Instructions

250-WATT FM
BROADCAST TRANSMITTER

G-E TYPE BT-1-B

MODEL 4BT1B1

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SYRACUSE, NEW YORK

INSTRUCTIONS

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ELECTRONICS DEPARTMENT
GENERAL ELECTRIC
ELECTRONICS PARK SYRACUSE 1, N.Y.
(In Canada, Canadian General Electric Company, Ltd., Toronto, Ont.
Outside the U.S.A., and Canada, by: International General Electric
Company, Inc., Electronics Dept., Schenectady, New York, U.S.A.)

5-49 (450)

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IMPORTANT

It is highly recommended that a schedule for routine preventive maintenance be set up and followed. The frequency of inspections may vary with different components and with operating conditions.

Some maintenance, such as inspection for accumulated dust, should probably occur daily, while other checks and adjustments need be made only weekly, monthly, or quarterly. Where uncertainty exists, it is recommended that checks be made at frequent intervals at first. Experience will then indicate what frequency of inspection and maintenance is necessary.

Refer to MAINTENANCE section.

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SAFETY TO HUMAN LIFE

Since the use of high voltages which are dangerous to human life is necessary to the successful operation of the FM broadcast transmitting equipment covered by these instructions, certain reasonable precautionary measures must be carefully observed by the operating personnel during the preliminary test and the operation of the equipment.

Major portions of the equipment are within a shielded enclosure provided where necessary with access doors which are generally fitted with safety interlock switches serving to shut off dangerous voltages within the enclosure when the access door is opened.

While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

1. KEEP AWAY FROM LIVE CIRCUITS.

Under no circumstances should any person be permitted to reach within or in any manner gain access to the enclosure with interlocked doors closed (or with power supply line switches to the equipment closed); or to approach or handle any portion of the equipment which is supplied with power; or to connect any apparatus external to the enclosure to circuits within the equipment; or to apply voltages to the equipment for testing purposes while any noninterlocked portion of the shielding or enclosure is removed or opened.

2. DON'T SERVICE OR ADJUST ALONE.

Under no circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

3. DON'T TAMPER WITH INTERLOCKS.

Under no circumstances should any access gate, door or safety interlock switch be removed, short-circuited, or tampered with in any way, nor should reliance be placed upon the interlock switches for removing voltages from the equipment.

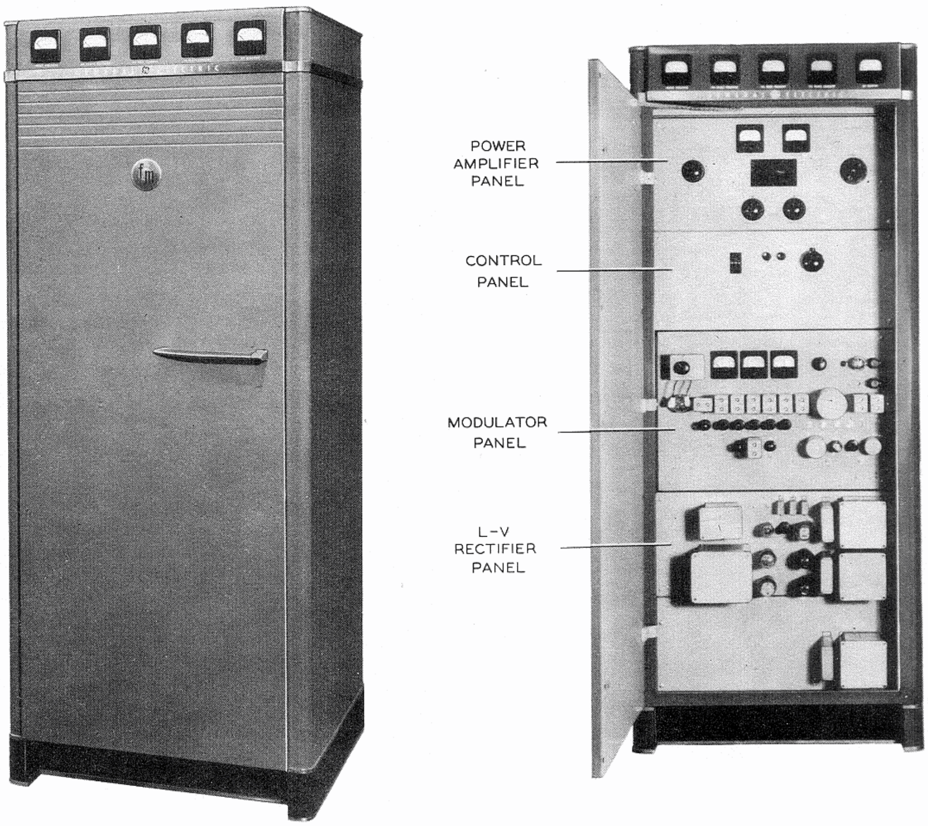

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Fig. 1 Front Views, Door Closed, and Door Open (Sub-Assemblies Identified)

250-WATT FM
BROADCAST TRANSMITTER
TYPE BT-1-B
MODEL 4BT1B1

EXPLANATORY

The 250-Watt Frequency-Modulation Broadcast Transmitter, General Electric Type BT-1-B, Fig. 1, embodies direct crystal control, plus "straight-through" operation with frequency multipliers only, obtained by use of a modulation system based on the Phasitron tube. This method of modulation permits the full realization of all the advantages of frequency-modulation broadcasting.

The use of the Phasitron modulation system completely segregates the two basic functions of frequency control and modulation. There is no more accurate method of controlling frequency than by the use of a stable temperature-controlled quartz crystal oscillator. The separation of the modulation process from frequency control leads to refinements in frequency-modulation broadcasting equivalent to those obtained in standard AM broadcasting when the functions of frequency control and modulation were divorced in that field.

This Transmitter has been designed for broadcast installations where a large primary service area is not essential. Where more extensive coverage is required, the Type BT-1-B Transmitter serves as an exciter for a General Electric 1-Kilowatt or 3-Kilowatt Frequency-Modulation Amplifier.

EQUIPMENT FURNISHED

The following units comprise a standard equipment:
One Model 4BT1B1 Transmitter (Type BT-1-B).
Two sets of vacuum tubes, each set consisting of:

(1) 6AG7
(1) 6SN7
(1) GL-5593
(9) 6SJ7
(1) 6V6
(1) GL-815
(2) GL-866-A
(1) GL-829-B
(2) GL-5D24 or 4-250A
(2) 6H6
(2) 5R4GY
(3) 6B4G
(1) OC3/VR105

Two crystal Thermocell* units, G-E drawing M-7478021.

A cabinet heater, G-E Model 4FH1A1, is available on separate order for use when the Transmitter is situated in humid locations.

*Registered U.S. Patent Office.

ELECTRICAL SPECIFICATIONS

CARRIER POWER OUTPUT—250 watts

CARRIER-FREQUENCY RANGE—88 to 108 mc/s

CARRIER-FREQUENCY STABILITY—Within ±1000 cycles over normal room-temperature range

FM CARRIER-NOISE LEVEL—65 db below ±75 kc swing, unweighted

AM CARRIER-NOISE LEVEL—50 db below 100 per cent amplitude modulation, unweighted

R-F LOAD CHARACTERISTICS—The r-f output coupling circuit is designed to operate into a load whose electrical characteristics are those of a coaxial transmission line of 51.5 ohms surge impedance, in which the voltage standing-wave ratio is not more than 1.75 to 1 at any one carrier frequency in the FM broadcast band. Provisions are made for the use of a single ⅞-inch coaxial transmission line having a surge impedance of 51.5 ohms.

MODULATION CAPABILITY—±100 kc carrier swing, 50 to 15,000 cycles with less than 3 per cent RMS distortion

A-F INPUT LEVEL—+10 dbm ±2 db required for 100 per cent modulation at 400 cycles; input impedance, 600/150 ohms, balanced or unbalanced

A-F RESPONSE—Within ±1 db of FCC pre-emphasis standard from 50 to 15,000 cycles

A-F HARMONIC DISTORTION—Less than 1.5 per cent rms for any single modulating frequency from 50 to 15,000 cycles and less than 1 per cent rms from 100 to 7500 cycles at a carrier swing up to ±75 kc

POWER SUPPLY—208/230 volts, 50/60 cycles, single-phase. A continuously variable input voltage control makes it possible to operate with any power supply voltage in the range of 195–245 volts. In addition, a very small amount of power (approximately 3.5 watts) is required from the station lighting supply at 115 volts for the crystal Thermocell* heater.

POWER INPUT—Approximately 1.3 kw at 90 per cent power factor

CONSTRUCTION

The G-E Type BT-1-B Transmitter (Fig. 1) is completely self-contained in a G-E styled steel cabinet finished in blue and trimmed with stainless steel. The cabinet provides radio-frequency shielding as well as high-voltage protection to station personnel. Access to the interior of the cabinet is gained through full-length doors at both front and rear.

The front door is not interlocked and may be opened anytime during operation, thus making available any normally needed tuning controls. The entire panel front, including controls, is "dead."

The rear door has two interlocks, plus an automatic high-voltage grounding switch. The interlocks remove power from the primaries of the two rectifier plate transformers.

All tuning controls requiring fine adjustment are driven by vernier dials.

Five instruments are mounted on the top front of the Transmitter cabinet (Fig. 2). Progressing from left to right they are: INPUT VOLTAGE, PA PLATE VOLTAGE, PA GRID CURRENT, PA PLATE CURRENT, and RF OUTPUT. The last instrument indicates relative r-f transmission line voltage. In addition, five other instruments are mounted on the front panels for tuning ease.

Shield covers can be removed easily and quickly for inspection and maintenance of shielded parts.

INSTALLATION

Upon receiving and unpacking the Transmitter give it a thorough inspection for possible shipping damage. Report any damage or shortages to the transportation company immediately.

Inspect all relays before power is applied to the Transmitter. Armatures should move freely making or breaking all contacts as the case may be. Detailed and careful inspection at this point for possible damage during packing and shipping may prevent trouble and subsequent part replacement after power has been applied.

Requirements and information for installation are given on the Installation Drawing, Fig. 33. The actual power requirements are given in the ELECTRICAL SPECIFICATIONS section above.

*Registered U.S. Patent Office.

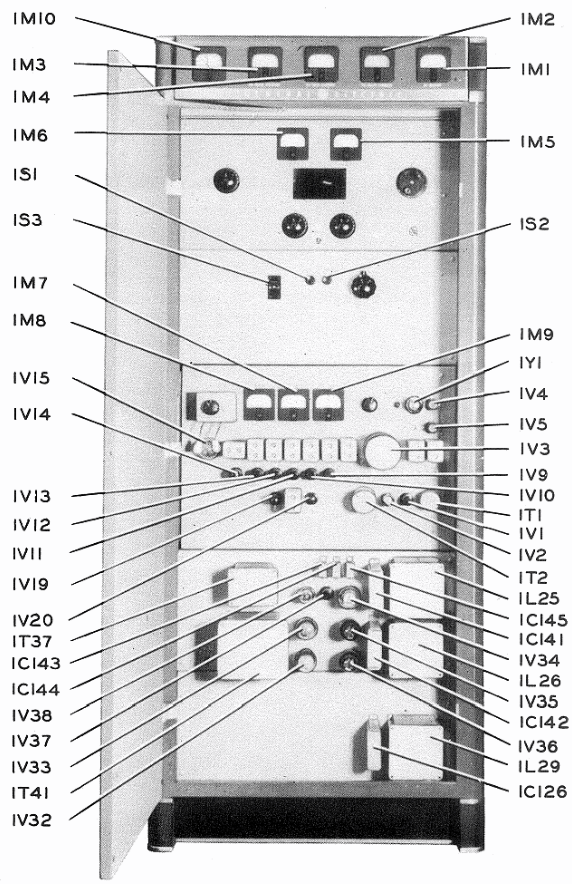

Fig. 2 Front View, Door Open, Parts Identified

Check that the Transmitter audio input agrees with the station requirements. Either 600 or 150 ohms, balanced or unbalanced, input impedance is available as selected by toggle switches located on the pre-emphasis box in the lower left of the Transmitter, as viewed from the rear. The audio input connections for balanced and unbalanced operation differ; make connections as shown on Fig. 33.

If desired, the pre-emphasis unit may be removed from the Transmitter cabinet and located elsewhere. Do not change the setting of potentiometers 1R195 and 1R196. If a limiting amplifier is used, the pre-emphasis network preferably should be connected ahead of it. In the event that a limiting amplifier is inserted between the pre-emphasis unit and the modulator audio input terminals, the following requirements must be met by the amplifier: input impedance, 600 ohms or less, balanced, ungrounded CT; output impedance, 600 ohms, balanced ungrounded CT. Reference to the Elementary Diagram, Fig. 34, will provide information on connections to be made to TB-14 of the pre-emphasis unit and TB-15 of the Transmitter when a limiting amplifier is used. Two-conductor No. 18 shielded twisted pair wire, G-E Type FA-19-H or equivalent should be used between units. Covered wire is preferred since it allows grounding at one point. Refer to the section of the Limiting Amplifier Instruction Book, GEI-24308B, on "Use of Limiting Amplifier in FM Systems" for specific operating conditions.

After the Transmitter is located and ready for operation (except for the actual application of power), install a complete set of tubes and one crystal. All tubes are installed from the front except the following:

- One Type GL-829-B intermediate power amplifier, p-a chassis
- Two Type GL-5D24 or 4-250A power amplifiers, p-a chassis
- Two Type GL-866-A high-voltage rectifier tubes on cabinet floor
- One Type 6H6 r-f voltmeter diode located just below the p-a chassis on the left side of the cabinet, from the rear

IMPORTANT

The Transmitter as supplied is connected for 60-cycle operation. For 50-cycle operation, change the following two internal connections.

1. Remove the red wire from terminal 5 on 1T33 and place it on terminal 4. 1T33 is the center transformer of the vertical bank of three located on the lower right side of the cabinet, viewed from the rear. (The blue wire should be left on terminal 5.)

2. Remove the pair of wires for 1BM1, the cabinet-cooling blower located on the roof, that go to 1TB2-1 and place them on 1TB2-2. 1TB2 is located on the roof several inches to the right of the blower, viewed from the rear.

Secure the plate connectors for the power amplifiers, 1V28 and 1V29, by tightening the $\frac{5}{64}$-inch Allen-head set screws with one of the wrenches furnished. These will be found at the top rear center of the p-a chassis.

Install the front-of-panel tubes in accordance with the type called for by the socket label. To install the Type GL-5593, merely pull off the shield, insert the tube in the socket, and replace the shield over the tube and modulation coil.

Before applying power to the Transmitter, throw the Power switch on the Transmitter control panel to OFF. Upon application of the 115-volt crystal heater power, observe that the green indicator light at the upper right corner of the modulator panel glows. After a short warm-up time the light should cycle off and on, indicating that the Thermocell* unit has reached operating temperature.

OPERATION

The following describes the proper method of placing the Transmitter in operation the first time after installation. The procedure is based on the assumption that the Transmitter modulator has been tuned completely at the factory, to the proper frequency. Because dial tuning controls probably will not be in the proper position, their tuning is included. Adjustment of certain other controls is also covered, because the setting of these controls may be affected by installation of tubes other than those used during test.

In no case should any controls be adjusted which are not mentioned specifically in this section. The adjustment of such controls is covered in a later section of this book under MAINTENANCE.

Remove the wire from terminal 3 of transformer 1T46. This is the p-a plate transformer located at the bottom right of the Transmitter, viewed from the rear. Also remove the i-p-a tube, Type GL-829-B.

CAUTION

Be sure the primary lead is removed from terminal 3 of 1T46.

*Registered U.S. Patent Office.

PRELIMINARY ADJUSTMENTS

Regulated supply voltage—Approximately 30 seconds after applying power the green PLATE ON push button should light, provided the rear door interlocks are closed.

Connect a test voltmeter to measure 250 volts d-c between test jack 1J6 and ground. 1J6 is located on the low-voltage power supply panel, second panel from the bottom. Push the green PLATE ON button.

The red PLATE OFF button should light and the plate contactor should close. Primary voltage is now applied to the low-voltage supply plate transformer, 1T41. The voltmeter reading should be 250 ±2 volts. If not, adjust 1R180 (a screwdriver control on the low-voltage supply panel) until a reading of 250 volts is obtained. The VOLTAGE INDICATOR meter reading when the SELECTOR SWITCH is in position 15 is proportional to this voltage and may be used to indicate any change from the correct value.

NOTE

During this time, if the i-p-a Type GL-829-B tube has not been removed, it may operate at slightly overrated plate dissipation before the circuits are properly adjusted. Therefore, its removal has been directed previously.

Remove the test voltmeter.

TUNING

During the following tuning procedure keep the INPUT VOLTAGE at 200 volts by means of powerstat 1T35.

Adjust the 815 PLATE TUNING control for minimum 815 CATHODE current. Then push the red PLATE OFF button. Open the rear door and reinstall the Type GL-829-B tube. Close the door and push the PLATE ON button.

Immediately adjust IPA GRID TUNING for maximum IPA GRID current and adjust IPA PLATE TUNING for minimum IPA CATHODE current. Retune 815 PLATE TUNING for maximum IPA GRID current. Proceed to PA GRID TUNING and adjust for maximum PA GRID current. When this current reaches approximately 6 to 8 milliamperes a distinct click will be heard as relay 1K6 energizes and closes surge-resistor-shorting relay 1K5.

At this time the 829-B IPA may be accurately neutralized if desired. Carefully tune IPA PLATE TUNING through IPA CATHODE current dip, meanwhile observing IPA GRID current. The maximum value of grid current should occur at plate dip if neutralization is accurate. To neutralize, loosen the screw holding moveable plate of capacitor 1C110 and swing it toward or away from the 829-B tube.

With the panel screwdriver COUPLING control, adjust the coupling between i-p-a plate and p-a grid for approximately 11 milliamperes* p-a grid current. Retune IPA PLATE TUNING for minimum IPA CATHODE current and PA GRID TUNING for maximum PA GRID current (RF transmission line connected and loosely coupled to final). Then vary PA PLATE TUNING, from one end of its range to the other, if necessary, until a point is reached where a definite reaction is produced in the PA GRID current.

This reaction indicates undesirable coupling through the p-a tubes between the plate and grid circuits. This coupling may be minimized or "neutralized" by proper adjustment of the PA SCREEN ADJ control. Such adjustment is made as follows:

Using the panel screwdriver control tune PA SCREEN ADJ until the reaction on the PA GRID current from PA PLATE TUNING is at a minimum. The effect cannot be eliminated entirely, but ought to be no more than a division or two. The PA SCREEN ADJ control is somewhat critical and the adjustment should be made methodically in small intervals. After arriving at a point of minimum reaction, readjust PA GRID TUNING for maximum PA GRID current. If an appreciable change has occurred in the tuning point, the PA SCREEN ADJ will require slight retuning for restoration of minimum reaction on PA GRID with PA PLATE TUNING.

Finally, leave PA PLATE TUNING at the point where it produces grid current reaction since this is the point of plate resonance. Adjust COUPLING for 11 milliamperes p-a grid current; touch up IPA PLATE TUNING and PA GRID TUNING.

Push the PLATE OFF control, open the rear door, and connect the primary wire, which had previously been removed from terminal 3 of 1T46 and connect to terminal 5. This is the 50 per cent tap and yields about one-half normal p-a plate voltage, or approximately 1300 volts. (This is a temporary connection; merely slip the terminal over the stud.) Close the rear door.

Observe through the p-a panel window and set OUTPUT COUPLING to minimum.

Push the PLATE ON control. Adjust PA PLATE TUNING for minimum PA PLATE CURRENT of about 50 to 75 milliamperes. Then gradually increase OUTPUT COUPLING, keeping the p-a plate in tune, until the p-a is loaded to about 100 milliamperes. Bad detuning of the p-a plate with increase in coupling indicates an improper load that reflects appreciable reactance into the p-a plate circuit.

Now make a check of correspondence between maximum PA GRID CURRENT and minimum PA PLATE

* It will not be possible to obtain this magnitude if the p-a screen capacitor is too far out of adjustment and the p-a plate happens to be tuned to resonance. If 11 milliamperes cannot be obtained, adjust PA PLATE TUNING slightly and note the effect on p-a grid current. It will probably increase appreciably.

CURRENT by varying PA PLATE TUNING through resonance. If grid current maximum does not occur at plate current minimum adjust slightly PA SCREEN ADJ until these conditions occur simultaneously. The direction of adjustment must be determined by trial; keep the increments of adjustment small.

After being satisfied that the p-a is properly "neutralized," push the PLATE OFF control, open the rear door, and move the primary wire to terminal 3 of 1T46. (Terminal 2 is a 110 per cent, and terminal 4 is a 90 per cent tap; terminal 1 is common to all taps.) Close the door, push the PLATE ON control and adjust PA PLATE TUNING for minimum PA PLATE CURRENT. The p-a should now be loaded somewhere around 200 milliamperes.

PA LOADING

Calculate the "transmission line input power required" as follows:

$$\frac{\text{EFFECTIVE RADIATED POWER}}{\text{ANTENNA POWER GAIN} \times \text{TRANSMISSION LINE EFFICIENCY}}$$

Then calculate the "p-a plate input power required" as follows:

$$\frac{\text{TRANSMISSION LINE INPUT POWER REQUIRED}}{\text{PA PLATE EFFICIENCY}}$$

The "p-a plate efficiency" is obtained from the curve, Fig. 3, for the particular carrier frequency.

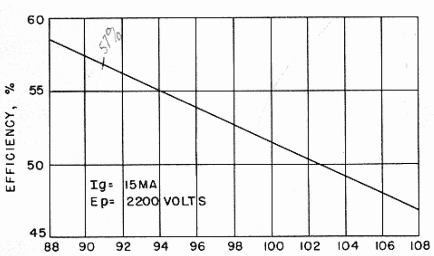

Fig. 3 Power-Amplifier Efficiency Curve (250-Watt Output)

Load the power amplifier by adjusting OUTPUT COUPLING until: PA PLATE VOLTAGE (kv) × PA PLATE CURRENT (ma) equals the "p-a plate input power required."

The p-a loading requirement may be summarized into a single formula as follows:

$$\text{PA PLATE CURRENT (ma)} = \frac{\text{EFFECTIVE RADIATED POWER}}{\text{PA EFF.} \times \text{TRANSMISSION LINE EFF.} \times \text{ANTENNA POWER GAIN} \times \text{PA PLATE VOLTAGE (kv)}}$$

After each change in OUTPUT COUPLING adjust PA PLATE TUNING for minimum PA PLATE CURRENT.

The PA GRID CURRENT should finally be set to approximately 15 milliamperes by adjusting the COUPLING control. This will slightly affect p-a loading, with consequent required adjustment of OUTPUT COUPLING, which in turn will cause a slight change in PA GRID CURRENT. Therefore several minor readjustments will have to be made.

RF OUTPUT METER ADJUSTMENT

This meter reading is adjusted by means of 1C131, whose screwdriver control is available from the rear of the Transmitter in the small box secured just at the transmission-line input. By trial and error adjust 1C131 until RF OUTPUT indicates 100. Slight effects on p-a loading must be compensated for by OUTPUT COUPLING adjustment.

MONITORING ADJUSTMENTS

If the station monitor (the FM Station Monitor, G-E Type BM-1-A, is recommended) is in operation it should be indicating carrier frequency deviation. By means of 1C10, located in the upper right of the modulator panel, from the front, compensate the crystal frequency (using an insulated screwdriver) until the station-monitor indicates the carrier frequency to be well within the FCC tolerance.

If the r-f input level to the monitor requires adjustment, bend the monitor pick-up loop, 1L15, forward or backward as required. "Forward" increases the level and "backward" decreases it. 1L15 is located near the p-a plate tank.

DISCRIMINATOR CHECK (1T16)

Place the SELECTOR SWITCH in position 17. If the VOLTAGE INDICATOR reads within ±25 of zero, tuning adjustment of the secondary of 1T16 may be considered satisfactory. If the reading is outside these limits or if better zero adjustment is desired, proceed as follows: With a well-insulated screwdriver, adjust the *lower* control (secondary) of 1T16 until the VOLTAGE INDICATOR reads zero. Be careful to avoid overadjustment. Only a very small adjustment is necessary.

After modulation signal is applied to the Transmitter (see below), modulate the Transmitter 100 per cent at 50 cycles. Then tune the primary (*upper* control) of 1T16 until the station monitor indicates

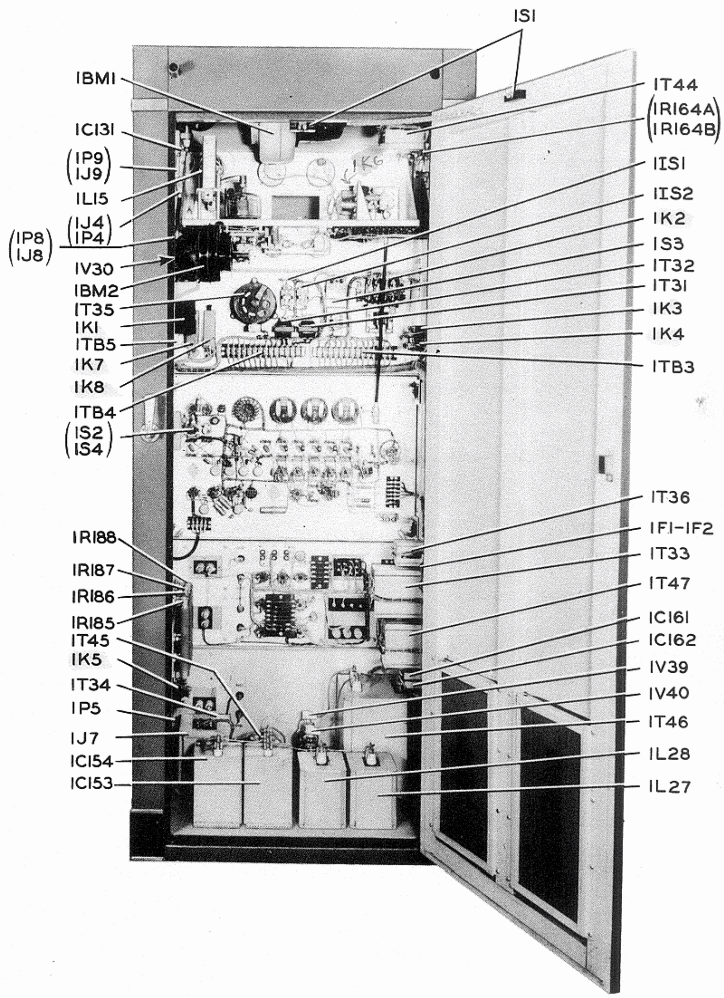

Fig. 4 Rear View, Door Open, Parts Identified

minimum modulation, which corresponds to maximum feedback.

Alternatively, the primary may be tuned for maximum deflection of the VOLTAGE INDICATOR, with the SELECTOR SWITCH on position 17, after the secondary has been tuned off slightly to give an initial deflection. However, the first method (tuning the primary for minimum modulation) is considered the more accurate.

MODULATION

The Transmitter is now ready for modulation. The monitor should indicate 100 per cent modulation with an audio input level to the Transmitter between 8 and 12 dbm, at 400 cycles per second, pure sine wave. The input level required at 15,000 cycles, sine wave, is 17 db less than that required at 400 cycles (pre-emphasis in transmitter). 1R2 controls gain through the modulator.

DATA

For future reference, record all dial settings and meter readings, including positions 1 to 16 of the SELECTOR SWITCH on the VOLTAGE INDICATOR meter located on the modulator panel.

MAINTENANCE

TROUBLE PREVENTION

It is important to consider maintenance from a preventive standpoint rather than from the angle of trouble-shooting.

Hence, routine maintenance involves periodic inspection with immediate repair where needed for avoidance of future trouble. If there is not time for such preventive repair when its need is found, record the work to be done and get at it as soon as possible.

During inspection notice the condition of various parts and sections of the Transmitter, especially as to cleanliness. Clean where needed. Make routine inspections of all relay contacts and of the carbon brush on the variable transformer, 1T35.

Check for loose components and loose connections at terminal boards.

On a regular schedule remove and test all receiver type tubes in a reliable tube checker. Replace any marginal tubes.

Note the readings of all meters, including the 17 readings of the VOLTAGE INDICATOR, daily, and compare to previous readings. A certain amount of day-to-day variation may be expected but any trend is cause for suspicion. For instance, if the p-a plate current should drop slightly day by day, chances are that one or both p-a tubes are losing emission.

Since the tubes operate in a chain, a trend in one meter reading may correspond to a similar trend further up or down the chain. Any difficulty then probably lies in the tube or circuit lowest in the chain.

TROUBLE-SHOOTING

Despite the most thorough maintenance procedure, trouble sometimes may occur suddenly at inconvenient times. Should this happen, remain calm, for methodical methods and clear thought will solve the problem quickest.

First of all observe the meter readings. Remember the chain idea. The fault most likely lies in the tube, or circuit, lowest in the chain, having an abnormal meter reading.

The 17 position readings of the VOLTAGE INDICATOR meter are identified here by SELECTOR SWITCH position number.

1. Cathode voltage, first audio tube, 1V1, Type 6SJ7.
2. Cathode voltage, first section of second audio tube, 1V2, Type 6SN7-GT.
3. Cathode voltage, second section of second audio tube, 1V2, Type 6SN7-GT.
4. Cathode voltage, crystal amplifier, 1V5, Type 6SJ7.
5. Neutral-plane voltage, Phasitron, 1V3, Type GL-5593.
6. First-focus voltage, Phasitron, IV3, Type GL-5593.
7. Second-focus voltage, Phasitron, 1V3, Type GL-5593.
8. Deflector voltage, Phasitron, 1V3, Type GL-5593.
9. Cathode voltage, first doubler, 1V9, Type 6SJ7.
10. Grid voltage, second doubler, 1V10, Type 6SJ7. Indicates drive from previous stage (first doubler, 1V9, Type 6SJ7).
11. Grid voltage, third doubler, 1V11, Type 6SJ7. Indicates drive from previous stage (second doubler, 1V10, Type 6SJ7).
12. Grid voltage, first tripler, 1V12, Type 6SJ7. Indicates drive from previous stage (third doubler, 1V11, Type 6SJ7).

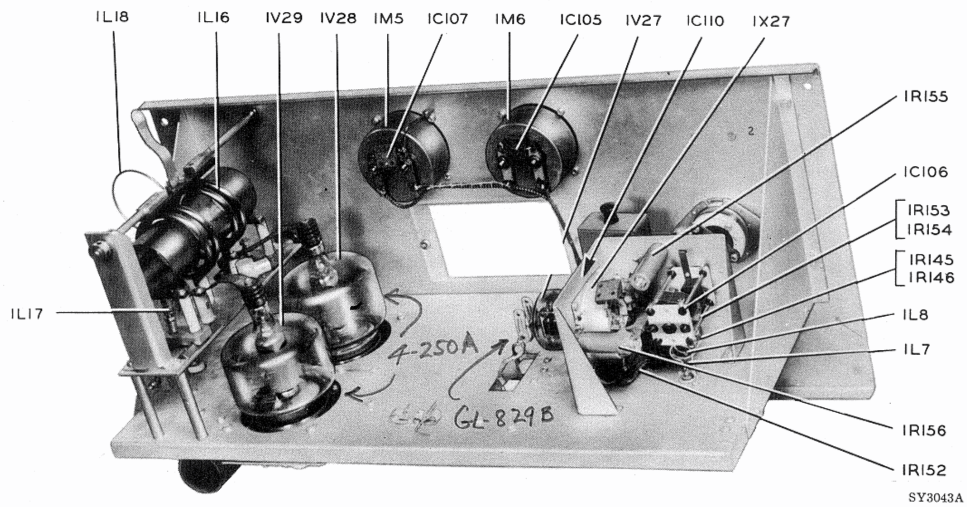

Fig. 5 Power-Amplifier Panel, Rear View, Parts Identified

13. Grid voltage, second tripler, 1V13, Type 6SJ7. Indicates drive from previous stage (first tripler, 1V12, Type 6SJ7).
14. Grid voltage, fourth doubler, 1V14, Type 6SJ7. Indicates drive from previous stage (second tripler, 1V13, Type 6SJ7).
15. Regulated voltage supply.
16. Cathode voltage feedback amplifier, 1V19, Type 6AG7.
17. Discriminator, 1V20, Type 6H6, d-c output voltage.

After isolating the troublesome tube or circuit by means of meter observations, replace the tube whose operation is monitored by this indication. Should the same condition remain, a bad connection or component may be at fault. Refer to the Elementary Diagram, Fig. 34. Check continuity to the various socket terminals or voltages on the panel sockets. Check the resistors associated with the stage, and finally replace capacitors if necessary.

In cases where operation seems normal despite an unusual meter reading, check the meter.

CAUTION

Never tune any of the modulator coupling transformers without first referring to the discussion TUNING THE MODULATOR INTERSTAGE COUPLING TRANSFORMERS on page 14.

A comment is in order here on the small black-on-white numbers located variously on the modulator panel and on the low-voltage power supply panel. These numbers correspond to the voltage indicator SELECTOR SWITCH positions. They are located at the controls that affect the VOLTAGE INDICATOR reading with the SELECTOR SWITCH in the similarly-numbered position. For example, consider position 10. The number 10 also appears on 1T10, which is the coupling transformer from the first doubler, 1V9, to the second doubler, 1V10. Tuning of this transformer affects the drive, and hence the grid voltage, of the second doubler, 1V10. This grid voltage is indicated in position 10.

REPLACING A PHASITRON, TYPE GL-5593

The low-frequency distortion of the system is inherently a function of the Phasitron, for low audio frequencies require the greatest phase shift. The Phasitron distortion is dependent upon all its electrode voltages and upon the tuning of phase-splitting transformers 1T3 and 1T4.

Failure of a Phasitron may be anticipated by observing the VOLTAGE INDICATOR reading at position 10 of the SELECTOR SWITCH. The tube should be replaced if this reading falls to 80 per cent of its original value. The replacement may then be made during a normal maintenance period.

Upon replacing the Phasitron, only a single, simple readjustment is necessary. Place the SELECTOR SWITCH in position 10. Then adjust the 1ST FOCUS control for maximum indication on the VOLTAGE INDICATOR.

In addition, it may be desirable to check that the VOLTAGE INDICATOR readings in positions 5, 7, and 8 are the same as previously recorded. If they are not, readjust the corresponding controls, NEUTRAL PLANE, 2ND FOCUS, and DEFLECTOR, until the VOLTAGE INDICATOR readings agree with previous values.

Any of the adjustments listed above may be made during operation.

The Transmitter distortion guarantee will be met under the above replacement conditions. Lower low-frequency distortion could probably be obtained by readjustment of 1T3 and 1T4, and of 2ND FOCUS, NEUTRAL PLANE, and DEFLECTOR to values other than "standard." The phasing adjustment of 1T3 and 1T4 is set to "standard" in factory test, as are the settings of 2ND FOCUS, NEUTRAL PLANE, and DEFLECTOR. The last three voltages can always be returned to "standard" (their originally recorded readings) even after any adjustment. However, the readjustment of 1T3 and 1T4 to standard, if once misadjusted, requires special equipment. Therefore, *it is recommended that adjustment of 1T3 and 1T4 never be made;* to do so may destroy the desirable feature of Phasitron interchangeability. Naturally, with distortion measuring equipment, adjustment can always be made to within guaranteed limits; but tube interchangeability requires standard adjustment of 1T3 and 1T4.

The standard voltages applying to NEUTRAL PLANE, 2ND FOCUS, and DEFLECTOR are, respectively, 30, 50, and 60 volts d-c. The voltages actually applied to the Phasitron may be checked and adjusted by use of a high impedance d-c voltmeter covering the above range. Connect the voltmeter to 1X3-2, and adjust NEUTRAL PLANE for 30 volts; then connect the voltmeter to 1X3-7, and adjust 2ND FOCUS for 50 volts; similarly set the voltage at 1X3-3 for 60 volts with the DEFLECTOR control. The VOLTAGE INDICATOR readings in positions 5, 7, and 8 of the SELECTOR SWITCH are proportional to these three voltages, respectively. For future reference record the readings.

REPLACING OTHER TUBES

All receiving-type tubes including those in the modulator, may be replaced without any circuit adjustment required. The same is true for replacement of any rectifier-type tube.

Should the Type OC3/VR105 tube be replaced, the regulated voltage may change and a readjustment of 1R180 may be required to return voltage to 250 volts. (Insert test meter at 1J6 on modulator panel.)

Replacing the Type GL-815, GL-829-B, or GL-5D24 (or 4-250A) tube may require slight retuning of the grid and plate circuits and some reneutralizing of the PA.

REPLACING THE CRYSTAL

In case of crystal failure, the spare crystal may be inserted immediately, even though "cold." The carrier frequency will be within FCC tolerance within three minutes or less.

When the crystal heater pilot light cycles on and off, indicating operation of the Thermocell* unit, the crystal is at operating temperature. The carrier frequency should then be adjusted to zero deviation on the FM station monitor (using an insulated screwdriver) by means of compensating capacitor 1C10.

REPLACING A CABINET METER

Access to the cabinet meters is gained by removal of the protective shield located below the meters slightly above the top of the front door opening. This shield is prevented from being pushed up by the stop screws at the rear and by a horizontal groove at the front.

The stop screws are removable from the rear of the cabinet. They are located just above the upper lip of the p-a panel, several inches in from each end. Remove them with a screwdriver.

Push up the rear edge of the protective screen until the front edge leaves the groove. The shield now can be dropped down and out.

The meters are secured by four screws, one in each corner, which clear through holes in the cabinet and tap into brass inserts in the meter case. Remove the screws with a short screwdriver after disconnecting the meter leads.

The PA PLATE CURRENT meter actually is mounted behind the cabinet front, with a dummy meter front outside the cabinet. This mounting is used for safety reasons, since the plate current meter runs at p-a plate voltage (about 2200 volts) above ground. The meter case itself has clearance holes, and the studs extend through these, through cabinet clearance holes, and into the dummy front.

INPUT VOLTAGE-ADJUSTING TRANSFORMER BRUSH

Periodic inspection should be made of this brush. If dirt or burning is indicated, clean the brush with fine sandpaper, never emery paper. Replace the brush if necessary.

* Registered U.S. Patent Office.

BLOWER MOTORS

Routine maintenance of the cabinet cooling blower motor (1BM1) calls for annual dismantling and thorough cleaning of the bearings and housings. The bearings should then be repacked with G-E ball bearing grease or other ball bearing grease recommended by competent lubricant distributors. G-E grease is available in bulk or in tubes from G-E distributors.

DISASSEMBLY

To disassemble the blower proceed as follows:

1. Remove all power to the blower circuit and disconnect the internal leads from the terminal board on the blower shock mount plate.
2. Remove the blower and shock mount plate from the cabinet by removing the four screws which extend through the shock mounts.
3. Disconnect the motor power leads from the terminal board.
4. Remove the motor from the shock-mount plate by removing the nuts on the four motor mounting studs.
5. Remove the two flanges on the blower intake by removing the four nuts on the flange mounting studs.
6. Mark the motor shaft and blower impeller hub so that, in reassembling, the impeller can be replaced on the motor shaft in the same axial and angular position.
7. Loosen the two Allen set screws on the blower impeller using a No. ¼-20 Allen wrench and remove the impeller.
8. Loosen the four through bolts at the nameplate end of the motor, using a properly fitting screwdriver.
9. Pull off motor flange with impeller housing attached. Take care not to lose the insulating sleeve on each of the four through bolts.
10. Pull out the armature and end casting at the nameplate end of the motor as far as the switch leads will permit.
11. Remove the four through bolts; be careful not to lose insulating sleeves.
12. One of the screws holding the switch is covered by the nameplate. Drive out (from inside) one of the two escutcheon pins holding the nameplate, and swing the nameplate out of the way.
13. Remove the small screws which hold the switch.
14. Remove the motor end flange.

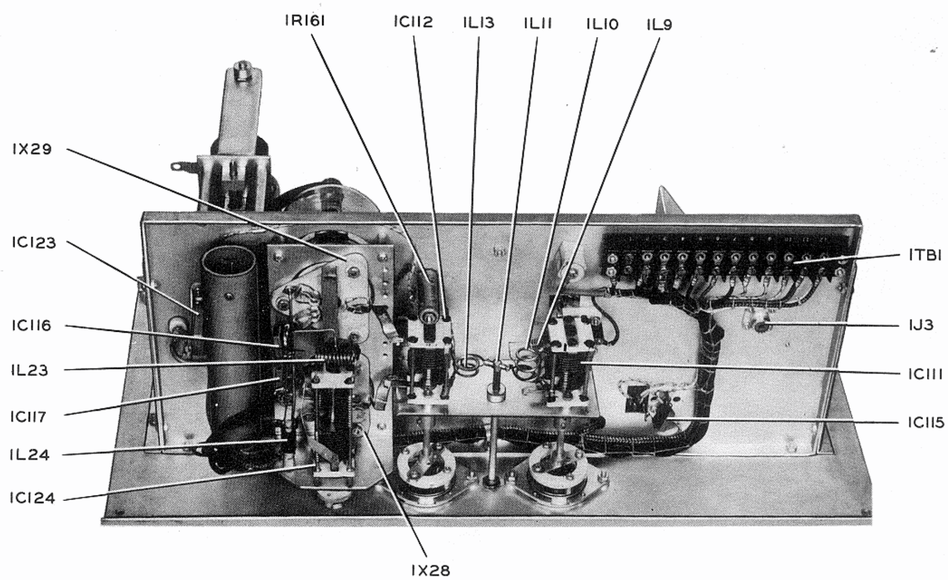

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Fig. 6 Power-Amplifier Panel, Bottom Rear View, Parts Identified

CLEANING AND REPACKING

Clean both bearings and housings with a small stiff brush and carbon tetrachloride. When using this solvent, be careful to remove all traces of it from the bearing housing and do not allow it to remain in contact with the insulated windings. The room should be well ventilated while using it.

Repack the bearings with G-E ball bearing grease or other ball bearing grease recommended by competent lubricant distributors. In repacking the bearings, fill the space between the inner and outer races ⅓ full. Be careful not to overgrease. When assembling the bearings in the housings, fill the space back of the housings ⅓ full of grease.

REASSEMBLY

To re-assemble the blower proceed as follows:

1. Replace the two small screws holding the starting switch to the end flange.
2. Prepare to replace end flange. Be sure that the leads are not pinched and that the switch leads do not interfere with the operation of the switch or armature. Replace the four through bolts into the end flange and slip an insulating sleeve on each bolt. The sleeves must insulate between the through bolts and the motor field winding.
3. Replace the end flange. Be sure that the grommet on the power leads is in place.
4. Place the four remaining insulating sleeves on the free ends of the through bolts.
5. Replace the motor flange with fan housing attached and tighten the through bolts.
6. Swing the nameplate back into position and re-insert the escutcheon pin.
7. Replace the impeller on the motor shaft making sure that the axial and angular position are the same as before disassembly.
8. Replace the flanges on the blower housing, making sure that the intake flange with the small hole has the flange projecting inward and that the flange with the large hole has the flange projecting outward.
9. Replace the blower on the shock mounting plate, making sure that the blower exhaust is centered in the hole in the shock-mounting plate and that the blower is positioned square with respect to the mounting plate.
10. Test the blower on the power supply to make sure it runs freely and smoothly.
11. Remount the assembly in the cabinet and connect the power leads as they were before disassembly.

NOTE

Emergency lubrication:

Under normal conditions it is not recommended that the bearings be relubricated between periods of regular servicing in accordance with the instructions given above. The plug in the end flange on the switch end of the motor is provided for unusual needs such as when a few drops of oil need to be inserted to restore grease to suitable condition after long storage, or during overload operation which may require the addition of some grease.

Lubricate the PA tube blower, 1BM2, every 3 months as follows: Add lubrication by removing the two screws and washers located in the edge of the motor end casting and place four or five drops of a good quality motor oil on the wick leading to the bearing.

CLEANING THE AIR FILTERS

The intake air filters, located at the rear door bottom, should be cleaned whenever inspection shows appreciable dust.

Remove them for cleaning by removing the clamping strips, which are held by screws. Be careful of the felt seal. Oiled metal is used as the filter medium. Clean by dipping in gasoline or cleaning fluid, then dip in light lubricating oil (SAE No. 10) and drain face (smooth side) downward. If a vacuum cleaner with spray attachment or a hand-operated spray gun are available, filters may be sprayed with oil rather than dipping per above.

AUDIO PRE-EMPHASIS ADJUSTMENT

Pre-emphasis resistors 1R195 and 1R196 have been adjusted properly at the factory. The procedure outlined below is suitable for readjustment anytime required or desired even for 600 ohms. VU meters calibrated for the proper impedance must be used.

It is assumed that 1R195 and 1R196 are completely out of adjustment. Initially set each at its mechanical center, estimated as closely as possible.

Modulate the Transmitter 100 per cent at 7500 cycles. Note the Transmitter input dbm (or vu) reading. Decrease the modulating frequency to 400 cycles and set the level to the Transmitter exactly 11.2 db higher than the value required for 100 per cent modulation at 7500 cycles.

Adjust 1R195 and 1R196 together (maintain balance) until the monitor indicates 100 per cent modulation.

Recheck that the level required for 100 per cent modulation at 7500 cycles is 11.2 db (or vu) lower than that required for 100 per cent modulation at 400 cycles. The final 100 per cent modulation level required at 400 cycles should fall between 8 and 12 dbm (adjustable at 1R2).

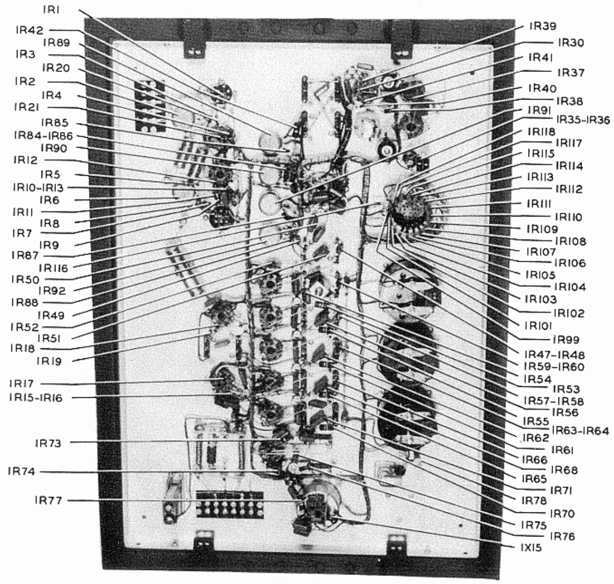

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Fig. 7 Modulator Panel, Rear View, Resistors Identified

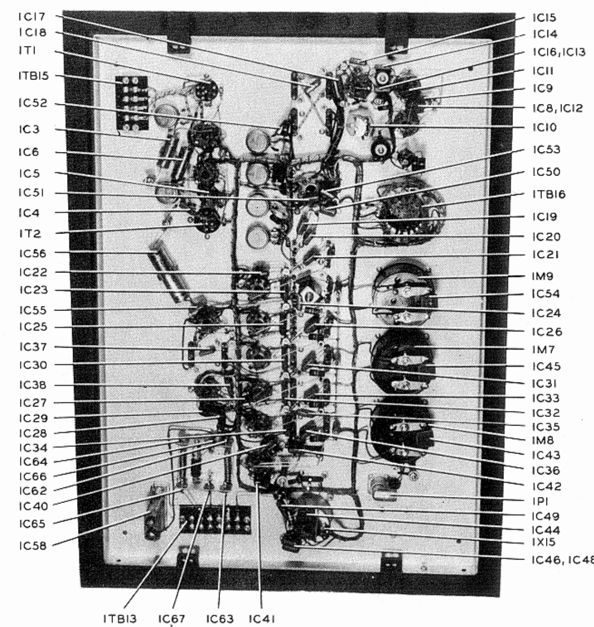

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Fig. 8 Modulator Panel, Rear View, Parts (Except Resistors) Identified

ADJUSTMENT OF 1R6

Potentiometer 1R6 is adjusted for over-all flat audio frequency response (without pre-emphasis). Pre-emphasis may be "removed" by shorting from 1TB17-2 to 1TB14-1, and from 1TB17-4 to 1TB14-3, both of which terminal boards are mounted on the pre-emphasis box. Before adjustment, make a discriminator check as outlined in the paragraph on Discriminator Check in the OPERATION Section, page 6.

Modulate the Transmitter 100 per cent at 50 cycles, noting accurately the audio input level required. Increase the modulating frequency to 5000 cycles, setting the audio input level to exactly the same value as occurred at 50 cycles. Then adjust 1R6 for 100 per cent modulation.

Return to 50-cycle modulation at the same audio input level as previously. If the per cent modulation is 100, adjustment is satisfactory. Otherwise, readjust the audio input level for 100 per cent modulation at 50 cycles, again very carefully noting the input level required. Then again modulate at 5000 cycles with the same input level just noted. Readjust 1R6 for 100 per cent modulation.

If adjustment of 1R6 was considerably in error initially, the process outlined may have to be repeated several times.

MODULATION SENSITIVITY ADJUSTMENT, 1R2

The setting of potentiometer 1R2 is made at the factory such that an audio input level of approximately 10 dbm is required for 100 per cent modulation at 400 cycles. Adjustment of this potentiometer, if accuracy of 100 per cent modulation level is desired, must be done after pre-emphasis adjustment and adjustment of 1R6 (see above), and discriminator check (see page 6).

Adjustment of 1R2 is made by applying to the transmitter audio input terminals (or ahead of pre-emphasis, if the unit is located elsewhere) a 400-cycle signal of desired level, usually 10 dbm. Then adjust 1R2 until the FM Station Monitor indicates 100 per cent modulation.

CARRIER AM HUM ADJUSTMENT

The Transmitter has been adjusted for minimum

of the Transmitter. The shield may be used as the ground wire but should be insulated from the metal cabinet. The shield should be grounded at a diode box mounting screw.

CAUTION

Secure the lead at various points in the cabinet so that it will not come in contact with any high-voltage terminals.

Measure the hum voltage between center conductor and shield with a high-impedance (preferably vacuum tube) voltmeter. The hum level is about 0.03 volt rms, with RF OUTPUT meter reading around 100. Adjust the hum level to a minimum by moving the center tap on resistor 1R163. This resistor is located under the p-a filament transformer, 1T44. This adjustment must be made by repeated trials, since the rear door must be opened for access to the resistor, with r-f carrier consequently off.

If the ratio of hum to carrier is desired, also measure the d-c voltage (about 40 volts) with a 20,000-ohms/volt meter. The ratio is:

$$\frac{\text{HUM LEVEL, RMS, } \times 1.4}{\text{D-C VOLTAGE (RECTIFIED CARRIER)}}$$

The ratio, if multiplied by 100, is percentage AM modulation of the carrier, and has a normal magnitude of about 0.1 per cent or −60 db. The maximum permissible is approximately one-third of one per cent.

TUNING THE MODULATOR INTERSTAGE COUPLING TRANSFORMERS

CAUTION

Use an insulated screwdriver when tuning any of the transformers.

The modulator is completely aligned at the factory and normally no tuning is required. In rare cases, however, it may be necessary to replace or retune an interstage coupling transformer. This transformer must be tuned to produce a flat response symmetrical about a center frequency. Proper tuning cannot be done directly by tuning for maximum indication on the VOLTAGE INDICATOR. The transformers are over-coupled and peak indication does not occur at flat response. If improperly adjusted, distortion of high audio frequencies would result from the ensuing non-

cy responses would be altered. Only in case
me emergency should a transformer be tuned
ximum VOLTAGE INDICATOR reading. Proper
should be made at the first opportunity.
e general procedures are available for tuning
ransformers properly. The first and simplest

for completeness.

Carrier AM hum is measured at the cathode of the r-f voltmeter, Type 6H6, diode, 1V37. Wrap the center conductor of a shielded wire around pin 8 of the Type 6H6 tube and reinstall the tube. The lead may be brought down to and out through the bottom

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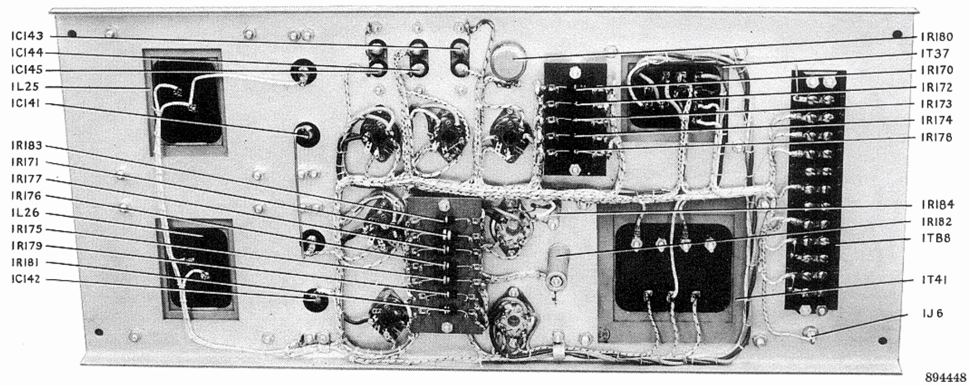

Fig. 9 Low-Voltage Rectifier Panel, Bottom View, Parts Identified

might be known as the *Resistor Loading* procedure. No special test equipment is required. The second is the *Visual Alignment* procedure; and the third is the *Point by Point* procedure. These methods are individually discussed in the following paragraphs.

Resistor-Loading Procedure. The following method makes use of the fact that overcoupled transformers, such as are used in the modulator, may effectively be undercoupled (or less than critically coupled) by adding additional resistance loading. It is then possible to tune the primary and secondary individually for peak response. Otherwise, this cannot be done, for the tuning of one will affect the tuning point of the other.

No special test equipment is needed. Only a 39,000-ohm (approximately) ½-watt resistor is needed for tuning all the transformers except 1T9. For tuning 1T9, two short clip leads and a 10-mmfd capacitor are required.

The procedure is outlined below for 1T9 through 1T15. In case any one transformer is replaced, only it need be tuned.

1T9

1. Short 1T9-4* to 1T9-6. (This shorts the primary and prevents its tuning from affecting subsequent secondary tuning.)
2. Couple the signal from 1T4-3 to 1T9-3, through a 10-mmfd capacitor. (This value of capacity must be used, approximately.) The capacitor lead should be connected directly to 1T9-3. (Step 1 shorts the Phasitron output and step 2 couples the signal from the crystal amplifier to the secondary of 1T9.)
3. Place the SELECTOR SWITCH in position 9.
4. Tune the secondary (upper control) of 1T9 for maximum indication on the VOLTAGE INDICATOR. (Without drive, the VOLTAGE INDICATOR reads about 20 in position 9. After tuning the 1T9 secondary, as above, the reading should run about 30 or more. If insufficient signal is present, tune 1T3 for greater signal.)
5. Remove the short from 1T9-4 to 1T9-6 and place it from 1T3-1 to 1T3-3. (This prevents output from the Phasitron, which would interfere with subsequent tuning of the primary of 1T9. The Phasitron must be in the socket and warm, with 6.3 volts on the filament, since its capacity affects primary tuning.)
6. Tune the primary (lower control) for minimum VOLTAGE INDICATOR indication with the SELECTOR SWITCH in position 9. (The minimum should be about 20.)
7. 1T9 is now tuned. Remove the short from 1T3-1 to 1T3-3. To obtain drive for tuning the rest of the transformers, either the output of the Phasitron may be used or the signal may be coupled around the Phasitron, as in step 2. If the latter method (coupling the signal from 1T4-3 to 1T9-3) is employed, the short should be replaced between 1T9-4 and 1T9-6.

1T10

1. Connect, by its own leads (to keep capacity low), a 39,000-ohm (approximate) ½-watt resistor directly across 1T10-4 and 1T10-6.
2. Place the SELECTOR SWITCH in position 10.
3. Tune the primary and secondary (both lower and upper controls) for maximum VOLTAGE INDICATOR reading. Remove the loading resistor.

*Transformer terminal numbers are marked on the base of transformers and can be seen through the panel slot.

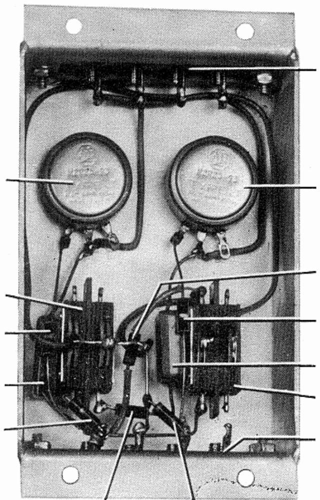

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Fig. 10 Pre-Emphasis Unit, Interior View, Parts Identified

1T11

1. Connect, by its own leads, a 39,000-ohm (approximate) ½-watt resistor directly across 1T11-4 and 1T11-6.
2. Place the SELECTOR SWITCH in position 11.
3. Tune the primary and secondary (both lower and upper controls) for maximum VOLTAGE INDICATOR reading. Remove the loading resistor.

1T12

1. Connect, by its own leads, a 39,000-ohm (approximate) ½-watt resistor directly across 1T12-4 and 1T12-6.
2. Place the SELECTOR SWITCH in position 12.
3. Tune the primary and secondary (both lower and upper controls) for maximum VOLTAGE INDICATOR reading. Remove the leading resistor.

1T13

1. Connect, by its own leads, a 39,000-ohm (approximate) ½-watt resistor directly across 1T13-4 and 1T13-6.
2. Place the SELECTOR SWITCH in position 13.
3. Tune the primary and secondary (both lower and upper controls) for maximum VOLTAGE INDICATOR reading. Remove the loading resistor.

1T14

1. Place the SELECTOR SWITCH in position 14.
2. Tune the primary and secondary for maximum VOLTAGE INDICATOR reading. Occasionally, two apparent tuning points may be found for the secondary (upper control). If the wrong one is used, primary (lower control) tuning will not increase the output. Usually, the correct secondary tuning point is the one giving the least output. The output then will greatly increase (to 30 or more) with primary tuning.
3. Connect, by its own leads, a 39,000-ohm (approximate) ½-watt resistor directly across 1T14-4 and 1T14-6.
4. Slightly retune the primary and secondary for maximum VOLTAGE INDICATOR reading. Remove the loading resistor.

1T15

Tune the primary and secondary of 1T15 for maximum 815 GRID current.

Visual Alignment Procedure. The general procedure is the same for any of the transformers except 1T9, and is somewhat similar to aligning receiver i-f transformers. The signal normally is injected at the grid of the previous stage to drive the transformer, and the indicator (oscilloscope) is connected across the grid resistor of the succeeding stage, which is used as a grid detector.

An additional factor exists here in that each of the stages, except 1V3, is a frequency multiplier. That is, the grid circuit is tuned to a submultiple of the plate circuit. Thus if a signal at plate frequency is injected at the grid, the grid circuit would act as an effective short-circuit on the signal generator.

Therefore, it becomes necessary either to: (1) disconnect the grid connection at the transformer, or (2) employ a specially modified Type 6SJ7 tube, called the "signal-injector tube" for signal injection (Fig. 11). An adapting socket cannot be used as the addi-

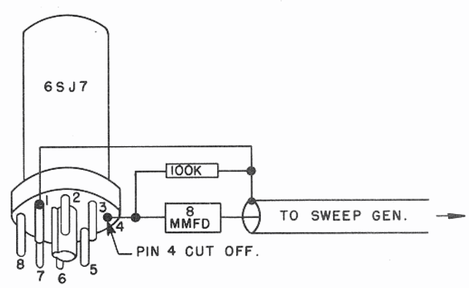

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Fig. 11 Signal Injector Tube

tional capacitance is sufficient to result in improper tuning. Method 2 is preferable and is detailed in the following paragraphs.

Transformer 1T9 cannot be driven through the Phasitron, 1V3, because transformers 1T3 and 1T4 which produce the three-phase deflector voltages (see section on THEORY AND CIRCUIT ANALYSIS) are narrow-band and would introduce an additional frequency response factor. Yet the transformer 1T9 must be driven from a high-impedance source, necessitating the use of a separate amplifier which essentially replaces the Type GL-5593 tube. Since this frequency is always in the neighborhood of 200 kilocycles, let the amplifier be called the "200-kc amplifier." An applicable Elementary Diagram is shown on Fig. 12, using a type 6SJ7 tube.

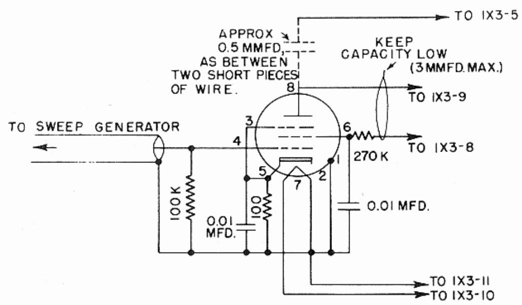

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Fig. 12 200-KC Amplifier, Elementary Diagram

Another basic problem is that the center frequencies of the transformer response curves must be accurately determined. Fortunately, this can be done by using harmonics of the crystal to produce "marker" signals. This will be discussed further.

The name "visual alignment" stems from the use of an oscilloscope, in conjunction with a sweep signal generator, to indicate visually the circuit frequency response curve. Such a generator has a constant average frequency, but has an instantaneous frequency which is a linear function of time within certain positive and negative excursion limits about the average frequency. This time function generally approaches a triangular wave. The theory behind this method is discussed further in this section under "Theory of the Visual Alignment Procedure." As representative cases, the tuning of 1T9 and 1T12 will be considered.

1T9

Remove tubes 1V14, Type 6V6, and 1V15, Type GL-815. Remove Phasitron 1V3, Type GL-5593. Connect "200-kc amplifier," previously discussed, to the Phasitron socket, 1X3, keeping the leads very short. Connect an oscilloscope to 1T9-1. Short out the cathode resistor, 1R52, of 1V9. Adjust the center frequency of the sweep generator approximately to the crystal frequency, and adjust the swing of the generator to approximately ±50 kc/s. Synchronize the 'scope sweep and adjust the gain. A response curve and its "image" should be visible on the 'scope.

The small capacitor shown dotted on Fig. 12 couples a small amount of crystal frequency energy into 1T9 and produces on the oscilloscope a "marker" which appears as a center of the "blurb" on the 'scope trace, on both the response curve and its image. The center of this "blurb" becomes the required center frequency for the response of 1T9.

Carefully shift the mean frequency of the signal generator until the two "markers" lie one over the other. Then tune the primary and secondary of 1T9 until a flat curve having the marker at its center is obtained.

CAUTION

Keep the signal level below stage saturation. Lack of 'scope trace amplitude change with input level signal change indicates saturation.

Curves *a*, *b*, *c*, *d*, *e*, and *f* of Fig. 13 illustrate a typical case.

Essentially a flat-top response will be obtained. A

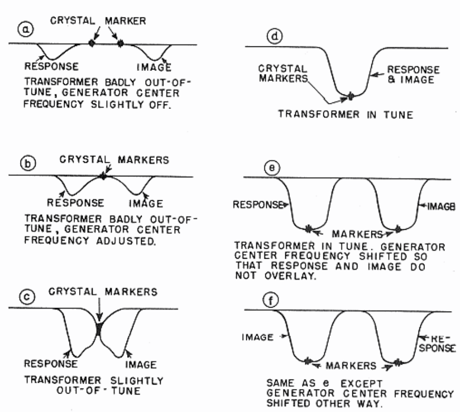

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Fig. 13 Typical Response Curves

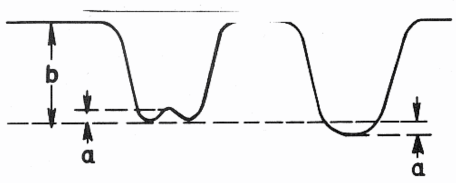

Fig. 14 Response Flatness Limit

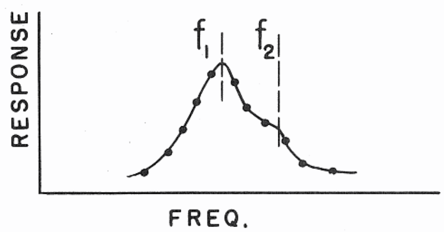

Fig. 15 Typical Point-by-Point Response

ratio of $\frac{a}{b}$ of 1/20 or less (Fig. 14) is permissible.

After completing the tuning of 1T9 restore conditions to normal, including the reinstallation of 1V3, Type GL-5593.

1T12

Remove tubes 1V14, Type 6V6, and 1V15, Type GL-815. Remove tube 1V11 and insert the signal injector. Set the signal generator center frequency to approximately eight times the crystal frequency. Connect an oscilloscope to 1T12-1. Then proceed as outlined under 1T9 tuning. The "marker" signal is now produced by the eighth multiple of the crystal frequency. The fourth multiple couples capacitively through the socket of the signal-injection tube and is doubled in 1T12, assuming that all stages up to 1V11 are functioning properly.

Tuning of all the other transformers is basically the same. Care must be exercised to set the signal generator frequency at the proper multiple of the crystal frequency. The table below will serve as a summarized guide.

Transformer 1T15 is tuned to produce maximum GL-815 grid current. The primary and secondary are alternately tuned until detuning either produces a reduction in grid current.

Point-by-Point Procedure. Any of the coupling transformers can be tuned by the point-by-point method, although this is slow and tedious. Here a fixed frequency signal generator is used, and its frequency is changed by small amounts at a time. At each frequency the VOLTAGE INDICATOR meter reading is recorded. The calibration of the signal generator may

TRANSFORMER	INJECTOR REPLACES	GENERATOR FREQUENCY TIMES CRYSTAL	APPROXIMATE GENERATOR DEVIATION KC	OSCILLOSCOPE CONNECTION	REMARKS
1T10	1V9	2	±50	1T10-1	
1T11	1V10	4	±50	1T11-1	
1T12	1V11	8	±100	1T12-1	
1T13	1V12	24	±300	1T13-1	*
1T14	1V13	72	±600	1T14-1	†

* To obtain sufficient crystal-marker amplitude, insert a two-inch (approx.) length of No. 22 insulated wire into number 4 socket 1X12. Then insert the signal generator injector tube into socket 1X12 with the lead surplus running out from under the tube base. Connect the conductor of the lead to the junction of the 8-mmf capacitor with pin 4 of the signal-injector tube (Fig. 4).

† Install the Type 6V6 tube. Bypass socket terminal 3 to ground with a mica capacitor of several thousand micromicrofarads. Short out cathode resistor 1R73. To obtain sufficient crystal-marker amplitude insert a two-inch (approx.) length of No. 22 insulated wire into number 4 of socket 1X13. Then insert the signal generator injector tube into socket 1X13 with the lead surplus running out from under the tube base. Connect the conductor of the lead to the junction of the 8-mmf capacitor with pin 4 of the signal-injector tube (Fig. 4).

be checked against the crystal and its harmonic frequencies.

Signal injection should be done as outlined under the visual alignment procedure.

A set of VOLTAGE INDICATOR meter readings versus frequency is then plotted and a smooth curve drawn through the points. Suppose, as a typical example, this comes out as shown on Fig. 15.

Note the frequencies f_1 and f_2. Adjust the frequency of the signal generator first to one and then to the other frequency, carefully adjusting the tuning until the response at each is equal. Then plot a new curve, which should look like that of Fig. 16.

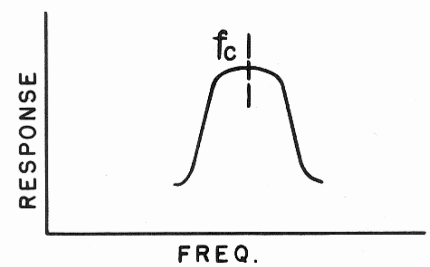

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Fig. 16 Point-by-Point Response After Tuning

Note frequency f_c. If it does not agree with the table previously given, additional tuning must be done until the same type curve is obtained about the correct center frequency. The curve can be shifted, without appreciably altering its shape, by making the same small increments of capacitance change in both the primary and secondary. This may not hold accurately since the primary and secondary may have unlike characteristics, but it is a fair approximation.

Generally the correct tuning will be arrived at soonest by making small, methodical tuning adjustments and plotting a rough response curve each time.

DISCRIMINATOR (1T16) TUNING

In case the discriminating transformer 1T16 is replaced or requires retuning, use the following procedure (the modulator interstage coupling transformers must be in alignment):

Place the SELECTOR SWITCH in position 17. Then tune the lower control, the secondary, of 1T16, until the VOLTAGE INDICATOR reads zero. Slight tuning either way should cause the needle to swing back and forth across zero. Finally tune the secondary slightly off zero indication. Then tune the primary of 1T16, the upper control, for maximum VOLTAGE INDICATOR deflection.

Retune the secondary for near zero, if necessary. The final desired condition is that of primary tuning for maximum deflection and secondary tuning for zero deflection. The secondary must be tuned slightly off zero for maximizing the primary.

Fine tuning of the discriminator is made with modulation, as outlined in the OPERATION section, page 6.

(Do not change factory adjustments unless trouble is encountered.)

TUNING 1L4

1L4 is tuned for maximum rejection of sideband frequencies spaced at crystal frequency on either side of the carrier. A field intensity meter having sufficient selectivity may be used. 1L4 is tuned for minimum intensity of either the upper or lower sideband.

Alternatively, and equally satisfactorily, an ordinary communication receiver, having an S (or carrier level) meter may be used as follows: Connect an insulated lead to the receiver antenna post and insert the other end into one of the tuning access holes in the shield can of 1T13. Tune the receiver to 24 times the crystal frequency (somewhere in the range 4.9 to 6 mc). This is the submultiple of the main carrier. The S meter will read full scale. Then tune the receiver either higher or lower an amount equal to the crystal frequency. The receiver is now tuned to one of the crystal-spaced sidebands. Tune the receiver for maximum S meter reading. Then tune 1L4 for minimum S-meter reading.

1L4 is the slug-tuned coil mounted in the rear of the modulator panel, just behind 1T10. The modulator shield must be removed to gain access to the screwdriver adjustment.

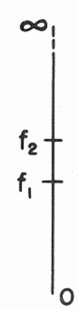

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Fig. 17 Arbitrary Circuit Response Limits in the Frequency Spectrum

THEORY OF VISUAL ALIGNMENT PROCEDURE

The following is a brief analysis of the visual procedure basis. A thorough understanding will aid materially in analyzing the meaning of a particular pattern on the 'scope.

The Response and the Image. First assume the circuit under study responds to frequencies between f_1 and f_2, anywhere in the frequency spectrum, as indicated on the vertical line of Fig. 17.

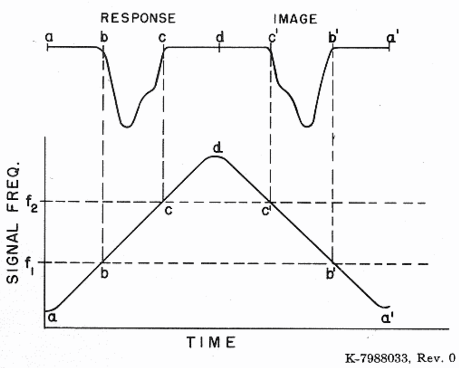

Fig. 18 Circuit Response and Image

It is possible with the use of a signal generator, whose frequency can be set where desired, and an indicator, to plot the response curve. If no tuning adjustments were required, such a method would be desirable. With tuning, however, this point-by-point method allows the change occurring in the response at only the frequency of the signal generator to be seen. Simultaneous response changes occurring at other frequencies cannot be observed.

However, if the signal frequency is made to sweep between f_1 and f_2, a complete response curve will be obtained. All that is needed is an indicator that will "record" this curve. For practical purposes this is the oscilloscope.

Basically, the signal frequency might be swept from f_2 to f_1 and back from f_1 to f_2 by hand. If the oscilloscope sweep started before or when the signal was at f_1 and finished when or after the signal returned to f_1, two response curves would be traced on the 'scope screen. To distinguish between the two, let the one produced on increasing frequency, f_1 to f_2, be called the "response" curve, and the one on decreasing frequency, f_2 and f_1, be called the "image" curve.

Provided the frequency increased and decreased at the same rate when the "response" and "image" were produced, the "image" appears like the reflection of the "response" in a mirror; hence, the name.

By varying the signal frequency electronically, usually at a 60-cycle rate, and synchronizing the 'scope with the generator sweep, a "steady" trace of the circuit response and image can be obtained. This is illustrated on Fig. 18.

As before, the response is from f_1 to f_2 and the image from f_2 to f_1. The 'scope here makes one trace for each cycle of signal sweep. Note that if the triangular sweep wave is moved up or down on the frequency scale, the response and image move apart or come together, respectively.

Now if the 'scope trace is made to sweep at a rate twice that of the signal sweep, the image section *dc'b'a* will overlay the response section *abcd*. By properly adjusting the average frequency of the signal generator (moving the triangular wave up or down), points *a* and *d*, *b* and *c'*, *c* and *b'*, and *d* and *a'* can be made to correspond. See Fig. 19.

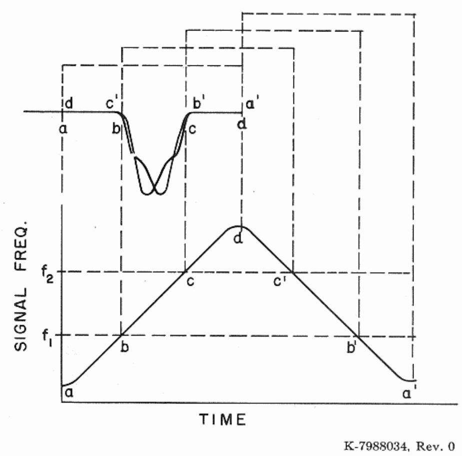

Fig. 19 Response and Image Overlay

The Frequency Marker. As mentioned in the visual alignment procedure, a frequency "marker" can be produced by injecting a small amount of single-frequency energy into the circuit being swept. A small "blurb" is produced whenever the generator frequency is near or equals the marking frequency.

This results because (1) the signal and marking frequencies intermodulate and yield difference and sum frequencies, and (2) the audio bandwidth of the detector is narrow and passes only a small portion of these frequencies.

As a typical example, the audio bandwidth of the detector might be as shown on Fig. 20.

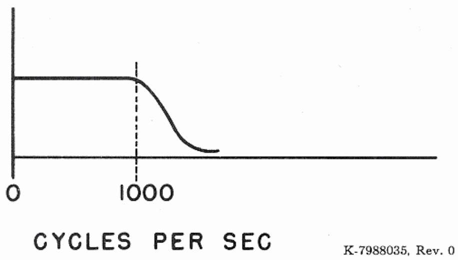

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Fig. 20 Typical Detector Audio Bandwidth

With a 60-cycle sweep r-f pulses of energy are applied to the detector 120 times per second. To reproduce the envelope of the r-f pulse an audio bandwidth of approximately the size pictured is needed.

Intermodulation frequencies lying only in this small frequency band produce additional amplitude variation on the 'scope trace. Frequencies in this band are produced only when the sweep signal frequency is practically the same as the marking frequency. Hence, the sweep signal frequency is "marked" accurately at at a frequency equal to the marking frequency.

A typical idealized marker, as it appears on a response, is shown on Fig. 21.

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Fig. 21 Typical Idealized Frequency Marker

The marking-frequency voltage fed into the system should always be small, just enough to produce a readable marker.

COMPONENT NAMES AND SYMBOLS

Symbol	*Panel Name*
1R89	Neutral Plane
1R90	1st Focus
1R91	2nd Focus
1R92	Deflector
1C104	815 Plate Tuning
1M8	815 Grid
1M7	815 Cathode
1M9	Voltage Indicator
1S5	Selector Switch
1S3	Power
1IS1	Plate On
1IS2	Plate Off
1T35	Input Voltage (Increase)
1C106	IPA Grid Tuning
1C111	IPA Plate Tuning
1L11	Coupling
1C112	PA Grid Tuning
1C124	PA Screen Adj
1L16	PA Plate Tuning
1L18	Output Coupling
1M6	IPA Grid
1M5	IPA Cathode
1M10	Input Voltage
1M3	PA Plate Voltage
1M4	PA Grid Current
1M2	PA Plate Current
1M1	RF Output

TYPICAL METER READINGS AND DIAL SETTINGS

	Frequency, Megacycles		
	88	98	108
Selector Switch	Voltage Indicator	Voltage Indicator	Voltage Indicator
1	21	21	21
2	22	22	22
3	22	22	22
4	+31	+31	+31
5	18	18	18
6	20	20	20
7	14	14	14
8	15	15	15
9	20	20	20
10	−15	−15	−15
11	−23	−23	−23
12	−18	−18	−18
13	−18	−18	−18
14	−30	−30	−30
15	25	25	25
16	12.5	12.5	12.5
17	0	0	0
815 Cathode	55 ma	55 ma	55 ma
815 Grid	1.7 ma	1.7 ma	1.7 ma
815 Plate Tuning	10	60	90
IPA Grid Tuning	30	60	80
IPA Plate Tuning	20	50	70
PA Grid Tuning	10	50	85
PA Plate Tuning	10	20	30
IPA Grid	1.5 ma	1.5 ma	1.5 ma
IPA Cathode	140 ma	140 ma	140 ma
Input Voltage	200 volts	200 volts	200 volts
PA Plate Voltage	2.2 kv	2.2 kv	2.2 kv
PA Grid Current	15 ma	15 ma	15 ma
PA Plate Current	200 ma	222 ma	227 ma
R-F Output	100	100	100

THEORY AND CIRCUIT ANALYSIS

Refer to the Block Diagram, Fig. 22, Control Diagram, Fig. 23, and main Elementary Diagram, Fig. 34.

POWER AND CONTROL

Main power (208/230 volts, 50/60 cycles) is supplied to the Transmitter through magnetic overload circuit breaker switch 1S3. Capacitors 1C161 and 1C162 are r-f by-pass capacitors.

Closing 1S3 energizes the cabinet cooling blower 1BM1, and tube seal cooling blower, 1BM2, the control isolating transformer, 1T33, all filament transformers 1T6, 1T36, 1T37, 1T44, 1T45, and 1T47, variable transformer 1T35, and bucking transformer 1T34.

The primaries of all filament and plate transformers are designed for operation at 200 volts. Adjustment to 200 volts is made with 1T35, controlled from the panel front. The voltage between terminals 3 and 5 of 1T35 is applied to the primary of 1T34, whose secondary is connected in series with the main line. This secondary voltage subtracts or adds to the line voltage. When the arm of 1T35 is between terminals 4 and 5, the secondary voltage of 1T34 bucks the line voltage; when the arm of 1T35 is to the right of terminal 5, the secondary voltage of 1T34 boosts the line voltage. By this method an input voltage of from 195–245 volts can be accommodated. That is, up to 45 volts buck and 5 volts boost can be obtained. The Transmitter operating voltage is indicated on voltmeter 1M10. Variable transformer 1T35 is located on the output side of the line control system to insure that operation is always well within rating.

The Elementary Diagrams, Figs. 23 and 34, are drawn with connections shown for 60-cycle operation. For 50-cycle operation two reconnections are required. One is the wiring change (red wire only) from terminal 5 to terminal 4 on 1T33. This reduces the operating voltage on the various control relays from 115 volts to 96 volts (5/6 of 115 volts). Thus, the relay rms operating current is held approximately the same at the two power-line frequencies. The other change is the line voltage step-down from 230 volts to 200 volts for operation of 1BM1 to prevent possible overheating of the motor at 50 cycles. This is done by reconnection from TB2-1 to TB2-2. TB2 is located several inches from the blower on the cabinet roof.

The entire control circuit operates from the secondary of 1T33, energized upon closing 1S3. Assume 1S3 to be closed. Motor-driven timing relay 1K1 is energized and after approximately 30 seconds, 1K1 times out and its normally open contact closes. Its normally closed contact opens and removes power from the relay motor.

Transformer 1T31, for the green indicating light 1IS1, now is energized through the normally closed contact of 1K2, provided rear door interlocks 1S1 and 1S2 are closed. The green light indicates that the Transmitter is ready for application of plate voltage. The timing relay, 1K1, prevents application of plate voltage before tube filaments are warm.

Plate voltage is applied by pressing momentary switch 1IS1. This energized relay 1K3, closing its normally open contact. Relay 1K2 now energizes through the closed contact of 1K3, the normally closed contact of 1K4, and the normally closed contacts of overload relays 1K7 and 1K8. As 1K2 closes, power is removed from green light 1IS1 and applied to red light 1IS2; power is applied to the low- and high-voltage rectifier plate transformers, 1T41 and 1T46; a shunt is placed across the contact of 1K3 which locks 1K2 in, and 1K3 may be de-energized by release of 1IS1; the plate contactor interlock between the 250-watt set and an additional power amplifier (if used) closes (TB11-6 and TB11-7).

1IS2 is a momentary contact switch that serves to remove plate voltage. Depressing 1IS2 energizes 1K4, whose normally closed contact opens and de-energizes 1K2, which falls out, and whose normally open contact closes and removes plate voltage from an additional amplifier (if used).

One set of normally closed contacts of low-voltage overload relay 1K7 and of high-voltage overload relay 1K8 are in series with 1K2. Another set of contacts is extended for use in conjunction with a higher-powered amplifier. A set of normally open contacts is extended to a supervisory light circuit, if used. Hence, an overload in the low- or high-voltage supply will cause 1K2 to drop out, will cause an amplifier plate contactor to drop out, and will cause a supervisory light circuit to operate and indicate in which circuit the overload occurred. The supervisory lights must be operated by auxiliary relays which will lock themselves in when the normally open contacts of 1K7 or 1K8 close for an instant. As soon as 1K2 falls out 1K7 or 1K8 will return to the unenergized position.

Relay 1K5, when energized, shorts out surge-limiting resistor 1R185. This resistor limits the peak charging current passed by the high-voltage rectifier tubes to a safe value when plate voltage is applied.

Relay 1K5 is energized through a contact of 1K6 after 1K6 is energized. Relay 1K6 closes when the p-a grid current exceeds approximately 8 milliamperes.

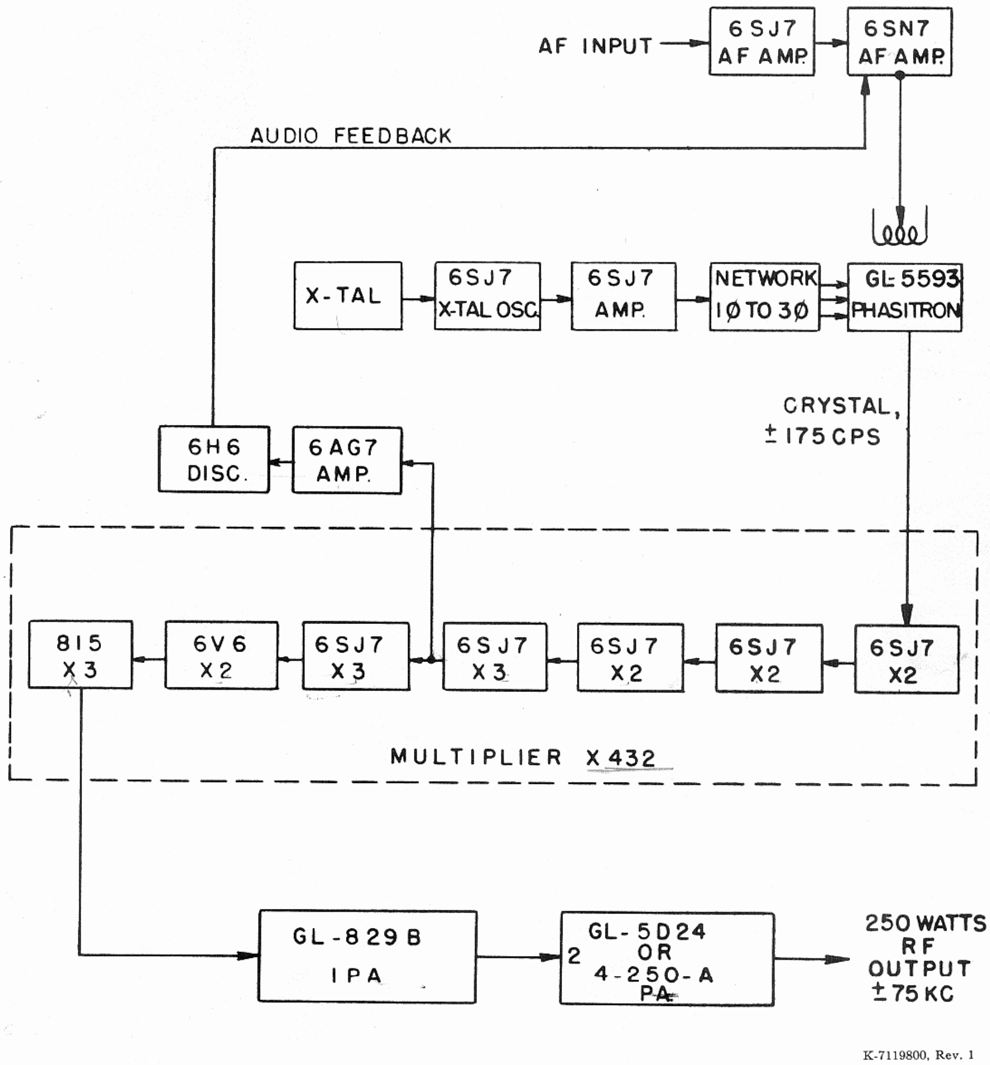

Fig. 22 Block Diagram, Type BT-1-B Transmitter

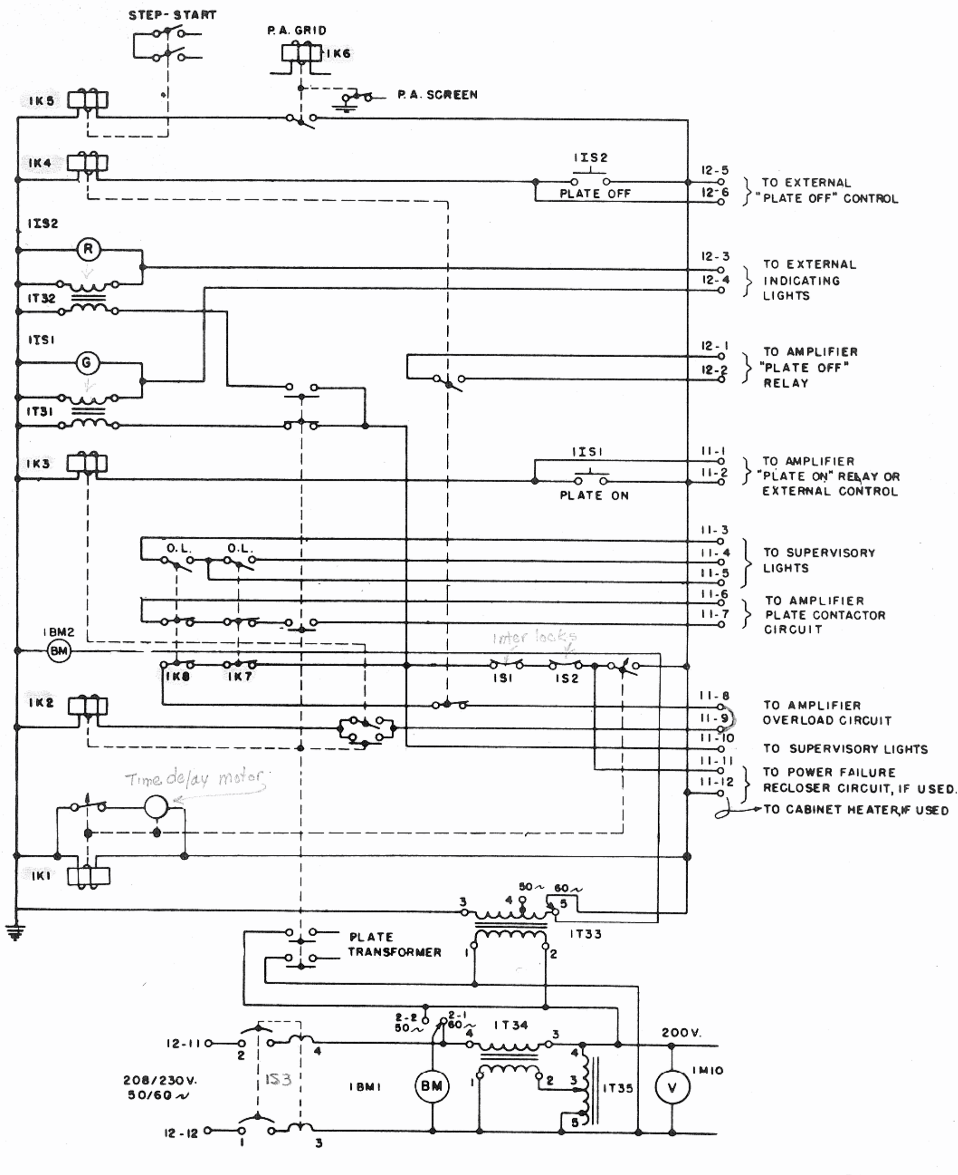

Fig. 23 Control Circuits, Elementary Diagram

Previous to this a normally closed contact of 1K6 shorts the p-a screens to ground, thus protecting the tubes from excessive dissipation before the grid excitation is sufficient to produce safe grid bias. By the time the p-a grid current builds up to 8 milliamperes and closes 1K6, the high-voltage rectifier capacitors are almost fully charged. The subsequent energizing of 1K5 and shorting of 1R185 then results in negligible surge current through the high-voltage rectifier tubes.

Leads may be extended in shunt with 1IS1 from 1TB11-1 and 1TB11-2 for an external plate "on" control, and in shunt with 1IS2 from 1TB12-5 and 1TB12-6 for an external plate "off" control. External indicating lights (6.3 volts) may be wired across 1TB 12-4 and ground (green) and across 1TB12-3 and ground (red).

The cabinet heater, if used, has a relay coil connected to 1TB11-12 and ground. The normally closed contacts carry power to the heater when power is removed from the Transmitter. See Fig. 24, the Elementary Diagram of the heater. Wattage of lamps to be installed must be varied between 40 and 100 watts depending on climatic conditions.

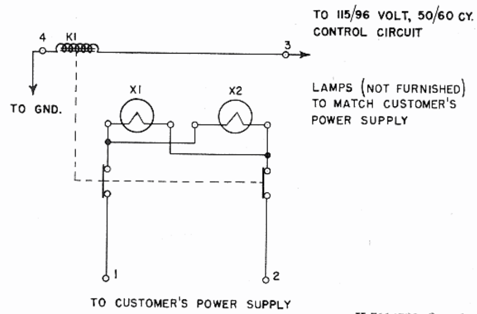

Fig. 24 Heater Unit, Elementary Diagram

An automatic power failure recloser may be employed. It must be of a nature to place a shunt across 1TB11-10 and 1TB11-11, and also a shunt across 1TB11-1 and 1TB11-2 in case of a brief power failure. These terminals are extended to the three-kilowatt amplifier (when used), which contains an automatic power failure recloser.

DC POWER SUPPLIES

Low-Voltage and Regulated Supply—The low-voltage rectifier is a conventional full-wave rectifier employing a pair of Type 5R4-GY tubes. The plates are cross-paralleled to cause an even division of current between the two tubes. A two-section L-C filter is employed to give about 70 decibels of ripple attenuation. The output from the filter supplies the Type GL-829-B i-p-a stage and the automatic voltage regulator. The d-c return is made through overload relay 1K7, whose function has been discussed previously.

The voltage regulator is a conventional degenerative type employing a Type OC3/VR105 tube for bias of the Type 6SJ7 control amplifier. Three Type 6B4-G tubes in parallel are used to carry the load current.

The plate voltage to the Type 6SJ7 tube, 1V37, is additionally filtered by means of 1R170 and 1C143. This voltage is applied directly to the regulator series tube grids, and the additional filtering results in added hum reduction in the regulated voltage.

Resistor 1R182 limits the current through gas-discharge tube 1V38 to approximately 11 milliamperes. The gas-discharge tube holds the voltage across 1R183 and 1R184 constant. The cathode of the Type 6SJ7 control tube, 1V37, is tapped down at the junction of 1R183 and 1R184. This prevents any of the cathode current of 1V37 from flowing through the gas-discharge tube, 1V38.

Potentiometer 1R180, a panel screwdriver control, is used to adjust for proper regulated voltage, which may be measured at panel monitoring jack 1J6.

The unregulated supply furnishes approximately 180 milliamperes at 450 volts; the regulated supply furnishes 150 milliamperes at 250 volts. The former supplies the plate and screen of the Type GL-829-B i-p-a; the latter, all tubes on the modulator panel. Taps 2 and 4 on 1T41 are 105 per cent and 95 per cent secondary voltage taps, respectively; tap 3 is the normal 100 per cent tap. Tap 3 is used in factory wiring.

High-Voltage Supply—This supply is a conventional rectifier, using a pair of Type GL-866-A tubes with a two-section L-C filter. To protect the tubes from excessive surge currents when plate voltage is applied, a resistor, 1R185, is connected in series with the filter capacitors, 1C153 and 1C154, to limit the charging current. This resistor is shorted out when 1K5 is energized, as explained previously.

The first choke, 1L27, has spark gap 1E1 across it. This gap permits discharge of the choke energy before the voltage rises to dangerous levels in case of rectifier tube misconduction or faulty commutation.

Resistors, 1R186, 1R187, and 1R188 serve as a high-voltage bleeder and also divide the voltage for the p-a screen grids.

The d-c return is made through 1KS, which gives overload protection. Switch 1S4 automatically grounds the high-voltage bus when the rear access door is opened.

The high-voltage supply normally furnishes the p-a plates with approximately 200 milliamperes at 2200 volts, and the p-a screens with about 30 milliamperes at 150 volts.

Plate transformer 1T46 is supplied with four taps. Taps 2, 3, 4, and 5 give, respectively, 110-, 100-, 90-, and 50-per cent of normal secondary voltage. Tap 5, the 50 per cent tap, is used during initial tuning of the p-a. The 100 per cent tap is used for normal operation of the Type BT-1-B Transmitter. When the Type BT-1-B unit is used as a driver, the 90 per cent tap is used.

CRYSTAL HEATER

Power for the crystal heater is supplied at 115 volts, 50/60 cycles, usually from the station lighting supply. Connection is made at 1TB12-9 and 1TB12-10, with fuse protection furnished by 3-ampere fuses 1F1 and 1F2. Transformer 1T36 steps the voltage down from 115 to 11 volts. The parallel combination of 1R35, 1R36, and 1I1 absorbs 4.7 volts, leaving 6.3 volts across the crystal heater resistor. The flow of current in this circuit is controlled automatically by a thermostat located in the crystal housing. The temperature of the crystal is maintained at 60 degrees Centigrade (140 degrees Fahrenheit).

PRE-EMPHASIS UNIT

Besides containing the pre-emphasis filters, the pre-emphasis unit provides for switching between 600- and 150-ohm input impedance and between balanced or unbalanced input. Resistors 1R191 and 1R192 terminate the input line for 600-ohm operation. For 150-ohm operation, resistors 1R197 and 1R198 are paralleled with 1R191 and 1R192 by means of switch 1S7. For balanced operation, the center bus of the system is grounded through switch 1S6, as shown on Fig. 34. For unbalanced operation, switch 1S6 grounds the bottom input lead to 1TB10-4. The high audio line is then connected to 1TB10-2.

Balanced attenuators consisting of 1R193, 1R195, and 1C165 and 1R194, 1R196 and 1C166 produce the required 75 microsecond pre-emphasis characteristic. Being high-impedance filters, they essentially control the amount of current through, and hence the voltage across, the primary of 1T1, which has an impedance of 600 ohms. The attenuation of these networks is a complex inverse function of frequency, with an attenuation at 400 cycles and below of 16.9 decibels greater than that at 15,000 cycles, provided that 1R195 and 1R196 are properly adjusted.

MODULATOR

Audio System—The audio signal enters the modulator at 1TB15 and drives input transformer 1T1. The secondary of 1T1 is operated unbalanced. The voltage for driving the first audio tube, 1V1, is taken from the arm of potentiometer 1R2. Thus 1R2 serves as a "gain" control and is used to adjust the modulation sensitivity of the system.

The output of 1V1 appears across the series combination 1C3, 1R5, 1R6, and 1C4, 1R7. A portion of this voltage is applied to grid 1 of 1V2, the second audio tube, from the arm of potentiometer 1R6. Simultaneously, audio feedback voltage, derived from discriminator 1V20, appears across 1R6, 1R5, 1C3, and 1R4 in series. This feedback voltage is counter to the output of 1V1. That is, 1V1 and 1V20 serve as generators of like polarity, having complex internal impedances, sending currents in opposite directions through 1R6.

Both the driving voltage and feedback voltage, appearing on grid 1 of 1V2, decay with increasing frequency through the common decay capacitor, 1C4. The net signal voltage on grid 1 is almost independent of the setting of 1R6 at low audio frequencies, because capacitor 1C4 is ineffectual here and 1R6 is small compared to the other impedances in the circuit.

The feedback voltage appears across the parallel combination of 1C4 and 1R7. At high audio frequencies, therefore, the feedback voltage approaches zero because of the shunting effect of 1C4; and the net signal on grid 1 of 1V2 is the proportion of driving voltage appearing between the arm and bottom of 1R6. Potentiometer 1R6 is adjusted so that the net signal at high audio-frequencies is equal to that at low audio frequencies, where the net signal is the difference between the driving and feedback voltages. Identical decay time-constants for each keep the response flat over the band. A maximum amount of feedback for lowering distortion is required only at low audio frequencies, where the system, being a phase-modulation system, is working over the greatest phase excursion.

The output of the first section of 1V2 is coupled to the second section of 1V2. The primary of 1T2 serves as the load for the second section of 1V2. The secondary of 1T2 drives modulation inductor 1L1. A portion of the secondary voltage of 1T2 is fed back to the cathode of the first section of 1V2 through resistor 1R13.

RF System—The r-f signal originates in a crystal oscillator at a frequency 1/432 of the carrier frequency.

The screen, control grid, and cathode of 1V4, Type 6SJ7, serve as a triode in Colpitts connection with the crystal. RF ground is established at the screen. 1C11 and 1C8 are the capacity voltage dividers. 1C10, adjustable from the panel, is used to compensate for small frequency errors in the crystal, in order that the carrier frequency may be adjusted. The voltage across this screen "triode" section is electron-coupled to the plate circuit of 1V4, and a portion of the voltage appears across load choke 1L3. Capacitor 1C13 and 1C14 partially resonate 1L3. This voltage is coupled by 1C16 to the grid of amplifier 1V5, Type 6SJ7.

The plate load of 1V5 consists of 1T3 and 1T4, which together change the single-phase crystal voltage to three-phase. (A separate discussion of this phase-splitting circuit is given below.) These three-phase voltages are applied to the deflectors of the Phasitron, 1V3, Type GL-5593, terminals 3, 4, and 5, through shielded leads. The shielding prevents pick-up of fixed-phase voltages which would distort the three-phase system.

The static potentials on the Phasitron elements are adjusted by 1R89, 1R90, 1R91, and 1R92, all variable by means of front-of-panel screwdriver controls.

(A separate analysis of the Phasitron is given on page 28.)

The Phasitron output voltage is developed across the tuned primary circuit of 1T9. The secondary of 1T9 is overcoupled to the primary and loaded to give 1T9 a flat bandwidth of approximately 31 kilocycles. The secondary voltage of 1T9 is applied to the grid of 1V9, Type 6SJ7. 1T10 is tuned to twice the frequency of 1T9, and 1V9 serves as a doubler.

The secondary of 1T10 is overcoupled to the primary and loaded to give 1T10 a flat bandwidth of about 31 kilocycles. The secondary voltage is applied to the grid of 1V10, Type 6SJ7, which also serves as a doubler, with 1T11 tuned to twice the frequency of 1T10.

The secondary of 1T11 is overcoupled to the primary and loaded to give 1T11 a flat bandwidth of 31.5 kilocycles. The secondary voltage is applied to the grid of 1V11, Type 6SJ7, which also acts as a doubler, with 1T12 tuned to twice the frequency of 1T11.

Transformer 1T12 has its secondary overcoupled to the primary and is loaded to give 1T12 a flat bandwidth of 33 kilocycles.

At this point note that resistors 1R48, across 1T9, 1R59 across 1T10, 1R57 across 1T11, and 1R63 across 1T12 have a connection shown dotted. These four resistors are used only with carrier frequencies below approximately 95 megacycles per second.

The grid of 1V12, Type 6SJ7, is driven by the secondary voltage of 1T12. 1V12 acts as a tripler, for 1T13 is tuned to three times the frequency of 1T12. The secondary of 1T13 is overcoupled to its primary and loaded to give 1T13 a flat bandwidth of 38.5 kilocycles.

Tube 1V13, Type 6SJ7, driven by the secondary voltage of 1T13, has its plate circuit, 1T14, tuned to three times the frequency of 1T13 and therefore serves as a tripler. The primary-to-secondary coupling of 1T14 is close to the critical value, and 1T14 has a bandwidth of 55 kilocycles.

If the bandwidth of the lower frequency multiplier stages is not sufficient or if the "top" is not sufficiently flat, phase distortion at the higher modulating frequencies will be produced. This results because of sideband clipping and nonlinear phase characteristics.

The secondary voltage of 1T14 is applied to the grid of 1V14, Type 6V6, which acts as a doubler, with 1T15 tuned to twice the frequency of 1T14. 1T15 is under-coupled. Here the frequency is high enough that sufficient bandwidth is obtained easily. The bandwidth is approximately 80 kilocycles.

The last stage on the modulator panel is the Type GL-815 push-pull tripler 1V15. Grid current of 1V15 is measured by 1M8, and the cathode current is measured by 1M7.

The audio feedback voltage is produced by standard discriminator rectifier 1V20. Transformer 1T16 is of the discriminating type, driven by amplifier and limiter 1V19. 1V19 is driven from the output 1V12.

The parallel circuit of 1L4 and 1C60, located in the grid circuit of 1V10, is resonant at the crystal frequency. This circuit serves to degenerate any of the crystal frequency voltage fed through first doubler 1V9. Otherwise low-level sidebands spaced at crystal frequency on either side of the carrier result. These sidebands are quite small without this circuit, but are reduced to insignificance with it.

A loop 1L6 is coupled to the plate tank of 1V15 to pick up power for driving the i-p-a. The i-p-a and p-a will be discussed later.

Voltage indicating meter 1M9 measures relative cathode, grid, and other pertinent voltages of various stages in the modulator, as selected by switch 1S5. A list of actual voltages measured is given in the MAINTENANCE section of this book.

Phase-Splitters 1T3 and 1T4—Familiarity with the Scott two-to-three-phase connection, used in power

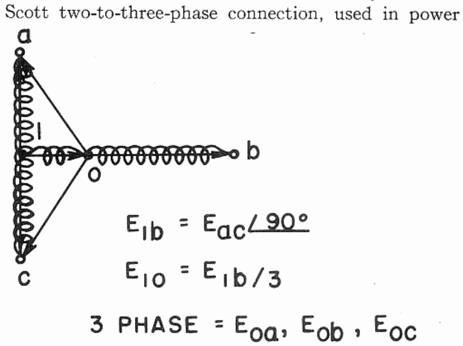

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Fig. 25 Scott Connection

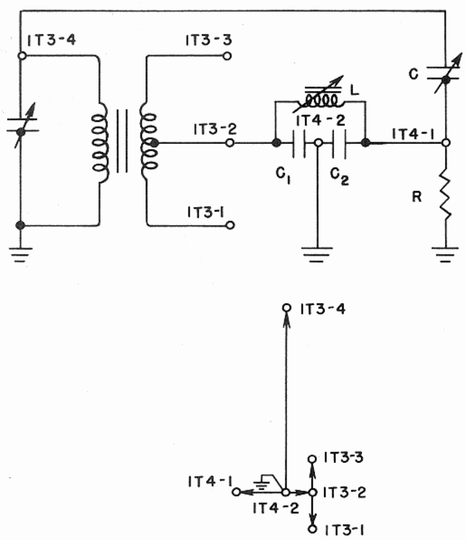

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Fig. 26 Phase Splitter, Elementary Diagram

work, will be assumed. A sketch reviewing the connection is shown on Fig. 25.

Transformers 1T3 and 1T4 are shown in somewhat the same fashion, Fig. 26.

The vector diagram shows the voltage relations in the circuit.

The three-phase voltages occur from 1T4-2 to 1T3-3, 1T4-2 to 1T3-1, and 1T4-2 to 1T4-1; that is, a wye system with grounded neutral results. This three-phase voltage is applied to the Phasitron deflectors.

The CR network cannot of itself shift the voltage at 1T4-1 90 degrees. However, note that tank LC_1C_2 is effectively across R, and normally is tuned so that R is shunted with inductance. This produces additional phase shift, and the phase at 1T4-1 can be swung back and forth by the tuning of L. Variation of this phase is the main function of L, in the range of normal operating adjustment.

Capacitor C is made variable, in order that the phase and amplitude at 1T4-1 may be adjusted quite closely without the necessity of severe detuning of the series tank. In the range of normal operating adjustment C functions mainly to change the amplitude of the voltage at 1T4-1.

Capacitors C_1 and C_2 act as voltage dividers to make 1T4-1 to ground have twice the voltage of 1T3-2 to ground. The capacitance of C_1 is twice that of C_2.

The Phasitron—The operation of the tube can best be studied by reference to its construction. Fig. 27 shows the entire structure of the tube; Fig. 28 is an enlarged cut-away view of the tube elements with each of the parts labeled.

Anodes No. 1 and No. 2 are at positive d-c potential and draw electrons from the cathode. The two focus electrodes form the electron stream into a tapered thin-edge disk. This disk with the cathode as its axis lies between the neutral plane and the deflector structure, and extends out to anode No. 1.

The deflectors consist of 36 separate wires, the active portions of which run radially out from the cathode. These wires are labeled A, B, and C on Fig. 28. All the A wires are connected together, all of the B wires are connected together, and all of the C wires are connected together. These three combinations of A, B, and C wires are brought out to the base of the tube and constitute the three deflectors (No. 1, 2, and 3). The neutral plane is connected to a pin on the base of the tube and constitutes the deflector No. 4. Fig. 29 shows a developed view of this grid structure and the neutral plane.

Three-phase, crystal-controlled, radio-frequency voltage is applied to the deflectors. Phases A, B, and C are each connected to the similarly marked deflector wires; and the neutral of the three-phase wye system is by-passed to ground. The deflecting

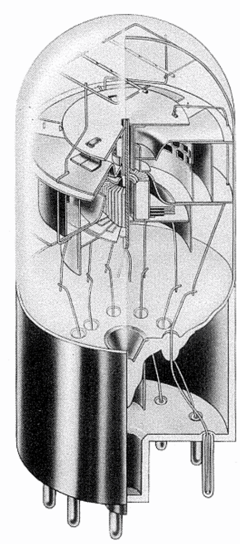

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Fig. 27 Cutaway View of Phasitron

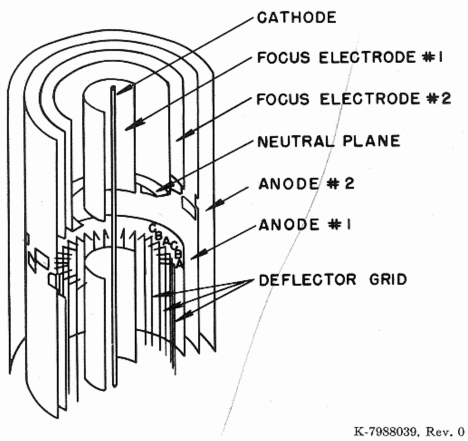


Fig. 28 Phasitron Elements

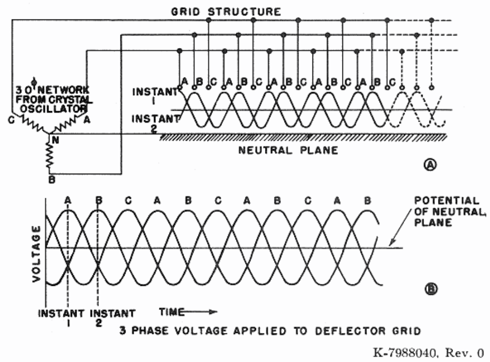


Fig. 29 Developed View of Grid Structure and Neutral Plane

action of these three-phase voltages on the disk of electrons passing between the neutral plane and the deflector grids can now be seen; at instant 1 the grid wires A are positive with respect to the neutral plane while grid wires B and C are negative. This results in deflection of the electron disk as shown at instant 1 on Fig. 29 and as shown in perspective on Fig. 30. At instant 2, one-third of a cycle later, deflector wire B is positive, and A and C are negative. The resulting effect would be that shown. The undulated disk edge of Fig. 30 would then appear to have moved the space of one grid wire during the time interval between instant 1 and instant 2.

From this explanation, it can be seen that with the three-phase voltage applied, the undulate electron disk edge rotates at a rate determined by the applied frequency and the number of deflector wires. The electrons themselves do not rotate, only the r-f field that produces the undulations does. The path of the electrons moves up and down, axially, as the electrons move radially from the cathode to the anode.

A developed view of a portion of anode No. 1 is shown on Fig. 31. This anode has 12 holes punched above the plane of the undeflected electron disk and 12 punched below. The rotating undulate edge of the electron disk therefore impinges on this series of holes. At an instant when the disk edge is lined up as shown by the solid line, most of the electrons pass on through the holes to anode No. 2. One-half cycle later the edge of the disk has moved on to the position shown by the dotted line. At this instant few, if any, electrons get through to anode No. 2. Thus, the current flowing to anode No. 2 varies sinusoidally at the crystal frequency.

The time occurring between peaks of the anode No. 2 current depends on the spacing between the holes and the angular velocity at which the undulated edge of the electron disk is traveling. Since the spacing between holes is fixed, the time between current maxima depends only upon the angular velocity. As long as this rate is constant, the anode No. 2 current maxima occur at constant time intervals.

Any phenomenon that changes the time interval occurring between peaks of any sine wave produces angular modulation of that wave. Phase and frequency modulation are only special forms of angular modulation.

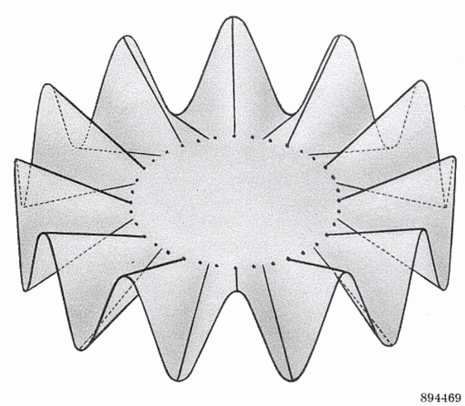


Fig. 30 Perspective View of Deflecting Action of 3-Phase Voltage on Electron Disk

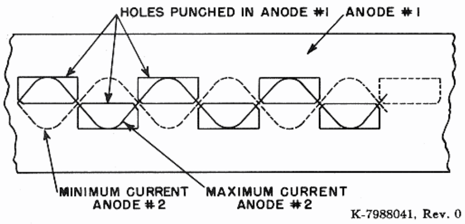


Fig. 31 Developed View of Portion of Anode No. 1

Now suppose the electron disk in the Phasitron is itself given an angular velocity. This velocity is effectively superposed on the constant angular velocity of the undulate field. Therefore the time interval occurring between peaks of the anode No. 2 current is changed, and angular modulation is produced in this current.

The Phasitron functions in such a way that the displacement of the anode No. 2 current peaks, compared to the original peaks, is directly proportional to the angular displacement produced in the electron disk. That is, a proportional phase-displacement results in the anode No. 2 current. Hence, the Phasitron is basically a phase-displacing or phase-shifting device. If the electron disk is angularly displaced at an audio rate, with the maximum displacement held constant, the anode No. 2 current is phase-modulated at the audio frequency.

Phase modulation when performed at a sinusoidal rate is always accompanied by frequency modulation which bears the following relationship to the phase displacement:

$$f_d = \phi f_a$$

Where: f_d = maximum frequency swing in cycles per second

ϕ = maximum phase displacement in radians

and f_a = audio modulating frequency in cycles per second

From this expression it is seen that if frequency modulation is to be produced in the anode No. 2 current, the maximum angular displacement that is given the electron disk must be inversely proportional to audio frequency.

The electron disk can be angularly displaced by applying an axial magnetic field to the tube. This is accomplished by surrounding the tube with a magnetic coil, or solenoid, as shown on Fig. 32.

If audio frequency currents are made to flow in this coil, the electron disk will be angularly displaced at audio frequency rates.

The maximum displacement produced in the disk, and hence the maximum phase displacement in the anode No. 2 current, is directly proportional to the maximum current in the coil. Since the coil is essentially a pure inductance, this maximum current is inversely proportional to audio frequency, if constant voltage is applied.

Hence, by applying constant audio frequency voltage to the coil, the phase-displacement of the anode No. 2 current is inversely proportional to the audio frequency and the desired frequency modulation results.

POWER-AMPLIFIER

The power-amplifier chassis contains a push-pull Type GL-829-B i-p-a tube, and a pair of Type GL-5D24 or 4-250A tubes as a push-pull final amplifier.

Energy picked up from the final tripler, 1V15, located in the modulator, is carried by a section of RG-8/U cable to the p-a chassis. Here the cable is terminated in a loop, 1L7, which is inductively coupled to the i-p-a grid tank coil, 1L8. Capacitor 1C106 tunes 1L8 to resonance.

Resistors 1R145, 1R146, 1R153, and 1R154 are parasitic suppressors and stabilize the operation of the i-p-a. Capacitor 1C110 couples to the anode of the i-p-a and acts as a cross-neutralizing capacitor.

The i-p-a grid current is measured by 1M6, the cathode current by 1M5.

The output of the i-p-a is link-coupled by means of 1L11 to the p-a grid tank coil, 1L13. The p-a grid current is used to energize relay 1K6, whose function has been discussed on page 22. This grid current is measured by 1M4.

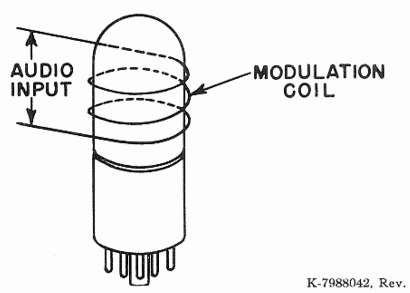


Fig. 32 Magnetic Coil Placed Around Phasitron

Amplitude modulation of the carrier is reduced by degenerative choke 1L29 in the p-a cathode and by screen bypass capacitor 1C126.

Adjustable resistor 1R163 establishes the p-a filament ground. The effective ground point is made adjustable to provide means for setting the carrier AM hum to a minimum.

Although the p-a tubes are tetrodes, "stable" operation will not be obtained unless the screens have no r-f potential relative to the cathode. This means that a low-impedance path for the r-f screen current must be provided. The impedance offered by the screen lead inductance is large enough to result in unstable operation. This difficulty is overcome by series-resonating the screen inductance.

Capacitor 1C124 performs this function. 1L23 is a center-tapped choke used to feed d-c to the screens. 1L24 provides additional r-f attenuation.

The external p-a plate circuit consists only of 1L16, which resonates with the internal tube capacity. In this way the tank circulating current is kept at a minimum, with resultant decrease in the circuit power loss.

The inductance of 1L16 is varied by moving short-circuited slugs into the field of the coil. The currents induced in the slugs produce fields which react with the magnetic field to alter the impedance of 1L16. The further the slugs are moved into the field, the lower the effective inductance of 1L16 and the higher the resonant frequency.

The p-a plate current is measured by 1M2. Meter 1M3, with multipliers 1R164-A and 1R164-B, measures the p-a plate voltage.

Power is coupled into the transmission line by means of loop 1L18, whose coupling to 1L16 is controllable from the panel.

RF VOLTMETER

The r-f voltmeter gives a relative indication of transmission line r-f input voltage. This indication is affected by standing waves on the line. Therefore, it is not necessarily a direct measure of power output, but will serve to show any change from a predetermined level during operation.

Capacitor 1C131, in conjunction with a short length of RG-8/U cable capacity and the diode input capacity, acts as a voltage divider.

The diode is a peak rectifier, with capacitor 1C133 and resistor 1R165 as the load. The average load current is measured by 1M1, which requires 1 milliampere for full-scale deflection. The scale is calibrated in arbitrary units. Adjustment of 1C131 affects the r-f voltage across the diode and hence the rectified current.

Capacitors 1C134 and 1C135 bypass the input filament leads to prevent stray r-f fields from affecting the meter reading.

MONITOR COUPLING

Loop 1L15 is inductively coupled to the p-a plate tank coil, 1L16. A length of RG-8/U cable carries the coupled power to an external connector in the bottom of the cabinet. The loop is located so that about 8 volts rms is produced across 50 ohms when the Transmitter is loaded to 250 watts. This voltage is used to feed the station modulation and frequency monitor, and may be adjusted by bending 1L15.

APPROXIMATE RF CIRCUIT OPERATING FREQUENCIES

Circuit	*Range*	*Times Crystal Frequency*	*Swing*	*Bandwidth*
Carrier	88.1–107.9 mc	432	±75 kc	200 kc channel
P-a plate	88–108 mc	432	±75 kc	>200 kc
P-a grid	88–108 mc	432	±75 kc	>200 kc
I-p-a plate	88–108 mc	432	±75 kc	>200 kc
I-p-a grid	88–108 mc	432	±75 kc	>200 kc
Final tripler plate	88–108 mc	432	±75 kc	>200 kc
1T16	4.9–6 mc	24	±4.2 kc	>200 kc
1T15	29.3–36 mc	144	±25 kc	80 kc
1T14	14.7–18 mc	72	±12.5 kc	55 kc
1T13	4.9–6 mc	24	±4.2 kc	38.5 kc
1T12	1.6–2 mc	8	±1.4 kc	33 kc
1T11	0.83–1 mc	4	±700 cycles	31.5 kc
1T10	406–500 kc	2	±350 cycles	31 kc
1T9	203–250 kc	1	±175 cycles	30.5 kc
1T4	203–250 kc	1	none	....
1T3	203–250 kc	1	none	....
Crystal	203–250 kc	...	none	....

PARTS LIST

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

When ordering a replacement part, please include description, symbol designation and reference number of the part and model number of the equipment. Orders may be sent to the nearest General Electric Office or to the General Electric Company, Transmitter Division, Electronics Department, Syracuse, New York.

Symbol	*Description*	*G-E Drawing*
	BLOWERS	
1BM1	Cooling Blower Motor: PA Tubes and Cabinet. Motor: rated 1/20 hp, 1725 rpm, ball bearing; 230 volts AC, single phase, 50/60 cycle. G-E Motor Cat. No. 5KH25AC272. Blower: clockwise rotation, down-blast discharge, free delivery 171CFM. American Blower Corp. Type No. OCW-DBD.	P-7767980-P2
IBM2	Seal-Cooling Blower for PA Tubes. Single phase-RH; 115 volts, 50/60 cycle; 2,800 rpm, 40 watts; horizontal top discharge.	K-7119828-P1
	CAPACITORS	
1C1	Not used.	
1C2	Not used.	
1C3	Coupling Time-Constant Capacitor. 1st –1V1– to 2nd –1V2– Audio. Paper, 0.05 mfd. + 30% – 10%, 600 vdcw. Sprague Cat. No. PPX-24B17.	P-7768969-P35
1C4	Feedback Time-Constant Capacitor: Discriminator –1V20– to 2nd –1V2– Audio. Mica, 8,200 mmfd. ±10%, 300 vdcw.	P-3R28-P8
1C5	Bypass Capacitor: Cathode, First Section of 2nd –1V2– Audio. Same as 1C4.	
1C6	Coupling Capacitor: First to Second Section of 2nd –1V2– Audio. Same as 1C3.	
1C7	Not used.	
1C8	Voltage Dividing Capacitor: for Crystal-1Y1. Mica, 1,000 mmfd ±10%, 300 vdcw.	P-3R26-P18
1C9	RF Bypass Capacitor: Crystal Heater–1Y1. Mica, 1,500 mmfd ±10%, 500 vdcw.	P-3R28-P3
1C10	Frequency Compensating Capacitor: for Crystal –1Y1. Air-trimmer, 25 mmfd.	P-3R47-P33
1C11	Voltage Dividing Capacitor for Crystal–1Y1. Silver mica, 27 mmfd ±5%, 500 vdcw.	P-3R26-P65
1C12	RF By-pass Capacitor: Signal Grid –1V4. Same as 1C4.	
1C13	Resonating Capacitor: Crystal Oscillator –1V4– Plate Load. (Not used for Carrier Frequencies above 95 MC/S approximately). Mica, 68 mmfd ±10%, 500 vdcw.	P-3R26-P10
1C14	Resonating Capacitor: Crystal Oscillator –1V4– Plate Load. Mica, 220 mmfd ±10%, 500 vdcw.	P-3R26-P14
1C15	Bypass Capacitor: Crystal Oscillator –1V4– Plate. Same as 1C4.	
1C16	Coupling Capacitor: Crystal Oscillator –1V4– to Crystal Amplifier –1V5. Mica, 470 mmfd ±10%, 500 vdcw.	P-3R26-P16

Symbol	*Description*	*G-E Drawing*
	CAPACITORS (CONT'D)	
1C17	Bypass Capacitor: Crystal Amplifier –1V5– Screen. Same as 1C4.	
1C18	Bypass Capacitor: Crystal Amplifier –1V5– Plate. Same as 1C4.	
1C19	Bypass Capacitor: Modulator –1V3– First Anode Dropping Resistor –1R50. Same as 1C4.	
1C20	Bypass Capacitor: Modulator –1V3– Anode Tank. Same as 1C4.	
1C21	Bypass Capacitor: 1st Doubler –1V9– Grid Tank. Same as 1C4.	
1C22	Bypass Capacitor: 1st Doubler –1V9– Cathode. Same as 1C4.	
1C23	Bypass Capacitor: 1st Doubler –1V9– Plate Tank. Same as 1C4.	
1C24	Bypass Capacitor: 2nd Doubler –1V10– Grid Tank. Same as 1C4.	
1C25	Bypass Capacitor: 2nd Doubler –1V10– Plate Tank. Same as 1C4.	
1C26	Bypass Capacitor: 3rd Doubler –1V11– Grid Tank. Same as 1C4.	
1C27	Coupling Capacitor: 1st Tripler –1V12– to Feedback Amplifier –1V19. Mica, 5 mmfd ±20%, 500 vdcw.	P-3R26-P1
1C28	Bypass Capacitor: Feedback Amplifier –1V19– Cathode. Same as 1C4.	
1C29	Bypass Capacitor: Feedback Amplifier –1V19– Screen. Mica, 680 mmfd ±10%, 500 vdcw.	P-3R28-P1
1C30	Bypass Capacitor: 3rd Doubler –1V11– Plate Tank. Same as 1C4.	
1C31	Bypass Capacitor: 1st Tripler –1V12– Grid Tank. Same as 1C4.	
1C32	Bypass Capacitor: 1st Tripler –1V12– Plate Tank. Same as 1C4.	
1C33	Bypass Capacitor: 2nd Tripler –1V13– Grid Tank. Same as 1C4.	
1C34	Bypass Capacitor: 2nd Tripler –1V13– Plate Tank. Same as 1C4.	
1C35	Bypass Capacitor: 2nd Tripler –1V13– Plate Supply. Same as 1C4.	
1C36	Bypass Capacitor: 4th Doubler –1V14– Grid Tank. Same as 1C4.	
1C37	Coupling Capacitor: Discriminator Transformer –1T16– Primary to Secondary. Same as 1C13.	
1C38	Bypass Capacitor: Feedback Amplifier –1V19– Plate Tank. (Discriminator Transformer –1T16– Primary) Same as 1C4.	
1C39	Resonating Capacitor: Discriminator Transformer –1T16– Secondary. Mica, 47 mmfd ±10%, 500 vdcw. (Mounted inside, but not part of 1T16).	P-3R26-P8
1C40	Bypass Capacitor: 4th Doubler –1V14– Cathode. Same as 1C9.	
1C41	Bypass Capacitor: 4th Doubler –1V14– Screen. Same as 1C9.	

CAPACITORS (CONT'D)

Symbol	Description	G-E Drawing
1C42	Bypass Capacitor: 4th Doubler -1V14- Plate Tank. Same as 1C9.	
1C43	Bypass Capacitor: Final Tripler -1V15- Grid Meter -1M8. Same as 1C9.	
1C44	Bypass Capacitor: Final Tripler -1V15- Filament. Same as 1C9.	
1C45	Bypass Capacitor: Final Tripler -1V15- Cathode Meter -1M7. Same as C9.	
1C46	Bypass Capacitor: Final Tripler -1V15- Screen. Same as 1C9.	
1C47	Resonating Capacitor: Discriminator Transformer -1T16- Primary. Same as 1C39. (Mounted inside of, but not part of 1T16.)	
1C48	Bypass Capacitor: Final Tripler -1V15- Cathode. Same as 1C9.	
1C49	Bypass Capacitor: Final Tripler -1V15- Grid. Same as 1C9.	
1C50	Bypass Capacitor: Phasitron -1V3- 2nd Focus Supply. Same as 1C4.	
1C51	Bypass Capacitor: Phasitron -1V3- 1st Focus Supply. Same as 1C4.	
1C52	Bypass Capacitor: Phasitron -1V3- Deflector Supply. Same as 1C4.	
1C53	Bypass Capacitor: Phasitron -1V3- Neutral Plane Supply. Same as 1C4.	
1C54	Bypass Capacitor: Voltage Indicator Meter -1M9. Same as 1C4.	
1C55	Load Capacitor: Discriminator -1V20. Same as 1C29.	
1C56	Coupling Capacitor: Audio Feedback, Discriminator -1V20- to 2nd Audio -1V2. Paper, 0.25 mfd +30% -10%, 600 vdcw. Sprague Cat. No. PPX24B21.	P-7768969-P37
1C57	Not used.	
1C58	Bypass Capacitor: Modulator Panel Regulated Supply. Pyranol, 1 mfd ±10%, 600 vdcw. G-E Cat. No. 28F45.	P-3R48-P1
1C59	Not used.	
1C60	Resonating Capacitor: Resonates 1L4 to Crystal Frequency to Degenerate Crystal Frequency Voltage fed through to 2nd Doubler -1V10- Grid. Mica, 270 mmfd ±5%, 500 vdcw.	P-7770296-P28
1C61	Not used.	
1C62	R-F Filter Capacitor: Modulator Panel Filament Supply. Ceramic, 470 mmfd ±20%, 350 vdcw. Electrical Reactance Corp. Type No. BCF.	K-7119809-P5
1C63	R-F Filter Capacitor: Crystal Heater Filament Supply. Same as 1C62.	
1C64	R-F Filter Capacitor: Crystal Heater Supply. Same as 1C62.	
1C65	R-F Filter Capacitor: Crystal Heater Supply. Same as 1C62.	
1C66	R-F Filter Capacitor: Modulator Panel Regulated Supply. Same as 1C62.	
1C67	R-F Filter Capacitor: Modulator Panel Regulated Supply. Same as 1C62.	
1C68 thru 1C103	Not used.	

CAPACITORS (CONT'D)

Symbol	Description	G-E Drawing
*1C104	Tuning Capacitor: Final Tripler -1V15-Plate Tank. Variable, 35 mmfd. Hammarlund Cat. No. HFAD-35-B.	M-2R26-P5
1C105	Bypass Capacitor: I-P-A Grid Meter -1M6. Same as 1C29.	
*1C106	Tuning Capacitor: I-P-A Grid Tank. Variable, 50 mmfd. Hammarlund Cat. No. HFAD-50-B.	M-2R26-P6
1C107	Bypass Capacitor: I-P-A Cathode Meter -1M5. Same as 1C29.	
1C108	Bypass Capacitor: I-P-A Screen. Same as 1C29.	
1C109	Not used.	
1C110	Neutralizing Capacitor: I-P-A	K-7861852-P1
1C111	Tuning Capacitor: I-P-A Plate Tank. Same as 1C106.	
1C112	Tuning Capacitor: P-A Grid Tank. Same as 1C106.	
1C113	Not used.	
1C114	Bypass Capacitor: P-A Grid Meter -1M4. Same as 1C29.	
1C115	Bypass Capacitor: P-A Grid. Same as 1C29.	
1C116	Bypass Capacitor: P-A Filament. Same as 1C29.	
1C117	Bypass Capacitor: P-A Filament. Same as 1C29.	
1C118 thru 1C120	Not used.	
1C121	Bypass Capacitor: P-A Voltmeter -1M3. Same as 1C29.	
1C122	Bypass Capacitor: P-A Plate Current Meter -1M2. Same as 1C29.	
1C123	Bypass Capacitor: P-A Plate Supply. Mica, 470 mmfd ±10%, 2500 vdcw.	P-3R32-P9
*1C124	Tunned Bypass Capacitor: P-A Screen; Series Resonates Screen Inductance. Variable, 100 mmfd. Hammarlund Cat. No. HFAD-100-B.	M-2R26-P7
1C125	Bypass Capacitor: P-A Plate Current Meter -1M2. Same as 1C123.	
1C126	Low-frequency Bypass capacitor: P-A Screen. Pyranol, 10 mfd ±10%, 600 vdcw.	P-3R24-P5
1C127 thru 1C130	Not used.	
1C131	Voltage Dividing Capacitor: R-F Voltmeter -1V30. Air-trimmer, 3.3-10 mmfd.	P-3R47-P31
1C132	Bypass Capacitor: R-F Output Meter -1M1. Same as 1C29.	
11C133	Load Capacitor: R-F Voltmeter -1V30. Mica 470 mmfd ±5%, 500 vdcw.	P-3R26-P56
1C134	Bypass Capacitor: R-F Voltmeter -1V30 Filament. Mica, 470 mmfd ±10%, 500 vdcw. Centralab Type No. 833-8.	M-7478611-P10
1C135	Bypass Capacitor: R-F Voltmeter -1V30- Filament. Same as 1C134.	
1C136 thru 1C140	Not used.	
1C141	Filter Capacitor: Low Voltage Supply. Same as 1C126.	
1C142	Filter Capacitor: Low Voltage Supply. Same as 1C126.	
1C143	Filter Capacitor: Voltage Regulators -1V34, 1V35, 1V36- Grids. Pyranol, 1 mfd ±10%, 600 vdcw. G-E Cat. No. 28F46.	P-3R48-P11

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

Symbol	*Description*	*G-E Drawing*
	CAPACITORS (CONT'D)	
1C144	Coupling Capacitor: Hum to Regulating Control –1V37– Grid. Same as 1C143.	
1C145	Bypass Capacitor: Regulating Control –1V37– Screen. Same as 1C143.	
1C146 thru 1C152	Not used.	
1C153	Filter Capacitor: High Voltage Supply. Pyranol, 10 mfd ±10%, 2500 vdcw. G-E Cat. No. 25F820.	P-3R22-P8
1C154	Filter Capacitor: High Voltage Supply. Same as 1C153.	
1C155 thru 1C160	Not used.	
1C161	Bypass Capacitor: Power Input Line. Pyranol, 0.5 mfd ±10%, 1000 vdcw. G-E Cat. No. 28F52.	P-3R48-P6
1C162	Bypass Capacitor: Power Input Line. Same as 1C161.	
1C163 and 1C164	Not used.	
1C165	Filter Capacitor: Audio Input Pre-emphasis. Mica, 10,000 mmfd ± 10%, 300 vdcw.	P-3R28-P9
1C166	Filter Capacitor: Audio Input Pre-emphasis. Same as 1C165.	
	MISCELLANEOUS ELECTRICAL PARTS	
1E1	Spark Gap: Surge Protective, High-voltage Rectifier.	K-7124263-P1
	FUSES	
*1F1	Input Fuse: Crystal Heater Power. Cartridge type; 250 volts, 3 amp. G-E Cat. No. 3167.	K-1R11-P1
*1F2	Input Fuse: Crystal Heater Power. Same as 1F1.	
	INDICATING DEVICES	
*1I1	Pilot Indicating Light: Crystal Heater On-Off. (Thermo controlled) 6–8 volts, 0.25 amp, miniature bayonet base. G-E Cat. No. 47.	
1S1	Control Indicating Switch: Plate "ON." Push button type, green translucent button, G-E lamp No. 46 included. G-E Cat. No. 2280664-G-3.	K-7107849-P6
1S2	Control Indicating Switch: Plate "OFF." Push button type, red translucent button, G-E lamp No. 46 included. G-E Cat. No. 2280664-G-2.	K-7107849-P5
	JACKS AND RECEPTACLES	
*1J1	Output Connector: Final Tripler –1V15. Bakelite, single contact, female. American Phenolic Corp. Cat. No. 83-1R.	M-2R22-P3
1J2	Not used.	
1J3	Input Connector: I-P-A Grid. Same as 1J1.	
1J4	Output Connector: Station-Monitor Coupling Loop. Same as 1J1.	
1J5	Not Used.	
*1J6	Monitoring Jack: Regulated Supply Voltage. Phone tip type, high voltage, female, standard size. Insuline Corp. Cat. No. 1889.	K-7107869-P1

Symbol	*Description*	*G-E Drawing*
	JACKS AND RECEPTACLES (CONT'D)	
*1J7	Output Connector: Station Monitor. Double end, sleeve contact, female. American Phenolic Corp. Cat. No. 83-1F.	M-2R22-P6
1J8	Input Connector: R-F Voltmeter –1V30. Same as 1J1.	
1J9	Output Connector: Transmission Line Voltage Divider, for R-F Voltmeter –1V30. Same as 1J1.	
	CONTACTORS AND RELAYS	
1K1	Timing Relay: Power Application to Plate Voltage Application Delay. (For Filament Heating) 115 volt, 60 cycle; 30 sec. ±10% time delay; contact rating 10 amp, 125 volts NIAC, 250 volts, 5 amp NIAC. Price Brothers Type No. 4052.	M-7478040-P1
1K2	Main Contactor: Plate Voltage Application. 115 volt, 60 cycle; 4 poles, 2 interlocks, left normally open, right normally closed. G-E Cat. No. 4986958N2.	P-7767981-P15
1K3	Control Relay: Plate "On". 115 volt, 60 cycle; 2 normally open, 2 normally closed, DPDT contacts. G-E Type No. 12HMA11B11.	P-7767982-P1
1K4	Control Relay: Plate "Off". Same as 1K3.	
1K5	Auxiliary Relay: Shorts Out Surge Resistor-1R185. Same as 1K3.	
1K6	Auxiliary Relay: Controls 1K5 and P-A Screen. (Energized by P-A Grid Current.) Coil resistance 2000 ohms approx, current break 60 ma., inductive 500 volts DC, 1 form A, 1 form B contact.	P-7766441-P15
1K7	Overload Relay: Low Voltage Supply. Coil resistance 10 ohms or less; pull in 600 ma ±25 ma; current break ½ amp, inductive 115 volts AC; 1 form A, 2 form B contacts.	P-7766441-P12
1K8	Overload Relay: High Voltage Supply. Same as 1K7.	
	INDUCTORS	
1L1	Modulation Coil: Produces Axial Field in Phasitron –1V3. 5000 turns No. 30 HF Formex wire.	ML-7478020-G1
1L2	D-C Return Choke Coil: Cathode of Crystal Oscillator –1V4. Inductance 25.0 mh ±5%, max. current 75 ma; resistance 159 ohms. F. W. Sickles Cat. No. SC-104A.	K-1R15-P8
1L3	R-F Load Choke Coil: Crystal Oscillator –1V4. Inductance 2.0 mh ±5%, max. current 125 ma., resistance 26 ohms. F. W. Sickles Cat. No. SC-98A.	K-1R15-P2
1L4	Tuning Inductor: Resonates 1C60 to Crystal Frequency to Degenerate Crystal Frequency Voltage Fed Through to 2nd Doubler –1V10– Grid.	ML-7480644-G1
1L5	Tank Coil: Final Tripler –1V15– Plate. 2 turns $\frac{7}{16}$" ID x 1" lg. of 0.080" diam. wire, right hand wound.	K-7114893-P1
1L6	Coupling Coil: Final Tripler –1V15– Output. 1 turn ⅞" ID of 0.064" diam. copper wire.	K-7114894
1L7	Coupling Coil: I-P-A Grid Tank. 1 turn $\frac{11}{16}$" ID of 0.064" diam. copper wire.	K-7114873-P1

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

Symbol	Description	G-E Drawing
	INDUCTORS (CONT'D)	
1L8	Tank Coil: I-P-A Grid. 3 turns 21/32" ID x 1⅛" lg. of 0.102" diam. copper wire, left hand wound.	K-7114871-P2
1L9	R-F Choke Coil: D-C Supply, I-P-A Plate. 20 turns equally spaced 5/16" ID x 1½" lg. of 0.040" diam. copper wire.	K-7114875-P1
1L10	Tank Coil: I-P-A Plate. 3 turns 21/32" ID x 1⅛" lg. of 0.102" diam. copper wire, right hand wound.	K-7114871-P1
1L11	Coupling Coil: Link, I-P-A Plate Tank to P-A Grid Tank.	ML-7114874-G1
1L12	Not used.	
1L13	Tank Coil: P-A grid. 2 turns ¾" ID x 1" lg. of 0.102" diam. copper wire, left hand wound.	K-7114872-P1
1L14	R-F Choke Coil: P-A Grid. Same as 1L9.	
1L15	Coupling Coil: P-A Plate Tank to Station Monitor. 1 turn 2¼" ID of 0.080" diam. copper wire, ⅜" gap.	K-7114896-P1
1L16	Tank Coil: P-A Plate. Variable inductor.	ML-7766898-G1
1L17	R-F Choke Coil: D-C Supply, P-A Plate. 16 turns equally spaced ½" ID x 2" lg. of 0.064" diam. copper wire.	K-7114876-P1
1L18	Coupling Coil: P-A Plate Tank to Output Transmission Line. 1 turn 2 5/16" ID of 0.102" diam. copper wire, ¼" gap.	K-7114545-P1
1L19	D-C Return Choke Coil: R-F Voltmeter –1V30– Diode Current. 15 turns equally spaced ¼" ID x 1 3/16" lg. of 0.040" diam. copper wire, right hand wound.	K-7114895-P1
1L20 thru 1L22	Not used.	
1L23	R-F Choke Coil: D-C Supply, P-A Screen. 11 turns ½" ID x 1⅛" lg. of 0.064" diam. copper wire, right hand wound.	K-7116144-P1
1L24	R-F Choke Coil: D-C Supply, P-A Screen. Inductance 2½ mh; distributed capacity 1 mmfd; DC resistance 50 ohms; current rating 125 ma.	ML-7107898-G1
1L25	Filter Reactor: Low-voltage Supply. Inductance 12 henries min. at 0.4 amp. DC; resistance 100 ohms max.	M-7475226-P1
1L26	Filter Reactor: Low-voltage Supply. Same as 1L25.	
1L27	Filter Reactor: High-voltage Supply. Inductance 12 henries min. at 0.3 amp. DC; resistance 165 ohms max.	M-7475225-P1
1L28	Filter Reactor: High-voltage Supply. Same as 1L27.	
1L29	Low-frequency Degenerative Choke: P-A Cathode. Same as 1L25.	
1L30 thru 1L32	Not used.	
1L33	R-F Filter Coil: Filament Supply to Modulator Panel. 13 turns ¼" I.D. x 2 1/16" lg. of 0.063" diam. copper wire.	K-7119343-P1
1L34	R-F Filter Coil: Crystal Heater Input to Modulator Panel. Same as 1L33.	
1L35	R-F Filter Choke Coil: Regulated Supply Input to Modulator Panel. Same as 1L24.	

Symbol	Description	G-E Drawing
	METERS	
1M1	Indicating Meter: R-F Output, Relative Level. 3½"; D.C. rating 1 ma. G-E Type No. DO53	M-7475091-P2
1M2	Indicating Meter: P-A Plate Current. 3½"; rating 500 ma; calibrated 7/32" behind a 0.090" magnetic panel.	K-7108892-P5
1M3	Indicating Meter: P-A Plate Voltage. 3½"; DC rating 3 KV; resistance 1000 ohms per volt. (supplied with external resistors 1R164A and 1R164B)	P-3R42-P24
1M4	Indicating Meter: P-A Grid Current. 3½"; DC rating 30 ma.	P-3R43-P29
1M5	Indicating Meter: I-P-A Cathode Current. 3½"; DC rating 300 ma.	P-3R35-P35
1M6	Indicating Meter: I-P-A Grid Current 3½"; DC rating 5 ma.	P-3R35-P24
1M7	Indicating Meter: Final Tripler –1V15– Cathode Current. 3½"; DC rating 100 ma.	P-3R35-P32
1M8	Indicating Meter: Final Tripler –1V15– Grid Current. Same as 1M6.	
1M9	Indicating Meter: Multivoltage. (Voltage Indicator) 3½"; DC rating 50–0–50 microamp. G-E Type No. DO-53.	M-7476192-P2
1M10	Indicating Meter: AC Transmitter Operating Voltage. 3½"; AC rating 300 volts. G-E Type No. AO-25.	M-7475041-P2
	PLUGS	
*1P1	90° Direction Changing Connector: 1J1 to 1P2, 3rd Tripler –1V15– Output. Coaxial angle plug adapter; pin contact one angle, socket sleeve contact the other. American Phenolic Corp. Cat. No. 83-1AP.	M-2R22-P2
*1P2	Cable Connector: Final Tripler –1V15– Output. High frequency; straight, pin contact, male. American Phenolic Corp. Cat. No. 83-1SP.	M-2R22-P1
1P3	Cable Connector: I-P-A Grid Input. Same as 1P2.	
1P4	Cable Connector: Station-Monitor Loop Output. Same as 1P2.	
1P5	Cable Connector: Station-Monitor Loop Output. Same as 1P2.	
1P6	Not used.	
1P7	Cable Connector: Station-Monitor Input. (Cable furnished by customer.) Same as 1P2.	
1P8	Cable Connector: R-F Voltmeter –1V30– Input. Same as 1P2.	
1P9	Cable Connector: Transmission Line Voltage Divider Output. (For R-F Voltmeter –1V30) Same as 1P2.	
	RESISTORS	
1R1	Load Resistor: Audio Input Transformer –1T1– Secondary. Composition, 0.51 meg. ±5%, ½ watt.	P-3R11-P224
1R2	Modulation Sensitivity Adjusting Potentiometer. Variable, 68,000 ohms ±20%; Allen Bradley Type J.	M-2R25-P100
1R3	Cathode Resistor: 1st Audio –1V1. Composition, 750 ohms ±5%, ½ watt.	P-3R11-P156
1R4	Load Resistor: 1st Audio –1V1– Plate. Composition, 0.10 meg. ±5%, 1 watt.	P-3R13-P207

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

Symbol	Description	G-E Drawing
	RESISTORS (CONT'D)	
1R5	Coupling Time-Constant Resistor: 1st -1V1- Audio to First Section of 2nd -1V2- Audio. Composition, 0.20 meg. ±5%, ½ watt.	P-3R11-P214
1R6	Audio-Driving-Signal to Audio-Feedback-Signal Ratio Adjusting Potentiometer. Variable, 100,000 ohms ±20%; Allen Bradley Type J.	M-2R25-P101
1R7	Grid Resistor: First Section of 2nd -1V2- Audio. Composition 1.0 meg. ±5%, ½ watt.	P-3R11-P231
1R8	Audio Feedback Time-Constant Resistor. Composition, 0.30 meg. ±5%, ½ watt.	P-3R11-P218
1R9	Cathode Resistor: First Section of 2nd -1V2- Audio. Composition, 1,500 ohms ±5%, ½ watt.	P-3R11-P163
1R10	Load Resistor: First Section of 2nd -1V2- Audio. Same as 1R4.	
1R11	Grid Resistor: Second Section of 2nd -1V2- Audio. Same as 1R7.	
1R12	Cathode Resistor: Section Section of 2nd -1V2- Audio. Composition, 910 ohms ±5%, ½ watt.	P-3R11-P158
1R13	Feedback Resistor: Audio Output Transformer -1T2- to First Section of Second Audio -1V2. Composition, 7,500 ohms ±5%, ½ watt.	P-3R11-P180
1R14	Not used.	
1R15	Grid Resistor: Feedback Amplifier -1V19. Composition, 30,000 ohms ±5%, ½ watt.	P-3R11-P194
1R16	Cathode Resistor: Feedback Amplifier -1V19. Composition, 150 ohms ±5%, ½ watt.	P-3R11-P139
1R17	Screen Dropping Resistor: Feedback Amplifier -1V19. Composition, 47,000 ohms ±5%, 1 watt.	P-3R13-P199
1R18	Load Resistor: Discriminator -1V20. Composition, 0.10 meg. ±5%, ½ watt.	P-3R11-P207
1R19	Load Resistor: Discriminator -1V20. Same as 1R18.	
1R20	Voltage Dividing Resistor: 1st -1V1- Audio Screen. Composition, 47,000 ohms ±10%, ½ watt.	P-3R11-P82
1R21	Voltage Dividing Resistor: 1st -1V1- Audio Screen. Composition, 0.12 meg. ±5%, 1 watt.	P-3R13-P209
1R22 thru 1R29	Not used.	
1R30	Cathode Resistor: Crystal Amplifier. Composition, 1,000 ohms ±5%, ½ watt.	P-3R11-P159
1R31 thru 1R34	Not used.	
1R35	Voltage Dropping Resistor: Crystal -1Y1- Heater. Composition, 22 ohms ±10%, 2 watt.	P-3R67-P42
1R36	Voltage Dropping Resistor: Crystal -1Y1- Heater. Same as 1R35.	
*1R37	Grid Resistor: Crystal Oscillator -1V4. Composition, 1.0 meg. ±10%, ½ watt.	P-3R11-P98
*1R38	Voltage Dropping Resistor: Crystal Oscillator -1V4- Screen. Composition, 0.22 meg. ±10%, 1 watt.	P-3R13-P90
1R39	Grid Resistor: Crystal Amplifier -1V5. Composition, 9,100 ohms ±5%, ½ watt.	P-3R11-P182
*1R40	Isolating and Voltmeter Multiplying Resistor: Crystal Amplifier -1V5- Grid Voltage. Composition, 0.10 meg. ±10%, ½ watt.	P-3R11-P86
	RESISTORS (CONT'D)	
*1R41	Voltage Dropping Resistor: Crystal Amplifier -1V5- Screen. Composition, 47,000 ohms ±10%, 1 watt.	P-3R13-P82
*1R42	Decoupling Resistor: Crystal Amplifier -1V5- Plate. Composition, 1,000 ohms ±10%, 2 watt.	P-3R67-P62
*1R43	Voltage Dropping Resistor: Crystal Oscillator -1V4- Screen. Composition, 0.12 meg. ±10%, 1 watt.	P-3R13-P87
1R44 thru 1R46	Not used.	
1R47	Loading Resistor: 1st Doubler -1V9- Grid. Composition. 56,000 ohms ±5%, ½ watt.	P-3R11-P201
1R48	Loading Resistor: 1st Doubler -1V9- Grid. Same as 1R5.	
*1R49	Decoupling Resistor: Phasitron -1V3- Anode. Composition, 1,000 ohms ±10%, 1 watt.	P-3R13-P62
1R50	Voltage Dropping Resistor: Phasitron -1V3- First Anode. Same as 1R20.	
1R51	Grid Resistor: 1st Doubler -1V9. Same as 1R40.	
*1R52	Cathode Resistor 1st Doubler - 1V9. Composition, 4,7000 ohms ±10%, ½ watt.	P-3R11-P70
*1R53	Decoupling Resistor: 1st Doubler -1V9- Plate. Composition, 22,000 ohms ±10%, 2 watt.	P-3R67-P78
1R54	Grid Resistor: 2nd Doubler -1V10. Same as 1R40.	
1R55	Decoupling Resistor: 2nd Doubler -1V10- Plate. Same as 1R53.	
1R56	Grid Resistor: 3rd Doubler -1V11. Same as 1R40.	
1R57	Loading Resistor: 3rd Doubler -1V11- Grid. Composition, 0.15 meg ±5%, ½ watt.	P-3R11-P211
*1R58	Loading Resistor: 3rd Doubler -1V11- Grid. Composition, 39,000 ohms ±5%, ½ watt.	P-3R11-P197
1R59	Loading Resistor: 2nd Doubler -1V10- Grid. Same as 1R8.	
1R60	Loading Resistor: 2nd Doubler -1V10- Grid. Composition, 75,000 ohms ±5%, ½ watt.	P-3R11-P204
1R61	Decoupling Resistor: 3rd Doubler 1V11- Plate. Same as 1R53.	
1R62	Grid Resistor: 1st Tripler -1V12. Same as 1R40.	
1R63	Loading Resistor: 1st Tripler -1V12- Grid. Same as 1R57.	
1R64	Loading Resistor: 1st Tripler -1V12- Grid. Composition, 0.13 meg ±5%, ½ watt.	P-3R11-P210
1R65	Decoupling Resistor: 1st Tripler -1V12- Plate. Same as 1R53.	
1R66	Loading Resistor: 2nd Tripler -1V13- Grid. Same as 1R18.	
1R67	Not used.	
1R68	Grid Resistor: 2nd Tripler -1V13. Same as 1R40.	
1R69	Not used.	
1R70	Decoupling Resistor: 2nd Tripler -1V13- Plate. Same as 1R53.	
1R71	Grid Resistor: 4th Doubler -1V14. Same as 1R40.	
1R72	Not used.	
*1R73	Cathode Resistor: 4th Doubler -1V14. Composition, 330 ohms ±10%, 2 watt.	P-3R67-P56
*1R74	Voltage Dropping Resistor: 4th Doubler -1V14- Screen. Composition, 10,000 ohms ±10%, 2 watt.	P-3R67-P74

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

Symbol	Description	G-E Drawing
	RESISTORS (CONT'D)	
1R75	Decoupling Resistor: 4th Doubler -1V14- Plate. Wirewound, 1,000 ohms ±5%, 10 watt. Ward Leonard Cat. No. K41382-1.	M-2R12-P31
1R76	Grid Resistor: Final Tripler -1V15. Same as 1R17.	
1R77	Voltage Dropping Resistor: Final Tripler -1V15- Screen. Same as 1R53.	
1R78	Decoupling Resistor: Final Tripler -1V15- Plate. Same as 1R75.	
1R79 thru 1R83	Not used.	
*1R84	Voltage Dividing Resistor: Phasitron -1V3- First Focus. Composition, 27,000 ohms ±10%, 2 watt.	P-3R67-P79
1R85	Voltage Dropping Resistor: Phasitron -1V3- Neutral Plane. Same as 1R40.	
1R86	Voltage Dropping Resistor: Phasitron -1V3- First Focus. Same as 1R84.	
1R87	Voltage Dividing Resistor: Phasitron -1V3- Second Focus. Same as 1R84.	
1R88	Voltage Dividing Resistor: Phasitron -1V3- Deflectors. Same as 1R41.	
1R89	Voltage Dividing and Adjusting Resistor Phasitron -1V3- Neutral Plane. Variable, 33,000 ohms ±20%; Allen Bradley Type J.	M-2R25-P98
1R90	Voltage Dividing and Adjusting Resistor: Phasitron -1V3- First Focus. Same as 1R89.	
1R91	Voltage Dividing and Adjusting Resistor: Phasitron -1V3- Second Focus. Variable, 47,000 ohms ±20%; Allen Bradley Type J.	M-2R25-P99
1R92	Voltage Dividing and Adjusting Resistor: Phasitron -1V3- Deflectors. Same as 1R91.	
1R93 thru 1R98	Not used.	
1R99	Voltmeter Multiplying Resistor: Multivoltage Voltage Indicator Meter -1M9. Composition, 51,000 ohms ±5%, ½ watt.	P-3R11-P200
1R100 and 1R101	Not used.	
1R102	Voltmeter Multiplying Resistor: First Section, 2nd -1V2- Audio Cathode Voltage. Composition, 36,000 ohms ±5%, ½ watt.	P-3R11-P196
1R103	Voltmeter Multiplying Resistor: Second Section, 2nd -1V2- Audio Cathode Voltage. Composition, 0.27 meg. ±5%, ½ watt.	P-3R11-P217
1R104	Voltmeter Multiplying Resistor: Crystal Amplifier -1V5- Grid Voltage. Composition 47,000 ohms ±5%, ½ watt.	P-3R11-P199
1R105	Voltmeter Multiplying Resistor: Phasitron -1V3- Neutral Plane Voltage. Composition, 0.91 meg. ±5%, ½ watt.	P-3R11-P230
1R106	Voltmeter Multiplying Resistor: Phasitron -1V3- First Focus Voltage. Same as 1R105.	
1R107	Voltmeter Multiplying Resistor: Phasitron -1V3- Second Focus Voltage. Composition, 3.9 meg. ±5%, ½ watt.	P-3R11-P245

Symbol	Description	G-E Drawing
	RESISTORS (CONT'D)	
1R108	Voltmeter Multiplying Resistor: Phasitron -1V3- Deflector Voltage. Same as 1R107.	
1R109	Voltmeter Multiplying Resistor: 1st Doubler -1V9- Cathode Voltage. Same as 1R1.	
1R110	Voltmeter Multiplying Resistor: 2nd Doubler -1V10- Grid Voltage. Composition, 2.7 meg. ±5%, ½ watt.	P-3R11-P241
1R111	Voltmeter Multiplying Resistor: 3rd Doubler -1V11- Grid Voltage. Composition, 3.6 meg. ±5%, ½ watt.	P-3R11-P244
1R112	Voltmeter Multiplying Resistor: 1st Tripler -1V12- Grid Voltage. Composition, 4.7 meg. ±5%, ½ watt.	P-3R11-P247
1R113	Voltmeter Multiplying Resistor: 2nd Tripler -1V13- Grid Voltage. Composition, 3.3 meg. ±5%, ½ watt.	P-3R11-P243
1R114	Voltmeter Multiplying Resistor: 4th Doubler -1V14- Grid Voltage. Same as 1R105.	
1R115	Voltage Dividing Resistor: Regulated Supply to Multivoltage Meter -1M9. Composition, 1.6 meg. ±5%, ½ watt.	P-3R11-P236
1R116	Voltage Dividing Resistor: Regulated Supply to Multivoltage Meter -1M9. Composition, 10,000 ohms ±5%, ½ watt.	P-3R11-P183
1R117	Voltmeter Multiplying Resistor: Feedback Amplifier -1V19- Cathode Voltage. Composition, 0.12 meg. ±5%, ½ watt.	P-3R11-P209
1R118	Voltmeter Multiplying Resistor: Discriminator -1V20- DC Output Voltage. Composition, 0.47 meg. ±5%, ½ watt.	P-3R11-P223
1R119 thru 1R144	Not used.	
*1R145	Parasitic Resistor: I-P-A Grid. Composition, 10 ohms ±10%, ½ watt.	P-3R11-P38
1R146	Parasitic Resistor: I-P-A Grid. Same as 1R145.	
1R147 thru 1R151	Not used.	
1R152	Grid Resistor: I-P-A. Same as 1R74.	
1R153	Parasitic Resistor: I-P-A Grid. Same as 1R145.	
1R154	Parasitic Resistor: I-P-A Grid. Same as 1R145.	
1R155	Cathode Resistor: I-P-A. Wirewound, 160 ohms ±5%, 25 watt. Ward Leonard Cat. No. K-41383-1.	M-2R14-P23
1R156	Voltage Dropping Resistor: I-P-A Screen. Wirebound, 12,000 ohms ±5%, 25 watt. Ward Leonard Cat. No. K-41383-1.	M-2R14-P42
1R157 thru 1R160	Not used.	
1R161	Grid Resistor: P-A. Same as 1R156.	
1R162	Not used.	
1R163	Balancing Resistor: P-A Filament Hum. Adjustable, wirewound; 50 ohms ±10%, 25 watt. Ohmite Cat. No. 0366.	K-7107846-P1

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

Symbol	Description	G-E Drawing
	RESISTORS (CONT'D)	
1R164A	Voltmeter Multiplying Resistor: P-A Plate Voltage Meter –1M3. Multiplier; 1 meg. ±0.2%, rating 1 KV. (Supplied with 1M3)	M-7475042-P5
1R164B	Voltmeter Multiplying Resistor: P-A Plate Voltage Meter –1M3. Multiplier; 2 meg. ±0.2% rating 2 KV. (Supplied with 1M3)	M-7475042-P5
1R165	Load and Voltmeter Multiplying Resistor: R-F Voltmeter –1V30– and R-F Output Meter –1M1. Composition, 82,000 ohms ±5%, ½ watt.	P-3R11-P205
1R166 thru 1R169	Not used.	
1R170	Filter Resistor: Voltage Regulators –1V34, 1V35, 1V36,– Grids. Composition, 6,800 ohms ±5%, 1 watt.	P-3R13-P179
*1R171	Filter Resistor: Voltage Regulators –1V34, 1V35, 1V36,– Grids. Composition, 0.10 meg. ±10%, 2 watt.	P-3R67-P86
*1R172	Isolating Resistor: Regulator –1V34– Grid. Composition, 1,000 ohms ±10%, ½ watt.	P-3R11-P62
1R173	Isolating Resistor: Regulator –1V35– Grid. Same as 1R172.	
1R174	Isolating Resistor: Regulator –1V36– Grid. Same as 1R172.	
1R175	Voltage Dividing Resistor: Regulator Control –1V37– Screen. Composition, 18,000 ohms ±5%, 2 watt.	P-3R67-P189
1R176	Voltage Dividing Resistor: Regulator Control –1V37– Screen. Same as 1R175.	
1R177	Voltage Dividing Resistor: Regulator Control –1V37– Screen. Same as 1R175.	
1R178	Isolating Resistor: Regulator Control –1V37– Grid. Same as 1R40.	
*1R179	Voltage Dividing Resistor: Regulator Control –1V37– Grid. Composition, 68,000 ohms ±10%, 1 watt.	P-3R13-P84
1R180	Voltage Dividing Resistor: Regulator Control –1V37– Grid. Same as 1R91.	
*1R181	Voltage Dividing Resistor: Regulator Control –1V37– Grid. Composition, 0.12 meg. ±10%, 1 watt.	P-3R13-P87
1R182	Current Limiting Resistor: Regulator Reference Bias Tube –1V38. Wirewound, 8,000 ohms ±5%, 25 watt. Ward Leonard Cat. No. K-41383-1.	M-2R14-P40
*1R183	Voltage Dividing Resistor: Regulator Control –1V37– Cathode. Composition, 220 ohms ±10%, 1 watt.	P-3R13-P54
1R184	Voltage Dividing Resistor: Regulator Control –1V37– Cathode. Wirewound 5,000 ohms ±5%, 10 watt. Ward Leonard Cat. No. K-41382-1.	M-2R12-P38
1R185	Surge Current Limiting Resistor: High-Voltage Supply. Wirewound, 5,000 ohms ±5%, 115 watts.	M-7464826-P38
1R186	Voltage Dividing Resistor: P-A Screen. (Also serves as part of Bleeder on High-Voltage Supply) Wirewound, 25,000 ohms ±5%, 115 watts.	M-7464826-P45

Symbol	Description	G-E Drawing
	RESISTORS (CONT'D)	
1R187	Voltage Dividing Resistor: P-A Screen. (Also serves as part of Bleeder on High-Voltage Supply) Wirewound, 16,000 ohms ±5%, 115 watts.	M-7464826-P43
1R188	Voltage Dividing Resistor: P-A Screen. (Also serves as part of Bleeder on High-Voltage Supply). Same as 1R186.	
1R189 and 1R190	Not used.	
1R191	Line Terminating Resistor: Audio Input. Composition, 300 ohms ±5%, ½ watt.	P-3R11-P146
1R192	Line Terminating Resistor: Audio Input. Same as 1R191.	
1R193	Filter Resistor: Audio Input Preemphasis. Composition, 5,100 ohms ±5%, ½ watt.	P-3R11-P176
1R194	Filter Resistor: Audio Input Preemphasis. Same as 1R193.	
1R195	Filter Resistor: Audio Input Preemphasis Adjustment. Variable, 4,700 ohms ±20%, Allen Bradley Type J.	M-2R25-P93
1R196	Filter Resistor: Audio Input Preemphasis Adjustment. Same as 1R195.	
1R197	Line Terminating Resistor: Audio Input Composition, 100 ohms ±5%, ½ watt.	P-3R11-P135
1R198	Line Terminating Resistor: Audio Input. Same as 1R197.	
	SWITCHES	
1S1	Safety Switch: Rear Door Interlock. Single circuit, normally open, 10 amp, 250 volts.	ML-7460330-G4
1S2	Safety Switch: Rear Handle Interlock. Momentary contact normally open, single circuit; 3 amp at 125 volts. G-E Cat. No. 1GA19A30 (Part of 1S4).	K-7870464
1S3	Power Circuit Breaker: Transmitter Supply. 2 pole, rating 10 amp, 230 volts AC Max., 60 cycle; interrupting rating 5,000 amp. Heineman Cat. No. 2263S-10.	P-7768829-P9
1S4	Safety Switch: High-Voltage Grounding. (Includes 1S2).	ML-7474516-G1
1S5	Selector Switch: Multivoltage Voltage Indicator—1M5. Wafer type, 1 circuit, 17 position, non-shorting, adjustable stop.	K-7108896
*1S6	Balanced to Unbalanced Audio Input Switch. Toggle; D.P.D.T. rating 1 amp, 250 volts; 3 amp, 125 volts. Arrow-Hart and Hegeman Electric Co. Type No. 20905-GH.	M-7478623-P4
1S7	600 to 150 Ohms Audio Input Switch. Same as 1S6.	
	TRANSFORMERS	
1T1	Input Transformer: 1st Audio –1V1. Primary Impedance: 600/150/150 ohms balanced center tap; Secondary: 60,000 ohms.	M-7478088
1T2	Output Transformer: 2nd Audio –1V2, Drives Modulation Inductor –1L1.	M-7475659
1T3	Phase Splitting Transformer: Single to Biphase. Used with 1T4 to split to Three Phase. R.F. includes tuning capacitors.	M-7478004

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

Symbol	Description	G-E Drawing
	TRANSFORMERS (CONT'D)	
1T4	Phase Splitting Transformer: Single to Quarter Phase, use with 1T3 to split to Three Phase. R.F. includes tuning capacitors.	M-7478003
1T5 thru 1T8	Not used.	
1T9	Coupling Transformer: Phasitron -1V3- to 1st Doubler -1V9. R.F. includes tuning capacitors.	P-7766849-P10
1T10	Coupling Transformer: 1st Doubler -1V9- to 2nd Doubler -1V10. R.F. includes tuning capacitors.	P-7766849-P11
1T11	Coupling Transformer: 2nd Doubler -1V10- to 3rd Doubler -1V11. R.F. includes tuning capacitors.	P-7766849-P5
1T12	Coupling Transformer: 3rd Doubler -1V11- to 1st Tripler -1V12. R.F. includes tuning capacitors.	P-7768620-P3
1T13	Coupling Transformer: 1st Tripler -1V12- to 2nd Tripler -1V13. R.F. includes tuning capacitors.	P-7768620-P4
1T14	Coupling Transformer: 2nd Tripler -1V13- to 4th Doubler -1V14. R.F. includes tuning capacitors.	P-7768620-P5
1T15	Coupling Transformer: 4th Doubler -1V14- to Final Tripler -1V15. R.F. includes tuning capacitors.	P-7768620-P6
1T16	Discriminator Transformer: Audio Feedback. R.F. includes tuning capacitors. (Does not include 1C39 and 1C47)	P-7766849-P12
1T17 thru 1T30	Not used.	
1T31	Stepdown Transformer: Green Plate "ON" Indicating Switch -1IS1. Rating 50/60 cycles 0.003 KVA; primary 115 volts; secondary 4 volts. G-E Cat. No. 74G657.	M-7467402
1T32	Stepdown Transformer: Red Plate "OFF" Indicating Switch -1IS2. Same as 1T31.	
1T33	Isolating Stepdown Transformer: Control Circuits. Primary 200 volts, 50/60 cycles; secondary 115/96 volts ±4%, 1 amp.	M-7475658
1T34	Bucking Transformer: Line to Transmitter-Operating Voltage Reducing. Primary 230 volts 50/60 cycles; secondary 60 volts ±2%, 7.5 amp.	M-7475624
1T35	Adjusting Transformer: Transmitter-Operating Voltage. Powerstat: input, 230 volts 60 cycles; output, 0–270 volts 3.0 amp. Superior Electric Co. Type No. 216-U.	P-7768970-P2
1T36	Stepdown Transformer: Crystal Heater Primary 115 volts, 50/60 cycles; secondary 11 volts, 0.6 amp.	M-7475244
1T37	Filament Transformer: Low-Voltage Rectifiers, Voltage Regulators and Control Tube. Primary: 200 volts, 50/60 cycles; Secondaries: 6.3 volts at 0.3 amp. 6.3 volts at 3.0 amp with center tap. 5.0 volts at 6.0 amp with center tap.	M-7475626
1T38 thru 1T40	Not used.	
1T41	Rectifier Stepup Transformer: Low-Voltage Supply. Single phase; primary: 200 volts with taps to give 95, 100 and 105% of secondary: 50/60 cycles; secondary: 1260/630 volts, 0.30 KVA.	M-7475623
	TRANSFORMERS (CONT'D)	
1T42 and 1T43	Not used.	
1T44	Filament Transformer: P-A. Primary: 200 volts, 50/60 cycles; secondary: 5 volts, 30 amp.	M-7475621
1T45	Filament Transformer: High Voltage Rectifiers. Primary: 200 volts, 50/60 cycles; secondary: 2.5 volts, −0+4%, 10 amp ±5%, center tap.	M-7475625
1T46	Rectifier Stepup Transformer: High-Voltage Supply. Single phase; primary: 200 volts with taps to give 50, 90, 100 and 110% of secondary voltage, 50/60 cycles; secondary: 5, 150/2,575 volts 1.2 KVA.	M-7475622
1T47	Filament Transformer: I-P-A and Modulator Panel. Primary: 200 volts 50/60 cycles; secondary: 6.3 volts 12.5 amp.	M-7475627
	TUBES	
*1V1	Amplifying Tube: 1st Audio. Type 6SJ7.	
*1V2	Amplifying Tube: 2nd Audio. Type 6SN7.	
1V3	Modulation Tube: Phasitron. Type GL-5593.	
1V4	Oscillating Tube: Crystal. Same as 1V1.	
1V5	Amplifying Tube: Crystal Phase-Splitting Transformer Driver. Same as 1V1.	
1V6 thru 1V8	Not used.	
1V9	Doubling Tube: 1st. Same as 1V1.	
1V10	Doubling Tube: 2nd. Same as 1V1.	
1V11	Doubling Tube: 3rd. Same as 1V1.	
1V12	Tripling Tube: 1st. Same as 1V1.	
1V13	Tripling Tube: 2nd. Same as 1V1.	
*1V14	Doubling Tube: 4th. Type 6V6.	
*1V15	Tripling Tube: Final. Type GL-815.	
1V16 thru 1V18	Not used.	
1V19	Amplifying Tube: Discriminator Driver. Type 6AG7.	
1V20	Rectifying Tube: Discriminator. Type 6H6.	
1V21 thru 1V26	Not used.	
*1V27	Amplifying Tube: Intermediate Power. Type GL-829B.	
*1V28	Amplifying Tube: Final Power. Type GL-5D24 or Type 4-250-A.	
1V29	Amplifying Tube: Final Power. Same as 1V28.	
1V30	Rectifying Tube: R-F Voltmeter. Same as 1V20.	
1V31	Not used.	
*1V32	Rectifying Tube: Low-Voltage Supply. Type 5R4-GY.	
1V33	Rectifying Tube: Low-Voltage Supply. Same as 1V32.	
*1V34	Regulating Tube: Regulated Supply. Type 6B4G.	
1V35	Regulating Tube: Regulated Supply. Same as 1V34.	
1V36	Regulating Tube: Regulated Supply. Same as 1V34.	
1V37	Amplifying Tube: Regulated Supply Control. Same as 1V1.	

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

Symbol	Description	G-E Drawing
	TUBES (CONT'D)	
1V38	Biasing Tube: Constant Voltage, 1V37 Cathode. Type VR105-30.	
*1V39	Rectifying Tube: High-Voltage Supply. Type GL-866-A.	
1V40	Rectifying Tube: High-Voltage Supply. Same as 1V39.	
	SOCKETS	
*1X1	Socket for 1V1. Octal. American Phenolic Corp. Type No. M1P8T.	K-1R14-P26
1X2	Socket for 1V2. Same as 1X1.	
1X3	Socket for 1V3. Steatite, 11 contacts, retaining ring. American Phenolic Corp. Type No. 49-SS11-L.	K-7115095-P1
1X4	Socket for 1V4. Same as 1X1.	
1X5	Socket for 1V5. Same as 1X1.	
1X6 thru 1X8	Not used.	
1X9	Socket for 1V9. Same as 1X1.	
1X10	Socket for 1V10. Same as 1X1.	
1X11	Socket for 1V11. Same as 1X1.	
1X12	Socket for 1V12. Same as 1X1.	
1X13	Socket for 1V13. Same as 1X1.	
1X14	Socket for 1V14. Same as 1X1.	
1X15	Socket for 1V15. Same as 1X1.	
1X16 thru 1X18	Not used.	
1X19	Socket for 1V19. Same as 1X1.	
1X20	Socket for 1V20. Same as 1X1.	
1X21 thru 1X26	Not used.	
1X27	Socket for 1V27. Miniature size with built-in bypass capacitors, 5 contacts. RCA Type UT-107.	K-7107794-P1
	SOCKETS (CONT'D)	
1X28	Socket for 1V28. Jumbo size 5 pin base. National Radio Products Cat. No. HX. 100.	K-7107795-P1
1X29	Socket for 1V29. Same as 1X28.	
1X30	Socket for 1V30. Same as 1X1.	
1X31	Not used.	
*1X32	Socket for 1V32. Steatite, octal. American Phenolic Corp. Type No. RSS8.	K-1R13-P47
1X33	Socket for 1V33. Same as 1X32.	
1X34	Socket for 1V34. Same as 1X1.	
1X35	Socket for 1V35. Same as 1X1.	
1X36	Socket for 1V36. Same as 1X1.	
1X37	Socket for 1V37. Same as 1X1.	
1X38	Socket for 1V38. Same as 1X1.	
*1X39	Socket for 1V39. Jumbo size, 4 contacts. E. F. Johnson Cat. No. 209B.	M-7475054-P1
1X40	Socket for 1V40. Same as 1X39.	
1X41	Not used.	
1X42	Socket for 1Y1. Same as 1X1.	
1X43	Not used.	
1X44	Socket for 1I1. Dial light, translucent light green jewel. Dial Light Co. Cat. No. 192L.	K-7117809P4
	CRYSTALS	
1Y1	Frequency Controlling Crystal and Thermocell † unit: Transmitter Carrier. Holder: G-E Type 32C401G63 Thermocell†; heater: 6.3 volts 50/60 cycles. (When ordering replacements specify frequency used.)	M-7478021

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

† *Registered in U.S. Patent Office*

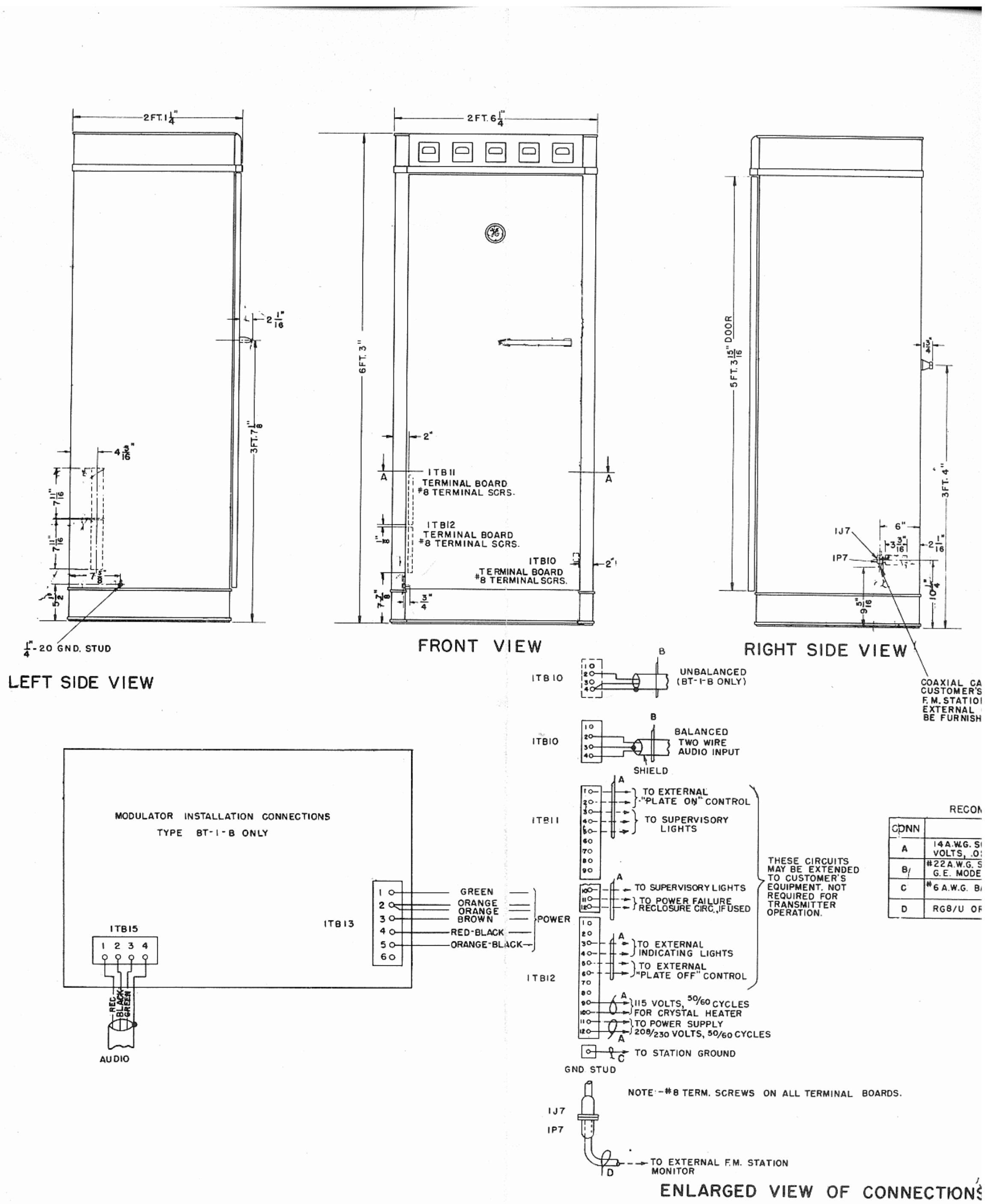
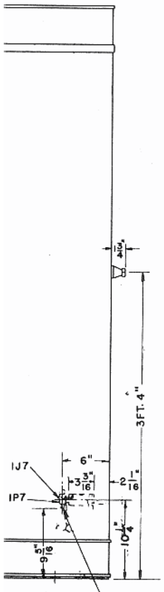
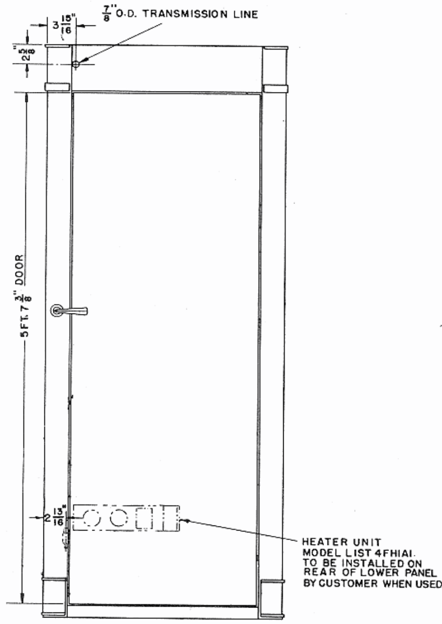


Fig. 33 Installation Diagram, Type BT-1-B Transmitter

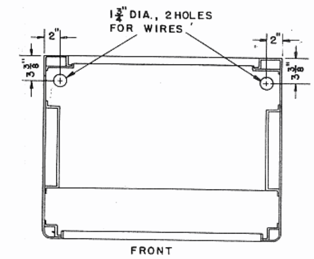


DE VIEW

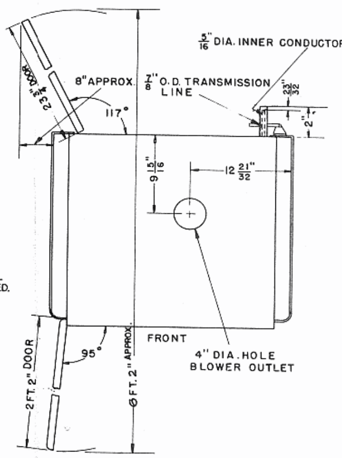
COAXIAL CABLE PLUG FOR CUSTOMER'S CONNECTION TO F.M. STATION MONITOR. EXTERNAL COXIAL CABLE TO BE FURNISHED BY CUSTOMER.



BACK VIEW



SECTION A-A



TOP VIEW

RECOMMENDED WIRE SIZES FOR CONNECTIONS

CONN	DESCRIPTION
A	14 A.W.G. SOLID, 5/64" VARNISHED CAMBRIC INSULATION FOR 600 VOLTS, .025" LEAD, O.D - .241". G.E. SPEC. S-392382-1-A1, OR EQUIV
B	#22 A.W.G. SOLID-TWISTED PAIR, SHIELDED G.E. MODEL 4FA19A? OR EQUIVALENT.
C	#6 A.W.G. BARE COPPER WIRE
D	RG8/U OR EQUIV. COAXIAL CABLE

UITS
ENDED
ER'S
NOT
OR
ER

WEIGHT - 765 LBS. NET
1070 LBS. GROSS

T-7663560, Rev. 8

INAL BOARDS.

OF CONNECTIONS

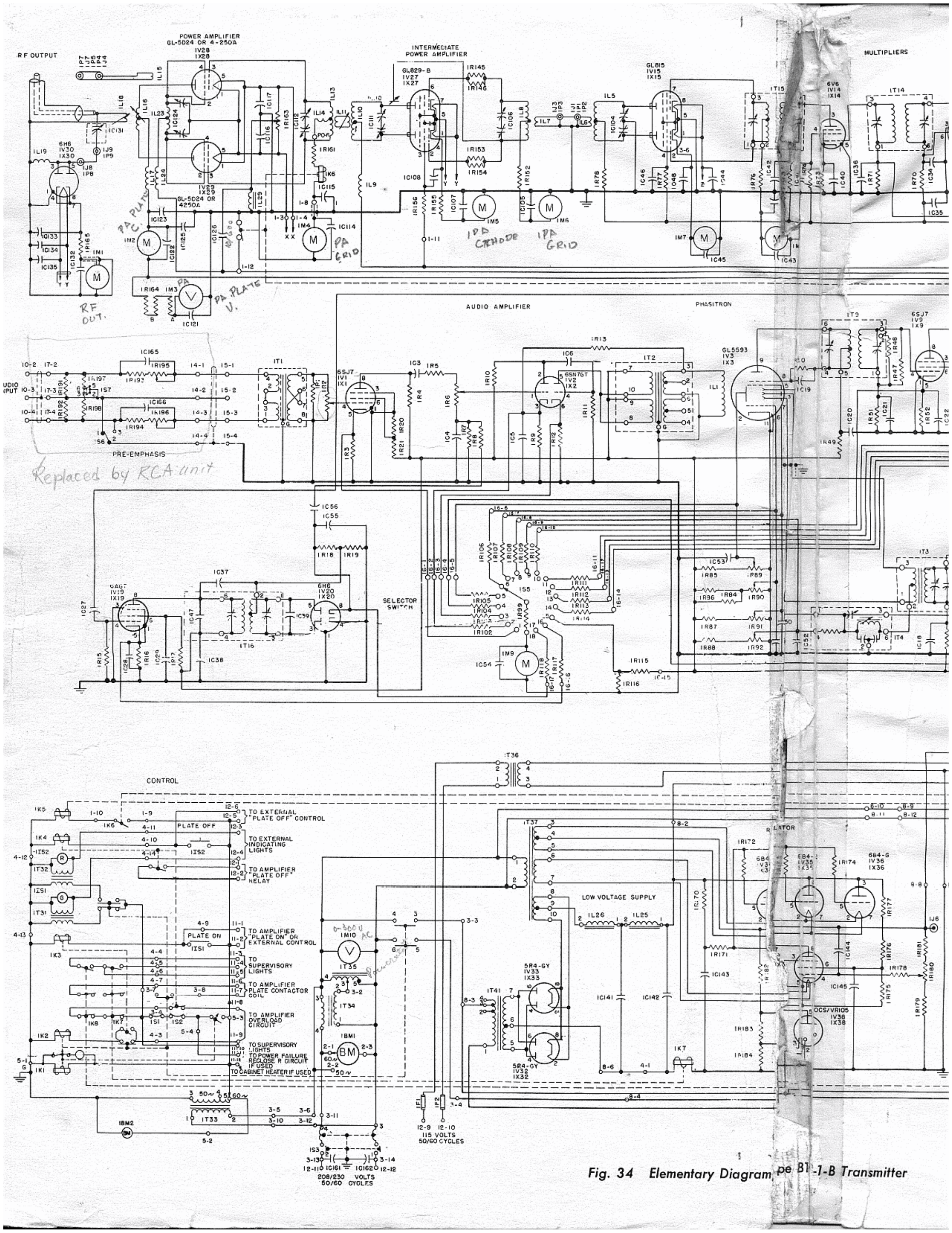
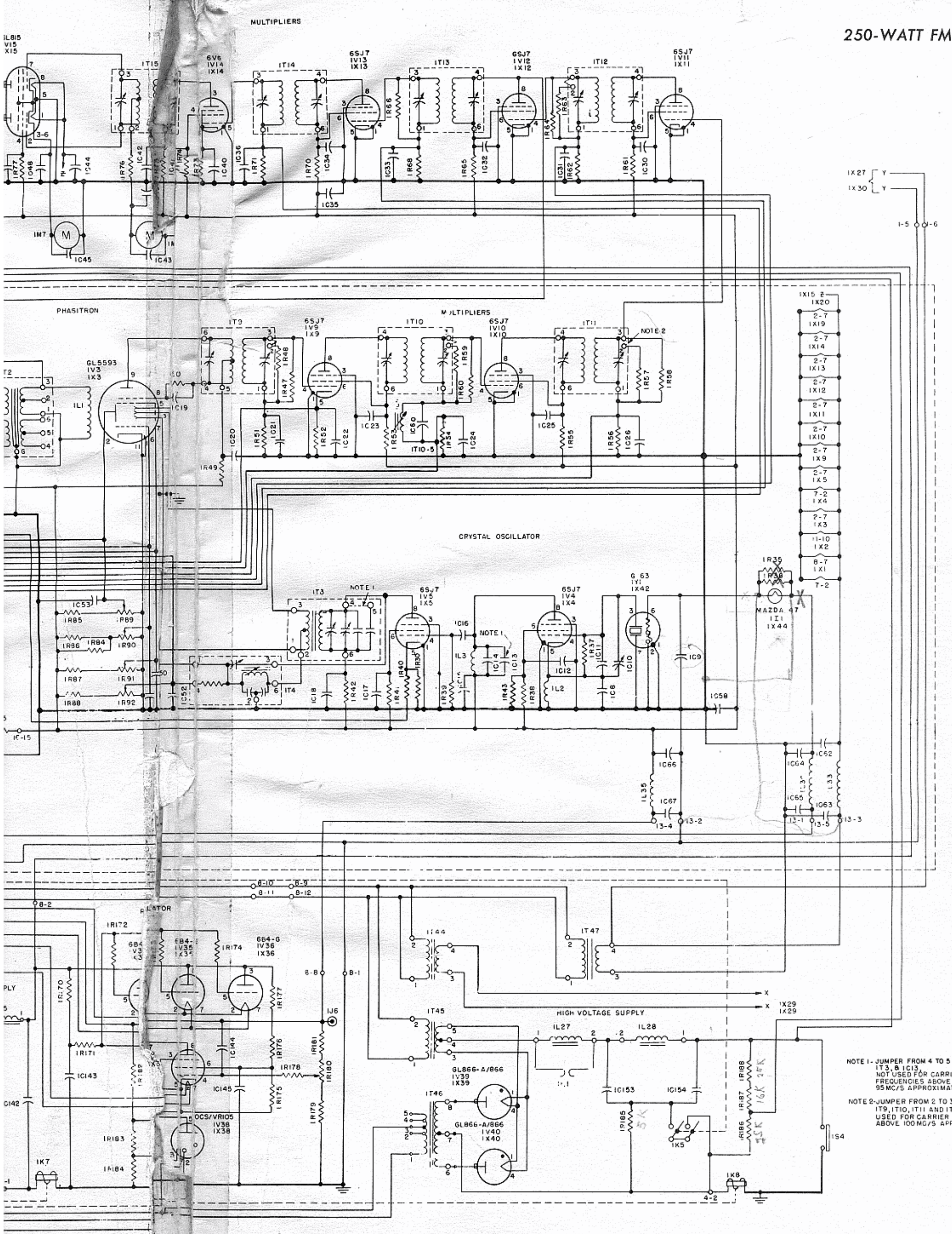


Fig. 34 Elementary Diagram ... *pe BT-1-B Transmitter*



NOTE 1 - JUMPER FROM 4 TO 5 ON 1T3, & 1C13, NOT USED FOR CARRIER FREQUENCIES ABOVE 95 MC/S APPROXIMATELY.

NOTE 2 - JUMPER FROM 2 TO 3 ON 1T9, 1T10, 1T11 AND 1T12 NOT USED FOR CARRIER FREQUENCIES ABOVE 100 MC/S APPROXIMATELY.

W-7351099, Rev. 12

Elementary Diagram ...pe BT-1-B Transmitter Fig. 34