60-2	Switch: safety interlock	14	6900	
76	1	30	Switch: special DPST	16	-	ESO-676800-7

TABLE VIII

EQUIPMENT SPARE PARTS LIST FOR CALIBRATOR BC-725-A

Item	Quantity	Symbol Designation	Description	Mfr.	Mfr. Designation	Contractor's Drawing and Part Number
77	1	7	Transformer: 77 va, 75 watts, 60 cps Primary: 115 V at 0.67 ampere Secondary: 6.75 V at 10 amperes	29	KS-8604	
78	1	9	Transformer: Output	29	D-162320	
79	1	10	Transformer: 222 va, 190 watts, 60 cps Primary: 115 V at 1.92 amperes Secondary No. 1: 1,080 V at 0.177 ampere, C.T. Secondary No. 2: 5.13 V at 4 amperes Secondary No. 3: 6.64 V at 1 ampere, insulated for 300 V DC Secondary No. 4: 2.63 V at 7.5 amperes, C.T. insulated for 600 V DC	29	KS-8606	
80	1	17-1, 17-2	Transformer: Input Primary resonates at 1,640 cycles with approximately 0.11 mf, 1:1 ratio Resonant impedance 5,000 ohms Coil Q at 1,640 cycles = 30	29	SR-1007	
81	1	18	Varistor	29	D-162356	
82	1	19	Varistor	29	D-161870	
83	1	-	Metal Box		ESO-682877-1	ESO-682877-1

Note 1. For list of manufacturers of components, see BL-10547.

Note 2. For List of Spare Vacuum Tubes, see ESL-689303.

Note 3. The Depot Spare Parts consist of one set of the Equipment Spares listed hereon, and one set of Vacuum Tube Spares listed on ESL-689303.

TABLE IX

VACUUM TUBE SPARES LIST FOR CALIBRATOR BC-725-A

Item	Mfr's. Designation	Mfr.	Description	Symbol	Spare Tubes
101	2A3	26	Power Amplifier Triode	83-1, 83-2, 83-3	6
102	6AC7	26	Television Amplifier Pentode	79-1, 79-2, 79-3, 79-4	8
103	6K6-GT	26	Power Amplifier Pentode	76	2
104	6SF5	26	High-mu Triode	78-1, 78-2	4
105	6SJ7	26	Triple-grid Detector Amplifier	80-1, 80-2, 80-3, 80-4	8
106	6SK7	26	Triple-grid Super Control Amplifier	77-1, 77-2	4
107	274B	29	Full-Wave Rectifier	84-1, 84-2	4
108	VR105-30	26	Voltage Regulator	82	2
109	VR150-30	26	Voltage Regulator	81	2

Note 1. For List of Manufacturers, see BL-10547.

Note 2. For Equipment Spares for Calibrator BC-725-A, see ESL-689302.

Note 3. The spare tubes listed above are in addition to the tubes supplied in the sockets of each calibrator.

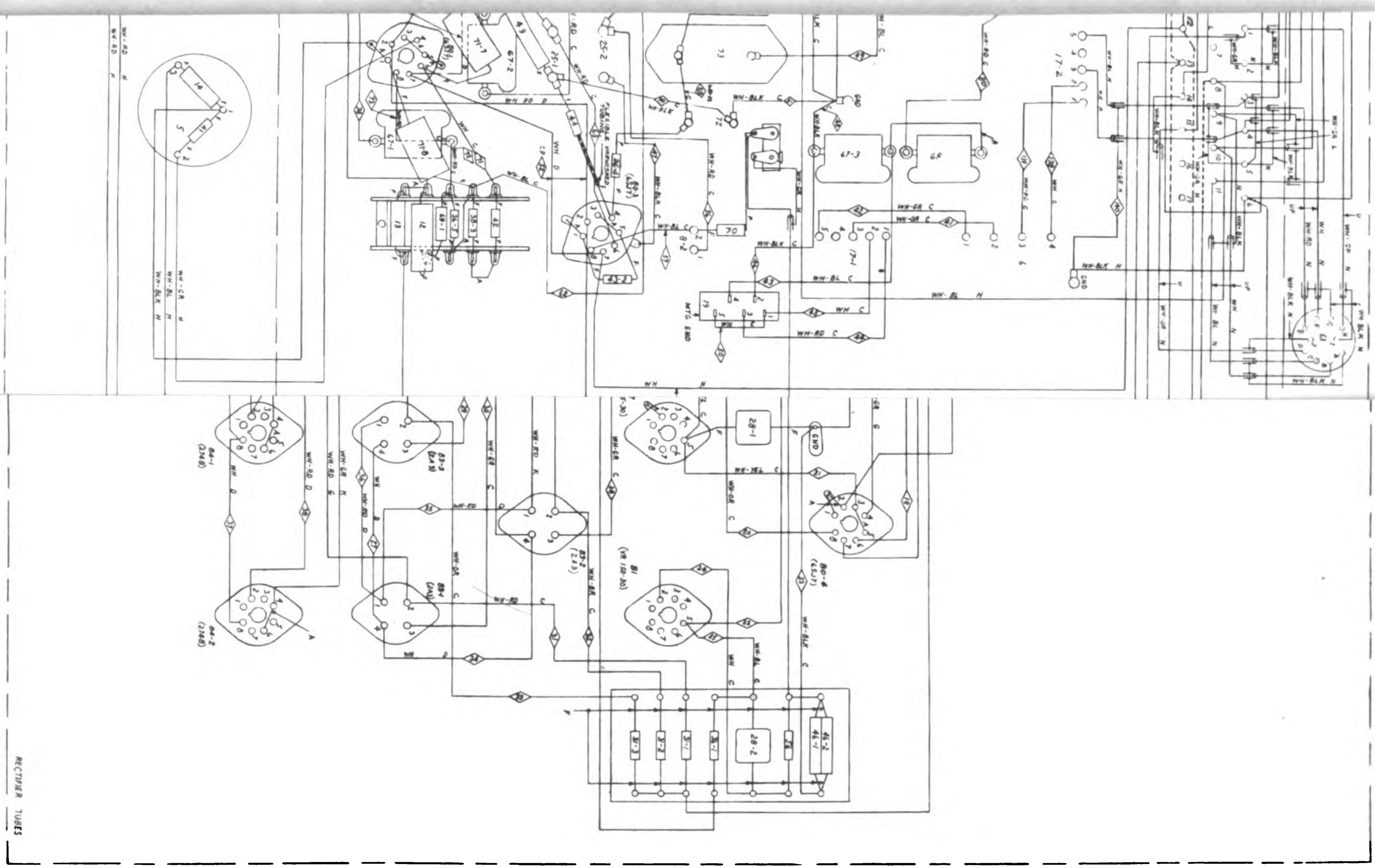

Fig. 22. Calibrator BC-725-A, Wiring Diagram

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