



# *Instructions*

## FREQUENCY-MODULATION BROADCAST STATION MONITOR

G-E TYPE BM-1-A



ELECTRONICS DEPARTMENT

GENERAL  ELECTRIC

SYRACUSE, NEW YORK

INSTRUCTIONS

**FREQUENCY-MODULATION  
BROADCAST STATION MONITOR**

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ELECTRONICS DEPARTMENT

**GENERAL  ELECTRIC**

SYRACUSE, NEW YORK

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IN  
U.S.A.

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## PRECAUTIONS

Check the equipment carefully upon receipt. Report any damage or shortage immediately to the transportation agency.

When unpacking and installing the instrument, avoid excessive vibration and jarring. Take care not to disturb any of the screwdriver controls located on the shield cans, chassis, and component boards inside the chassis.

Great care has been taken in the manufacture and testing of the Station Monitor, and each control has been carefully adjusted in the laboratory by trained personnel using highly specialized measuring equipment. This measuring equipment was built specifically for the testing of the Monitor; it is not and cannot be made available in the field, except at excessive cost to either the customer or the General Electric Company. *Any change in the adjustment of any controls except those mentioned in these instructions will destroy the accuracy and usefulness of the Monitor as a precision measuring instrument, and will void the General Electric Company guarantee.* If for any reason it is thought that these controls require readjustment, the Indicator unit should be returned to the General Electric Company for servicing after first obtaining written authorization from the Company to do so.

The user is especially cautioned that his Monitor will not function correctly unless the r-f signal level to the Monitor is within the limits specified under OPERATION, pages 9 and 10, and the procedure outlined for the adjustments is followed. Excessive r-f input to the Monitor will damage or destroy r-f input terminating resistors R11 and R24.

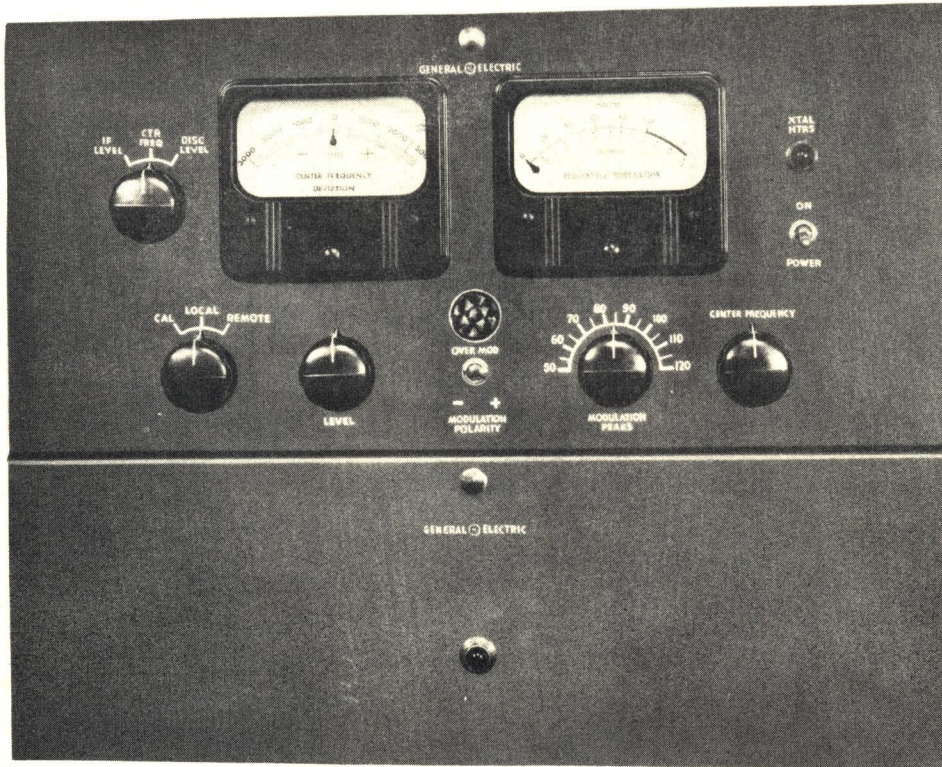
*Do not turn on the transmitter at full power until the Monitor pick-up loop has been adjusted in accordance with instructions on page 9.*

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**Fig. 1. FM Broadcast Station Monitor, G-E Type BM-1-A. Front view of Indicator and Regulated Power Supply Units, panels closed. (SY3207)**

# FM BROADCAST STATION MONITOR

## G-E TYPE BM-1-A

### INTRODUCTION

This instruction book describes the installation, operation, and maintenance of the Frequency-modulation Broadcast Station Monitor, General Electric Type BM-1-A. The Monitor is designed to measure and indicate continuously the center frequency, the percentage modulation, and the overmodulation peaks of frequency-modulation broad-

cast transmitters. Facilities are provided for a quality audio output and for making over-all transmitter proof-of-performance tests. The Monitor is also designed so that it can be used in conjunction with the Transmitter Console, General Electric Type BC-3-A, to provide remote indication of the transmitter center frequency and percentage modulation.

### GENERAL SPECIFICATIONS

**Power Supply:** 105 to 125 volts, single phase, 50/60 cycles with commercial stability; power consumption approximately 170 watts.

**Carrier Frequency:** 88 to 108 megacycles.

**R-F Input Level:** Approximately 1.0 watt into 50 ohms.

**Center Frequency Deviation Indicator:**  $\pm 3000$  cycles range, modulated or unmodulated, scale illuminated.

**Center Frequency Accuracy:**  $\pm 1000$  cycles;  $\pm 500$  cycles after adjustment to external standard.

**Percentage Modulation Indicator:** Scale marking 0 to 133 per cent, also  $-20$  db to  $+3$  db, positive or negative polarity, scale illuminated.

**Overmodulation Indicator:** Remote alarm or panel flasher lamp; adjustable over range from 50 to 120 per cent peak modulation.

#### Audio Output:

##### FIDELITY MONITOR

600 ohms balanced; low-frequency level approximately 2 volts rms at 100 per cent modulation; frequency characteristics within  $\pm 0.5$  db of standard de-emphasis curve from 50 to 10,000 cps;  $\pm 0.0$  to  $-1.0$  db, 10,000 to 15,000 cps; total harmonic distortion less than 0.5 per cent; noise level at least 70 db below 100 per cent modulation.

##### MEASUREMENT MONITOR

Impedance 50,000 ohms; low-frequency level approximately 20 volts rms at 100 per cent modulation; total harmonic distortion less than 0.25 per cent; frequency characteristics  $\pm 0.5$  db of standard de-emphasis curve from 50 to 15,000 cycles, and  $\pm 1$  db from 15,000 to 30,000 cycles; noise level approximately 75 db below 100 per cent modulation.

**Remote Indicators:** Provision for remote center-frequency and percentage-modulation instruments and overmodulation indicator.

**Ambient Temperature Range:** 10 to 40 degrees centigrade.

#### Physical Specifications:

##### INDICATOR UNIT

Panel Width	19 inches
Panel Height	8 $\frac{3}{4}$ inches
Depth behind Panel	9 inches
Weight	18 pounds

##### POWER SUPPLY UNIT

Panel Width	19 inches
Panel Height	7 inches
Depth behind Panel	9 inches
Weight	26 pounds

### SERVICE PARTS AND ACCESSORIES

#### Tube Complement:

QUANTITY	TYPE	MFR.
2	6SL7	G.E.
2	6SN7	G.E.
2	6J6	G.E.
1	6AG7	G.E.
1	6H6	G.E.
1	GL-502-A	G.E.
1	5V4G	G.E.
2	6B4G	G.E.
1	6SH7	G.E.

QUANTITY	TYPE	MFR.
1	OD3/VR-150	G.E.

**Fuses:** 3 amperes, G-E Cat. No. 132767G25 (Power Supply).

#### Lamp Bulbs:

Crystal Heater Pilot Lamp, 6-8 volts, G-E Type 44 (blue bead).  
Instrument Illumination, 6-8 volts, G-E Type 44 (blue bead).  
Flasher Lamp, 120 volts, G-E Type 6-S-6.

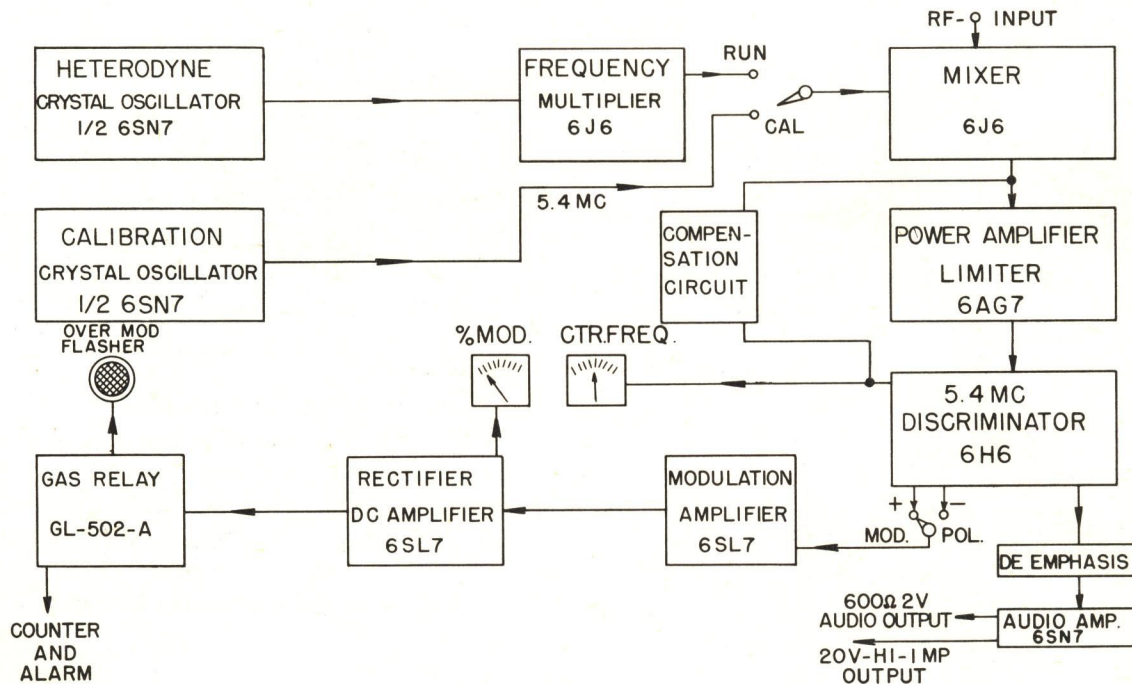


Fig. 2. FM Broadcast Station Monitor, Block Diagram

## DESCRIPTION

The Station Monitor, G-E Type BM-1-A, is essentially a stable precision FM receiver with additional measuring and indicating circuits. As shown in the block diagram (Fig. 2) and schematic diagram (Fig. 8), it consists of a heterodyne crystal oscillator, heterodyne multiplier channel, calibration crystal oscillator, mixer, power amplifier and limiter, discriminator modulation circuit, audio output amplifier, and an electronically regulated power supply.

The Monitor consists of an Indicator unit and a Power Supply unit, each having a hinged front panel. These units are supplied without a cabinet for standard 19-inch rack mounting, as illustrated in Fig. 1. The essential controls are located on the front panels.

The chassis are mounted vertically and the front panels are hinged so that they swing downward 90 degrees, exposing the wiring inside the chassis (see Figs. 3, 4a and 4b). The tubes, crystals, tuned transformers, and potentiometers are mounted on the rear of the chassis (see Fig. 5).

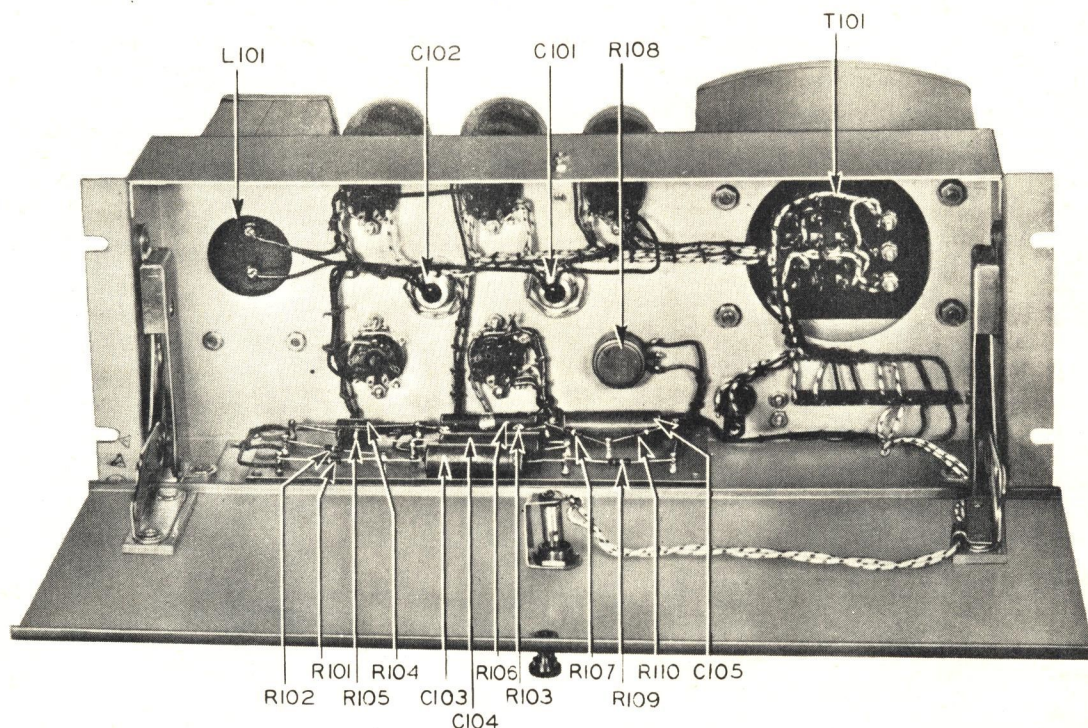
On the Indicator front panel are located the CENTER FREQUENCY DEVIATION and PERCENTAGE MODULATION instruments and all the controls necessary for the normal operation of the Monitor. These controls are: the IF LEVEL-CTR FREQ-DISC LEVEL and CAL-LOCAL-REMOTE

selector switches, the MODULATION POLARITY switch, the POWER switch, the CENTER FREQUENCY control, the LEVEL control, and the MODULATION PEAK control. On the rear of the front panel is located the r-f level switch. The location and function of each are described in the following paragraphs.

The CENTER FREQUENCY DEVIATION instrument, located in the upper part of the Indicator panel to the left of center, has a 50-0-50 microampere movement which is energized by the difference of the d-c output currents of the discriminator diodes. This instrument indicates the mean or center frequency of the transmitter carrier, with or without modulation.

The selector switch S2, on the upper left side of the panel, has three positions, marked IF LEVEL, CTR FREQ, and DISC LEVEL. In the IF LEVEL position, the CENTER FREQUENCY DEVIATION instrument is switched into the V4 (Type 6AG7) grid circuit to indicate the rectified grid bias, and hence the i-f level. The normal i-f level should always be within the range marked in red on the CENTER FREQUENCY DEVIATION instrument. When the selector switch is in the CTR FREQ position, the instrument indicates the center frequency of the FM Transmitter. In the





**Fig. 3. Regulated Power Supply Unit, G-E Type BP-2-A. Front view, panel open, parts identified. (SY 3205)**

DISC LEVEL position the instrument is connected to read the d-c output voltage of the discriminator diodes. A LEVEL control, R20, located below the CENTER FREQUENCY DEVIATION instrument, adjusts this level by varying the gain of the Type 6AG7 amplifier. A red line marked "Disc Level" on the CENTER FREQUENCY DEVIATION instrument indicates the proper discriminator level.

The selector switch S1, located in the lower left of the front panel, has three positions, marked CAL, LOCAL, and REMOTE. In the CAL position, the 5.4-megacycle calibration oscillator is turned on and the second heterodyne multiplier stage is turned off. The CENTER FREQUENCY control R26, located at the lower right of the front panel, unbalances the d-c output current of the discriminator diodes in such a manner as to compensate for any slight change in constants of the discriminator secondary. It is used for "zeroing" the CENTER FREQUENCY DEVIATION instrument with the signal from the 5.4-megacycle crystal calibration oscillator (CAL position of S2).

The LOCAL, or normal, operating position of S1 switches off the calibration oscillator and turns on the heterodyne multiplier channel.

The REMOTE position disconnects the CENTER FREQUENCY DEVIATION instrument and inserts the remote CENTER FREQUENCY DEVIATION instrument.

The r-f level switch, S5, on the rear of the front panel, has two positions. In the RF position, the CENTER FREQUENCY DEVIATION instrument is connected to the grid circuit of the V3 (Type 6J6) mixer to indicate rectified grid bias. This indication is used in adjusting the r-f input level. The normal r-f level reading is within the range marked "I.F. Level" on the instrument. In the NOR position of S5 the CENTER FREQUENCY DEVIATION instrument is connected to the CAL-LOCAL-REMOTE selector switch. (S5 should always be in this position except for measuring r-f level.)

The PERCENTAGE MODULATION instrument, located on the upper part of the Indicator panel to the right of center, has a 500-microampere movement and meets all the FCC specifications for per-cent modulation indicators. To permit indication of both positive and negative peaks of modulation a MODULATION POLARITY switch, S3, is provided below the instruments at the center of the panel. Unlike the CENTER FREQUENCY DEVIATION instrument, the PERCENTAGE MODULATION instrument reads continuously when a remote indicating instrument is used.

The MODULATION PEAKS control, R49, located below the PERCENTAGE MODULATION instrument, adjusts the bias on the gas tube which operates the overmodulation flasher and alarm circuits. It may be adjusted so that the flasher and alarm relay operate at any value of modulation

FM BROADCAST STATION MONITOR

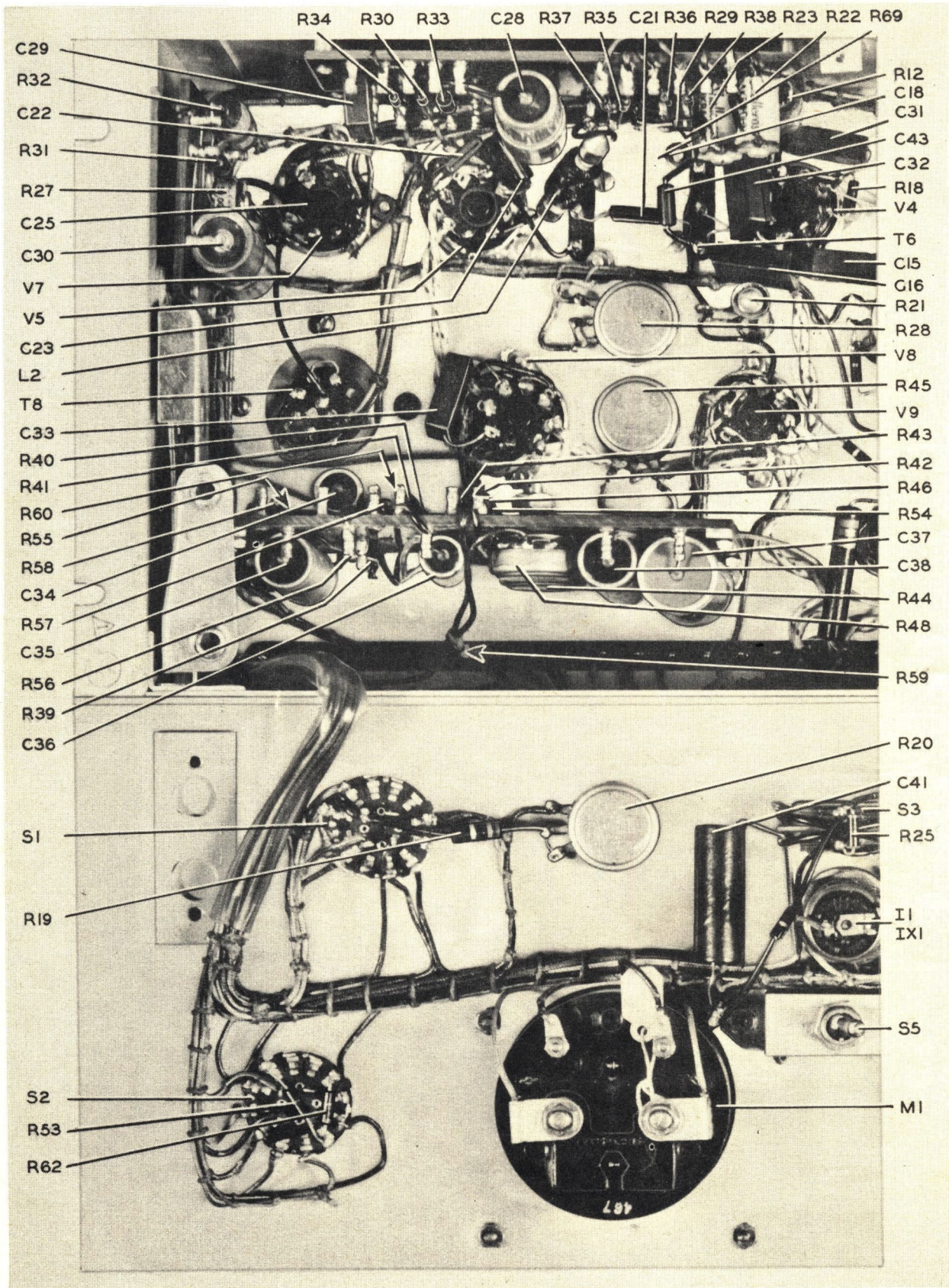


Fig. 4a. Indicator Unit, G-E Type BZ-1-A. Front view of left side, panel open, parts identified. (SY3206A)

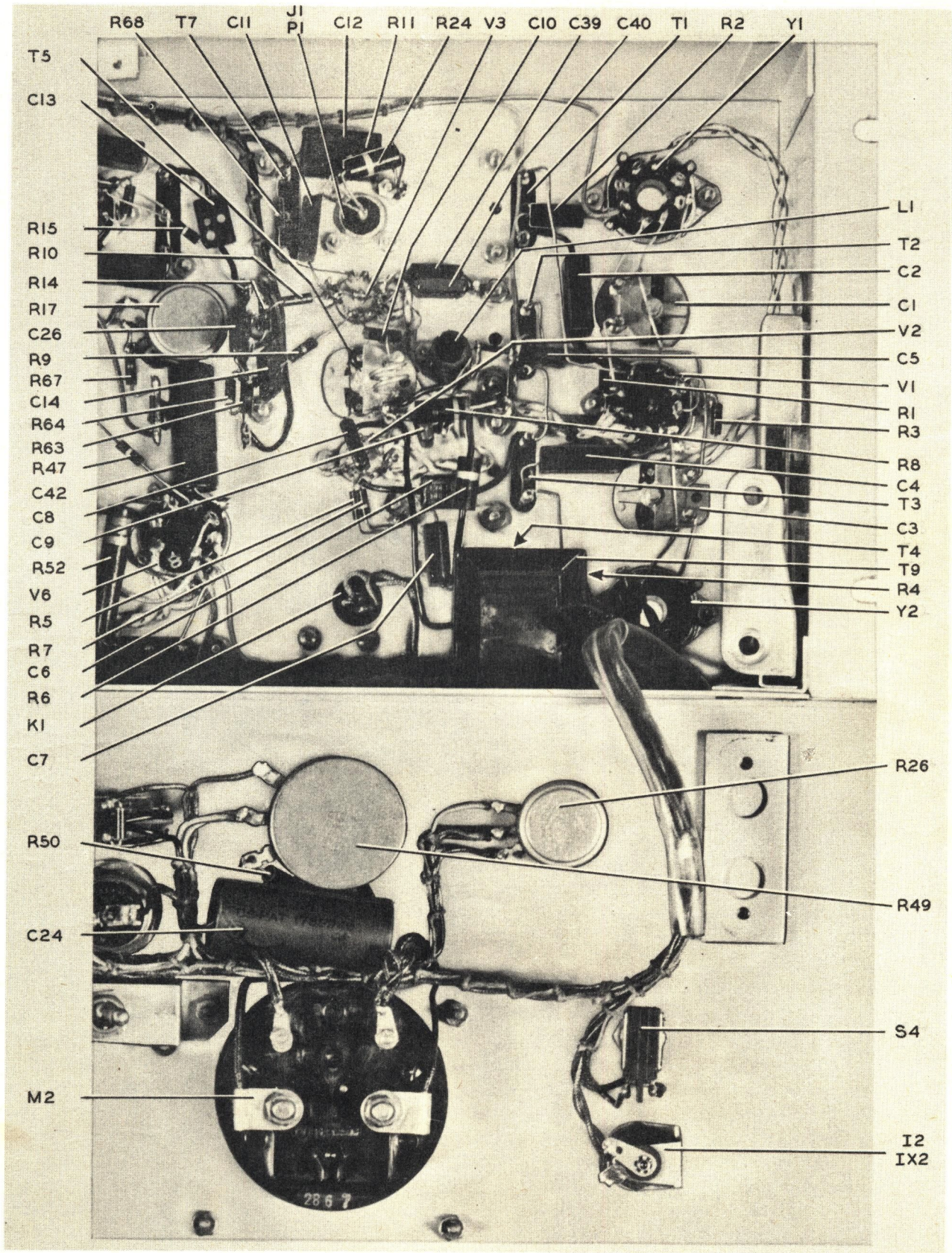


Fig. 4b. Indicator Unit, G-E Type BZ-1-A. Front view of right side, panel open, parts identified. (SY3206B)

from 50 to 120 per cent. The overmodulation flasher, OVER MOD, is located in the center of the front panel below the instruments.

The a-c POWER switch, S4, is on the right-hand side of the Indicator panel. This switch controls the line voltage to the Power Supply unit, but since the crystal heater

voltages are supplied by a transformer whose primary is connected directly to the a-c line, turning the a-c POWER switch off does not affect the crystal heater voltage.

The green pilot light, XTAL HTRS, is located above the POWER switch. It dims and brightens when the crystal heaters are operating properly.

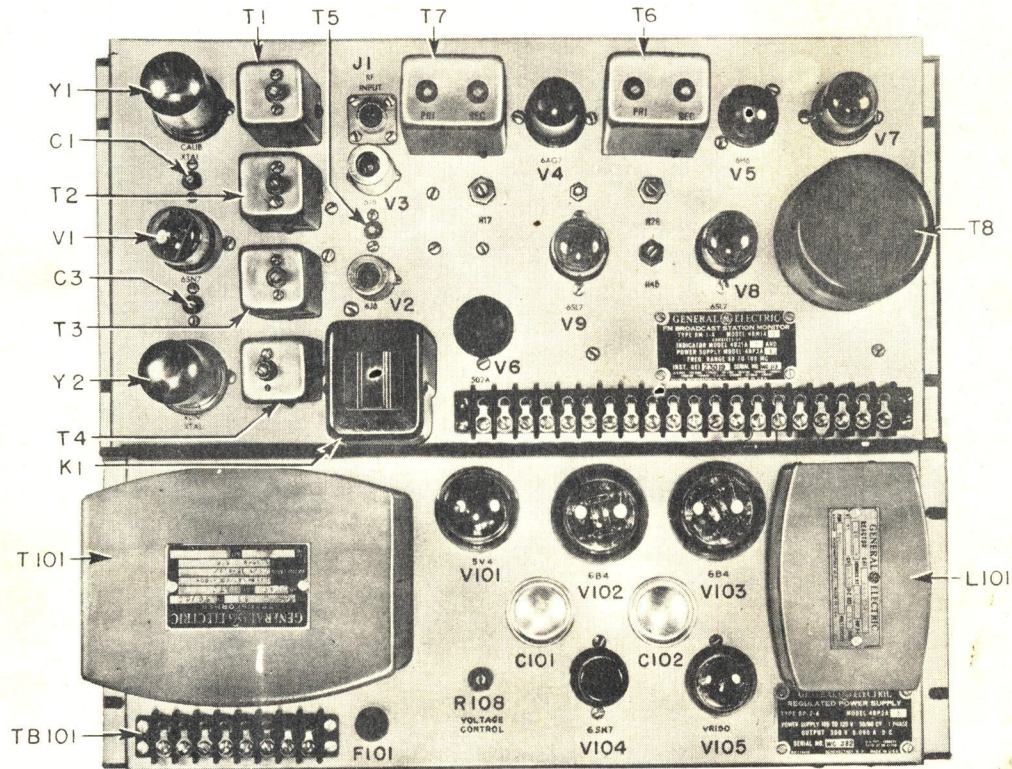


Fig. 5. FM Broadcast Station Monitor. Rear view, parts identified. (SY 3204)

## THEORY OF OPERATION

### 1. Heterodyne Crystal Oscillator and Multiplier

The heterodyne crystal oscillator and multiplier channel consists of three stages: A triode crystal oscillator (one half of tube V1, Type 6SN7) with a third-harmonic tuned circuit in the plate, followed by two additional multipliers (V2, using a miniature twin triode, Type 6J6). For station frequencies above 95.4 megacycles, the multipliers are triplers, giving a total frequency multiplication of twenty-seven. For station frequencies below 95.4 megacycles, the second multiplier is a quadrupler, and the last multiplier is a doubler, giving a total frequency multiplication of twenty-four. Variable capacitor C3 is connected across the heterodyne crystal for adjusting the crystal-oscillator frequency to an external standard.

### 2. Calibration Oscillator

The calibration oscillator, the other half of V1, provides a crystal-controlled signal at 5.4 megacycles for exact calibration of the discriminator and CENTER FREQUENCY DEVIATION instrument. This signal is injected at the low side of the final multiplier-tuned circuit where the bypass capacitor has appreciable impedance to 5.4 megacycles.

### 3. Mixer

The output of the final heterodyne multiplier is applied to the grid of the mixer, V3, and the station signal is injected at the cathode. The mixer is a miniature Type 6J6 triode with the two sections in parallel. The station signal is injected at a saturation level so as to produce consider-

able limiting action, thus reducing any amplitude modulation on the station signal. The plate load of the mixer consists of a broad-band, double-tuned, 5.4-megacycle i-f transformer, T7.

The circuit for measuring r-f level is also included at the mixer. The center frequency instrument is switched into the grid circuit and used to measure the d-c grid current.

**4. Discriminator**

The FM discriminator, T6, is driven by a Type 6AG7 power-amplifier tube, V4, which operates as a limiter as well as an amplifier. Since the discriminator must give less than 0.2 per cent distortion to the audio output signal, its bandwidth must be at least 0.5 megacycle.

In designing the equipment, great care has been taken to insure that, under normal operating conditions, no change will occur in the capacitance and inductance of either the components or the wiring. To a large degree the secondary capacitance controls the cross-over frequency, and the tuning of the primary capacitance controls the linearity of detection. The Type 6H6 output diode, V5, is connected in a manner that permits direct, high-sensitivity, center-frequency measurement.

The limiting action obtained by saturation of the grid of V4 (Type 6AG7) generates in the plate circuit appreciable second and third i-f frequency harmonic currents to which the discriminator has some response. These currents are proportional to the level at the grid, and would ordinarily produce a spurious center-frequency indication. To offset this effect, a compensating network has been inserted between the grid circuit of V4 and the diode output circuit. This circuit furnishes a current which varies in magnitude with the i-f amplitude in the same manner as the spurious response due to harmonic currents, but in opposite phase so that the center-frequency indication is not affected by the i-f level at the grid over the specified range of level.

Since the transconductance of V4 will vary with tube age and with different tubes, screen-voltage-gain control R20 (LEVEL) has been included to permit setting the level at the discriminator to the correct value. A switching circuit enables the operator to measure this level during adjustment with the center-frequency instrument.

**5. Audio Amplifier**

The audio circuit is a two-stage amplifier (both halves of the Type 6SN7 tube, V7) driven through the de-emphasis circuit, R27 and C25, by the audio output of the discriminator. A large amount of negative feedback is provided by the resistance divider connected from the plate of the second stage, through R33, to the cathode of the first stage.

The design of the amplifier is such that a carrier frequency modulated 100 per cent by a 400-cps signal will give an audio gain of 20 with less than 0.16 per cent distortion (due to the amplifier alone). With this high gain

it is possible to obtain sufficient output level (approximately 20 volts) to operate commercial noise and distortion analyzers, even when the audio output is low (because of de-emphasis at high audio frequencies) and when the carrier signal is modulated only 25 per cent. This high-level audio output is a high-impedance, single-ended source provided especially to supply the noise and distortion analyzers used in making transmitter proof-of-performance measurements. Another output, a 600-ohm balanced line at a level of 2 volts, is provided for continuous audio-quality monitoring.

**6. Modulation Circuits**

The modulation circuit consists of a fixed-gain modulation amplifier, detector, cathode-follower amplifier with indicator, and overmodulation-amplifier flasher circuit. Modulation-amplifier tube V8, Type 6SL7, is very similar to the audio amplifier in that it is driven by the same signal (but without de-emphasis) and employs the same type of negative feedback. The output of the modulation amplifier drives the detector, one half of tube V9, Type 6SL7. The cathode-follower circuit, the other half of V9, furnishes a low output impedance for driving the PERCENTAGE MODULATION instrument. Network C37-R45 is connected in series with the PERCENTAGE MODULATION instrument. This greatly increases its ballistic response without appreciably increasing the overshoot.

The flasher circuit consists essentially of V6 (a Type GL-502-A tube), a flasher lamp, and an alarm relay. The flasher tube is driven by the cathode follower, and its bias may be set to cause it to fire at any predetermined modulation level.

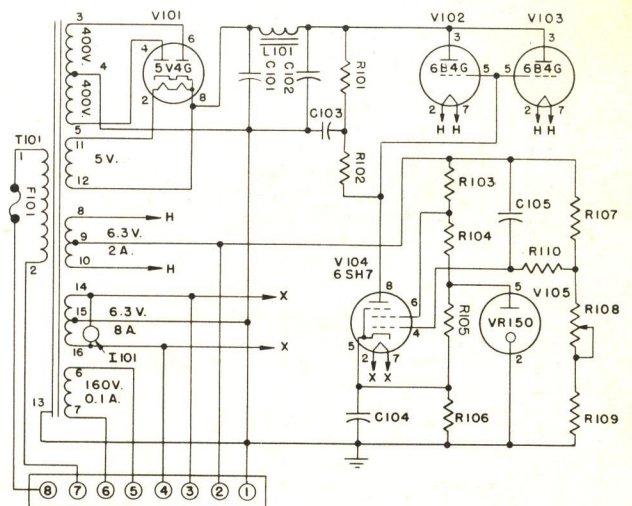


Fig. 6. Regulated Power Supply Unit, G-E Type BP-2-A, Elementary Diagram. (K-7118892, rev. 1)

## 7. Power Supply Unit

All voltages for the tubes, overmodulation flasher, alarm relay, pilot lamp, and instrument illumination in the Indicator unit are obtained from the Power Supply unit, General Electric Type BP-2-A. As described previously, this unit is of the same construction as the Indicator unit—that is, vertical chassis with hinged front panel.

The a-c, 60-cycle power to the Power Supply unit is controlled by the a-c POWER switch, S4, on the Indicator unit. A red pilot light located in the center of the Power Supply front panel indicates when the power supply is turned on.

## 8. Power Supply Fuse

The Monitor is fused by a 3-ampere a-c line fuse. The

fuse holder is located on the rear of the Power Supply chassis to the right of the terminal board (see Fig. 5).

## 9. Voltage Control

The 300-volt, 100-milliampere plate supply for the Indicator unit is a conventional regulated power supply (see Fig. 6). Two Type 6B4G tubes are used as series regulators, a Type 6SH7 tube as an amplifier, a Type OD3/VR-150 gas tube for the reference voltage, and a Type 5V4G tube as the rectifier.

The d-c output voltage of the supply can be adjusted by VOLTAGE CONTROL R108 to the correct value of 300 volts. The d-c voltage should be measured and adjusted, if necessary, whenever any of the tubes in the supply are changed.

# INSTALLATION

## 1. Location and Mounting

After unpacking, inspect the two units of the Monitor for possible damage or loss in shipment. Report any damage or shortage immediately to the carrier agency. Mount the two units in the rack at convenient locations, taking care not to locate the Indicator unit near power transformers, which might introduce hum. The Power Supply unit may be installed below and adjacent to the Indicator without increasing the noise level above the specification; however, all controls are on the Indicator panel, so the Power Supply may be located wherever there is space.

## 2. Power Cables

Since the relative position of the two units for individual installations is not known by the manufacturer, no inter-

connection cables are furnished. The required cables, number of wires in each cable, and terminal board connections are shown in Fig. 7.

The cable between the Power Supply and Indicator units consists of eight wires. Of these, only the 6.3-volt filament wires are critical with respect to resistance, requiring a total resistance in both wires of less than 0.02 ohm.

The 115-volt a-c source connects to terminals No. 8 and No. 9 on the Indicator.

## 3. Remote Cable

The remote cable is required when remote indicating instruments or the Transmitter Console, General Electric Type BC-3-A, is used. It may consist of either six or two wires, depending upon whether or not remote indication of center frequency and modulation is desired. This cable should be kept away from strong a-c fields in order to prevent pickup which might be fed back to the Monitor. The overmodulation counter and alarm connect to terminals No. 10 and No. 11 on the terminal board in the Indicator. The CENTER FREQUENCY DEVIATION instrument connects to terminals No. 12 and No. 13. The PERCENTAGE MODULATION instrument connects to terminals No. 14 and No. 15. Resistor R59 is removed if a remote modulation instrument is used.

## 4. Audio Output Cable

For audio monitoring, a standard twisted-pair line is connected to the 600-ohm balanced output, terminals No. 17 and No. 18 of the Indicator unit. The high-impedance output terminals, No. 19 and No. 20, are used only for proof-of-performance tests. A shielded cable of less than 300-micromicrofarad capacitance, with the shield connected to terminal No. 20, should be used for this connection.

## 5. R-F Cable

Low-loss, 50-ohm, coaxial cable should be used to connect the adjustable pick-up loop in the Transmitter to the

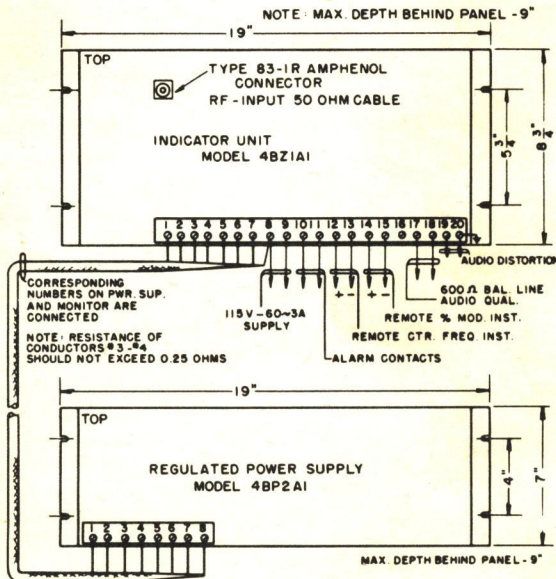


Fig. 7. FM Broadcast Station Monitor, Outline Drawing. (K-7120947)

Indicator. The r-f cable connector, Type 831SP, is furnished with the Indicator. The input connector is located on the Indicator chassis next to the Type 6J6 mixer tube, V3.

*The r-f level to the Monitor must be known to be within the specified limits before the Monitor is connected to the Transmitter. (See page 9 under OPERATION for procedure.)*

## 6. Preliminary Adjustments

Carefully insert the tubes in the correct sockets in accordance with the markings on the chassis and Fig. 5.

After installation check the power supply d-c voltage between terminals No. 1 and No. 2. This should be 300 volts. If it is not, adjust VOLTAGE CONTROL R108 on the Power Supply chassis.

## OPERATION

After the power has been applied and the Monitor has "warmed-up" for thirty minutes, proceed as follows to obtain the normal operating conditions of the Monitor.

### 1. R-F Level Measurement

a. Set the RF-NOR switch, S5, to the RF position. (S5 is on the back of the Indicator panel.)

b. Turn on the Transmitter at reduced power (such as half-plate voltage operation). Observe the level indication on the Monitor. If it is less than half normal, the Transmitter may be operated at full power. It should be possible to operate the Transmitter at full power without exceeding the maximum r-f input limit to the Monitor. If this is not the case, the pick-up loop should be decreased in size, or its location changed, to reduce the r-f level coupled to the Monitor.

c. If normal transmitter level and minimum loop coupling do not give sufficient r-f level as indicated by the Monitor, slowly increase the coupling to the Transmitter until there is an indication midway between the limits marked "I.F. Level" on the CENTER FREQUENCY DEVIATION instrument.

### CAUTION

Excessive r-f level to the Monitor may damage or burn out input terminating resistors R11 and R24.

With normal operation of the Transmitter at the output level to which the input to the Monitor was adjusted it will be found that measurement of the r-f level will be necessary only when abnormal indications are obtained on the Monitor.

## 7. Frequency Accuracy

Although the Station Monitor has been adjusted at the factory to indicate frequency well within the specified accuracy, severe jars in shipping or handling might affect the calibration. Therefore the frequency of the Monitor crystals, Y1 and Y2, should be checked at installation against a standard of known accuracy, such as station WWV.\* To maintain the accuracy of the Monitor in accordance with FCC requirements, the crystal frequencies should be checked periodically. The frequency of the crystals, marked on the crystal shell, should be set within one or two parts per million, using variable shunt capacitors C1 for the 5.4-megacycle calibration oscillator and C3 for the station operating crystal.

### 2. I-F Level Measurement

a. Set the RF-NOR switch, S5, to the NOR position.

b. Set the CAL-LOCAL-REMOTE switch to the CAL position.

c. Set the IF LEVEL-CTR FREQ-DISC LEVEL switch to the IF LEVEL position.

d. The CENTER FREQUENCY DEVIATION instrument should indicate a level in the i-f range.

### NOTE

With an r-f input indication at or slightly above the low limit, the i-f level indication should be at or slightly below the high limit, and vice versa. Thus, with an r-f input level that indicates the center of the range, the i-f level should also indicate the center of the range.

e. Set the CAL-LOCAL-REMOTE switch to the LOCAL position.

f. The CENTER FREQUENCY DEVIATION instrument should indicate in the i-f range. If it does not in either the CAL or LOCAL position, refer to the MAINTENANCE AND SERVICING section, Page 11, for correct procedure.

Excessive frequency drift and errors in frequency indications will occur if the i-f level is not maintained in this range.

\*See G-E bulletin EBR-167, "Carrier-Frequency Measurement of G-E FM Transmitters and Monitor," for discussion of various methods of checking frequency.

James Millen Manufacturing Co., Inc., is manufacturing a FM Frequency-Measurement Equipment, Model No. 90515, including a Multiplier and Secondary Frequency Standard. Their Model No. 90511 includes the Multiplier and Crystal Mixer units only, with provision for attachment to their Secondary Frequency Standard, Model No. 90505.

**g.** For optimum operating conditions the i-f level should be equal with the CAL-LOCAL-REMOTE switch in the CAL and LOCAL positions.

### 3. Calibration of Discriminator

**a.** Set the IF LEVEL-CTR FREQ-DISC LEVEL switch to the DISC LEVEL position.

**b.** Set the CAL-LOCAL-REMOTE switch to the CAL position.

**c.** Adjust the LEVEL control on the front panel to give the proper level as indicated by the CENTER FREQUENCY DEVIATION instrument. If it is impossible to obtain the proper level by adjusting the front panel control, refer to the MAINTENANCE AND SERVICING section for procedure.

**d.** Set the IF LEVEL-CTR FREQ-DISC LEVEL switch to the CTR FREQ position and adjust the CENTER FREQUENCY control to give zero frequency on the CENTER FREQUENCY DEVIATION instrument. If it is impossible to perform this adjustment, refer to the MAINTENANCE AND SERVICING section for procedure.

#### NOTE

After this adjustment has been made, it may be necessary to repeat the i-f level measurement described in Paragraph 2 of this section.

### 4. Discriminator Level Adjustment

It is now necessary to adjust the discriminator level on the station signal. This is done as follows:

**a.** Set the CAL-LOCAL-REMOTE switch to the LOCAL position and the IF LEVEL-CTR FREQ-DISC LEVEL switch to the DISC LEVEL position.

**b.** The CENTER FREQUENCY DEVIATION instrument should give an indication very close to the "Disc Level" mark on its scale. A slight variation from this can be corrected by readjusting the LEVEL control. A large variation should be corrected by adjusting the i-f levels as described under MAINTENANCE AND SERVICING.

### 5. Center Frequency Measurement

Since there will probably be no appreciable change in the r-f level from hour to hour, it will be necessary to perform only the following operations during normal measurements of center frequency.

**a.** Set the discriminator level as outlined above in Paragraph 3. Then adjust the CENTER FREQUENCY control for zero on the CENTER FREQUENCY DEVIATION instrument, with the IF LEVEL-CTR FREQ-DISC LEVEL switch on the CTR FREQ position and the CAL-LOCAL-REMOTE switch on the CAL position.

**b.** Switch the CAL-LOCAL-REMOTE switch to the LOCAL position and set the discriminator level as outlined above in Paragraph 4 of this section. Then set the IF LEVEL-CTR FREQ-DISC LEVEL switch on the CTR FREQ

position and read the carrier-frequency deviation on the CENTER FREQUENCY DEVIATION instrument.

The operations under "a" calibrate the Monitor and those under "b" set it for measurement of station frequency.

### 6. Remote Indicator Operation

If remote indicator operation is desired, it is necessary to proceed as follows:

**a.** Use the indicator instruments mounted on the front panel of the Monitor for all calibration operations listed above.

**b.** Set the CAL-LOCAL-REMOTE switch to the REMOTE position for remote indicator operation.

**c.** Both the remote and front panel PERCENTAGE MODULATION instruments will operate with the CAL-LOCAL-REMOTE switch in either the LOCAL or REMOTE position. This condition does not apply to the CENTER FREQUENCY DEVIATION instrument.

### 7. Proof-of-Performance Tests

For noise and distortion measurements such as are made during proof-of-performance tests of the station, use the high-impedance output terminals, No. 19 and No. 20, on the Indicator terminal board. This output level has deliberately been made high so that there will be enough level at the high-modulation frequencies to operate commercial distortion meters.

To obtain the minimum noise level in the Monitor, reverse the power leads and use the polarity which gives minimum output with the CAL-LOCAL-REMOTE switch in the CAL position. The inherent FM noise level in the Monitor is approximately 75 db below 150-kc peak-to-peak frequency swing. When making noise measurements, take care to use shielded cables and suitable grounding arrangements to prevent direct pickup of r-f or audio fields from increasing the noise level.

Remove any load or line connected to the audio-monitoring terminals, No. 17 and No. 18. This will reduce the distortion level of the Monitor (which was less than 0.25 per cent when tested in the laboratory). Measure the distortion with the MODULATION POLARITY switch in both the positive and negative positions to average out the distortion occurring in the audio amplifier. Use the average of the two readings as the final distortion figure.

In taking frequency-response characteristics of the Transmitter, connect a 600-ohm non-inductive load to terminals No. 17 and No. 18 to maintain the frequency characteristics of the Monitor given under GENERAL SPECIFICATIONS—that is, within  $\pm 0.5$  db of standard de-emphasis curve from 50 to 15,000 cycles and  $\pm 1.0$  db between 15,000 and 30,000 cycles.



## MAINTENANCE AND SERVICING

During the installation and operation of the Monitor, only the controls on the front panel and those mentioned in this section of the instruction book should ever be adjusted by the operator. The Monitor is a precision instrument; if normal operation cannot be obtained by following the instructions given in the sections on OPERATION and MAINTENANCE AND SERVICING, the Indicator unit should be returned to the General Electric Company for servicing after obtaining written authorization from the Company to do so.

### 1. R-F Level

If it is impossible to obtain the proper r-f level by adjusting the coupling loop at the Transmitter, measure the voltages at the converter tube, V3, and check these with the tabulated values on Page 15. Inspect the two 100-ohm r-f cable terminating resistors, R11 and R24, to be certain that they have not been damaged by excessive r-f power.

Measure the r-f voltage across R11 and R24. This should be between the limits of 2 volts and 7 volts rms.

### 2. I-F Level

When installing the Monitor, it may be necessary to adjust the i-f level. This, however, should not be done until the correct r-f level indication has been obtained on the CENTER FREQUENCY DEVIATION instrument, and the power-supply voltage has been measured and adjusted to 300 volts d-c.

The i-f level is adjusted as follows:

a. Set the Monitor controls in accordance with the instructions given under Paragraph 2e of OPERATION.

b. Adjust the tuning of circuit T5, located on the left of the chassis between the two Type 6J6 tubes, until an i-f level indication midway between the limit marks on the CENTER FREQUENCY DEVIATION instrument is obtained. The circuit T5 should always be tuned to the low-frequency side of resonance.

c. The r-f level should be remeasured to ascertain that the indication has not been changed by the tuning of circuit T5.

d. Set the CAL-LOCAL-REMOTE switch to the CAL position.

e. Adjust the tuning of circuit T1, located on the top of the shield can in the upper left corner of the Indicator chassis, to give the same indication as in "b" above.

If the correct i-f level cannot be obtained, measure the voltages (as tabulated on Page 15) for tubes V1 and V3 to be certain that they are operating properly. If necessary, replace either or both of the tubes.

In replacing tubes V1, V2, or V3 in the multiplier and converter circuits, it may be necessary to retune one or more of the multiplier-tuned circuits T2, T3, T4, or T5. Proper procedure is described on page 12.

### 3. Discriminator Level

If it is impossible to adjust the discriminator level to the "Disc Level" mark on the CENTER FREQUENCY DEVIATION instrument by means of the front panel LEVEL control, it is an indication that tube V4 is defective; a new tube may be required. No disc level indication suggests a defective Type 6H6 (V5) or Type 6AG7 (V4) tube. It will not be necessary to make any adjustments other than varying the front panel LEVEL control when the Type 6AG7 tube (V4) is replaced.

### 4. Replacement of Type 6H6 Tubes

Since minute changes of capacitance are caused by aging or changing of the Type 6H6 tube (V5), it may not be possible to adjust the center frequency to zero deviation by using the front panel control. When such a change occurs, the secondary circuit of the discriminator (marked SEC on T6) should be tuned slightly to compensate accordingly. *Do not disturb the setting of the primary of T6 under any circumstances.*

To maintain the low distortion characteristics of the Monitor, a Type 6H6 tube should always be replaced by a tube selected in accordance with the instructions given below. The original tube furnished with the equipment was selected in this manner, and the Monitor was then adjusted to give minimum distortion. The maintenance of the low distortion limit of 0.25 per cent requires careful servicing; it is, therefore, essential that replacement tubes must be of the same quality as the tubes furnished with the equipment.

To select a replacement Type 6H6 tube, measure the d-c current through each section of the tube by connecting a 3.2-volt battery (two No. 6 dry cells) in series with the diode section and a 10-milliamper instrument. The heater of the tube should be operated at 6.3 volts,  $\pm 0.15$  volt. The average of the two currents through the diode sections should fall between the limits of the 2.0 and 4.0 milliamperes d-c, and the ratio of the two currents should not exceed 1.4.

When changing Type 6H6 diodes, measure the over-all noise level of the Monitor with the CAL-LOCAL-REMOTE switch in the CAL position to be certain that the new diode has not increased the level above the original specification of 75 db below the 100 per cent modulation point. At installations where large changes in power-line voltage exist, excessive drift of center frequency of the Monitor will occur with some diodes. This is due to changes in cathode operating temperature and unbalance in the diode. The diode furnished with the Monitor was selected so that a change of 5-volts line voltage causes a drift of only 300 cycles in frequency indication.

### 5. Center Frequency Deviation, Zero Setting

When a Type 6H6 tube is changed, it may be necessary to retune the secondary of transformer T6 in order to set the CENTER FREQUENCY DEVIATION instrument to zero by the front panel CENTER FREQUENCY control. This retuning of the secondary of T6 should be done with the CAL-LOCAL-REMOTE switch in the CAL position, and the front panel CENTER FREQUENCY control in the center of the range. Tune the secondary of T6 until the indication on the CENTER FREQUENCY DEVIATION instrument returns to approximately zero; then adjust it to exactly zero by means of the CENTER FREQUENCY control.

After changing the Type 6H6 tube, adjust T1 with the IF LEVEL-CTR FREQ-DISC LEVEL switch in the IF LEVEL position and the CAL-LOCAL-REMOTE switch in the CAL position—to give low, high, and middle levels of the i-f range. Note the center-frequency indication for each level. If the difference in center-frequency indication is more than 200 cps adjust R17, located on the chassis below T7, until the difference is less than 200 cps for the full range of i-f level.

### 6. Percentage Modulation, Zero Setting

Failure of the PERCENTAGE MODULATION indicator to function suggests that tubes V8 or V9, or both, have failed. If either of these tubes are changed, the PERCENTAGE MODULATION instrument may have to be set at zero. The indicator zero set is controlled by potentiometer R44, located on the component board in the lower left corner inside the chassis. It is the potentiometer nearest the chassis. No other adjustments will be necessary when replacing V8 or V9.

### 7. Accuracy of Percentage Modulation Instrument

An over-all calibration of the PERCENTAGE MODULATION instrument can be made by the Bessel 'zero method', using the transmitter and a communication type a-m receiver with a *narrow-band* intermediate-frequency amplifier. The latter requirement is necessary to obtain the required high degree of selectivity. The receiver should preferably have a crystal filter for most accurate results.

Since the amplitude of the carrier component of frequency-modulated waves becomes zero when the ratio of frequency swing to the modulating frequency has any of the following values: 2.40, 5.52, 11.79, etc., these zero points may be used to check carrier deviation or percent modulation.

To calibrate the PERCENTAGE MODULATION instrument, tune in the unmodulated carrier of the FM transmitter on the a-m receiver with the i-f selectivity adjustment in the narrow position and the beat oscillator of the receiver set to produce a beat note of approximately 100 cps. Apply a modulating signal of 5000 cps to the transmitter and increase the modulating level from zero

until the 100-cps beat note disappears. The transmitter frequency swing is then 2.40 times the modulating frequency, or 12 kc. Further increase of the modulation level until the second zero occurs will increase the swing to 27.6 kc, which is 5.52 times, or 43 kc. Similarly, at the fourth zero, it is 11.79 times or 59 kc.

To check the calibration, a different modulating frequency should be used. For example, with 13,600 cps the transmitter frequency swing at the second zero will be 75 kilocycles per second. 'Swing' in the above description means displacement (modulation) of the transmitter frequency from its central or mean position and has been assumed to be one-half of the total frequency excursion; that is, the modulation has been linear.

### 8. Audio Amplifier

No adjustments are required when changing the audio-amplifier tube, V7.

### 9. Overmodulation Flasher

If the PERCENTAGE MODULATION instrument is functioning properly and the flasher on the front panel has failed, replace tube V6 or the front panel flasher lamp.

### 10. Instrument Lamp

In case of failure, the instrument lamp is easily accessible for replacement. Remove the two screws on the front of the instrument case, and lift off the front part of the case.

### 11. Tuning and Adjustment of Multiplier Stages (T2, T3, T4, and T5)

#### EQUIPMENT REQUIRED

a. Absorption wavemeters to cover the range from 3 mc to 140 mc. James Millen 90605A, 90606A, 90607A, and 90608A are recommended.

b. A high-resistance, low-current, d-c voltmeter to measure rectified grid voltage. (A suitable instrument can be made from a 30-microampere instrument and ½-watt, 1-megohm Allen Bradley resistor or a vacuum tube voltmeter may be used.)

*Note:* In use, the "+" terminal of the microammeter is connected to ground and the resistor is connected between the instrument and the grid at which the measurement is being made. The pigtail lead on the end of the resistor connecting to the grid circuits should be cut as short as possible but should still be long enough to make a small hook in the lead to hang the resistor on the various points of connection. A wire of suitable length can be used between the resistor and the instrument so that the microammeter may be placed in a convenient position.

#### MULTIPLIER FREQUENCY TABLE

The frequency of the run crystal is multiplied either 24 or 27 times, depending on the station frequency. The

1490 3590  
47.0

final harmonic frequency is heterodyned with the station frequency to produce the 5.4 mc i-f. The following chart will assist in determining the frequencies of the various multiplier stages.

Station Frequency	
88.1 mc to 95.3 mc	95.5 mc to 107.9 mc
Run Crystal Frequency	
3895.83 kc to 4195.83 kc	3737.04 kc to 4196.30 kc
Total Multiplication Factor	
24	27
T2—Crystal Fundamental	T2—Crystal Fundamental
T3—Crystal 3rd Harmonic	T3—Crystal 3rd Harmonic
T4—Crystal 12th Harmonic	T4—Crystal 9th Harmonic
T5—Crystal 24th Harmonic	T5—Crystal 27th Harmonic

**PROCEDURE**

The steps outlined below should be followed when it is known or considered probable that the tuning of the run crystal oscillator or the multiplier stages has to be changed.

**a. Preliminary Check and Adjustment**

- (1) Check Power Supply voltage. This should be accurately adjusted to 300 volts d-c.
- (2) Set the CAL-LOCAL-REMOTE switch, S1, in the LOCAL position.
- (3) Set the IF LEVEL-CTR-FREQ-DISC LEVEL switch, S2, in the IF LEVEL position.
- (4) Set the RF-NOR switch, S5, in the NOR position.
- (5) Disconnect the r-f input cable at the Monitor.

**b. Crystal Oscillator Tuning (T2)**

Connect the high-resistance, low-current voltmeter to the grid of the "run crystal" oscillator stage (Pin 4 of V1). It must be remembered that the capacitance added to the grid circuit must be negligible. This will be true with the instrument suggested, provided that the pigtail lead in the end of the resistor connecting to the tube grid is short.

An indication of approximately 25.5 volts should be obtained. If this is not the case, replace the tube V1 before attempting to tune the fundamental frequency tank circuit.

When tuning the fundamental frequency tank circuit, note that, for uniform rotation of the tuning capacitor, the d-c grid voltage will increase rapidly to a peak value and then decrease slowly, or vice versa depending on the direction of rotation. The range of tuning where the d-c grid voltage changes most slowly is on the high frequency or low capacitance side of peak tuning. The oscillator tuning should always be set at the point in this

region where the d-c grid voltage of 25.5 volts is obtained. Tuning in this region was selected because changes in tank circuit components will have a minimum effect on the oscillator frequency.

*Never leave the tuning of this stage at a point where the grid voltage exceeds 26 volts, as this will cause increased frequency drift.*

**c. First Multiplier (T3)**

Transformer T3 connected in series with the fundamental tank circuit in the plate of the crystal oscillator is always tuned to the third harmonic of the crystal.

- (1) Connect the voltmeter to the grid of the next multiplier tube (Pin 6 of V2).
- (2) Tune T3 for maximum indication of the voltmeter. A reading between 15-24 volts should be obtained.
- (3) Measure the frequency at which T3 is peaked by closely coupling the lowest range wavemeter to the top of R5 in the grid circuit of this stage (Pin 6 of V2). Very carefully tune the wavemeter to give this dip with minimum coupling. *This should be the third harmonic of the crystal.*

**d. Second Multiplier (T4)**

The tank circuit connected to the plate of this stage (Pin 1 of V2) may be tuned to either the 9th or 12th harmonic of the crystal, depending on the station frequency. *See the chart above for correct harmonic.*

- (1) Connect the voltmeter to Pin 5 of V2.
- (2) Tune T4 for maximum indication at the correct harmonic. A reading between 10-20 volts should be obtained.
- (3) Measure frequency with wavemeter having correct range by tuning over the range and noting the dip in grid volts at Pin 5 of V2. The wavemeter should be coupled closely to the top of R7 in the grid circuit of this stage (Pin 5 of V2). After obtaining definite indication of the wavemeter tuning point, loosen coupling as much as possible to reduce de-tuning effects of the wavemeter.

**e. Third Multiplier (T5)**

The tank circuit connected to the plate of this stage (Pin 2 of V2) may be tuned to either the 24th or 27th harmonic of the crystal, depending on the station frequency. *See the chart above for correct harmonic.*

- (1) Connect the voltmeter to Pin 6 of V3.
- (2) Tune T5 for maximum indication which will be approximately 0.5 to 1.5 volts.
- (3) Measure the frequency with the wavemeter having correct range by tuning over the range and noting the dip in grid volts at Pin 6 of V3. The wavemeter should be lowered a short distance over the

top of L1 and leaned toward the tank coil of T5. Tune until dip is noted on the voltmeter connected to grid (Pin 6 of V3).

However, transformer T5 does not remain tuned to resonance. During the adjusting of the local i-f level, T5 is de-tuned on the *high capacity* side until the correct i-f level is obtained. Therefore, it must be remembered that under normal running conditions, the voltage at Pin 6 of V3 will be considerably lower than the value given above.

The de-tuning of T5 also prevents changes in local i-f level for small changes in crystal operating level.

## 12. Operating Voltages

The following grid voltages were measured with an accurate vacuum-tube voltmeter; the other d-c voltages were measured with a 20,000 ohms-per-volt voltmeter, after the power-supply voltage was adjusted to 300 volts. It is necessary to use a resistor (500,000 ohms or greater) in series with the voltmeter probe at the points that are so designated in order to avoid detuning the high-frequency circuits.

All voltages, except the heater-supply voltages, should be measured to "ground" in order to correspond to the tabulated values.

The following measurements were made without r-f input from the Transmitter; the CAL-LOCAL-REMOTE switch was in the CAL position, all the other controls were in the normal operating position, and the discriminator level was set correctly for the CAL position.

TUBE	TUBE ELEMENT	POINT OF MEASUREMENT	VOLTS D-C† (Unless otherwise noted)
V1 (6SN7)	Heater	Pins 7 and 8	6.1 a-c
	Cathode	Pin 3	0.0
	Grid*	Pin 1	-7.7
	Plate	C2 and R2	127.0
V3 (6J6)	Heater	Pins 3 and 4	6.1 a-c
	Cathode	Pin 7	3.0
	Grids*	Pins 5 and 6	0.02
	Plates	C12 and R12	111
V4 (6AG7)	Heater	Pins 2 and 7	6.1 a-c
	Cathode	Pin 5	5.8
	Screen	Pin 6	190.0
	Grid*	Pin 4	-12.0
	Plate	C18 and R21	209.0
V5 (6H6)	Heater	Pins 2 and 7	6.1 a-c
	Plate	Pin 3	-15.1
	Cathode	Pin 8	11.5
V6 (GL-502-A)	Heater	Pins 2 and 7	6.1 a-c
	Cathode	Pin 6 or Pin 8	35.8
	Grid	Pin 5	7.9
	Plate (to cathode)	Pin 3 to Pin 8	159.0 a-c
V7 (6SN7)	Heater	Pins 7 and 8	6.1 a-c
	Cathode	Pin 3	5.4
	Grid	Pin 1	1.3
	Plate	Pin 2	131.0
	Cathode	Pin 6	3.7
	Grid	Pin 4	0.0
	Plate	Pin 5	145.0
V8 (6SL7)	Heater	Pins 7 and 8	6.1 a-c
	Cathode	Pin 3	1.0
	Grid	Pin 1	-1.5
	Plate	Pin 2	185.0
	Cathode	Pin 6	1.75
	Grid	Pin 4	0.0
	Plate	Pin 5	221.0
V9 (6SL7)	Heater	Pins 7 and 8	6.1 a-c
	Cathode	Pin 3	5.6
	Grid	Pin 1	5.7
	Plate	Pin 2	5.7
	Cathode	Pin 6	14.1
	Grid	Pin 4	5.6
	Plate	Pin 5	300.0

\*Insert in series near the grid pin a resistor of at least 500,000 ohms to prevent detuning of tuned circuits.

†D-c voltages may vary  $\pm 15$  per cent from the above values.

The following measurements were made with the CAL-LOCAL-REMOTE switch in the LOCAL position and all the other controls in the normal operating position.

TUBE	TUBE ELEMENT	VOLTAGE MEASURED AT OR BETWEEN	VOLTS
V1 (6SN7)	Heater	Pins 7 and 8	6.1 a-c
	Cathode	Pin 6	0
	Grid*	Pin 4	-25.2
	Plate	C4 and R4	115
V2 (6J6)	Heater	Pins 3 and 4	6.1 a-c
	Grid*	Pin 6	-12.0 to -35
	Plate	R6 and C7	175
	Grid*	Pin 5	-20.5
	Plate	C9 and R8	125.0
Y1 (5.4-mc Xtal)	Both Heaters On	Pins 6 and 7	6.2
Y2 (Xtal)	Heaters Off	Pins 6 and 7	.67

\*Insert in series near the grid pin a resistor of at least 500,000 ohms to prevent detuning of tuned circuits.

**PARTS LIST**  
for  
**FM BROADCAST STATION MONITOR**  
**G-E TYPE BM-1-A**

This list includes all principal replacement parts. The symbol numbers used are the same as those appearing on schematic and other diagrams.

When ordering parts from the General Electric Company, it is requested that as much of the following information as possible be furnished:

1. Symbol number
2. Name of part
3. Drawing and Catalogue number
4. Name and Model number of equipment

**INDICATOR UNIT**

Symbol	Description	G-E Dwg.	Symbol	Description	G-E Dwg.
CAPACITORS			CAPACITORS CONT'D		
C1	Air-trimmer, 25 + mmfd 3.5 — mmfd	P-3R47-P5	C34	Paper, mineral-oil impregnated; hermetically sealed un-insulated case; 0.10 mfd + 30% — 10%, 600 vdcw; Sprague Cat. No. PX24B20, or equivalent	P-7768969-P6
C2	Mica, 10,000 mmfd ± 10%, 300 vdcw	P-7766603-P4	C35	Paper, mineral-oil impregnated; hermetically sealed un-insulated case; 0.25 mfd + 30% — 10%, 600 vdcw; Sprague Cat. No. PX24B21, or equivalent	P-7768969-P7
C3	Same as C1	P-3R26-P16	C36	Paper, mineral-oil impregnated; hermetically sealed un-insulated case; 0.05 mfd + 30% — 10%, 600 vdcw; Sprague Cat. No. PX24B17, or equivalent	P-7768969-P5
C4	Same as C2	P-3R26-P12	C37	Paper, mineral-oil impregnated; hermetically sealed un-insulated case; 0.50 mfd + 30% — 10%, 600 vdcw; Sprague Cat. No. PX24B22, or equivalent	P-7768969-P8
*C5	Mica, 470 mmfd ± 10%, 500 vdcw	P-3R26-P2	C38	Same as C35	
*C6	Mica, 100 mmfd ± 10%, 500 vdcw	P-3R26-P18	*C39, *C40	Same as C11	
C7	Mica, 4,700 mmfd ± 10%, 500 vdcw		C41	Electrolytic, 25 mfd — 0% + 150%, 25 vdcw; Cornell Dubilier Cat. No. BR252A	P-7768109-P1
*C8	Mica, 10 mmfd ± 10%, 500 vdcw		C42	Electrolytic, 10 mfd — 0% + 150%, 50 vdcw; Cornell Dubilier Cat. No. BR105, or equivalent	P-7768109-P3
*C9, *C10	Same as C6		C43	Special temperature-compensating capacitor mounted external to T6 in first few equipment shipped.	
*C11	Mica, 1,000 mmfd ± 10%, 300 vdcw		INDICATING DEVICES		
C12	Same as C2		I1	120 volts, 6 watts; candelabra screw base; Type No. 6S6	
*C13, *C14	Same as C5		I2	6-8 volts, 0.25 amp; miniature bayonet base; Type No. 44	
C15, C16	Same as C2		IX1	Dial light socket; red jewel, faceted face, clear back; Dial Light Co. Type No. 100-F, or equivalent	M-7477461-P16
C17	Not used				
C18	Same as C2				
C19, C20	Not used				
*C21 through *C23	Same as C5				
C24	Electrolytic, 30 mfd — 0% + 150%, 25 volts a-c, non-polarized; Cornell Dubilier Cat. No. BR-1011, or equivalent	K-7121331-P1			
C25	Mica, 1,500 mmfd ± 2%, 300 vdcw	P-7769801-P58			
*C26	Same as C5				
C27	Not used				
C28	Paper, mineral-oil impregnated; hermetically sealed un-insulated case; 0.25 mfd + 30% — 10%, 600 vdcw; Sprague Cat. No. SPPX24B21, or equivalent	P-7768969-P97			
C29	Same as C2				
C30	Electrolytic, 12 mfd — 0% + 100%, 350 vdcw; Cornell Dubilier Cat. No. BR1235, or equivalent	P-7768109-P15			
C31 through C33	Same as C2				

\*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Dwg.	Symbol	Description	G-E Dwg.
INDICATING DEVICES CONT'D			RESISTORS CONT'D		
*IX2	Dial light socket; translucent, light green jewel; Dial Light Co. Cat. No. 95410-1921, or equivalent	K-7117809-P4	R13	with Style C mounting, or equivalent <del>Not used</del> Same as R42	
RECEPTACLE			*R14	Composition, 39,000 ohms $\pm$ 5%, 1/2 watt	P-3R11-P197
*J1	Chassis connector; mica-filled bakelite; single contact, female; American Phenolic Corp. Cat. No. 83-1R, or equivalent	M-2R22-P3	*R15	Composition, 100 ohms $\pm$ 10%, 1/2 watt	P-3R11-P50
RELAY			R16	Not used	
K1	Resistance 11,300 ohms d-c, operating voltage 120 vdc; 1 contact, normally open	P-7770602-P3	R17	Variable, 47,000 ohms $\pm$ 20%; linear taper; locknut, screwdriver control; Allen Bradley Type J, or equivalent	M-2R25-P99
COILS			*R18	Composition, 200 ohms $\pm$ 5%, 1/2 watt	P-3R11-P142
L1	Inductance 24 to 26 microhenries; max. d-c resistance 5 ohms	K-7118890-P1	+*R19	Composition, 7,500 ohms $\pm$ 10%, 1 watt	P-3R13-P73
L2	Inductance 2 1/2 mh; distributed capacity 1 mmfd d-c; 50 ohms; current rating 125 ma; National Co. Cat. No. R-100, or equivalent	K-7119414-P1	R20	Variable, 15,000 ohms $\pm$ 20%; linear taper, 7/8-in. shaft; Allen Bradley Type J, or equivalent	M-2R25-P16
METERS			R21	Wirewound, 4,000 ohms $\pm$ 5%, 10 watts; Ward Leonard Cat. No. K41382-2	M-2R12-P87
M1	4 1/2-in. d-c microammeter; 50-0-50 $\mu$ a	P-7771131-P1	R22	Wirewound, 3,900 ohms $\pm$ 1%, 1 watt; Shallcross Mfg. Co. Type No. 190, or equivalent	K-7120487-P2
M2	4 1/2-in. d-c microammeter; 500 $\mu$ a	P-7771131-P2	R23	Same as R22	
JACK			*R24	Same as R11	
*P1	Straight connector, mica-filled bakelite, single contact, male; American Phenolic Corp. Cat. No. 83-1SP, or equivalent	M-2R22-P1	*R25	Composition, 820 ohms $\pm$ 5%, 1/2 watt	P-3R11-P157
RESISTORS			R26	Variable, 100 ohms $\pm$ 20%, 7/8-in. shaft; Allen Bradley Type J, or equivalent	M-2R25-P3
*R1	Composition, 51,000 ohms $\pm$ 5%, 1/2 watt	P-3R11-P200	R27	Wirewound, 50,000 ohms $\pm$ 1%, 1/4 watt; Shallcross Mfg. Co. Type No. 172, or equivalent	K-7120487-P1
*R2	Composition, 30,000 ohms $\pm$ 5%, 2 watts	P-3R67-P194	R28	Variable, 220,000 ohms $\pm$ 20%; linear taper, 5/8-in. shaft; locknut, screwdriver control; Allen Bradley Type J, or equivalent	M-2R25-P103
*R3	Same as R1		††R29	Composition, 0.51 meg $\pm$ 5%, 1/2 watt	P-3R11-P224
*R4	Same as R2		*R30	Composition, 2,400 ohms $\pm$ 5%, 1/2 watt	P-3R11-P168
*R5	Composition, 100,000 ohms $\pm$ 10%, 1/2 watt	P-3R11-P86	*R31	Same as R5	
*R6	Composition, 15,000 ohms $\pm$ 10%, 2 watts	P-3R67-P76	R32	Wirewound, 16,000 ohms $\pm$ 5%, 5 watts; Sprague Resistor Corp. Type 5KT with Style C mounting	M-7478632-P103
*R7	Same as R5		*R33	Composition, 75,000 ohms $\pm$ 5%, 1 watt	P-3R13-P204
*R8	Composition, 47,000 ohms $\pm$ 10%, 2 watts	P-3R67-P82	*R34	Composition, 1.0 meg $\pm$ 10%, 1/2 watt	P-3R11-P98
*R9	Composition, 22,000 ohms $\pm$ 10%, 1/2 watt	P-3R11-P78	*R35	Composition, 560 ohms $\pm$ 5%, 1/2 watt	P-3R11-P153
*R10	Composition, 510 ohms $\pm$ 5%, 1/2 watt	P-3R11-P152	*R36	Composition, 220 ohms $\pm$ 10%, 1/2 watt	P-3R11-P54
*R11	Composition, 100 ohms $\pm$ 10%, 2 watts	P-3R67-P50			
R12	Wirewound, 31,000 ohms $\pm$ 5%, 5 watts; Sprague Resistor Corp. Type No. 5KT,	M-7478632-P106			

\*This item or equivalent should be obtained from a local radio dealer.

†For serial nos. preceded by "WC" value was 4700 ohms.

††For serial nos. preceded by "WC" value was 0.68 meg.



Symbol	Description	G-E Dwg.	Symbol	Description	G-E Dwg.
RESISTORS CONT'D			RESISTORS CONT'D		
*R37	Composition, 0.22 meg $\pm$ 10%, 1/2 watt	P-3R11-P90	*R63	Composition, 1.1 meg $\pm$ 5%, 1/2 watt	P-3R11-P232
*R38	Same as R36		*R64	Composition, 390 ohms $\pm$ 5%, 1/2 watt	P-3R11-P149
*R39	Composition, 82,000 ohms $\pm$ 5%, 1/2 watt	P-3R11-P205	R65, R66	Not used	
*R40	Composition, 0.12 meg $\pm$ 10%, 1/2 watt	P-3R11-P8,	*R67	Same as R42	
*R41	Composition, 5.1 meg $\pm$ 5%, 1/2 watt	P-3R11-P248	*R68	May vary from 6500 to 30,000 ohms or be omitted entirely. Selected in Test.	
*R42	Composition, 10,000 ohms $\pm$ 10%, 1/2 watt	P-3R11-P74	†*R69	Composition, 2.2 meg $\pm$ 20%, 1/2 watt	P-3R11-P33
*R43	Composition, 20,000 ohms $\pm$ 5%, 1/2 watt	P-3R11-P190	SWITCHES		
R44	Variable, 10,000 ohms $\pm$ 20%, linear taper, 5/8-in. shaft; locknut, screwdriver control; Allen Bradley Type J, or equivalent	M-2R25-P95	S1	Selector type, single section, 4 pole, 3 position, non-short- ing; Chicago Telephone Supply Co. Type No. N-W-228-43, or equivalent	P-7769815-P49
R45	Variable, 100,000 ohms $\pm$ 20%, linear taper, 5/8-in. shaft; locknut, screwdriver control; Allen Bradley Type J, or equivalent	M-2R25-P101	S2	Same as S1	
*R46	Composition, 0.30 meg $\pm$ 5%, 1/2 watt	P-3R11-P218	S3	Toggle; 1 amp 250 volts, 3 amps 125 volts; dpdt; Ar- row-Hart and Hegeman Type No. 20905-GH, or equivalent	M-7478623-P4
*R47	Same as R34		S4	Toggle; 3 amps 250 volts; spst; Arrow - Hart and Hegeman Type No. 20994- EY, or equivalent	M-7478623-P1
R48	Same as R28		S5	Same as S3	
R49	Variable, wirewound, 50,000 ohms $\pm$ 10%; Clarostat Mfg. Co. Series No. 58, Code 101A, 300° rotation, or equivalent	K-7118889-P1	TRANSFORMERS		
*R50	Same as R1		T1		P-7763676-P1
R51	Not used		T2		P-7763676-P2
R52	Wirewound, 1.80 ohms $\pm$ 10%, 2 watts	P-3R21-P4	T3		P-7763676-P3
*R53	Composition, 1,300 ohms $\pm$ 5%, 1/2 watt	P-3R11-P162	T4		P-7763676-P4
*R54	Composition, 0.43 meg $\pm$ 5%, 1/2 watt	P-3R11-P222	T5		K-7120551-P1
*R55	Composition, 0.47 meg $\pm$ 10%, 1/2 watt	P-3R11-P94	T6		P-7763676-P6
*R56	Composition, 5,100 ohms $\pm$ 5%, 1/2 watt	P-3R11-P176	T7		P-7763676-P7
*R57	Composition, 1,100 ohms $\pm$ 5%, 1/2 watt	P-3R11-P160	T8		M-7479948
*R58	Same as R1		T9		M-7479627-P1
*R59	Composition, 1,000 ohms $\pm$ 10%, 1/2 watt	P-3R11-P62	TUBES		
*R60	Same as R34		*V1	Type 6SN7/GT	
R61	Not used		*V2	Type 6J6	
*R62	Composition, 4.3 meg $\pm$ 5%, 1/2 watt	P-3R11-P246	*V3	Same as V2	
			V4	Type 6AG7	
			*V5	Type 6H6	
			V6	Type GL-502-A	
			*V7	Same as V1	
			*V8	Type 6SL7/GT	
			*V9	Same as V8	
			CRYSTALS		
			Y1	Type G-31, Thermocell crys- tal unit for 5.4 mc	M-7478830
			Y2	Type G-31, Thermocell crys- tal unit (per Customer's Frequency)	M-7478830

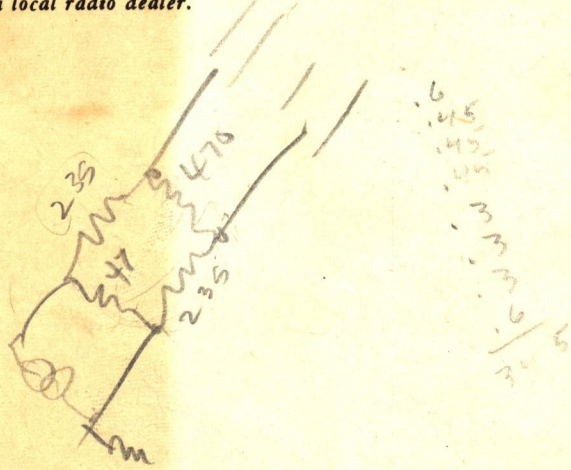
\*This item or equivalent should be obtained from a local radio dealer.

†Appears only in units with serial nos. preceded by "WC"; later combined with R29.

REGULATED POWER SUPPLY UNIT

Symbol	Description	G-E Dwg.	Symbol	Description	G-E Dwg.
CAPACITORS			RESISTORS Cont'd		
C101	Electrolytic, 8 mfd — 10% + 50%, 600 vdcw; screw-base type; Mallory Co. Cat. No. HS693, or equivalent	K-7121176	*R104	Composition, 3,000 ohms ± 5%, 2 watts	P-3R67-P170
C102	Same as C101		*R105	Composition, 8,200 ohms ± 10%, 2 watts	P-3R67-P73
C103	Paper, 0.10 mfd — 10% + 50%, 600 vdcw; Solar Type No. S-6-1-1050, or equivalent	M-7477524-P26	*R106	Same as R105	
C104, C105	Same as C103		*R107	Same as R101	
			R108	Variable, 220,000 ohms ± 20%, linear taper, 5/8-in. shaft; locknut, screwdriver control; Allen Bradley Type J, or equivalent	M-2R25-P103
FUSE			*R109	Composition, 0.27 meg ± 10%, 1/2 watt	P-3R11-P91
F101	3 amps, 250 volts; G-E Cat. No. 132767G25, or equivalent		*R110	Same as R101	
INDICATING DEVICES			TRANSFORMERS		
I101	Lamp; 6-8 volts, Type No. 44; miniature bayonet base		T101	Power primary: 115 volts 50/60 cycles; secondary No. 1: 800/400 volts, 0.130 amp; secondary No. 2: 160 volts, 0.1 amp; secondary No. 3: 6.3/3.15 volts, 8.0 amps; secondary No. 4: 6.3/3.15 volts, 2.5 amps; secondary No. 5: 5.0 volts, 3.0 amps	M-7479625
IX101	Dial light socket; dark red translucent jewel; Dial Light Co. Cat. No. 95410-192D, or equivalent	K-7117809-P5			
COIL			TUBES		
L101	Reactor; 10 henries min. inductance at 125 amps d-c, 173 ohms d-c resistance	M-7479626	V101	Type 5V4G	
			*V102	Type 6B4G	
RESISTORS			*V103	Same as V102	
*R101	Composition, 1.0 meg ± 10%, 1/2 watt	P-3R11-P98	V104	Type 6SH7	
*R102	Same as R101		V105	Type OD3/VR-150	
R103	Wirewound, 7,000 ohms ± 10%, 10 watts; Ohmite Type "Brown Devil," or equivalent	K-7117962-P4			

\*This item or equivalent should be obtained from a local radio dealer.



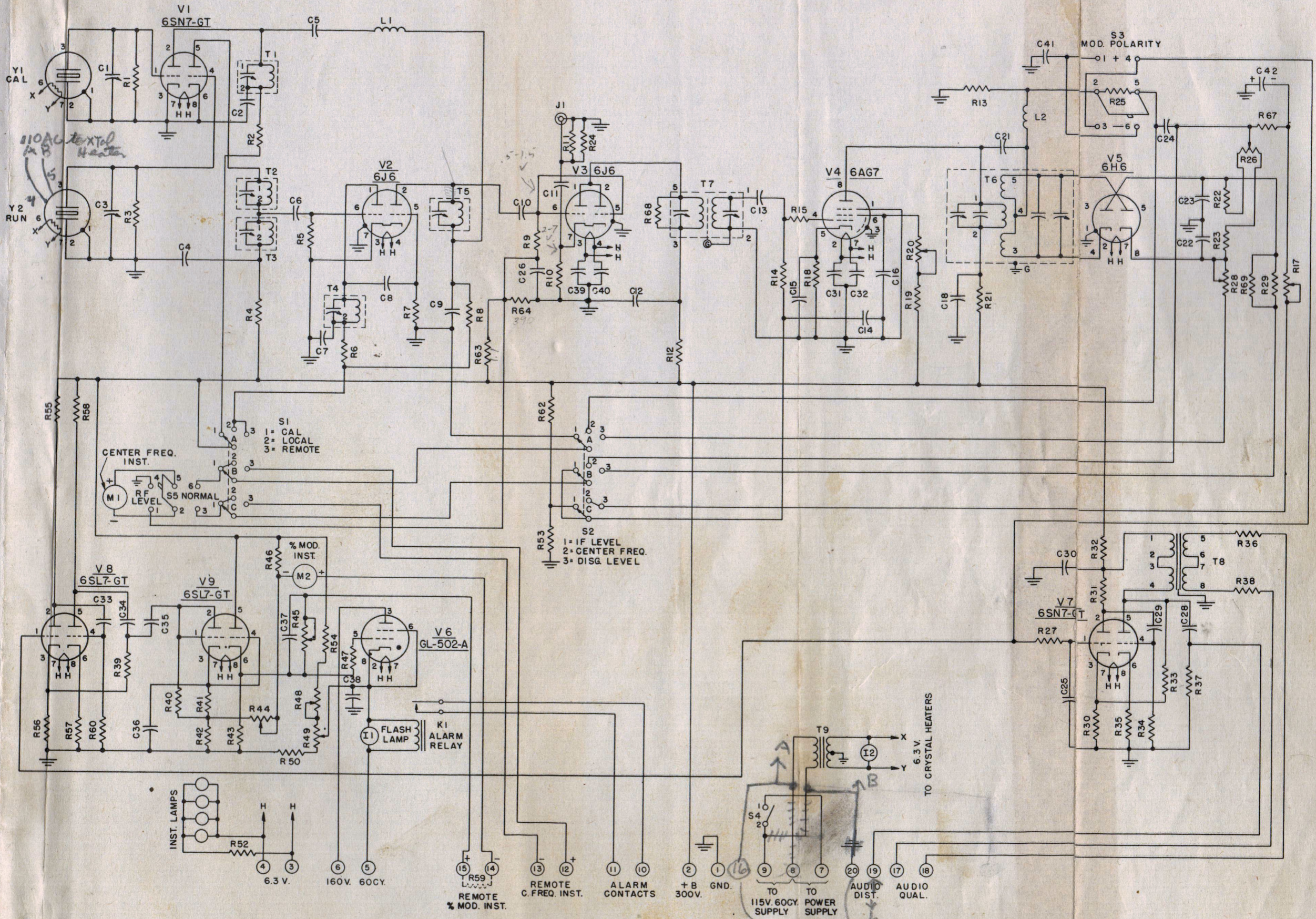


Fig. 8. Indicator Unit, G-E Type BZ-1-A, Elementary Diagram (T-7665039, rev. 2)

115V 60CY  
to XTals