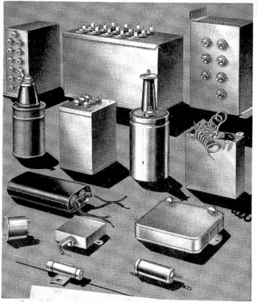

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SERVICE TUBE TESTS

PART 2. COMPLETE TEST SETS

By the Engineering Department, Aerovox Corporation

In Part 1 of this series, we described the simple circuits used for rapid checking of emission, transconductance, and power output of vacuum tubes. Any one of these circuits might be set up, with no alterations, for testing one particular type of tube. But because many different bases and base-pin arrangements are employed in the large number of tubes presently available, rewiring of the simple test circuit would become necessary in order to check other types of tubes.

In professional service tube testers, a socket is provided for each type of tube base, and a circuit switching arrangement permits test connections to be made quickly to proper socket terminals. This flexible feature in effect re-wires the test circuit for each type of tube to be tested.

It is customary for the scale of the indicating meter in these test sets to be graduated in English units — that is, to read BAD—?—GOOD or REPLACE—?—GOOD, with the question mark at or near center-scale.

Complete service tube testers of recent manufacture fall into two categories — emission testers and dynamic transconductance testers. The schematics of these instruments, in the order just named, are shown in Figures 7 and 8. These drawings reproduced here are not the exact schematics employed by particular manufacturers of tube testers, but are functionally correct and indicative of those arrangements in actual commercial instruments.

The first type, shown in Figure 7, checks emission of *all* tubes and has a separate short-circuit test. The emission test portion of the circuit is an elaboration of the arrangement shown in Figure 1 (Part 1). The short-circuit test portion is identical with the circuit in Figure 6. The second type of tester checks dynamic transconductance of all grid-type tubes except class-B amplifiers; power output of class-B tubes; plate current of rectifiers, diodes, and the diode sections of multipurpose tubes; and short circuits in all types. The transconductance portion of the circuit is an adaptation of the circuit in Figure 3-B (Part 1), the class-B power output portion an adaptation of Figure 4, the diode and rectifier portion is identical with Figure 5, and the short-circuit portion identical with Figure 6.

It will be noted that in each of these circuits, Figures 7 and 8, the various tube socket terminals are connected to corresponding lines numbered according to standard tube base-pin numbering. These lines, labelled 1 to 8 in the drawings, correspond to socket terminals having the same numbers. Line 9 is connected to a grid cap connector for use with tubes having the top-cap terminal. Switches connect each of these lines to appropriate points of the test circuit.

EMISSION TESTER

In Figure 7, the circuit schematic of a type complete emission tester, the tube socket lines terminate in 2-position single-pole toggle switches, S_1 to S_9. When these switches are thrown to the left, all tube electrodes are connected to the short circuit tester, which has the same arrangement as that shown in Figure 6, Part 1. When these switches are thrown to the right, they connect the various tube electrodes (except cathode) together and to the milliammeter, M, and the a. c. test voltage. The set-up then is identical with the emission test circuit shown in Figure 1. Since most tubes do not employ all nine connections, only those switches which actually communicate with base connections are thrown to either position.

R_1 is the adjustable shunt resistor which enables the meter range to be set so that the end-of-life point for each type of tube is coincident with center-scale deflection. No meter reading is obtained until pushbutton switch S_{11} is depressed. This prevents damage to the meter when initial instrument settings are being made.

In order that tests may be made at all times at the same line voltage level, a line-voltage adjustment rheostat, R_3, is included in the circuit. When pushbutton switch S_{12} is depressed, the milliammeter is connected to the output of the oxide rectifier, REC; and the rectifier is connected, in turn, across the 50-volt secondary of transformer T_1 through a multiplier resistor, R_2, of such size that center-scale deflection of the meter is obtained when R_3 is at a designated setting.

The single pole rotary switch, S_{14}, selects the proper filament voltage for the tube under test from the secondary taps of transformer T_2, and this voltage is applied to the proper socket terminals by the 2-pole filament terminal selector switch, S_{15}. This filament selector arrangement has been described previously in some detail in connection with the short circuit tester shown in Figure 6, Part 1.

A second 2-pole selector switch, S_{16}, selects the proper cathode terminal. In position I, this switch selects as the effective cathode the filament of directly-heated tube types. R_4 is a 100-ohm center-tapped resistor which is shunted across the filament. The center tap becomes the test-circuit return.

The following example is offered to illustrate how settings are made with the emission tester. Assume the tube under test to be a type 75. The tube is placed in the 6-pin socket and the grid cap clipped to the tube's top-cap connector. S_{14} then is set for 6.3 volts, and S_{15} to position D (socket terminals 1 and 6). S_{12} then is depressed, and R_3 set for center-scale deflection of the meter. For the emission test; R_1 is set to the scheduled value which will permit center-scale meter deflection for a type 75 tube at its end-of-life point; cathode selector S_{16} is set to position E (socket terminal 5); S_2, S_3, S_4, and S_9 are thrown to the right, and pushbutton S_{11} is depressed for a tube-quality reading on the meter.

For the short-circuit test; all settings remain the same except that S_2, S_3, S_4, and S_9 are thrown to the left, and S_{10} is rotated while the neon lamp is watched for the continuous glow that indicates a short circuit.

TRANSCONDUCTANCE TESTER

The second type of tester (See Figure 8) has many circuit features which are identical with those in the emission tester (Figure 7). For example; the sockets are connected to lines numbered in the same way; and the filament voltage selector (S_{30}), filament terminal selector (S_{28}), and cathode selector (S_{31}) are the same as those shown in Figure 7.

Important circuit differences are (1) The internal power supply comprised by transformer T_1, a. c. voltage selector S_{13}, rectifier tube V, filter choke L_2, filter capacitors C_4 and C_5, and d. c. voltage selectors R_4, R_6, and R_7; (2) a ganged 9-pole, 2-position switch S_{19} to S_{27}), rather than the separate toggle switches shown in the emission tester, which shifts the circuit from tube-test to short-test; and (3) the selector switches S_{15}, S_{16}, S_{17}, and S_{18}, which apply d. c. operating voltages to the tube electrodes.

The short circuit tester is the same as that shown in Figure 7 and explained in detail in Part I. It is connected to the open lines (labelled in the diagram "to short-circuit tester") from switch S_{19} to $_{27}$, and has been omitted from the drawing in order to reduce the complication.

Line Voltage Test. S_2, S_5, and S_8 are sections of a triple-pole, two-position pushbutton switch which when depressed connects the oxide rectifier, REC, through the multiplier resistor, R_8, across the primary of transformer T_1, and removes the shunt rheostat, R_2, from across the meter terminals. The 7-pole, 2-position switch ($S_{3, 4, 5, 6, 7, 11, 12}$) is a changeover component and is in the "up" position for this test, as shown in Figure 8. Pushbutton switch S_9 must be depressed. The resistance of R_8 is so chosen that center-scale deflection of the meter will be obtained when R_9 is set for correct primary voltage. This point is generally marked by a single line on the meter scale, and designated LINE OK.

Transconductance Test. After all switching operations are completed, the final circuit set-up for the transconductance test is identical with Figure 3-B in Part 1. The tube to be tested is inserted into the proper socket. Toggle switch S_{19} to $_{27}$ then is thrown to the right, proper filament voltage is selected by S_{30} and applied to the proper filament terminals by S_{28}, switch S_{31} is set to select the proper cathode terminal of the socket, changeover switch $S_{3, 4, 5, 6, 7, 11, 12}$ is in the up position, potentiometers R_4, R_6, and R_7 are set respectively for correct values of tube cathode, plate, and screen d. c. voltages, selector switches S_{15}, S_{16}, and S_{17} are set to distribute these voltages to the proper socket terminals, switch S_1 is closed, R_2 is adjusted for a setting permitting center-scale deflection of the meter for border-line transconductance of the tube type under test, switch S_1 is closed and S_{29} set for a 1-volt R. M. S. grid signal, and pushbutton S_9 is depressed for a tube-quality reading on the meter scale.

Class-B Test. All settings are made exactly as described for the transconductance test, except that switch S_1 is opened, a higher value of signal voltage must be selected by S_{29} and R_{10}, and shunt rheostat R_2 must be set to its OFF position (open circuit). The final circuit arrangement is similar to that shown in Figure 4 (Part 1), except that choke L_1 is used in lieu of a plate load resistor. Resistor R_1, which must be set to a different value for each tube type, corresponds to R_M in Figure 4. This resistor makes center-scale deflection of the meter, M, correspond to the critical power output value for the class-B tube under test. S_9 is depressed for a tube-quality deflection of the meter.

Rectifier and Diode Test. For this test; changeover switch $S_{3, 4, 5, 6, 7, 11, 12}$ is thrown to the down position. R_3 is set to the proper rectifier load resistance value for the tube under test. S_{10} is set for recommended value of load capacitance for the tube. Filament voltage and cathode are selected in the same manner as described in earlier portions of this article, by means of S_{28} and S_{30}, and by S_{31}.

A. c. plate voltage to be applied to the rectifier or diode plate is selected by switch S_{13} and is applied to the proper socket terminal by S_{15}. Shunt rheostat R_2 is set to a resistance value which will permit full-scale deflection of the meter to correspond to end-of-life plate current for rectifier tubes. Pushbutton switch S_9 is depressed for a tube-quality deflection of the meter. After checking one rectifier or diode section of a dual tube, S_{15} is set to connect the second plate, and the remaining section tested. The final rectifier test circuit is identical with the one shown in Figure 5, Part 1.

Short-Circuit Test. After the tube to be tested has been inserted into the proper socket of the tube tester and has reached normal filament temperature (filament voltage being selected by S_{28} and S_{30}), changeover switch S_{19} to $_{27}$ is thrown to the left and the short-circuit test made in the same manner already explained in the description of the emission tester, Figure 7.

GAS TEST

Since gassy vacuum tubes occasionally cause radio receiver trouble, it is desirable to check for the presence of gas. Not all service tube testers make provision for this test. A simple method consists of observing the plate current of the tube under test while a 1-megohm resistor connected between control grid and cathode is successively short circuited. If the tube is gassy, a grid current will flow through the resistor, changing the grid bias and causing a change in the plate current reading. Normal d. c. operating voltages must be applied to each tube electrode during the gas test.

NOISE TEST

Noises other than microphonics develop in tubes from a number of causes. Damaged electrodes, leads, or supports, and similar causes give rise to hissing, cracking, frying, or buzzing noises in high vacuum tubes. Noise is checked best by placing a pair of headphones in some appropriate leg of the tube circuit. Generally this will be the plate lead. However, tubes drawing large values of plate current which might damage the headphones, may be tested by connecting the headphones across a plate load resistor in series with a 0.1 or 0.25-mfd. capacitor. While listening for noise, it is advisable to strike the outside of the tube sharply with the finger tip or with a rubber mallet. Some commercial service tube testers provide a headphone jack for this test.

HUM TEST

The hum test is made in the same manner as the noise test, except that the operator listens for hum only. Hum, such as the type produced by defective cathodes and some forms of interelectrode short circuit, generally is of 60 cycles frequency. In commercial service tube testers, the headphone jack serves for noise, hum, and microphonic tests.

TEST FOR MICROPHONICS

With headphones inserted in the test circuit, as explained under NOISE TEST and HUM TEST, the outside of the tube is struck sharply with the finger tip or with a small rubber mallet while the operator listens for the bell-like sounds that typify microphonics. This test will locate a microphonic tube unfailingly. However, the operator must keep in mind that certain tubes, particularly some of the older style battery types, are normally microphonic and should not be rejected for showing this characteristic.

REFERENCES

Electronics' Engineering Manual. Volume 1. (McGraw-Hill Publishing Co.; New York, N. Y.). pp. 24, 160.

Electronics' Engineering Manual. Volume 2. (McGraw-Hill Publishing Co.; New York, N. Y.). pp. 236-239.

Henney, Keith. *Radio Engineering Handbook.* 3rd Edition. (McGraw-Hill Book Co., Inc.; New York, N. Y.). pp. 244-264.

Hickman, R. W. and Hunt, F. V. Exact measurement of electron tube coefficients. *Review of Scientific Instruments.* September 1935. p. 268.

Maggion, J. B. Measurement of dynamic characteristics of vacuum tubes. *Electronics.* July 1941. p. 73.

Moyer, J. A. and Wostrel, J. F. *Radio Construction and Repairing.* 3rd Edition. (McGraw-Hill Book Co., Inc.; New York, N. Y.). pp. 41-58.

Moyer, J. A. and Wostrel, J. F. *Radio Handbook.* 1st Edition. (Mc-Graw-Hill Book Co., Inc.; New York, N. Y.). pp. 273-322.

Moyer, J. A. and Wostrel, J. F. *Radio Receiving Tubes.* 2nd Edition. (Mc-Graw-Hill Book Co., Inc.; New York, N. Y.). pp. 86-125.

Polk, H. S. Measuring vacuum tube coefficients. *Electronics.* July 1939. p. 38.

Radio Amateur's Handbook. 22nd Edition. (The American Radio Relay League, Inc.; West Hartford, Conn.). p. 438.

RCA Receiving Tube Manual, Technical Series Rc-14. (RCA Manufacturing Co., Inc.; Camden, N. J.). pp. 195-197.

Sarbacher, R. I. Graphical determination of power amplifier performance. *Electronics.* December 1942. p. 52.

Smith, F. L. *Radiotron Designer's Handbook.* 3rd Edition. (Distributed in the United States by RCA Manufacturing Co., Inc.; Camden, N. J.). pp. 240-249.

Stewart, W. D. Thyratron tube tester. *Radio News.* March 1943. p. 20.

Street, C. C. Technique for tube data; taking tube characteristics as trace on screen of cathode ray oscilloscope. *Electroniics.* October 1941. p. 50.

Terman, F. E. *Measurements in Radio Engineering.* 1st Edition. (McGraw-Hill Book Co., Inc.; New York, N. Y.). pp. 157-178.

Terman, F. E. *Radio Engineer's Handbook.* 1st Edition. (McGraw-Hill Book Co., Inc.; New York, N. Y.). pp. 959-964.

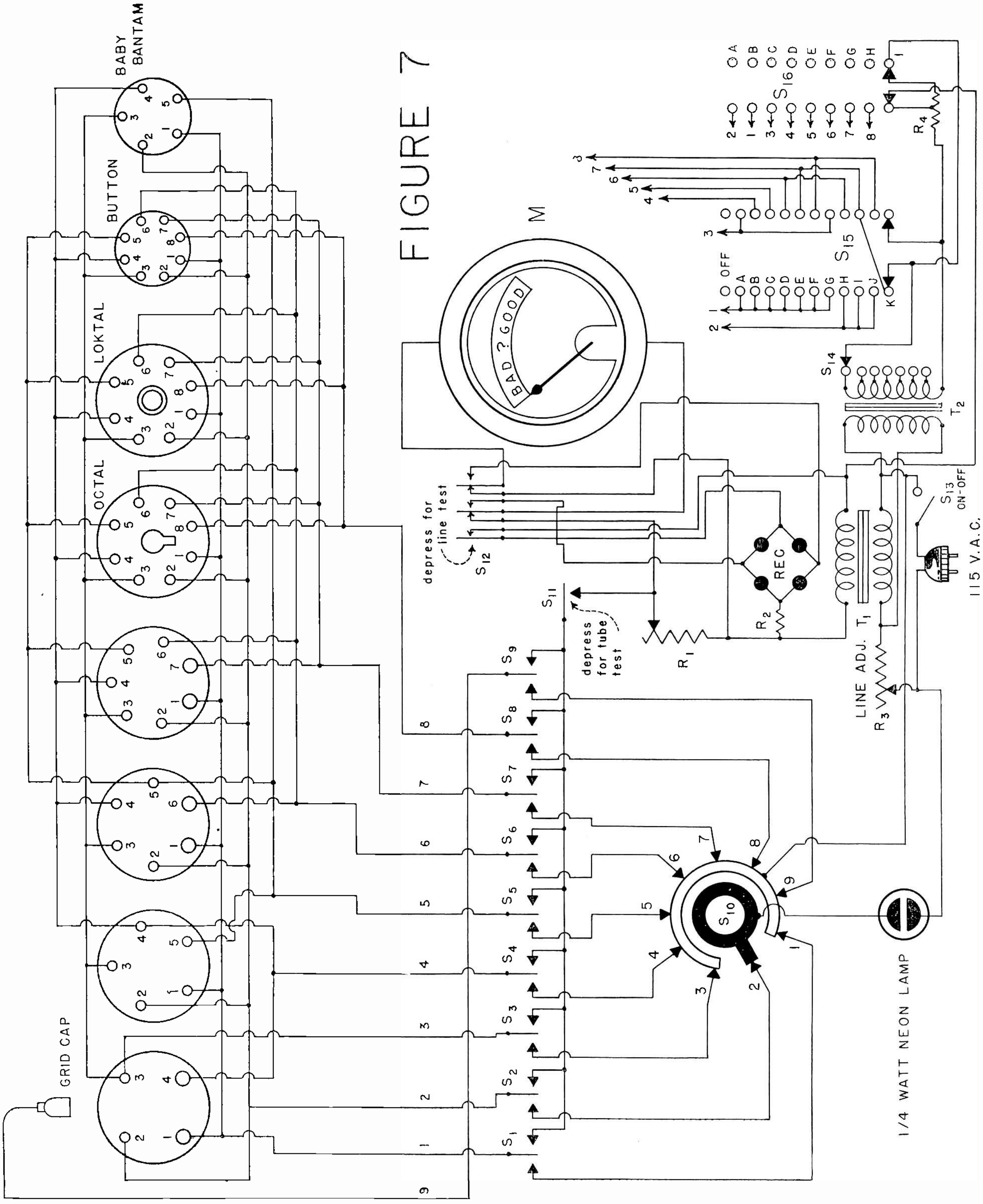
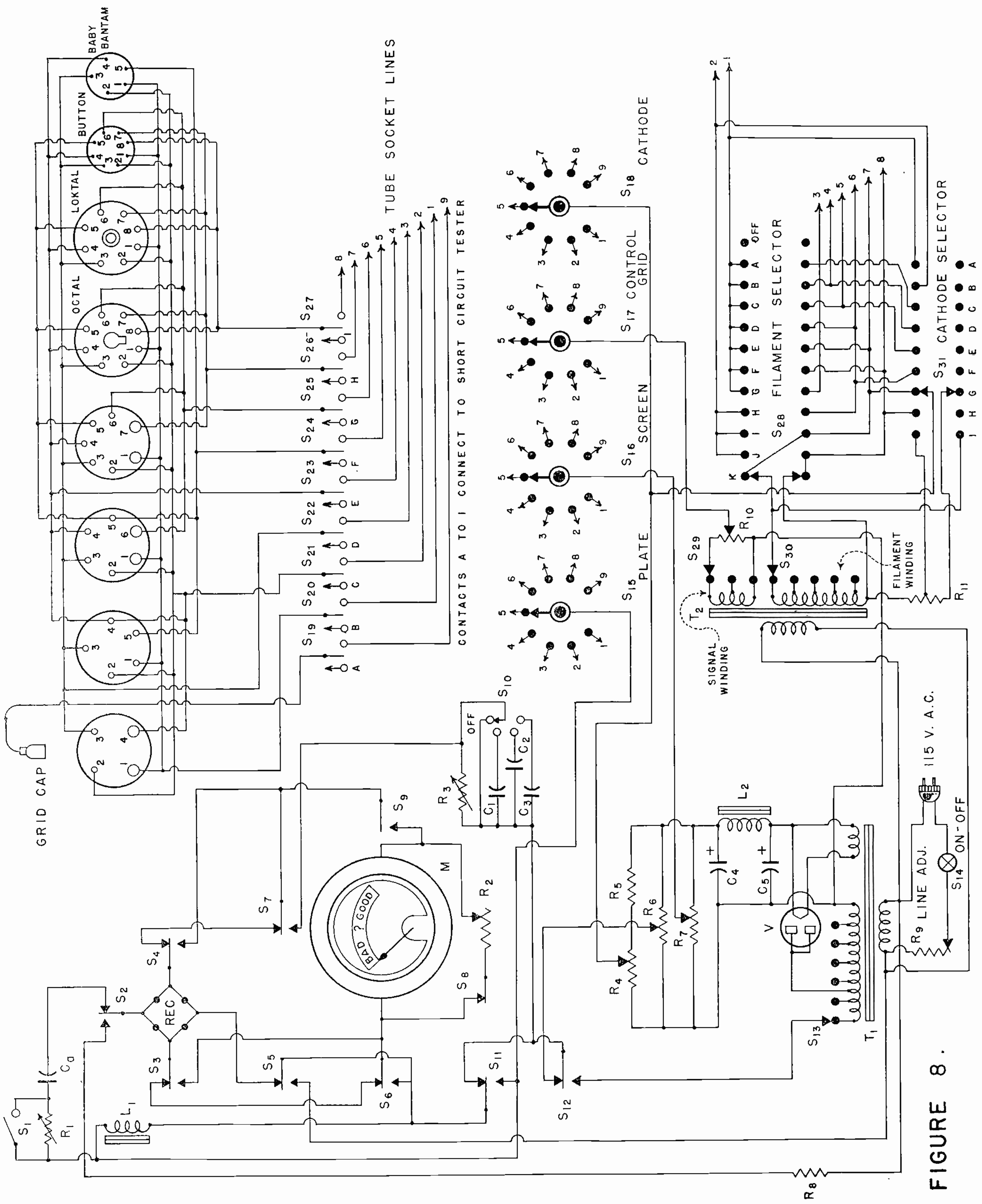

BABY BANTAM
BUTTON
LOKTAL
OCTAL
GRID CAP
M
BAD ? GOOD
S16
A B C D E F G H
S15
OFF A B C D E F G H I J K
depress for line test
S12
S11
depress for tube test
R1
R2
REC
R3
R4
T1
T2
S13 ON-OFF
S14
115 V.A.C.
LINE ADJ.
S1 S2 S3 S4 S5 S6 S7 S8 S9
S10
1/4 WATT NEON LAMP

FIGURE 7



GRID CAP
BABY BANTAM
BUTTON
LOKTAL
OCTAL
TUBE SOCKET LINES
CONTACTS A TO I CONNECT TO SHORT CIRCUIT TESTER
S19 S20 S21 S22 S23 S24 S25 S26 S27
A B C D E F G H I
1 2 3 4 5 6 7 8 9
S15 PLATE
S16 SCREEN
S17 CONTROL GRID
S18 CATHODE
S28 FILAMENT SELECTOR
S31 CATHODE SELECTOR
A B C D E F G H I J K OFF
S29
S30
R10
R11
FILAMENT WINDING
SIGNAL WINDING
T2
S10
OFF
C1 C2 C3
R3
S9
M
BAD ? GOOD
R2
S7
S8
S4
S2
REC
S3
S5
S6
S11
S12
S1
R1
Ca
L1
L2
C4 C5
R4 R5 R6 R7
V
S13
T1
R8
R9 LINE ADJ.
S14 ON-OFF
115 V. A. C.

FIGURE 8.