Instructions

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REPLACEMENT PA

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GENERAL ELECTRIC

GENERAL SERVICE INFORMATION

SAFETY NOTICE

WARNING

VOLTAGES USED FOR THE OPERATION OF THIS EQUIPMENT ARE DANGEROUS TO HUMAN LIFE.

This instruction manual is written for the general guidance of maintenance and service personnel who are familiar with and aware of the dangers of handling electric and electronic circuits. It does not purport to include a complete statement of the safety precautions which should be observed in servicing this or other electronic equipment. The servicing of this equipment by inadequately trained or inexperienced personnel involves risks to such personnel and to the equipment for which the manufacturer can not accept responsibility. Personnel servicing this equipment should familiarize themselves with first-aid treatment for electrical burns and electrical shock.

PRODUCTION CHANGES

From time to time it becomes necessary to make changes in the equipment described in this book. Such changes are made to improve performance or meet component shortages and are identified by a revision letter following the model number stamped on the nameplate. The changes in the equipment as they affect the instruction book are listed on a Production Change Sheet included in the book. If no Production Change Sheet is included, no changes have been made. The revision letter appearing on the title page indicates the equipment revision to which the book corresponds.

This information is provided as a servicing aid; it should not be used to modify earlier equipments to incorporate later revisions except under specific instructions. Please mention the revision letter in any correspondence.

REPLACEMENT PARTS

The parts list contained in this book includes all principal replacement parts. The symbol numbers are the same as those appearing on elementary and other drawings. Whenever possible, replacement parts should be obtained from a local electronics supply dealer. If it is necessary to order a part (other than a tube) from the General Electric Company, please include the symbol number, description, and drawing number of the part and model number of the unit. Orders may be sent to the nearest Electronics Division office appearing on the list at the end of this book or the General Electric Company, Technical Products Department, Electronics Park, Syracuse, N.Y.

REPLACEMENT TUBES

In all cases replacement tubes must be ordered from a local tube distributor.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

INDUSTRIAL ELECTRONICS DIVISION

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

EBI-17B 8/58 (5M)
12/58 (5M)
4/59 (5M)

PRINTED IN U.S.A.

WARRANTY

The General Electric Company (hereinafter called the Company) warrants to the Purchaser that the equipment will be free from defects in material, workmanship, and title, and will be of the kind and quality designated or described in the contract. The foregoing warranty is exclusive of all other warranties whether written, oral, or implied (including any warranty of merchantability or fitness for purpose). If it appears within one year from the date of shipment by the Company that the equipment described in this instruction book does not meet the warranties specified above and the Purchaser notifies the Company promptly, the Company shall thereupon correct any defect, including non-conformance with the specifications, at its option, either by repairing any defective part or parts or by making available at the Company's plant, a repaired or replacement part. In lieu of the foregoing, the standard published tube warrranties in effect on the date hereof shall apply to new electronic tubes. If the equipment is installed, or its installation supervised, by the Company, said one year shall run from the completion of installation provided same is not unreasonably delayed the Purchaser. The conditions of any test shall be mutually agreed upon and the Company shall be notified of and may be represented at all tests that may be made. The liability of the Company to the Purchaser (except as to title) arising out of the supplying of the said equipment, or its use, whether on warranty, contract or negligence, shall not in any case exceed the cost of correcting defects in the equipment as herein provided and upon the expiration of said one year, all such liability shall terminate. The foregoing warranty does not apply to any used equipment supplied under contract or any equipment supplied under contract which bears a trademark of a manufacturer other than that of the Company. Because of the more restrictive warranties expressed by other manufacturers, the Company under contract can only make available to the Purchaser the warranty of the manufacturer on all such equipment. The Company will secure for the Purchaser at his request copies of the manufacturer's standard published warranty applicable to all such equipment. Used equipment is sold as is without warranty unless otherwise specifically provided in writing in the sales contract. The foregoing shall constitute the sole remedy of the Purchaser and the sole liability of the Company.

SAFETY TO HUMAN LIFE

Since the use of high voltages which are dangerous to human life is necessary to the successful operation of the f-m 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 shielded enclosures or framework, provided where necessary with access doors or gates which are generally fitted with safety interlock switches serving to shut off dangerous voltages within the enclosures when the access door or gate is opened.

Antenna tuning houses, substations, and switch enclosures which are noninterlocked and normally unattended should be kept locked and Rules 1 and 2, below, should apply particularly to these portions of the equipment.

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 gates or 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 circumstancess hould 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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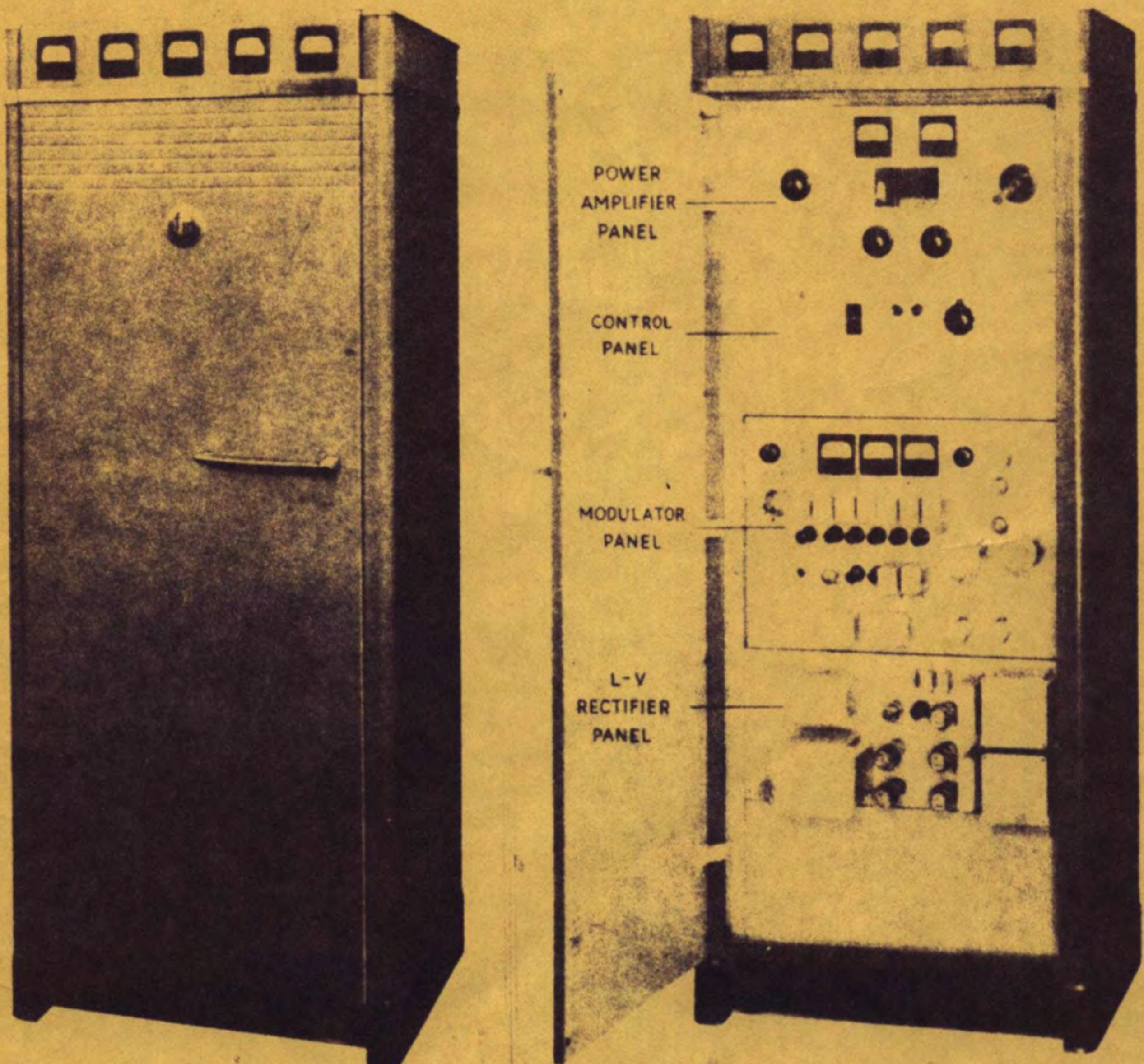


Fig. 1.

250-Watt Frequency-modulation Broadcast Transmitter, General Electric Type BT-1-A. Front views, door closed and door open (sub-assemblies identified) (894440, 894441).

250-WATT FM BROADCAST TRANSMITTER

G-E TYPE BT-1-A

GENERAL

THE 250-watt Frequency-modulation Transmitter, General Electric Type BT-1-A, embodies the latest in circuit and tube developments. Direct crystal control, plus "straight-through" operation with frequency multipliers only, is obtained by use of a modulation system based on a new tube called the "Phasitron." This revolutionary 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. The General Electric Type BT-1-A Transmitter is unique in this respect.

Conservative rating of all components means long and trouble-free service with a minimum of maintenance.

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-A 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 4BT1A Transmitter (Type BT-1-A).

Two sets of vacuum tubes, each set consisting of:

(1) 6SL7 (1V1)	(1) GL-829-B
(1) 6SN7 (1V2)	(2) GL-5D24 or 4-250A
(1) GL-2H21 (1V3)	(1) 6H6
(8) 6SJ7	(2) 5R4GY
(1) 6V6	~~(3) 6B4G~~ (2) 6AS7/6080
(1) GL-815	(1) OC3 VR105
(2) GL-866-A 866	

Two crystal thermocells, G-E drawing M-7478021.

Accessories (G-E drawing K-7116313G2), consisting of:

One can of blue lacquer

One can grey lacquer

One can thinner.

A kit of parts is available on separate order for changing the Transmitter to 150-ohm audio input.

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

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 7/8-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 ohms (150 ohms provisional).

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 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-A Transmitter (Fig. 1) is completely self-contained in a modern, blue-lacquered steel cabinet finished with stainless steel trim. 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 high-voltage 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.

Requirements and information for installation are given on the included installation drawing, Fig. 32. The actual power requirements are given under the "Electrical Specifications" section of this book.

A kit of parts is available on separate order to make a change to 150-ohm audio input, if desired.

If this change is made, pre-emphasis resistors 1R5 and 1R7 must be readjusted for proper pre-emphasis characteristic. The procedure is outlined under "Maintenance".

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/866 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, make the following two reconnections internal to the transmitter:

1. **Remove the 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.**
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.**

The Transmitter as supplied is connected for 600-ohm audio input. For 150-ohm audio input, make the following reconnections and parts replacements in the modulator. Remove the shield for access to the rear of the panel.

1. **On 1T1, remove the bus jumper from 2 to 3, and the ground wire from 2 to 3. Connect 1 to 3, and 2 to 4. (This parallels the two primary sections.)**
2. **Short out resistors 1R6 and 1R8.**
3. **Replace 1C1 and 1C2 (0.01 mfd) with 0.04-mfd capacitors.**
4. **Remove 1R1 and 1R2 (300 ohms) and replace each with a 75-ohm resistor.**

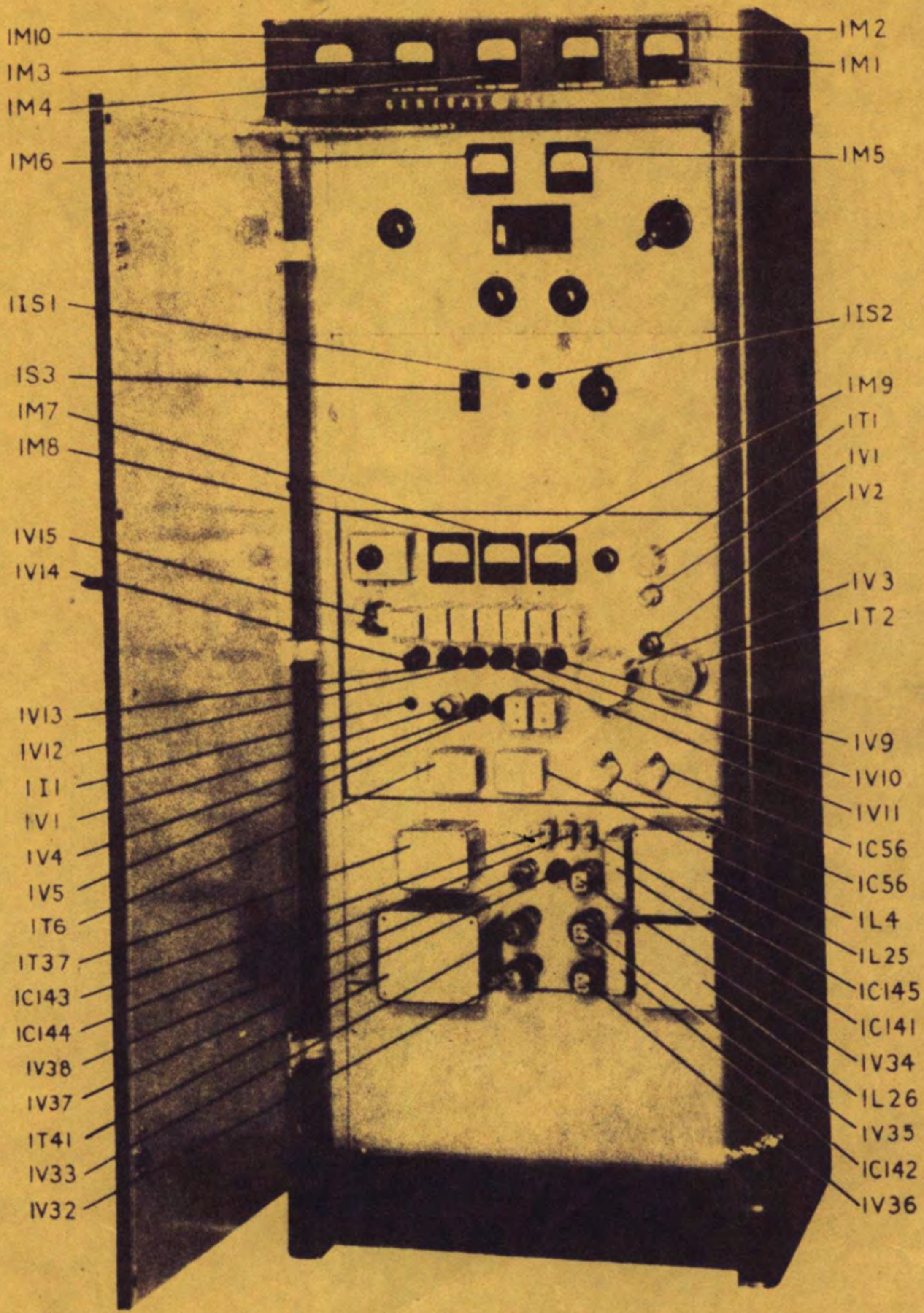


Fig. 2

250-Watt Frequency-modulation Broadcast Transmitter, General Electric Type BT-1-A. Front view, door open, parts identified (894442).

Secure the plate connectors for the power amplifiers, 1V28 and 1V29, by tightening the 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-2H21, 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 lower left corner of the modulator panel glows. After a short warm-up time the light should cycle off and on, indicating that the thermocell 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. (If the Transmitter audio input has been modified for 150-ohm operation, a readjustment of pre-emphasis resistors 1R5 and 1R7 is required. The procedure is outlined under "Maintenance." The Transmitter must be in full r-f operation for audio pre-emphasis adjustment. Therefore, proceed as outlined until the transmitter is ready for modulation.) 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, from the rear. Also remove the i-p-a tube, Type GL-829-B.

1. Preliminary Adjustments

PHASITRON FILAMENT VOLTAGE.—Remove the shield from the rear of the modulator panel and connect across pins 10 and 11 of 1X3 (phasitron socket) a d-c voltmeter which will accurately measure the 6.3-volt d-c filament potential. Throw on the POWER switch located on the control panel. Note that the cooling blower runs and that the filaments of the various tubes light. Adjust the input voltage to 200 volts with the INPUT VOLTAGE adjusting control located on the control panel, then unlock and adjust 1R96, on the modulator panel, until the test voltmeter indicates 6.3 volts. Relock 1R96, remove the voltmeter, and replace the shield. The VOLTAGE INDICATOR meter reading when the SELECTOR SWITCH is in position *16* is proportional to this voltage and may be used to indicate any change from the correct value. Replace the modulator shield.

CAUTION

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

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

Remove the voltmeter.

2. Tuning—During the following tuning procedure keep the INPUT VOLTAGE at 200 volts.

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.

With the panel screwdriver Coupling control adjust the coupling between i-p-a plate and p-a grid for approximately 11 milliamperes[1] p-a grid current. Retune IPA Plate Tuning for minimum IPA Cathode current and PA Grid Tuning for maximum PA Grid current. 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 eliminated 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 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, to terminal 5. This is the 50-per cent tap and yields about one-half normal p-a plate voltage, or approximately 1100 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, which occurs when the loop axis is in a plane approximately horizontal with the loop mounting shaft, with the loop out toward the p-a tubes.

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 a load that reflects appreciable reactance into the p-a plate circuit.

[1] 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. Proceed to next paragraph.

Now make a check of correspondence between maximum PA Grid Current and minimum PA Plate 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.

3. P-a 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:

$$\frac{\text{TRANSMISSION LINE INPUT POWER REQUIRED}}{\text{P-A PLATE EFFICIENCY}}$$

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

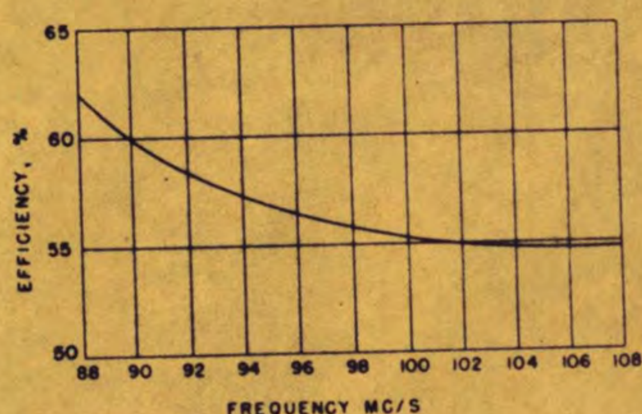


Fig. 3.
Power-amplifier Efficiency Curve (250-watt output) (K-798025, Rev. 1).

Load the power amplifier by adjusting Output Coupling until:

PA PLATE VOLTAGE (kv) × P-A 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.

4. R-f 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.

5. 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 lower left 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.

6. 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.

7. 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

1. Trouble Prevention—It is important to consider maintenance from a preventive standpoint rather than from the angle of trouble-shooting. "An ounce of prevention is worth a pound of cure"—and the "ounce" can be done at your choosing while the "pound" may need to be done at an inopportune and expensive time.

From this standpoint, 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 tubes in a reliable tube checker. Replace any marginal tubes. Some tubes, such as the Type GL-2H21, GL-815, GL-829-B, GL-5D24 or 4-250A, and OC3/VR105 cannot be checked in a tube tester.

Note the readings of all meters, including the 16 readings of the VOLTAGE INDICATOR, daily, and compare to previous readings. A certain amount of day-to-day variation can 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 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.

2. 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 section of first audio tube, 1V1, Type 6SL7-GT. (21)

2—Cathode voltage, second section of first audio tube, 1V1, Type 6SL7-GT. (22)

3—Cathode voltage, second audio tube, 1V2, Type 6SN7-GT. (22)

Alignment of Exciter

Resistor- Loading Procedure

Equipment Needed

1- 39,000 1/2 Watt Resistor

1- 10 mmf cap.

2- Short Clip Leads

PROCEDURE

IT9

1- Short IT9-4 to IT9-6 Shorts Primary Out

2- Couple Signal From IT4-3 to IT9-3 through a 10mmf Cond. Connect Cond. Direct to IT9-3

3- Set Selector Swith to #9

4- Tune Upper of IT9 for Maximum Indication on #9 (Should run to 30) If not enough signal tune IT3 for greater signal.

5- Remove Short From IT9-4 to IT9-6 and Place it to IT3-1 to IT3-3

6- Tune Lower Control of IT9 for MINIMUM on #9 ---Should be about 20

7- Remove Short From IT3-1 to IT3-3. 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 is employed the Short should be Replaced on Between IT9-4 and IT9-6.

IT 10

1- Connect resistor across IT10-4 and IT10-6

2- Set Selector to #10

3- Tune Primary (Lower) and Secondary (Upper) for MAXIMUM Indication. Remove Resistor.

IT 11

1. Connect resistor across IT11-4 and IT11-6.

2. Set Selector to 11.

3. Tune Primary (lower) and Secondary (Upper) for MAXIMUM Indication. Remove Resistor.

IT 12

1. Connect Resistor Across IT12-4 and IT12-6.

2. Set Selector to 12.

3. Tune Primary (lower) and Secondary (Upper) for MAXIMUM Indication. Remove Resistor.

IT 13

1. Connect Resistor across IT13-4 and IT13-6.

2. Set Selector to 13

3. Tune Primary (Lower) and Secondary (Upper) for MAXIMUM Indication. Remove Resistor.

IT 14

1. Set Selector to 14

2. Tune Primary (lower) and Secondary (Upper) for MAXIMUM Indication.

   Occasionally Two apparent tuning points are found for the Secondary (Upper). If the Wrong One is used Primary (Lower) Tuning will not increase Output. Usually the Correct Secondary (Upper) Tuning Point is the one giving the Least Output. The Output then will greatly increase (to 30 or more) with Primary (Lower) Tuning.

3. Connect Resistor across IT14-4 and IT14-6.

IT 14 - Continued

4. Slightly Re-tune Primary (lower) and Secondary (Upper) for MAXIMUM Voltage. Remove Resistor.

IT 15

1. Tune Primary (lower) and Secondary (Upper) for MAXIMUM 815 Grid Current

REPLACING A PHASITRON

Place Selector to #10

Adjust 1st Focus for MAXIMUM indication

Lower-LOW Frequency distortion could be obtained by Readjustment of IT3 and IT4 and 2nd Focus Neutral Plane and Deflector to Values Other Than Standard. The Phasing Adjustments of IT3 and IT4 is Set to a Standard in Factory Test as are Settings of 2nd Focus, Neutral Plane and Deflector. The Last Three can always be Returned to Standard. However the Readjustment of IT3 and IT4 to Standard requires special equipment.

IT3 and IT4 can be adjusted with Distortion Measuring Equipment, but Tube Interchangeability requires Standard Adjustment of IT3 and IT4.

The Standard Voltages for Neutral Plane is 30V, 2nd Focus is 50V, and Deflector is 60V.

Connect Meter to 1X3-2 and Adjust Neutral Plane for 30V.

Connect Meter to 1X3-7 and Adjust 2nd Focus to 50V.

Connect Meter to 1X3-3 and Adjust Deflector for 60V.

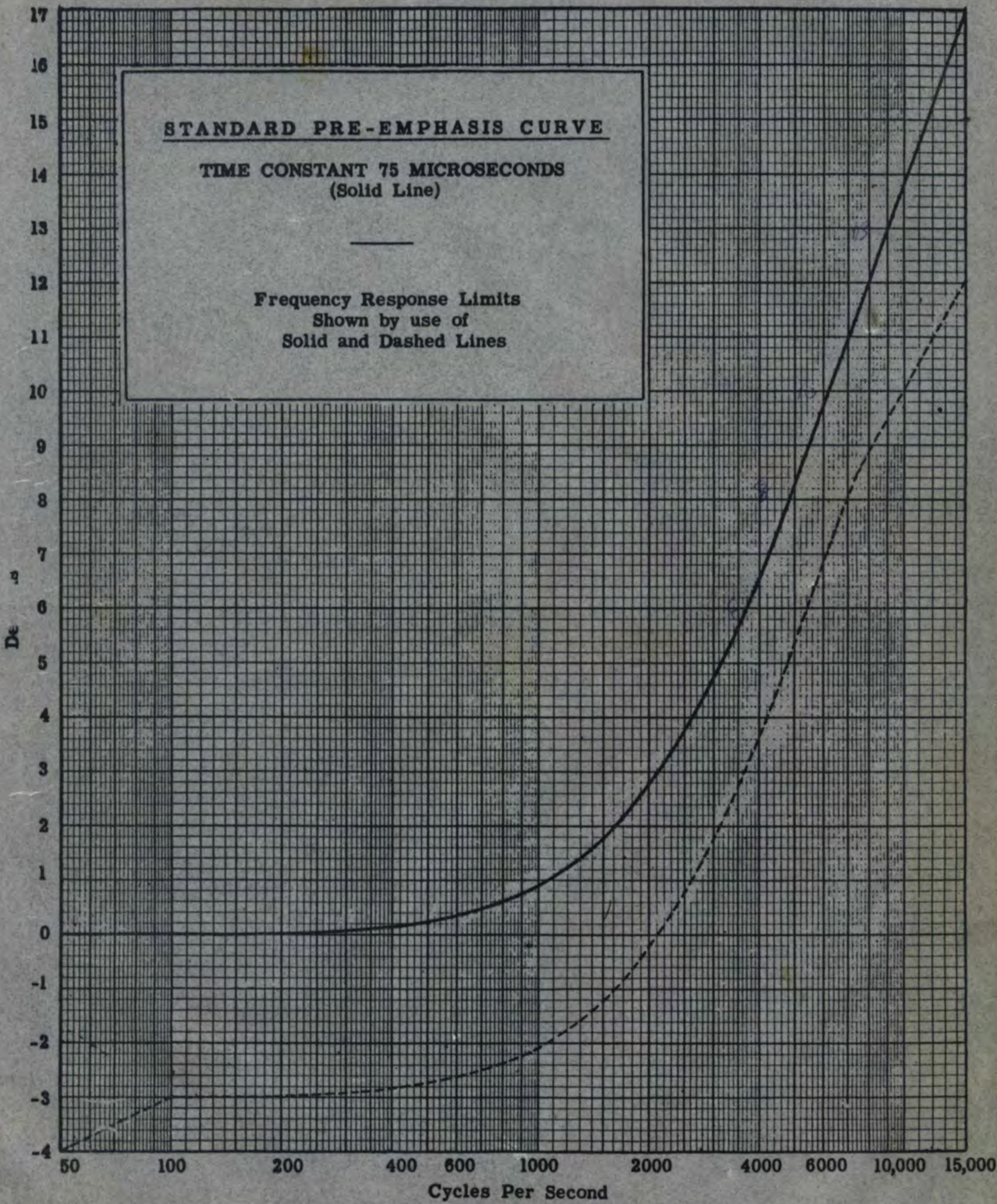


FIGURE 2

369781 O—56 (Face p. 50) No. 2

4—Grid voltage, crystal amplifier, 1V5, Type 6SJ7. Indicates drive from previous stage (crystal oscillator, 1V4, Type 6SJ7).

5—Neutral-plane voltage, phasitron, 1V3, Type GL-2H21.

6—First-focus voltage, phasitron, 1V3, Type GL-2H21.

7—Second-focus voltage, phasitron, 1V3, Type GL-2H21.

8—Deflector voltage, phasitron, 1V3, Type GL-2H21.

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).

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—Filament voltage, phasitron, 1V3, Type GL-2H21.

17—Off.

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 schematic diagram, Fig. 33. 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."

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*.

3. Replacing a Phasitron, Type GL-2H21—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, it may be necessary to make some readjustment for a minimum of distortion. (If replacement was necessary during operating hours, such readjustment may be left until the day's schedule is completed.)

The following is a discussion of the procedure, predicated on the assumption that the rest of the modulator is functioning properly.

A practically distortionless source of sine-wave audio voltage at a level of about 10 dbm is required. It is recommended that the source distortion not exceed 0.2 percent. Also needed is a distortion analyzer, capable of operating from the station-monitor audio output. First set SELECTOR SWITCH to position *10* and adjust the controls labeled NEUTRAL PLANE, 1ST FOCUS, 2ND FOCUS, and DEFLECTOR for maximum indication on the VOLTAGE INDICATOR. This corresponds to maximum GL-2H21 output. Then adjust phase-splitting transformers 1T3 and 1T4 (using an insulated screwdriver) for a minimum of distortion with 100 per cent modulation at 100 cycles.

Then with 100 per cent modulation at 50 cycles adjust the electrode voltages (mentioned above) for a minimum of distortion, followed by adjustment of the phase-splitting transformers for a new minimum. It should be possible to obtain a distortion reading well below 1.5 per cent rms during this procedure.

Return to 100-cycle, 100 per cent modulation. If the distortion is 1 per cent or below, adjustment can be considered satisfactory. If not, readjust the phase-splitters and electrode voltages for a minimum. By readjusting alternately at 100 cycles and 50 cycles it should be possible to obtain appreciable less than 1.5 per cent rms distortion at 50 cycles and less than 1 per cent rms distortion at 100 cycles. The distortion at all frequencies above 100 cycles will remain below 1 per cent, provided the modulator coupling transformers are properly aligned.

4. 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 tubes.

Should the Type OC3 VR105 tube be replaced, the regulated voltage may change and a readjustment of 1R180 may be required.

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.

5. 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, the crystal is at operating temperature. The carrier frequency should then be adjusted (using an insulated screwdriver) by means of compensating capacitor 1C10.

6. 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 a stop screw at the rear and by a horizontal groove at the front.

The stop screw is removable from the rear of the cabinet. It is located just above the upper lip of the p-a panel, about in the center. Remove it 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.

7. 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.

8. Blower Motor—Routine maintenance of this motor calls for annual dismantling with thorough cleaning of the bearings and housings. The bearings should then be repacked with G-E ball-bearing grease, available in tubes.

In repacking the bearings, fill the space between the inner and outer races ⅓ full. Be careful not to over-grease. When assembling the bearing in the housing, fill the space back of the housing about ⅓ full of grease, as a reserve supply.

9. 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 and drain face (smooth side) downward.

10. Audio Pre-emphasis Adjustment—Pre-emphasis resistors 1R5 and 1R7 have been adjusted properly at the factory for 600-ohm audio input impedance. If the Transmitter has been altered for 150-ohm impedance, as outlined under "Installation," pre-emphasis readjustment will be required. The procedure outlined below is suitable for readjustment anytime required, even for 600 ohms. Vu meters calibrated for the proper impedance must be used.

It is assumed that 1R5 and 1R7 are completely out of adjustment. Initially set each at its mechanical center, estimated as closely as possible. Check balance with an ohmmeter.

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 1R5 and 1R7 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.

11. Carrier AM Hum Adjustment—The Transmitter has been adjusted for minimum AM hum at the factory. The procedure is given here 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 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**
>
> **Tie down 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 the 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 multipled 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.

12. 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 by tuning for maximum indication on the VOLTAGE INDICATOR. The transformers are overcoupled and peak indication does not occur at flat response. If improperly [illegible]usted, distortion of high audio frequencies would [illegible] from the ensuing n[illegible] linear phase characteristic. O[illegible]ase of ext[illegible]me emergency should a transformer be tuned for maximum VOLTAGE INDICATOR reading. Proper tuning should be made at the first opportunity.

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. 4). An adapting socket cannot be used as the additional capacitance is sufficient to result in improper tuning. Method 2 is preferable and is detailed in the following paragraphs.

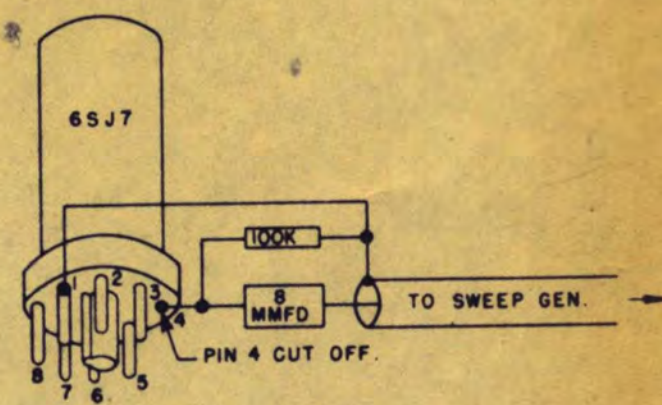


Fig. 4.

Signal Injector Tube (K-7988026).

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-2H21 tube. Since this frequency is always in the neighborhood of 200 kilocycles, let the amplifier be called the "200-kc amplifier." An applicable schematic diagram is shown in Fig. 5.

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.

RECOMMENDED PROCEDURE—The recommended procedure is that known as "visual alignment." This name 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 paragraph 13, "Theory of the Visual Alignment Procedure." As representative cases the tuning of 1T9 and 1T12 will be considered.

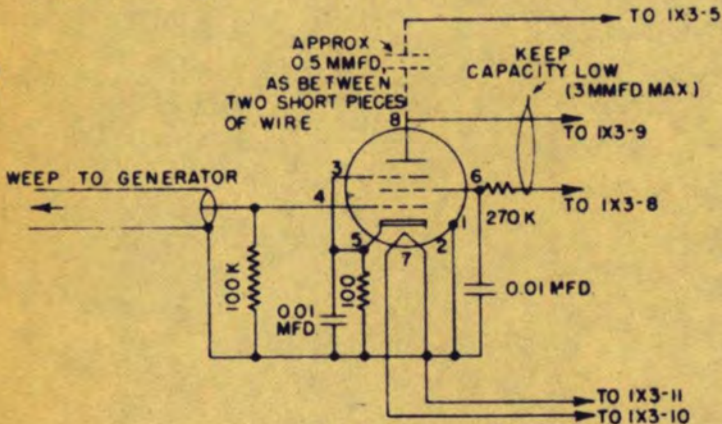


Fig. 5.

200-Kc Amplifier, Schematic Diagram (K-7988027).

(1) Transformer 1T9.—Remove tubes 1V14, Type 6V6, and 1V15, Type GL-815. Remove phasitron 1V3, Type GL-2H21. Connect the "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 deviation 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 in Fig. 5 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 over one another. 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 signal level change indicates saturation.

The following curves, *a*, *b*, *c*, *d*, *e*, and *f* of Fig. 6, illustrate a typical case.

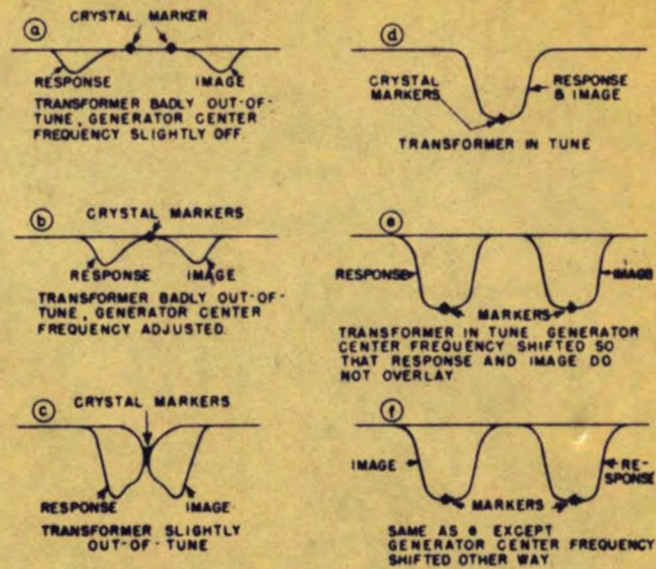


Fig. 6.

Typical Response Curves (K-7988028).

Essentially a flat-top response will be obtained. A ratio of $\frac{a}{b}$ of 1/20 or less, Fig. 7, is permissible.

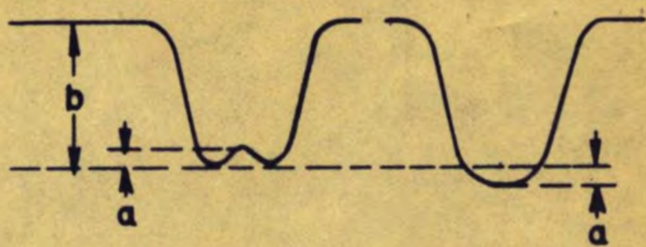


Fig. 7.

Response Flatness Limit (K-7988029).

After completing the tuning of 1T9 restore conditions to normal, including the reinstallation of 1V3, Type GL-2H21.

(2) Transformer 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 following table will serve as a summarized guide:

Transformer	Injector Replaces	Gen. Freq. Times Crystal	Approx. Gen. Dev. 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 #22 insulated wire into number 4 of 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 #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).

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 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 below in Fig. 8.

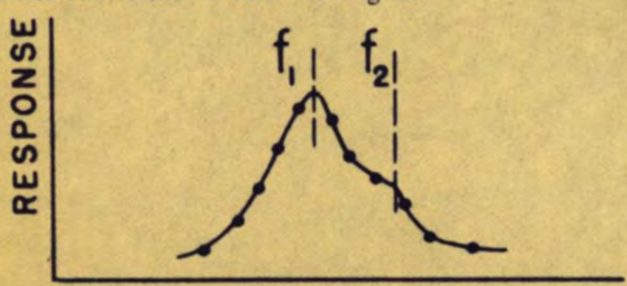


Fig. 8.

Typical Point-by-point Response (K-7988030).

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. 9.

Note frequency f_c. If it does not agree with the table previously given, additional tuning must be done until

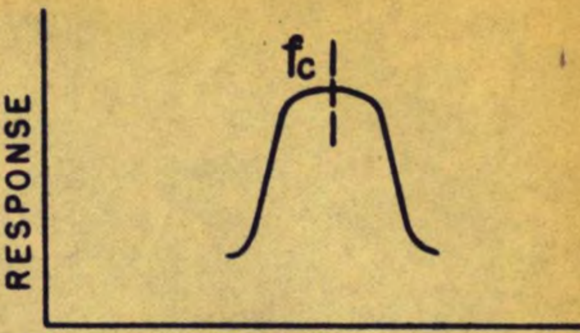


Fig. 9.

Point-by-point Response after Tuning (K-7988031).

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.

13. 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. 10.

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

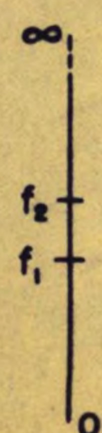


Fig. 10.

Arbitrary Circuit Response Limits in the Frequency Spectrum (K-7988032).

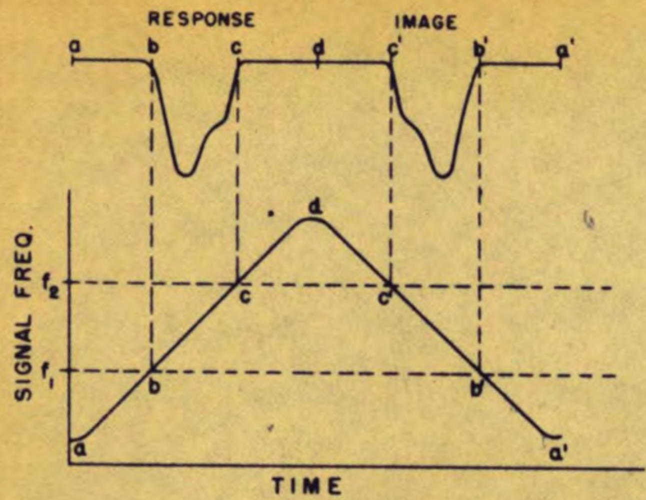


Fig. 11.

Circuit Response and Image (K-7988033).

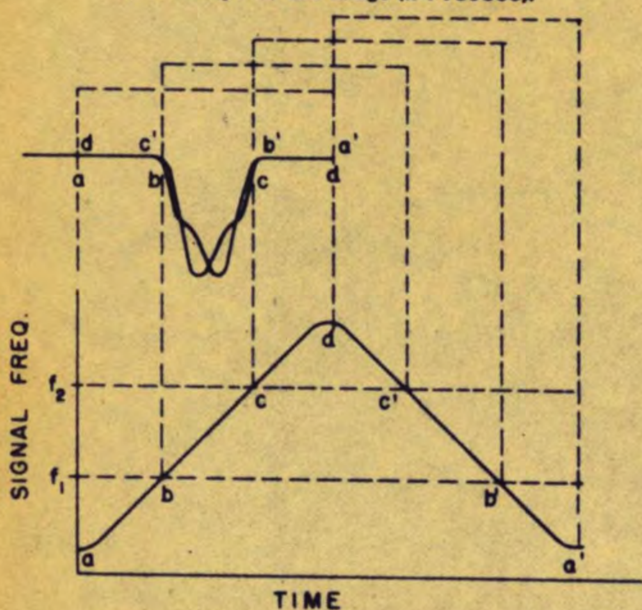


Fig. 12.

Response and Image Overlay (K-7988034).

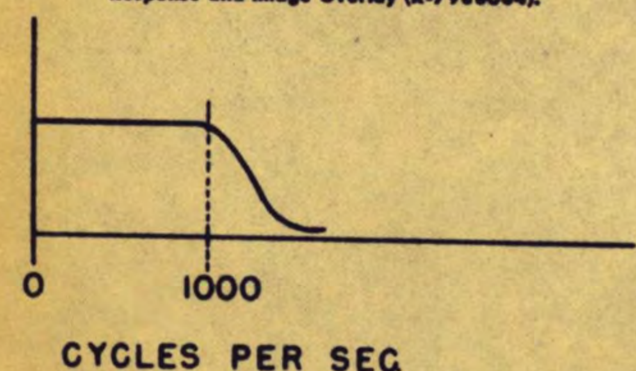


Fig. 13.

Typical Detector Audio Bandwidth (K-7988035).

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_1 to f_2 and back from f_2 to f_1 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 to 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 in Fig. 11.

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. 12.

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 in Fig. 13.

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 a frequency equal to the marking frequency.

A typical idealized marker, as it appears on a response, is shown in Fig. 14.

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

14. 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

Fig. 14.
Typical Idealized Frequency Marker (K-7988036).

15. Approximate Meter Reading and Dial Settings

	Frequency, mc/s		
	88	98	108
	Voltage Indicator	Voltage Indicator	Voltage Indicator
Selector Switch 1	21	21	21
Selector Switch 2	22	22	22
Selector Switch 3	22	22	22
Selector Switch 4	−15	−15	−15
Selector Switch 5	5	5	5
Selector Switch 6	7	7	7
Selector Switch 7	33	33	33
Selector Switch 8	15	15	15
Selector Switch 9	20	20	20
Selector Switch 10	−15	−15	−15
Selector Switch 11	−23	−23	−23
Selector Switch 12	−18	−18	−18
Selector Switch 13	−18	−18	−18
Selector Switch 14	−30	−30	−30
Selector Switch 15	25	25	25
Selector Switch 16	31.5	31.5	31.5
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	185 ma	185 ma	185 ma
R-F Output	100	100	100

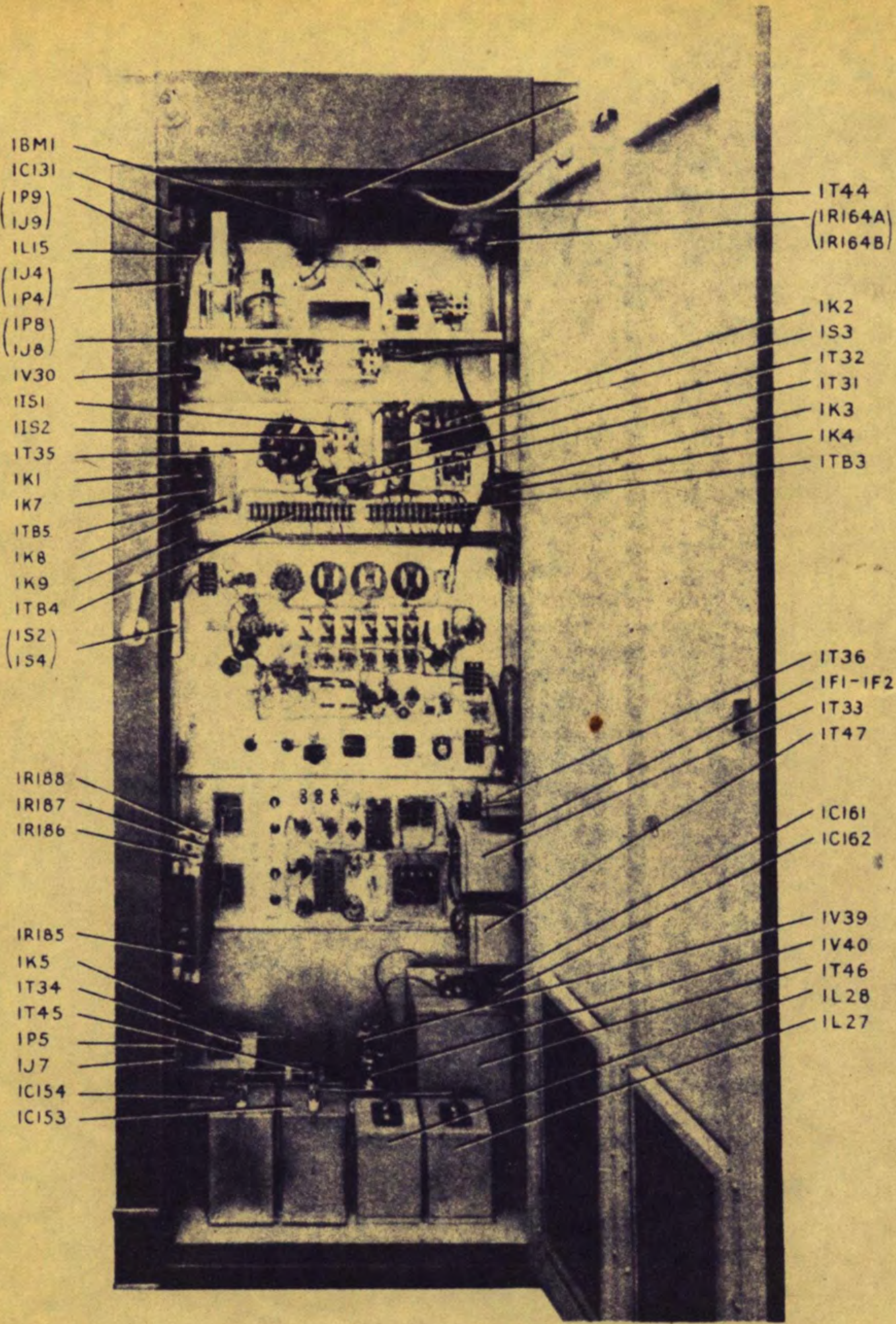


Fig. 15.

250-Watt Frequency-modulation Broadcast Transmitter, General Electric Type BT-1-A. Rear view, door open, parts identified (894443).

REFER to the block diagram, Fig. 22, control schematic diagram, Fig. 23, and main schematic diagram, Fig. 33.

1. 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, 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 if 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 accomodated. 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 schematic diagrams, Figs. 23 and 33, are drawn with connections shown for 60-cycle operation. For 50-cycle operation two reconnections are required. One is the terminal change from 5 to 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 from line voltage to 200-volt 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 through a normally-closed contact of 1K9 and begins operation. After 30 seconds (normal setting) 1K1 times out and its contact closes. Upon this closing, relay 1K9 is energized. The normally-open contact of 1K9 then shunts across the timed contact of 1K1. The other contact of 1K9 removes power from 1K1, 1K1 resets, and the contact of 1K1 falls out. The motor inertia of 1K1 holds its contact closed long enough to allow 1K9 to lock itself in. Power is removed from 1K1 to insure long motor life.

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 energizes relay 1K3, closing its normally-open contact. Relay 1K2 is now energized 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 high-voltage overload relay 1K8 is 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 current passed by the high-voltage rectifier tubes to a safe value when plate voltage is applied.

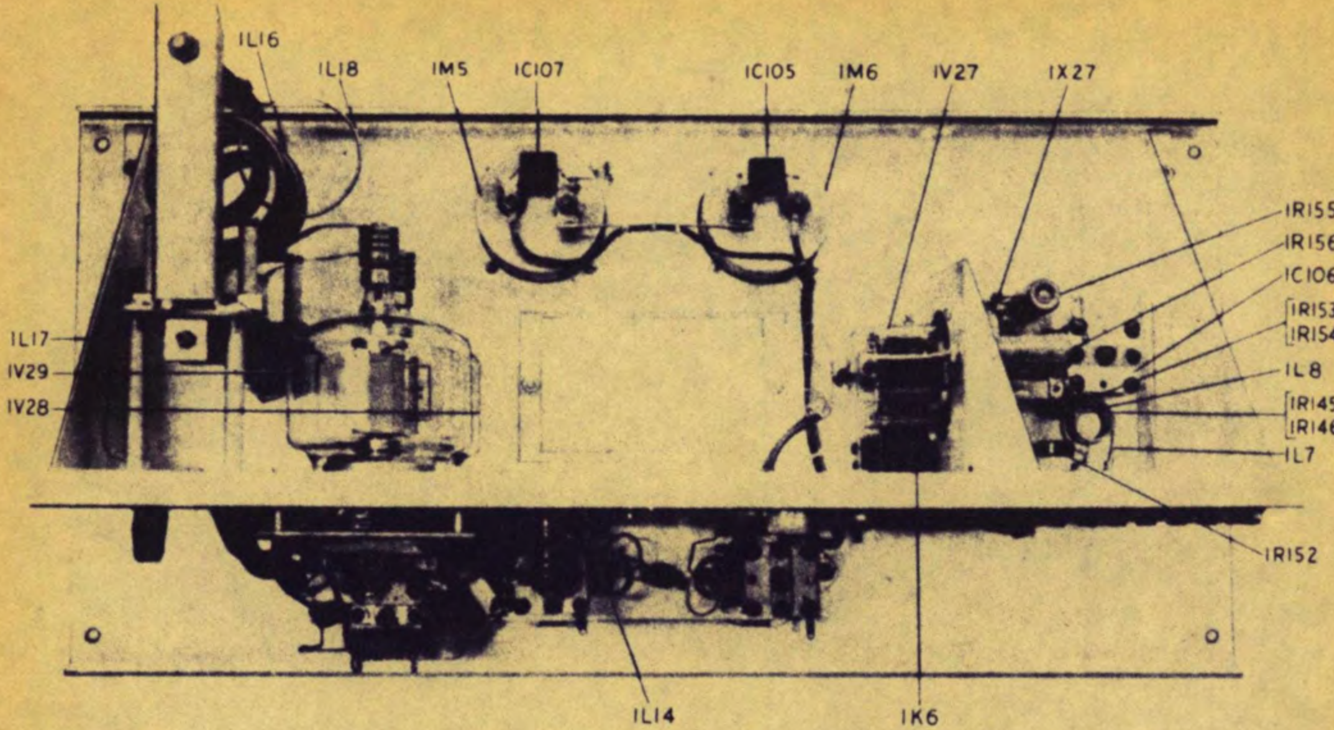


Fig. 16.

Power-amplifier Panel. Rear view, parts identified (894444).

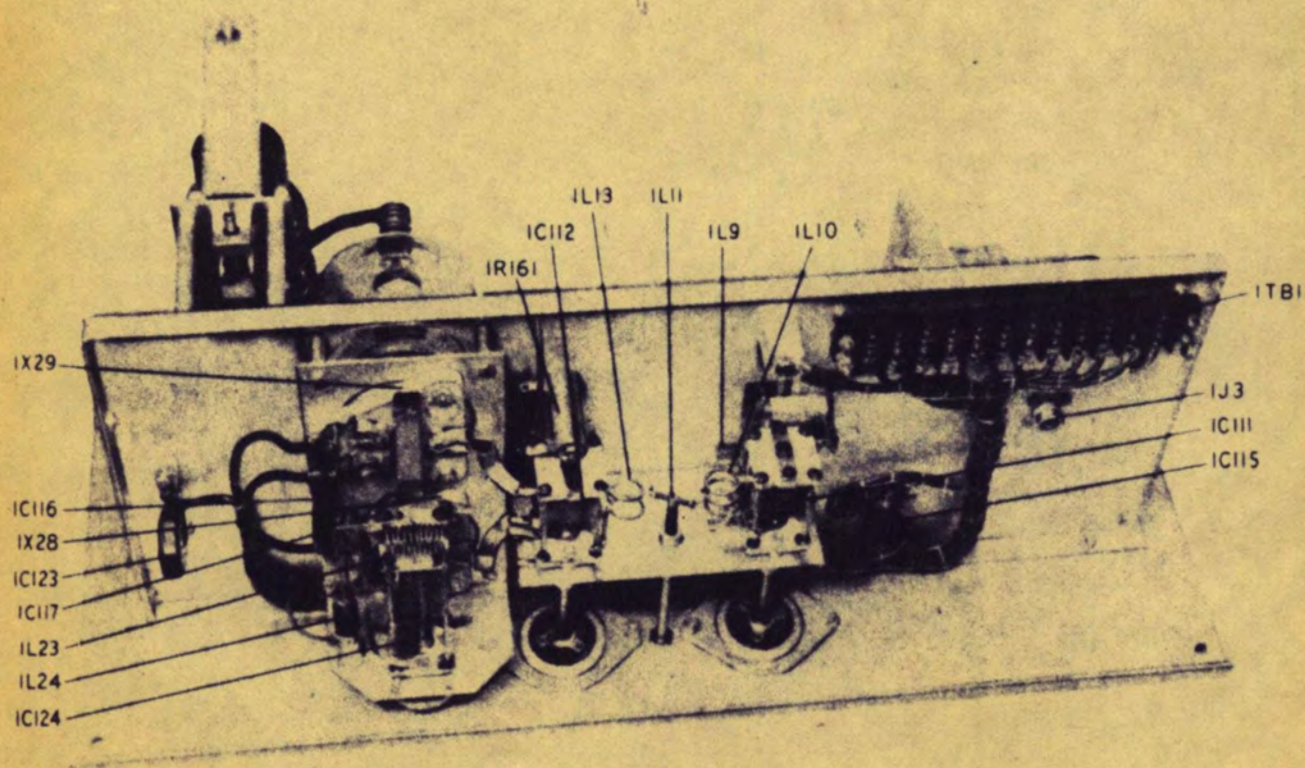


Fig. 17.

Power-amplifier Panel. Bottom rear oblique view, parts identified (894445).

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. 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 1TB12-4 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.

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.

2. D-c 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 the 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.

High-Voltage Supply.—This supply is a conventional rectifier, using a pair of Type GL-866-A 866 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.

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 1K8, which acts as 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.

Phasitron Filament Supply.—A bridge-type selenium rectifier, 1CR1, is used to supply the Type GL-2H21 phasitron filament through a capacitance input L-C filter. Resistor 1R97 loads down the rectifier and prevents the d-c voltage from exceeding the rating of the filter capacitors if the Type GL-2H21 tube is removed.

Rheostat 1R96 with a screwdriver panel adjustment is used to adjust the voltage at the phasitron filament to 6.3 volts.

The phasitron is supplied with d-c for the filament in order that the hum level of the modulator output may be kept adequately low.

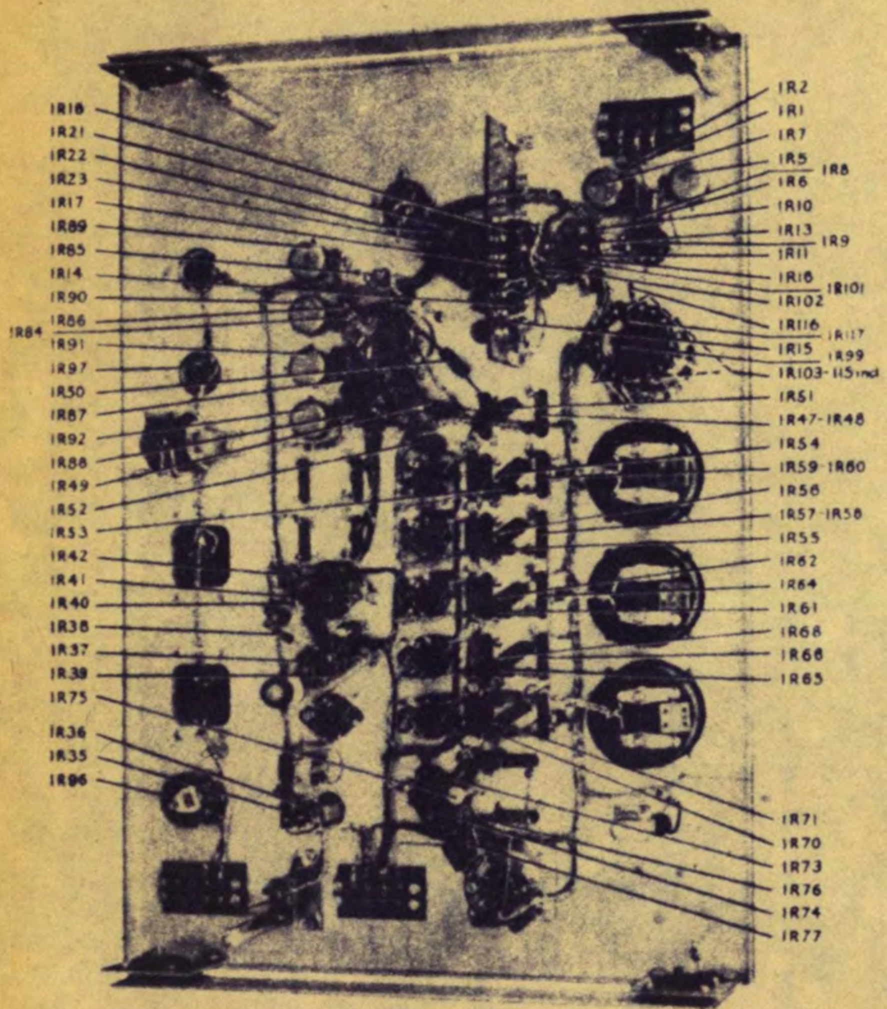


Fig. 18.

Modulator Panel. Rear view, resistors identified (894446).

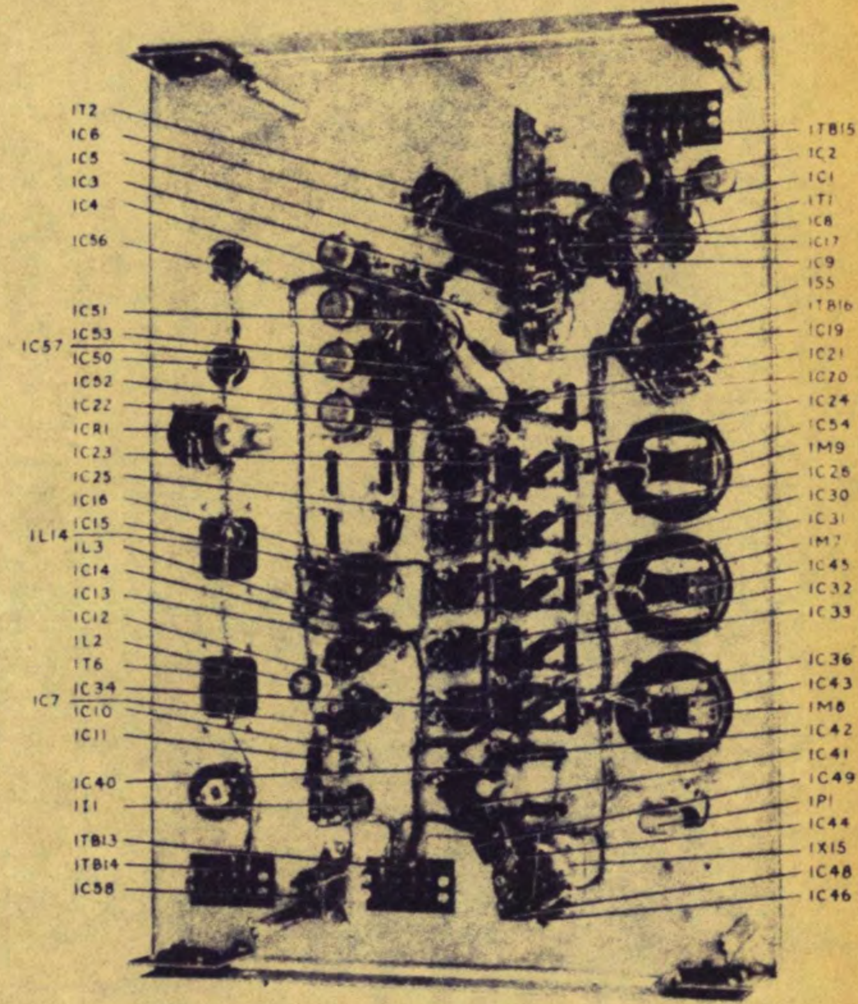


Fig. 19.

Modulator Panel. Rear view, parts identified (resistors excepted) (894447).

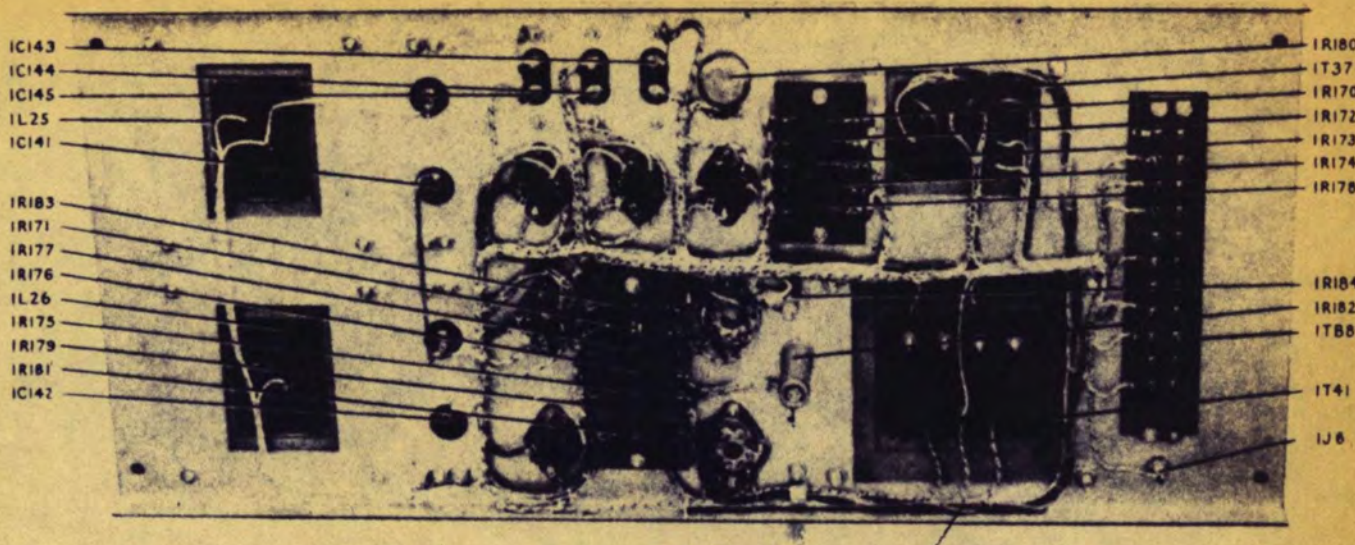


Fig. 20.
Low-voltage Rectifier Panel. Bottom view, parts identified (894448).

3. 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).

4. R-f Filters—All the power supplies to the modulator panel are individually filtered with low-pass pi filters. 1C146, 1L21, and 1C147 filter the 250-volt regulated supply; 1C151, 1L22, and 1C152 filter the filament supply; 1C60, 1L20, and 1C61 filter the crystal heater supply. These filters are all housed in a common shield.

Such filtering insures low modulator noise level by eliminating r-f coupling through interunit wiring.

5. Modulator

Audio System.—Balanced audio voltage enters the transmitter at 1TB10, and the modulator at 1TB15. A level of 10 dbm ± 2 db is required for 100 per cent modulation at 400 cycles. The input is 600 ohms as normally furnished. Modifications for 150-ohm operation are described in the "Installation" section of this book.

Resistors 1R1 and 1R2 terminate the input line. Balanced attenuators consisting of 1R5, 1R6, 1C1, and 1R7, 1R8, 1C2 produce the required pre-emphasis characteristic. The attenuation of these networks, when operating into 600-ohm transformer 1T1, is a complex inverse function of frequency, with an attenuation at 400 cycles of 16.9 decibels greater than that at 15,000 cycles.

Transformer 1T1 drives balanced amplifier 1V1, Type 6SL7GT, which drives balanced amplifier 1V2, a Type 6SN7GT tube. The latter operates into transformer 1T2, whose secondary is loaded with the modulation coil, 1L1.

Negative voltage feedback from the second to the first audio stage is fed through networks 1R14-1C3, and 1R15-1C4.

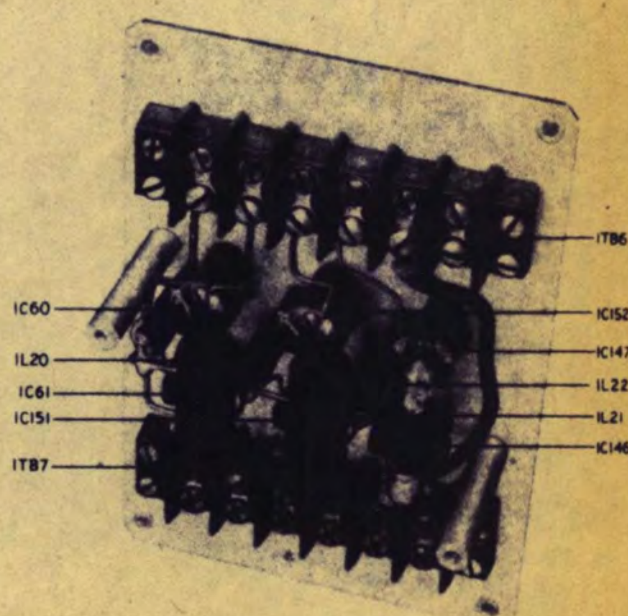


Fig. 21.
R-f Filter Assembly. Interior view, parts identified (8[illegible]9).

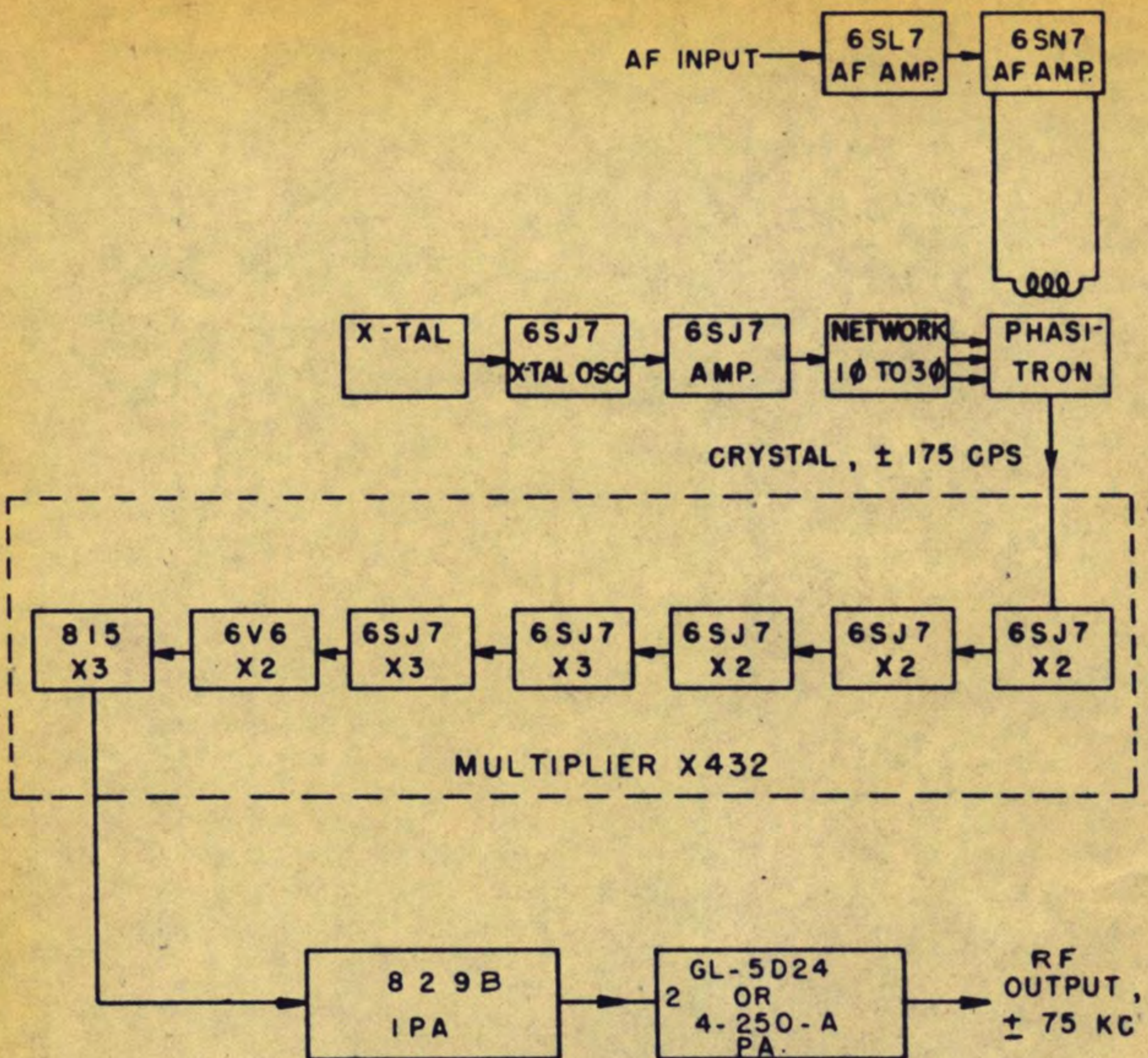


Fig. 22.
250-Watt Frequency-modulation Broadcast Transmitter, General Electric Type BT-1-A, Block Diagram (K-7117120, Rev. 1).

The final audio voltage output is about 3 volts for 100 per cent modulation. The overall audio voltage gain is approximately 0 db, from input to output, at 400 cycles.

R-F 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. R-f ground is established at the screen. 1C11 and 1C12 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. This is coupled by 1C14 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 near the end of this section.) These three-phase voltages are applied to the deflectors of the phasitron, 1V3, Type GL-2H21, 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 near the end of this section.)

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.

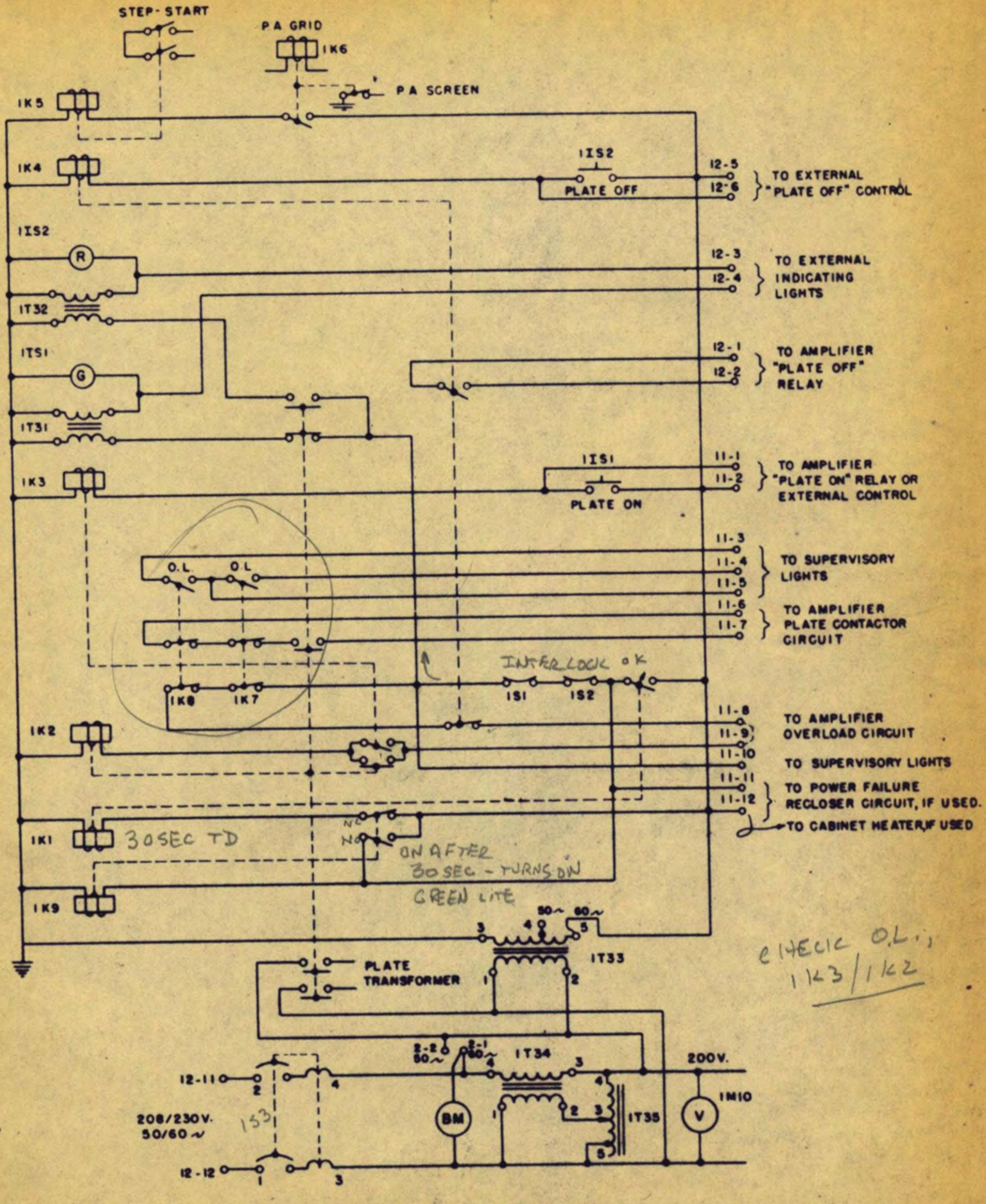


Fig. 23.
Control Circuits, Schematic Diagram (P-7769333, Rev. 3).

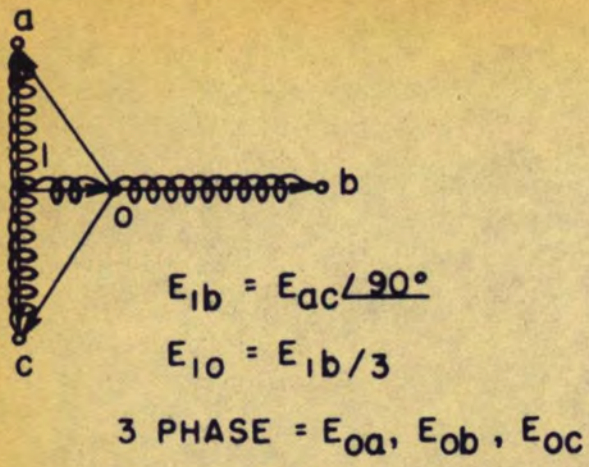


Fig. 24.
Scott Connection (K-7988037).

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.

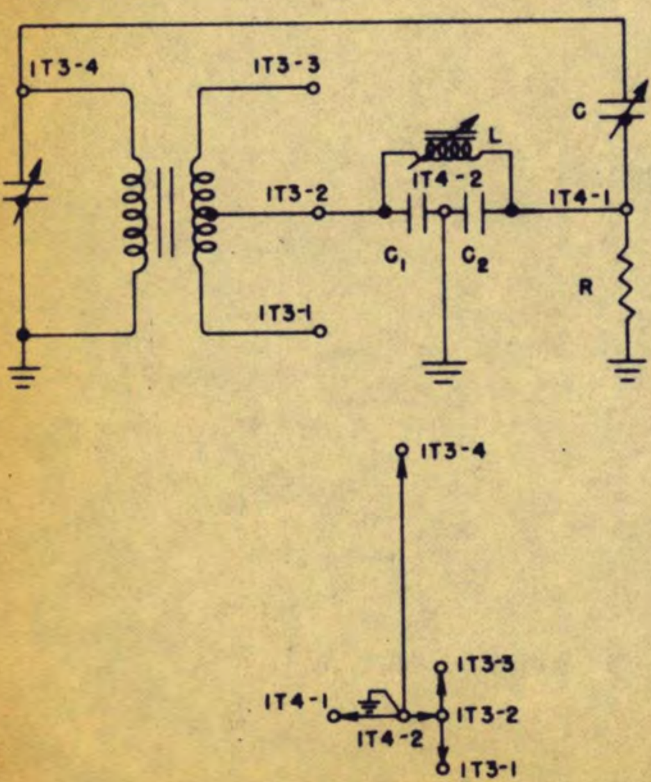


Fig. 25.
Phase-splitter, Schematic Diagram (K-7988038).

At this point note that resistors 1R48 across 1T9, 1R59 across 1T10, 1R57 across 1T11, and 1R64 across 1T12 have the connections shown dotted. These four resistors are used only with carrier frequencies below approximately 100 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 undercoupled. Here the frequency is high enough taht sufficient bandwidth is obtained easily. The bandwitdh 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, the cathode current is measured by 1M7.

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 work, will be assumed. A sketch reviewing the connection is shown in Fig. 24.

Transformers 1T3 and 1T4 are shown in somewhat the same fashion, Fig. 25.

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. These voltages are 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_1, 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. Figure 26 shows the entire structure of the tube; Figure 27 is an enlarged cut-away view of the tube elements with each of the parts labelled.

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 in Fig. 27. 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. Figure 28 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 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 in Fig. 28 and as shown in perspective in Fig. 29. 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

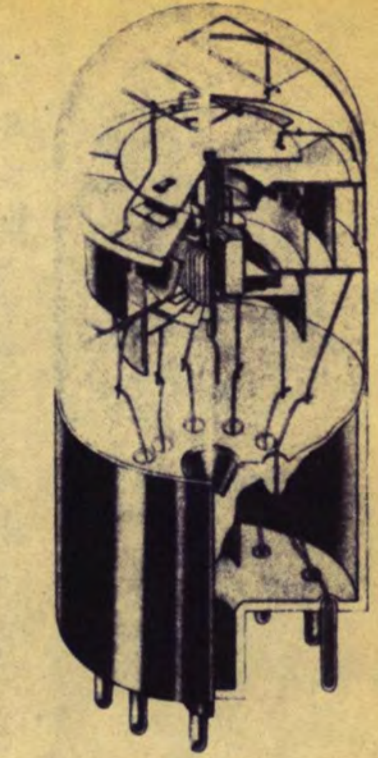


Fig. 26.
Cutaway View of Phasitron (894450).

shown. The undulate disk edge of Fig. 29 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 field that produces the undulations does. The path of the electrons moves

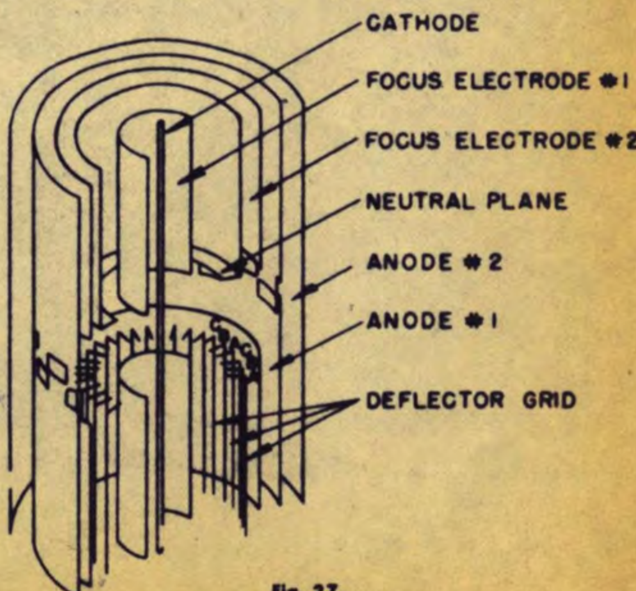


Fig. 27.
Phasitron Elements (K-7988039).

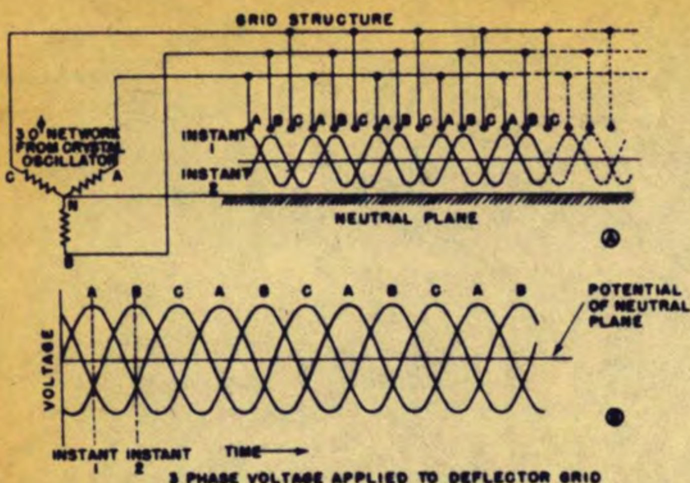


Fig. 28.

Developed View of Grid Structure and Neutral Plane (K-7988040).

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 in Fig. 30. This anode has 12 holes punched above 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 undulate edge of the electron disk is travelling. 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.

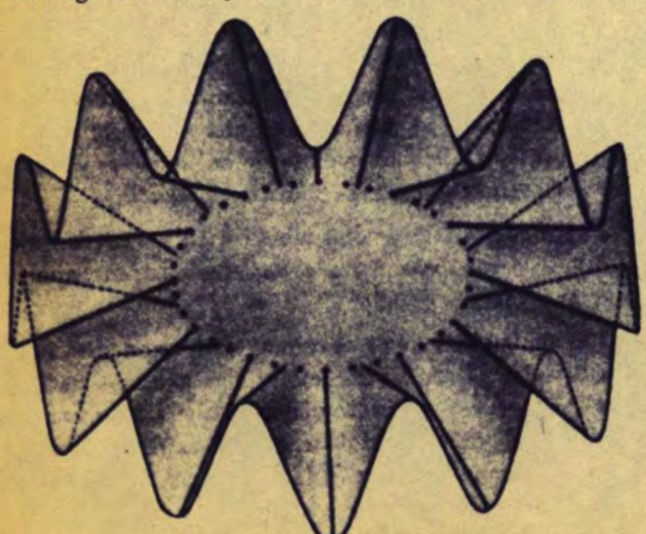


Fig. 29.

Perspective View of Deflecting Action of 3-phase Voltage on Electron Disk (894469).

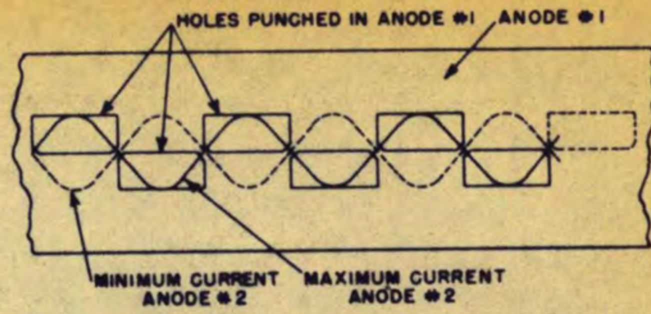


Fig. 30.

Developed View of Portion of Anode No. 1 (K-7988041).

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.

Now suppose the electron disk in the phasitron is itself given an angular velocity. This velocity effectively superposes 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 deviation in cycles.
ϕ = maximum phase displacement in radians
and f_a = audio modulating frequency.

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 in Fig. 31.

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.

6. 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.

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 (paragraph 1). This grid current is measured by 1M4.

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.

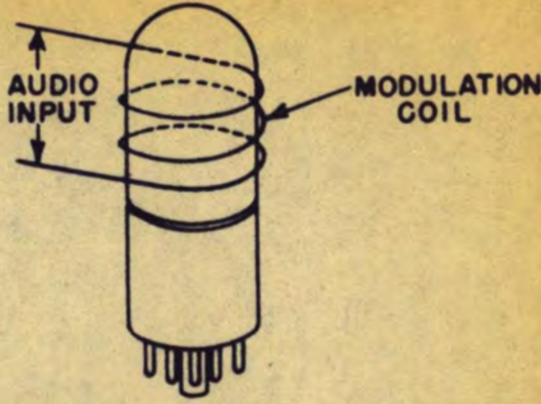


Fig. 31.
Magnetic Coil Placed Around Phasitron (K-7988042).

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.

7. R-f 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 conjuction 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.

8. 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.

9. Approximate R-f Circuit Operating Frequencies

Circuit	Range	Times Crystal Freq.	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
1T15	29.3-36 mc	144	±25 kc	80 kc
1T14	14.7-18 mc	72	±12.5 kc	55 kc
IT13	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	....
IT3	203-250 kc	1	None	....
Crystal	203-250 kc	...	None	....

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

GL-2H21 Phasitron—Description and Rating

GENERAL DESCRIPTION

Principal Application: Phase-modulator tube for use at frequencies below 500 kilocycles

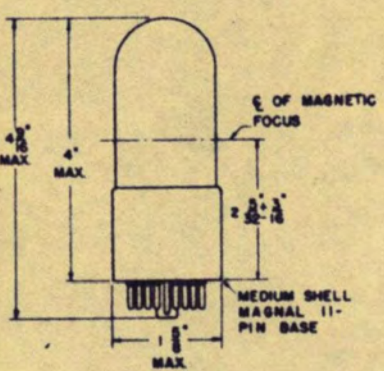
Characteristics

Cathode-Indirectly Heated

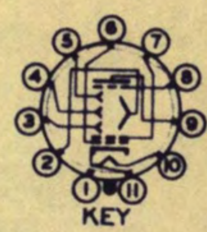
Heater Voltage	6.3 Volts D-C
Heater Current	0.3 Ampere

Direct Interelectrode Capacitances, Approximate	
Deflectors to Plate 1	0.025 μμf
Plate 1 to Plate 2	1.0 μμf
Frequency for Maximum Ratings	500 Kilocycles
Mounting Position-Any	

PHYSICAL DIMENSIONS:



TERMINAL CONNECTIONS:



Pin 1 - Internal connection
Pin 2 - Deflector No. 4
Pin 3 - Deflector No. 1
Pin 4 - Deflector No. 2
Pin 5 - Deflector No. 3
Pin 6 - Grid No. 1
Pin 7 - Grid No. 2
Pin 8 - Plate No. 1
Pin 9 - Plate No. 2
Pin 10- Heater
Pin 11- Heater & Cathode

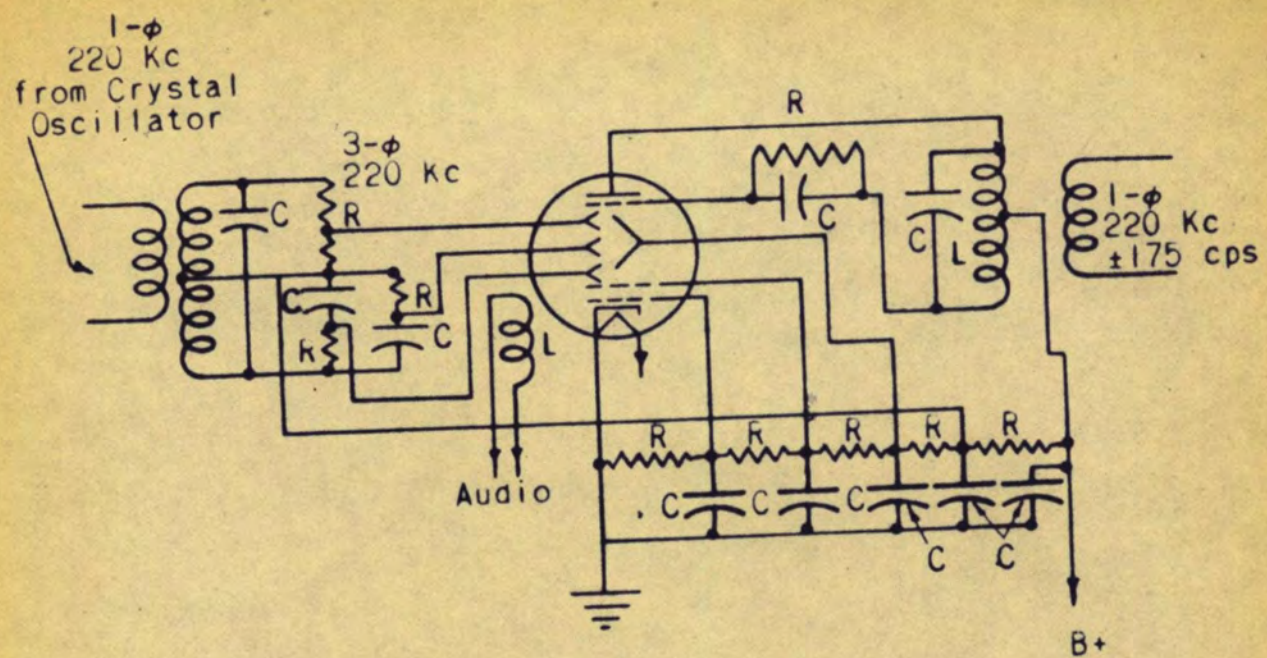
MAXIMUM RATINGS

Plate No. 1 Voltage	300 Volts
Plate No. 2 Voltage	300 Volts
Deflectors No. 1,2 and 3 Voltage	100 Volts
Deflector No. 4 Voltage	100 Volts
Grid No. 1 Voltage	25 Volts
Grid No. 2 Voltage	150 Volts
Cathode Current	6 Milliamperes

CHARACTERISTICS AND TYPICAL OPERATION

Phase Modulator *	
Plate No. 1 Voltage	200 VOLTS
Plate No. 2 Voltage	250 VOLTS
Deflectors No. 1,2 and 3 Voltage	85 VOLTS
Deflector No. 4 Voltage	30 VOLTS
Grid No. 1 Voltage	10 VOLTS
Grid No. 2 Voltage	25 VOLTS
Cathode Current	4 MILLIAMPERES
Radio-Frequency Driving Voltage, phase to neutral	35 VOLTS RMS
Maximum Audio-Modulating Power for ±180° Phase Shift	50 MILLIWATTS
Radio-Frequency Output Voltage	4 VOLTS RMS
Distortion at ±180° Phase Shift	1.2 PER CENT

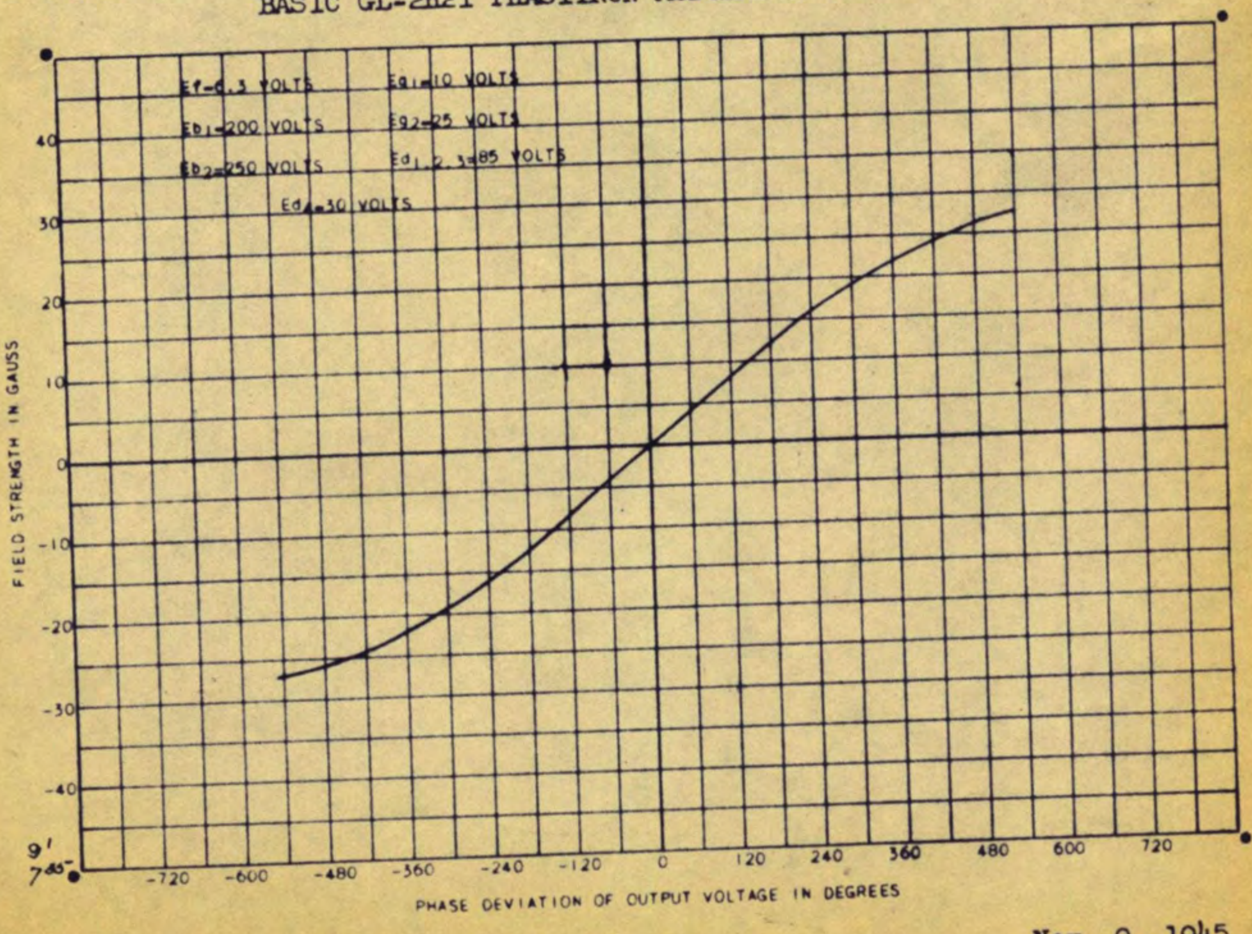
* CIRCUIT SHOWN ON REVERSE



Dec. 3, 1945

K-9033986

BASIC GL-2H21 PHASITRON MODULATOR CIRCUIT



Nov. 9, 1945

K-9186053

GL-2H21 MODULATION CHARACTERISTIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

GEI-23009A

INSTRUCTIONS

3-KILOWATT FM BROADCAST AMPLIFIER

TYPE BF-2-A

(MODEL 4BF2A1)

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.)

FOREWORD

The instructions for your 3-KW Frequency Modulation Transmitter, G-E Type BT-3-A or -B (Figs. 1, 2 and 3), are written in accordance with the block system in the same manner as your transmitter is constructed. By combining the instructions for your General Electric 250-Watt FM Exciter and these instructions for your 3-KW FM Amplifier, G-E Type BF-2-A, you have complete instructions for your 3-KW FM Transmitter, G-E Type BT-3-A or -B. Instructions relating to the correlation of your Exciter (250-Watt Transmitter) and your Amplifier are included in this Amplifier Instruction Book.

This ample size binder is designed to enclose both sets of instructions. You may discard the cover on your 250-Watt Transmitter instruction book.

The information contained in these instructions supersedes that contained in the PRELIMINARY 3-KW FM BROADCAST AMPLIFIER Instruction Book (GEI-23009).

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LIST OF ILLUSTRATIONS

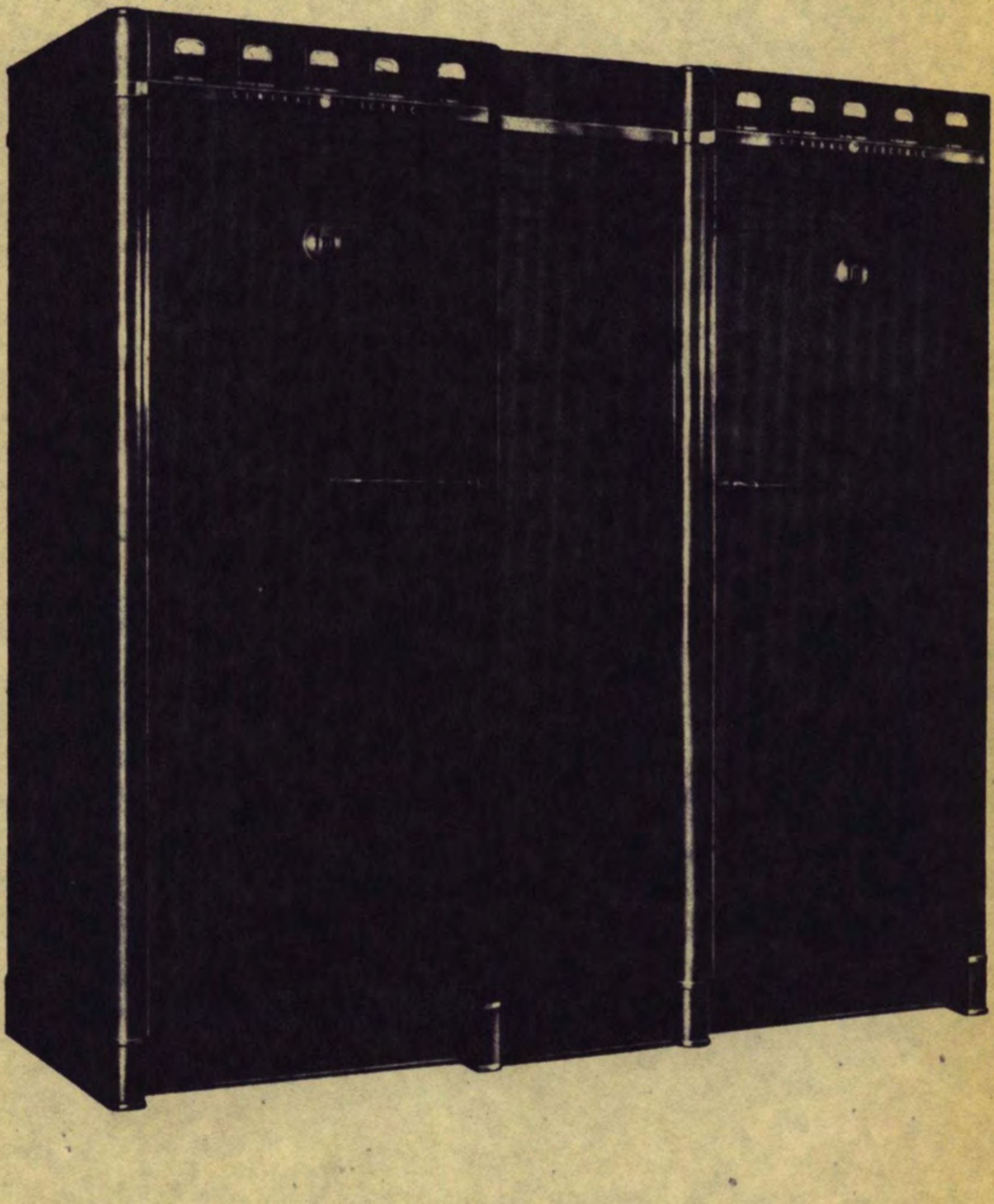


Fig. 1. Front Oblique View (SY1168A)

3-KILOWATT FM BROADCAST AMPLIFIER

TYPE BF-2-A

(MODEL 4BF2A1)

INTRODUCTION

The General Electric 3-Kilowatt Frequency Modulation Amplifier combines with the General Electric 250-Watt Exciter to make one of broadcasting's most modern station units (Figs. 1, 2 and 3).

General Electric has pioneered in the Frequency Modulation field and has designed and built many Frequency Modulation Broadcast Transmitters. This experience, combined with the experience of the numerous broadcasters using General Electric equipment, has formed the basis for the design of this new, improved equipment.

This Amplifier is designed to be used for broadcast installations where a larger primary service area is desired than that obtainable when using the 250-Watt or 1-Kilowatt Transmitter, and is an ideal foundation for future station expansion to 10 and 50 kilowatts.

Use of the newly developed air-cooled type GL-7D21 screen-grid tubes in the power-amplifier stage insures stable and efficient operation. Conservative operation of tubes and components is the foundation of satisfactory performance.

It is hoped that the following sections of this book will familiarize you with your Amplifier and enable you to receive maximum value from your investment.

ELECTRICAL SPECIFICATIONS

Nominal Carrier Power Output

3000 watts.

Radio-frequency Range

88 to 108 mc.

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.

RF Output Coupling Circuit

The r-f output coupling circuit is designed to operate into an unbalanced load, the electrical characteristics of which 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 the carrier frequency. Provisions are made for the use of a single 1⅝ inch coaxial-transmission line having a surge impedance of 51.5 ohms. The output-transmission line may be pressurized.

AF Input Level

10 dbm ± 2 db required for 100 per cent modulation at 400 cycles; input impedance, 600 ohms.

AF Response

Within ± 1 db of FCC pre-emphasis standard from 50 to 15,000 cycles.

AF 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.

Modulation Capability

± 100 kc carrier swing, 50 to 15,000 cycles with less than 3 per cent rms distortion.

Power Supply

208/230 volts, 50/60 cycles, three phase ± 5 per cent line voltage tolerance. In addition, a very small amount of power is required from the station lighting supply at 115 volts for the crystal Thermocell heater.

Power Input

8.0 kw at 90 per cent power factor.

Methods and conditions of measurement conform with RMA proposed standards.

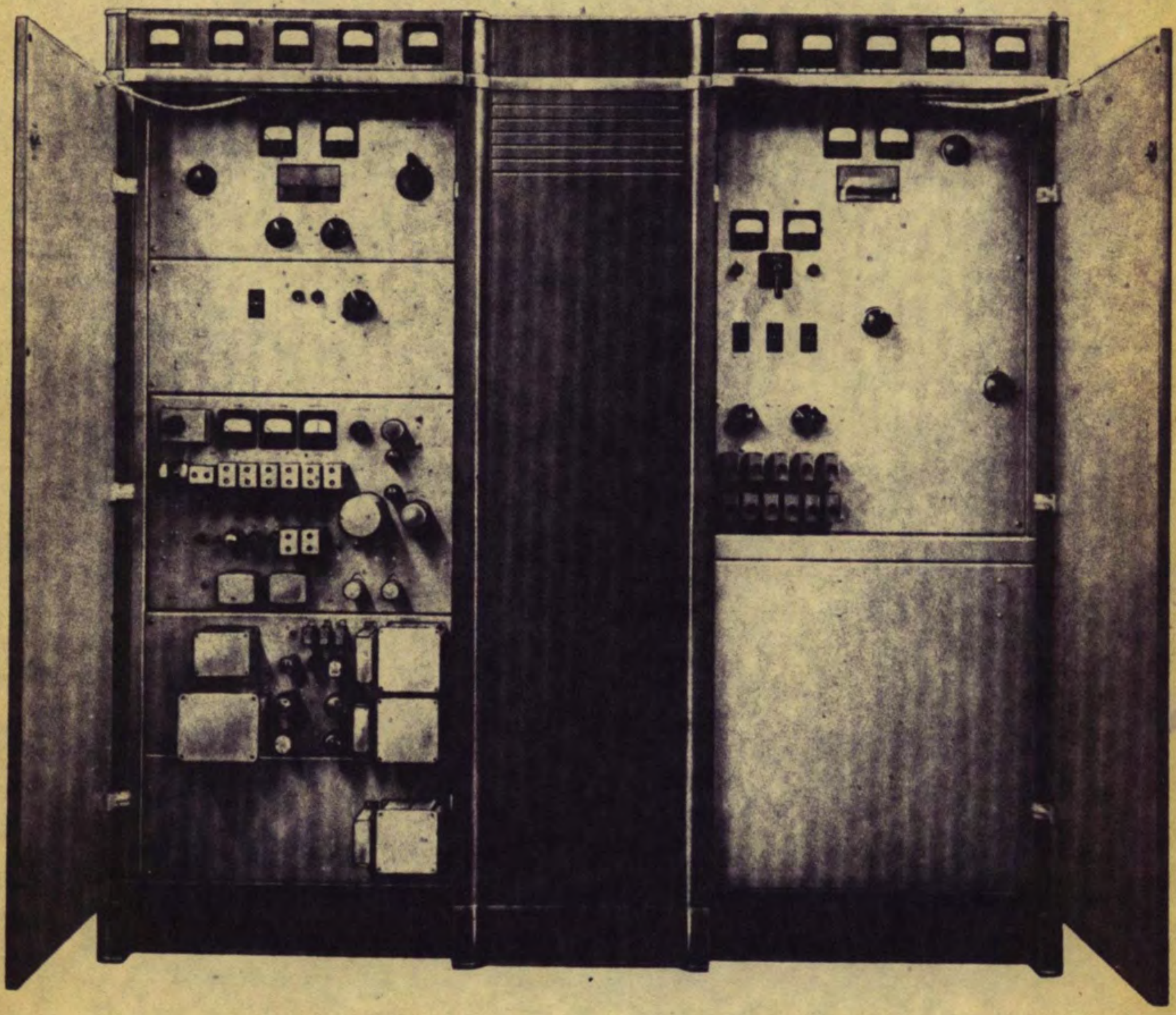


Fig. 2 Front View with Doors Open (SY1167A)

DESCRIPTION

1. EQUIPMENT FURNISHED

A Standard equipment consists of the following units:

A. 1 G-E Type BF-2-A Amplifier (3-KW)

B. 2 sets of Vacuum Tubes, each set consisting of:

6-GL-8008	1-6H6
2-GL-7D21	2-GL-866-A/866

C. Accessories:

Item	*Description*	*G-E Dwg. Ref.*	*Quantity*
1	Dark blue touch-up paint	MLK-7126433G2	½ pint can
2	Gray touch-up paint	#115 Gray, National Paint products or equivalent	1 pint can
3	Thinner for touch-up paint	G-E #1500	1 pint can
4	Transmission line (exciter to amplifier)	K-7118586P1	1
5	Phillips binder head screw	Recessed F70C1A ¼-20 x 1 inch	8
6	Washer	F70C1B ¼ inch	8
7	Lockwasher	K-7867352P5	8
8	Inter-connecting wire	MLK-7116973G2	1
9	Hex nut	F70C1B ¼-20	8

Note: Items 5, 6, 7 and 9 are packed in cloth bag.

2. GENERAL CONSTRUCTION

The 3-Kilowatt Amplifier is completely self-contained in two steel cabinets finished in smooth blue lacquer with chromium trim; see Figs. 1, 2 and 3. The smaller cabinet, mounted between the exciter and amplifier cabinets, contains the plate-power supply for the Amplifier and enhances the modernistic styling of the 3-KW Transmitter as a unit. The cabinets provide radio-frequency shielding as well as high-voltage protection to the station personnel.

Air used for cooling the tubes and other components is filtered before it is circulated through the cabinets.

The front door permits access to the operating controls only (See Fig. 4); no voltages are exposed. The rear doors are equipped with interlock switches and grounding switches which automatically open the high-voltage transformer primaries and ground the high-voltage plate circuit before the doors can be opened. Opening a rear door of either the Exciter or the Amplifier shuts off both units.

A toe kick-port is provided under the front door and a six-inch high composition panel protects the other sides of the cabinets from shoe marks along the bottom edge.

All tuning controls requiring fine adjustments are driven with smooth-acting vernier dials. All controls necessary to the adjustment of the Transmitter while it is in operation are accessible from the front of the cabinet.

The five instruments mounted above the door on the front of the unit are, reading from left to right: FIL VOLTAGE, PA PLATE VOLTAGE, PA GRID CURRENT, PA PLATE CURRENT, RF OUTPUT. See Fig. 4. The last instrument indicates relative r-f transmission-line voltage in the output-transmission line feeding the antenna.*

In addition to the above mentioned instruments, four others are mounted on the control panel and are visible when the front door is open. The two meters at the top of the panel indicate the PA CATHODE CURRENT of each p-a tube individually. The other two meters indicate the SCREEN VOLTAGE and the SCREEN CURRENT.

3. AUXILIARY EQUIPMENT

A. A cabinet heater, G-E Type FH-1-A, is available on separate order for use when the Transmitter is situated in a humid location.

B. An FM Station Monitor, G-E Type BM-1-A, is available on separate order for use in monitoring the Amplifier output.

INSTALLATION

Upon receiving and unpacking the Amplifier give it a thorough inspection for possible shipping damage. Make careful inspection of all relays and contacts to make sure none have been jammed during shipment. Report any damage or shortages to the transportation company at once.

1. SPECIFIC INSTALLATION REQUIREMENTS

Requirements and information for installation are given on the Installation Requirements Diagram, Fig. 15. Fig. 14 shows a typical installation. The actual power requirements are given under the ELECTRICAL SPECIFICATIONS section of this book.

External wires other than inter-unit wiring are furnished by the customer. The external wire recommended on Fig. 15 may be secured on separate order from the General Electric Company.

IMPORTANT

The Amplifier, as shipped, is connected for 60-cycle operation. For 50-cycle operation, make the following internal reconnection to the Amplifier: Remove the brown wire from terminal 6 on 3T1 which is connected to the relays and place it on terminal 5. Leave the red-white-blue wire which is connected to the selenium rectifier, 3CR1, on terminals 6. 3T1 is mounted on the floor of the amplifier cabinet, and is the transformer farthest to the right, looking from the rear.

The Amplifier, as shipped, is connected for 230-volt input operation. For line voltage 5 per cent less than 230 volts, change leads on terminal 7, 12, and 17 of 3T7 to terminals 6, 11, and 16; for line voltage 5 per cent higher than 230 volts, change to terminals 8, 13, and 18. For 208-volt, ±5 per cent input operation make the following internal changes to the Amplifier:

A. On 3T8, 3T9, 3T10, 3T11, 3T12, 3T13, 3T14, 3T15, and 3T16 move the lead from the number 2 terminal of each transformer to the number 3 terminal of each transformer.

B. On 3T4 move the lead from the number 3 terminal to the number 2 terminal.

C. On 3T1 move the leads from the number 3 terminal to the number 2 terminal.

D. On 3T6 reverse leads on terminals 3 and 4.

E. On 3T5 reverse leads on terminals 1 and 4.

F. On 3T7 change leads from 7, 12, and 17, to 5, 10, and 15, respectively. If line voltage is 5 per cent less than 208 volts, change the leads to 4, 9, and 14; for line voltage 5 per cent higher than 208 volts, change the leads to 6, 11, and 16.

2. INSTALLATION OF TUBES

After the Transmitter is located and ready for operation (except for the actual application of power) install a complete set of tubes, consisting of the following:

Two Type 7D21, power amplifiers (3V10 and 3V11) mounted on the p-a chassis. See Fig. 8.

One Type 6H6, r-f voltmeter diode (3V9), located near the roof of the cabinet, on the left side as viewed from the rear. See Fig. 9.

Six Type GL-8008 high-voltage rectifier tubes (3V3-3V8) mounted in the plate-power supply cabinet. See Fig. 10.

Two Type GL-866 rectifier tubes (3V1 and 3V2) mounted on screen power-supply shelf. See Fig. 11.

Install each type GL-7D21 tube as follows (refer to Fig. 5).

CAUTION

Great care should be exercised in handling a type GL-7D21 tube. Since the mass of the anode radiating surface is quite large, it is easy to jar the thoriated tungsten filaments excessively when placing the tube on a hard surface.

A. Loosen the clamp on the stationary section of the plate line and slide the movable section of the plate line downward.

B. Loosen the clamp on the movable section.

C. Holding the GL-7D21 tube by the anode radiator, insert it into the movable section, as illustrated in Fig. 5.

D. Carefully slide the movable section and the tube up as far as they will go ensuring good contact between the tube contact surfaces and the fingers of the tube socket; then tighten the clamp on the stationary section to hold the movable section and the tube in this raised position.

E. Tighten the clamp on the movable section and the installation is complete.

Use the following procedure to remove a type GL-7D21 tube:

A. Holding the tube by the radiator anode, loosen the clamp on the stationary section and carefully slide the movable section and the tube down.

CAUTION

To eliminate the possibility of the tube's slipping and falling, be sure that the clamp on the movable section is tight during this first operation.

B. Loosen the clamp on the movable section.

C. Holding the tube by the radiator anode, lift it up and out of the movable section.

A warm-up period of 15 minutes with filament power ON, but no plate power, is recommended for the GL-8008 mercury rectifier tubes, when they are first installed. After the first warm-up period, the normal time delay-relay period will be sufficient.

NOTE

Remove the Type 6H6 r-f diode whose socket is located just below the p-a chassis on the left side of the exciter cabinet, looking from the rear. Its use is unnecessary in the operation of the G-E Type BT-3-A Transmitter.

3. INSTALLATION OF EQUIPMENT NAMEPLATE

If this Amplifier, G-E Type BF-2-A, is used as a final Amplifier, an envelope will be packed with the equipment containing the equipment nameplate. This nameplate should be mounted below the final Amplifier Unit nameplate with the screws provided. The equipment type number on this nameplate must agree with the type number filed with the Federal Communications Commission.

4. PRELIMINARY CHECKS

A. Air Flow: If a duct is used to carry exhaust air from the transmitter-blower outlet, care must be taken to prevent any back pressure in the duct. The blower system of the Transmitter is designed to exhaust at atmospheric pressure, so that external resistance to exhaust air flow will reduce cooling efficiency of the blower.

B. Power Switches: Before applying power to the Amplifier, throw all POWER switches (FIL, MAIN, and SCREEN) on the front panel to the OFF position.

Fig. 3. Rear View with Doors Open (SY3029A)

THEORY OF OPERATION

1. EXPLANATION OF CONTROL CIRCUITS

A. The control circuits may be analyzed by referring to the Elementary Diagram of Control Circuits, Fig. 7a or 7b. These drawings show the control circuits in both the 250-watt Exciter, G-E Type BT-1-A or -B, and the 3-KW Amplifier, G-E Type BF-2-A, with the necessary inter-connecting wiring.

Either the G-E Type BT-1-A or BT-1-B 250-Watt Transmitter may be used as an exciter with the 3-KW Amplifier. Therefore, two Control Diagrams, Figs. 7a and 7 b are included in this book. (Fig. 7a applies when the Type BT-1-A Exciter is used, and Fig. 7b applies when the Type BT-1-B Exciter is used). Since the customer is concerned only with the drawing which applies to his particular equipment, he may discard the diagram which does not apply.

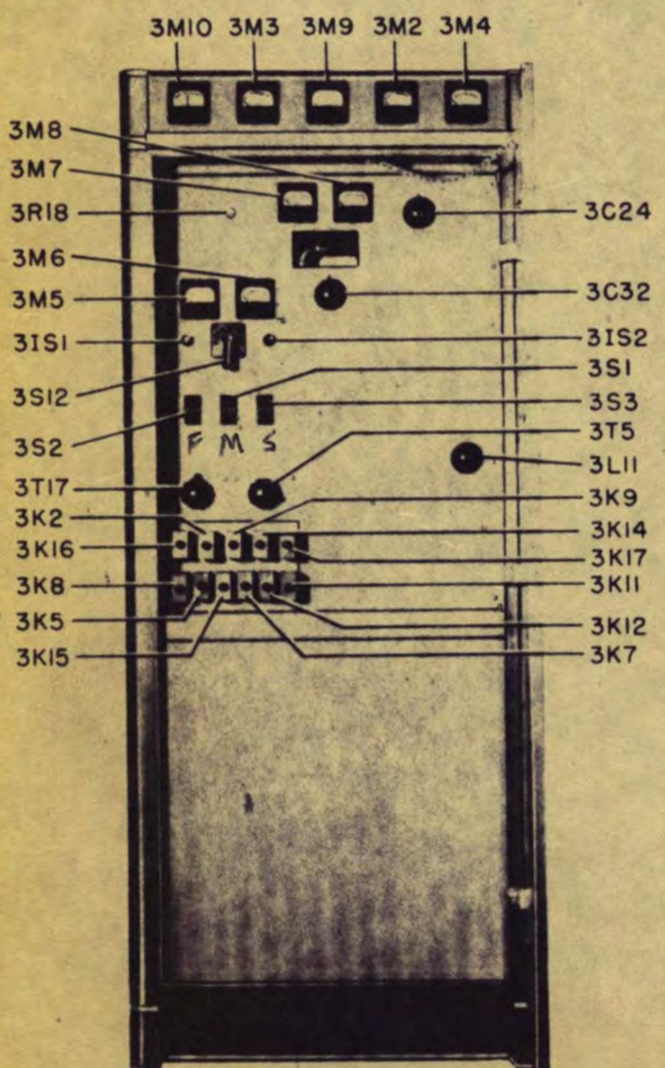


Fig. 4. Front View, Door Open, Components Identified (SY5270A)

The control circuits for the 250-watt Exciter are analyzed in the 250-watt Transmitter Instruction Book and therefore need not be described again. However, where the control circuit of the exciter and amplifier are interlocked or effect one another, the circuits will be analyzed in this book.

B. Let us start with the power input terminals of the amplifier (lower right corner of Fig. 7a or 7b) and analyze the circuits of the switches and relays which will start the amplifier, protect its operation, and shut it off.

First, note that all relays on this diagram are drawn with the contacts in their normal position when the relay is *not energized*. Further, relay contacts with small arrows on them indicate that the action is not instantaneous, but that some period of time is required for action to take place in the direction of the arrow (time delay relay).

(1) The 208/230 volt, 50/60 cycle, three-phase power is switched on by means of the main power breaker 3S1. 3S1 is a magnetically-operated circuit-breaker type switch with inverse time characteristic. This type switch is used to eliminate fuses in the power lines. Its breaker action affords protection to the power circuits and rectifier circuits up to the rectifier filter output. Beyond this point, d-c overload protection is provided.

The control circuits, filament transformer circuits, and blower motor operate single phase and are connected to the three-phase supply in such a way that the load is approximately equally distributed.

(2) The power to the filament transformers and control circuits is controlled by circuit breaker 3S2.

(3) The primaries of the filament transformers are designed for operation at 208 or 230 volts. When the transmitter input voltage is 208, the filament transformers are all connected for 230-volt operation, the combination of variable transformer 3T5 and buck-boost transformer 3T6 providing the necessary boost voltage from 208 to 230 volts. Manipulation of variable transformer 3T5 (FIL VOLTAGE-INCREASE) on the input panel varies the boost voltage to compensate for moderate changes of the transmitter input voltage and thus makes it possible to maintain all filaments at their proper operating voltage (6.3 volts as indicated by 3M10, FIL VOLTAGE meter).

Likewise, when the transmitter input voltage is 230 volts, the filament transformers are all operated at

208 volts and the combination of 3T5 and 3T6 provide the necessary buck voltage.

The Control Diagram, Fig. 7a or 7b is drawn showing connection for a transmitter input voltage of 230 volts. Under this condition it is possible to adjust 3T5 for correct filament voltage with a transmitter input voltage in the range 218 to 245 volts.

For 208-volt input operation of the amplifier the following changes are necessary in the filament supply circuits:

(a) On 3T8, 3T9, 3T10, 3T11, 3T12, 3T13, 3T14, 3T15, and 3T16 move the lead from the number 2 terminal of each transformer to the number 3 terminal of each transformer. In all cases, terminal 2 is the 208-volt tap and terminal 3 is the 230-volt tap.

(b) On 3T6 reverse leads on terminals 3 and 4. This enables the secondary voltage of 3T6 to boost the line voltage instead of buck it.

(c) On 3T5 reverse the leads on terminals 1 and 4. This is necessary if the filament voltage is to increase when the FIL VOLTAGE control is turned in the INCREASE direction.

With the amplifier thus connected for 208-volt input operation, the voltage to the filament transformers can be maintained at the proper value for input voltages from 195 to 230.

(4) The power to the three-phase rectifier transformer is controlled by a DELTA-WYE switch, 3S12, which connects the transformer primary either in delta (for full plate voltage) or in wye (approximately 58 per cent plate voltage). Auxiliary contacts on 3S12 perform two other functions as follows:

(a) When the switch is operated, contact BA opens first, causing power to be removed from the plate transformer. Contacts BU and BT then operate as required to reconnect the transformer. Finally as the switching operation is completed, contact BA again closes, preparatory to re-application of plate power.

(b) Contact BP provides an interlock for higher-powered transmitters.

(5) The power to the screen grid power supply is controlled by circuit breaker 3S3 and is so connected to the DELTA-WYE switch, 3S12, that the screen voltage is also reduced to 58 per cent when this switch is in the WYE position.

(6) A centrifugal safety switch, 3S10, has been provided on blower motor 3BM1. This switch opens the circuit to the primary of the filament transformer when the blower is not running and thus prevents the filaments from being energized when the blower motor is not operating.

(7) An additional switch, 3S11, mounted on the rear of the p-a shelf, makes it possible to turn off the tube filaments without turning off the blower (contacts BR). This permits the blower to operate and cool the tubes, thus facilitating quick changing of hot tubes. A second set of contacts on 3S11 opens the plate voltage interlock circuit while the filaments are shut off. This prevents application of plate voltage until 3S11 has been returned to the "ON" position.

(8) Control transformer 3T1 reduces the voltage from the 208/230-volt supply to 115 volts on the

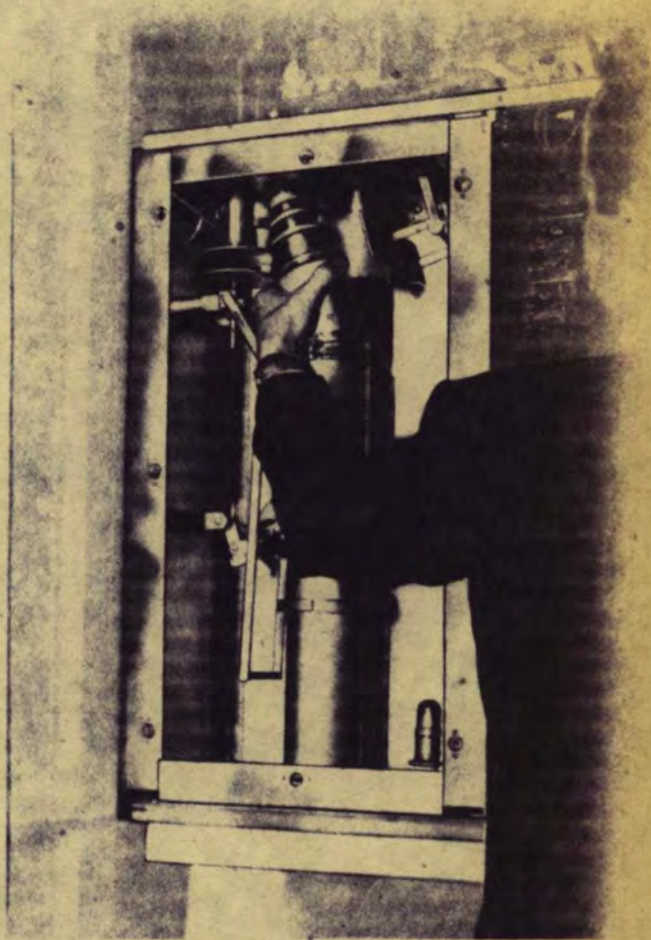


Fig. 5. Type GL-7D21 Amplifier Tube Being Installed in Socket (SY2062A)

60-cycle tap (terminal 6) and 96 volts on the 50-cycle tap (terminal 5). The purpose of this transformer is threefold: first, it permits the use of standard 115-volt relays on either 50 or 60 cycles; second, it reduces the exposed potentials on all the control circuits which remain energized when the rear door is opened; and third, it allows one side of the control circuit to be grounded. As shown on the Control Diagram, Fig. 7a or 7b, 3T1 is connected for 230-volt input operation. For 208-volt input operation, the lead on terminal number 3 should be moved to terminal number 2.

(9) In analyzing the control circuits of the amplifier section, assume that 3S11 is in the "ON" position, door interlocks 3S4, 3S5, 3S6, and 3S7 are closed, power switches 3S1, 3S2, and 3S3 have been switched on, the Exciter Unit is in operation with plate power applied, and the filament voltage as indicated by 3M10 has been adjusted to 6.3 volts by means of variable transformers 3T5. With the exciter coupled into the amplifier, grid current relay 3K16 will be energized, closing contact BH.

Under these conditions current is flowing from the secondary of 3T1 through 3 circuits as follows:

(a) Through time delay-relay 3K1.

(b) Through relay 3K2.

(c) Through selenium rectifier 3CR1.

Let us now examine each of these circuits.

(10) Filament time delay-relay 3K1 requires about 30 seconds to close. This gives the filaments time to warm up before plate voltage can be applied. When 3K1 has timed out, it performs the following operations:

(a) It closes contact BM which completes the circuit through normally closed contact AY and energizes lamp transformer 3T2. Thus, the green light, 31S1, in the PLATE ON button is illuminated, indicating that the filaments have had time to warm up and that plate power may now be applied. A lead is extended to 3TB4-9 for external indicating lights.

(b) It opens contact BQ which de-energizes the time-delay motor which is part of 3K1. This prevents the motor from remaining energized in the stalled position.

(11) When door relay 3K2 is energized it closes contact BD and opens contact BC. Contact BD is in series with the plate power contactor circuit in the Exciter Unit. This interlocking system prevents the application of plate power to the Exciter Unit if Amplifier Unit filament and control power are not turned on, or if either rear door of the Amplifier Units is open. Contact BC is in series with a circuit which is brought out to 3TB2-4 and 2-5 for door interlock supervisory light, if used. (Part of higher-powered transmitter.)

(12) Selenium rectifier 3CR1 is permanently connected to the 60-cycle tap, terminal 6, of 3T1. The purpose of this fixed connection is to maintain the same output voltage from 3CR1 (the 50-cycle tap is necessary to reduce the a-c voltage on the relays to 96 volts when operating at 50 cycles).

Current from 3CR1 flows through two paths as follows:

(a) It flows through normally closed contact AD and relay 3K12. When 3K12 is thus energized it opens contact AB. Step-start relay 3K13 originally is energized as the control power is switched on, but falls out almost immediately as relay 3K12 is energized and opens contact AB.

(b) It also flows through resistor 3R3, normally closed contact AH and relay 3K11. Resistor 3R3 has very high resistance so that the current which flows through it is not sufficient to pull in 3K11. The operation of 3K11 is explained under "Plate Power Reclosure Circuit Operation."

(13) PLATE ON button 31S1 is pushed to energize relay 3K8. 3K8 can also be energized externally through 3TB3-8 and 3-9. When 3K8 is energized it closes contacts AL and BN.

Contact AL is connected to shunt the PLATE ON switch in the Exciter Unit, and turn on the exciter plate power if it is not already on.

Contact BN is in series with the coil of plate contactor auxiliary relay 3K3.

(14) Relay 3K3 is now energized since current may now flow through contacts 3S7, 3S6, 3S5, 3S4, BM, BN, 3S11, BK, J, I, H, BH, BG, and BJ. Contact J in the exciter is closed when plate power is applied to the exciter, and contacts I and H are closed providing there are no overloads in the exciter. This interlocking system prohibits amplifier plate power being applied or maintained if exciter plate power is not applied, or if an overload occurs in the exciter.

(15) When relay 3K3 closes, it performs two operations:

(a) It closes contact AZ, which energizes plate contactor 3K4.

(b) It switches contact AY, de-energizing transformer 3T2 and energizing 3T3. Thus the green light in the PLATE ON button is turned off, and the red light in the PLATE OFF button is turned on. This indicates to the operator that plate power is applied.

(16) When plate contactor 3K4 is energized it performs six functions:

(a) It closes contacts BS, thereby supplying power to the primary of the high-voltage plate transformer.

(b) It closes contact BO which is in parallel with contact BN. Therefore, relay 3K3 is sealed in, i.e., will remain energized after the PLATE ON button is released and relay 3K8 drops out.

(c) It opens contact AD thus opening the circuit through relay 3K12. Note that the contact arm AB of relay 3K12 has an arrow on it which denotes that time is required for it to close. This is a slow action relay by virtue of a heavy copper ring around the coil forming a shorted turn. The collapse of magnetic flux in the core of the relay is therefore delayed, because

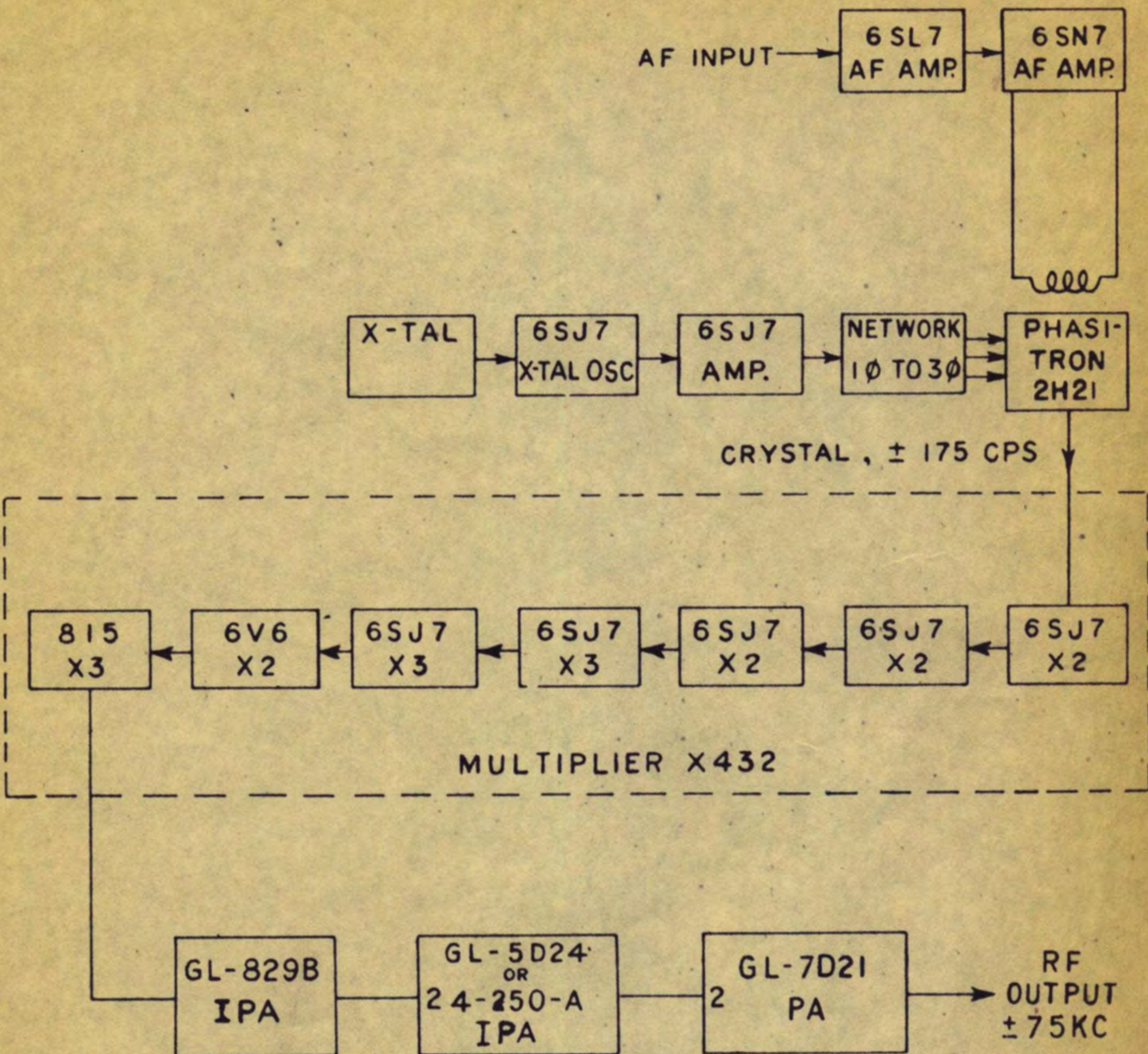


Fig. 6a. Block Diagram of 3-KW FM Broadcast Transmitter with Type BT-1-A Exciter (K-7119815, Rev. 1)

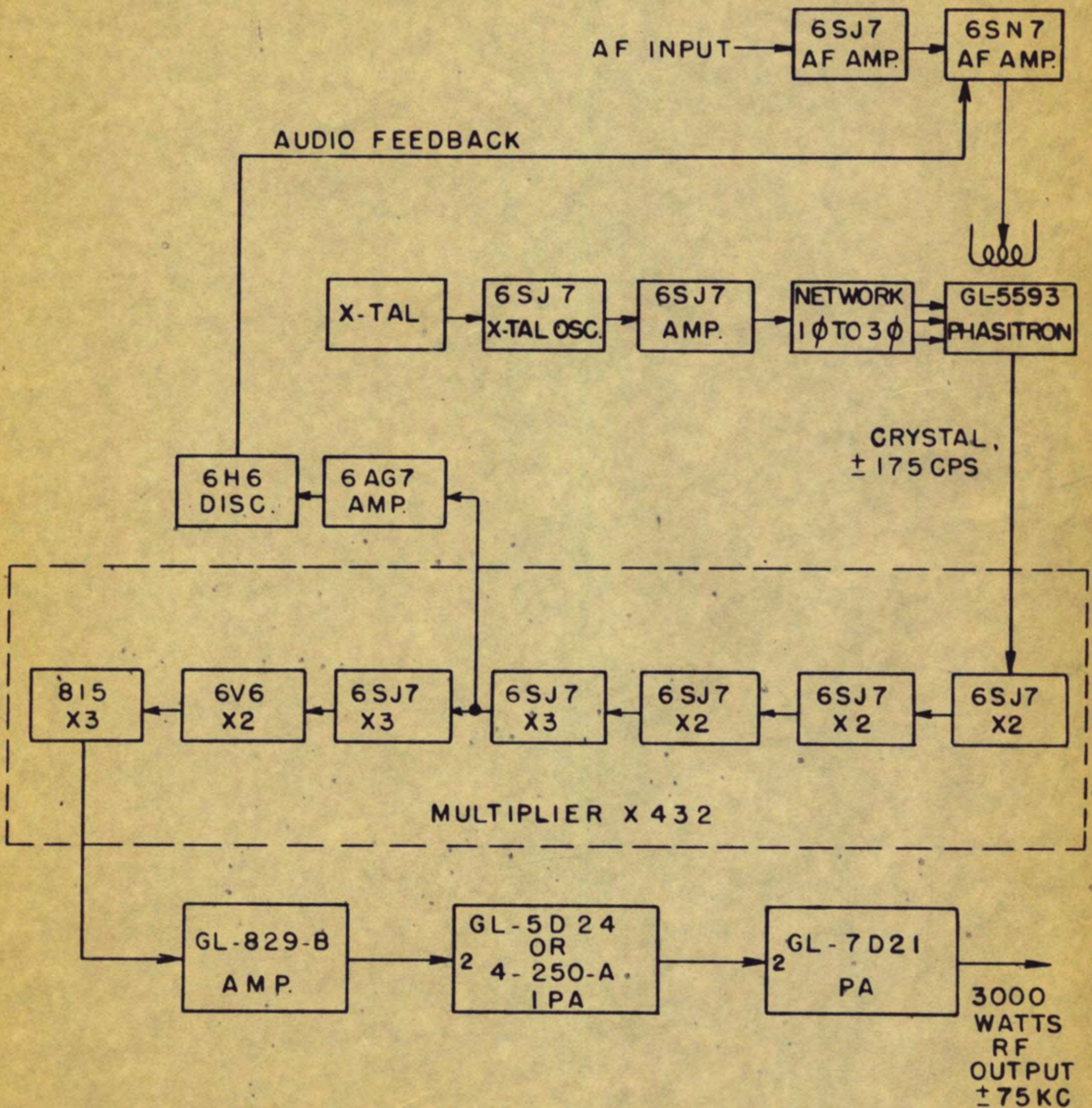


Fig. 6b. Block Diagram of 3-KW FM Broadcast Transmitter with Type BT-1-B Exciter (K-7121463, Rev. 0)

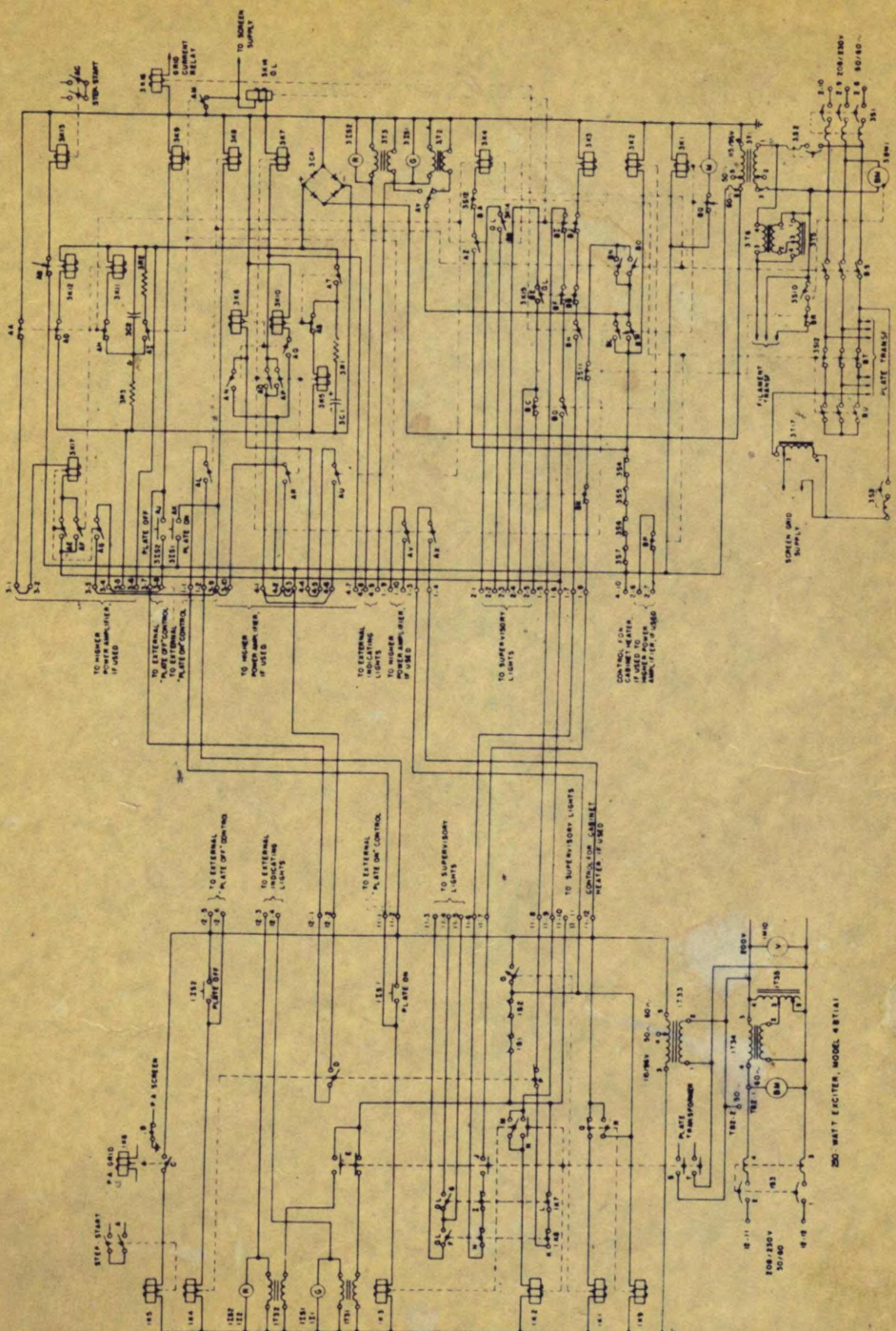


Fig. 7a. Elementary Diagram of Control Circuits with Type BT-1-A Exciter (T-7665024, Rev. 5)

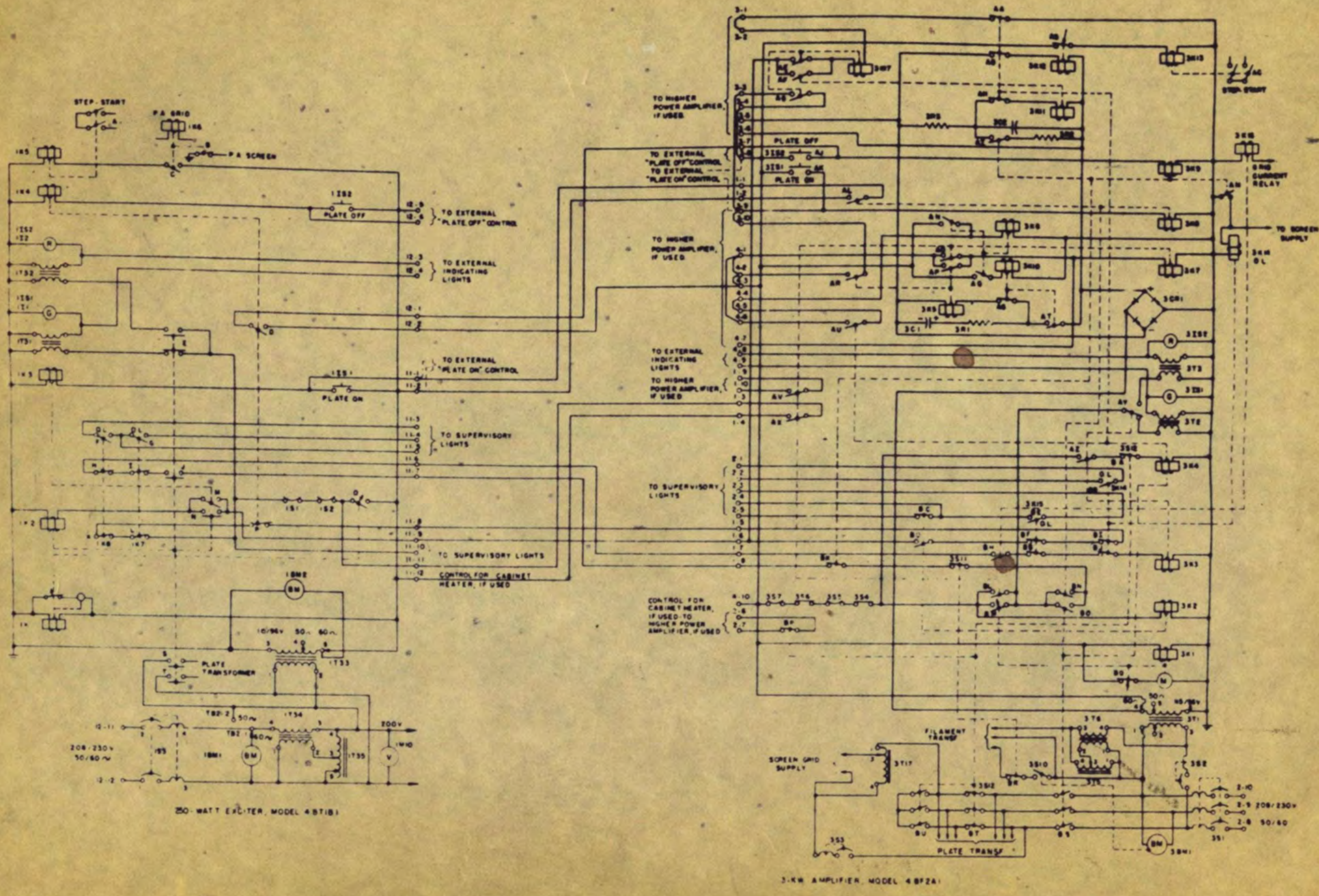


Fig. 7b. Elementary Diagram of Control Circuits with Type BT-1-B Exciter (T-7665576, Rev. 1)

the circulating current induced in the shorted turns prevents any sudden change in the flux linking it. Consequently, it is a short time after the circuit to 3K12 is opened before the contact AB in series with 3K13 closes. The delay is sufficient to properly operate the step-starting relay, 3K13. The function of the step-start relay is identical to that described in connection with the step-start mechanism of the Exciter Unit. Relay 3K13 closes contact AC and thereby shorts out step-start resistor 3R4.

(d) It opens contact AH in series with plate reclosure relay 3K11. Thus capacitor 3C2 is allowed to charge up through high resistance 3R3. As stated before, the resistance of 3R3 is sufficiently high that 3K11 has not been closed even though it has had some current flowing through it.

(e) It opens contact AA. Its purpose is explained under "Plate Power Reclosure Current Operations."

(f) It closes contact AU, which allows current to flow through 3TB4-3, 3TB4-2, 3TB4-1, 3TB4-6, contact AU, 3TB4-5, 3TB4-4, and the coil of relay 3K6. The purpose of 3K6 is explained under "Power Failure Reclosure Circuit Operation."

(17) Pushing PLATE OFF switch 3IS2 energizes relay 3K9. Relay 3K9 may also be energized externally through 3TB3-7 and 3-8. When 3K9 picks up it performs three operations:

(a) It opens contact BK. Relay 3K3 is de-energized and plate contactor 3K4 is consequently de-energized, removing plate voltage.

(b) It closes contact AI, which permits capacitor 3C2 to discharge through current limiting resistor 3R2. This prevents the plate power reclosure circuit from operating. (Details of the plate power reclosure circuit are explained in paragraph 18.)

(c) It closes contact AM. This prevents the momentary surge of screen current, occurring at the instant the PLATE OFF button is pushed, from tripping the screen overload relay, 3K14, thereby turning off the 250-Watt Exciter plate power. When relay 3K3 and plate contactor 3K4 are de-energized, the transmitter reverts to the same stage of operation which existed before plate power was applied (paragraph 13) with one exception—the power failure reclosure circuit remains active.

Note that the plate power for both the 250-Watt Exciter and the 3-KW Amplifier may be turned on by pressing the amplifier PLATE ON button (3IS1) and that the plate power for both the exciter and amplifier may be turned off by pressing the exciter PLATE OFF button (1IS2).

(18) The Plate Power Reclosure Circuit is designed to automatically reapply plate power to the transmitter after an overload has turned the plate power off. An overload caused by a condition such as arcing within a power tube may clear itself as soon as the plate power is turned off by the overload relay. The reclosure circuit is designed to automatically turn the plate power back on so quickly that there is no objectionable interruption in the program. If the overload is such that it will not clear itself when plate power is removed, the reclosure circuit will make approximately two attempts to put the equipment back on the air. If these attempts fail, the plate power stays off. It is then necessary to repair the fault and apply the plate power manually by use of the PLATE ON switch.

The action of the plate power reclosure circuit is as folows:

When plate power is applied, plate contactor relay 3K4 opens contact AH. Capacitor 3C2 is then able to charge up to the average potential of rectifier 3CR1 through high resistance 3R3. It requires 7 or 8 seconds for 3C2 to become fully charged.

If a d-c overload occurs in either the Exciter Unit or the Amplifier Unit, plate contactor 3K4 is de-energized by overload relay operation. Contact AH is closed connecting relay 3K11 across capacitor 3C2. 3K11 is energized by the discharge from capacitor 3C2 and closes contact AF. Current then flows from the exciter control voltage supply through contacts 0, 1S2, 1S1, L, K, P, 1TB11-8 and in the amplifier through contacts 3TB1-5, BI, BF, BD, the coil of relay 3K17, 3TB3-2, 3TB3-1, and contact AA. Thus 3K17 is energized, closing contacts AG and AE.

Contact AG is connected by external wiring in parallel with the PLATE ON button 3IS1. Therefore, the plate power is turned back on in the same manner as if the PLATE ON button had been pushed. Contact AE seals in relay 3K17 until the plate contactor relay 3K4 closes and opens contact AA.

If the overload is still present, the reclosure circuit will make approximately one more attempt to re-apply plate power, and if that is unsuccessful the plate power will remain off.

The plate power reclosure circuit is limited to approximately two reclosure attempts because of the limited capacity of 3C2. The current which pulls in relay 3K11 depends primarily upon the storage capacity of 3C2 since resistor 3R3 is sufficiently high that it will not pass enough current to pull in 3K11. The charge on 3C2 is of such value that it is exhausted after approximately two successive reclosure attempts.

When plate power is turned off by pushing the PLATE OFF button 3IS2, relay 3K9 closes contact AI, discharging 3C2 almost immediately through the current limiting resistor 3R2. In this way the reclosure circuit is prevented from operating.

(19) The Power Failure Reclosure Circuit is

designed to re-apply plate power automatically to the transmitter after a momentary failure of supply power has caused the control circuit to be de-energized. The reclosure circuit will eliminate the filament time delay in both the exciter and amplifier control circuits and attempt to re-apply plate power if the power-failure is less than 2 seconds duration. If power is not restored within that time, the reclosure circuit becomes inoperative. Therefore, if power is off for more than approximately 2 seconds before it is restored, it is necessary to wait for the 30-second filament time delay and re-apply plate power manually by use of the PLATE ON button.

The action of the power failure reclosure circuit is as follows:

When plate power is applied, plate contactor 3K4 closes contact AU, energizing relay 3K6. Relay 3K6 closes contacts AN and AQ. Contact AN seals in relay 3K6 so that even if the plate contactor falls out and opens contact AU, relay 3K6 will remain closed. When contact AQ is closed, relay 3K10 is energized, which closes contact AT and opens contact AS.

Capacitor 3C1 is now able to charge up to the average potential of rectifier 3CR1 through resistance 3R1.

If a power failure occurs, relay 3K10 is de-energized, so contact AT is opened and contact AS is closed. Thus relay 3K5 is energized by the discharging of capacitor 3C1 and closes contacts AR and AP. Contact AR is connected in parallel with the PLATE ON button 3IS1.

If power is restored before the charge of 3C1 is exhausted to the extent that 3K5 drops out (approximately 2 seconds) current will flow through contact AP and energize relay 3K7. Thus contacts BL, AX, AV, and AO will be closed. Contacts BL and AX parallel the filament time delay relay contacts in the Amplifier Unit and Exciter Unit, respectively. Contact AV is wired to 3TB1-9 and 1-10 for use with a higher-power amplifier and contact AO seals in relay 3K7.

Therefore, plate power will be turned back on in the same manner as if the PLATE ON button had been pushed.

(20) Overload protection is provided through the operation of plate overload relay 3K15 and screen

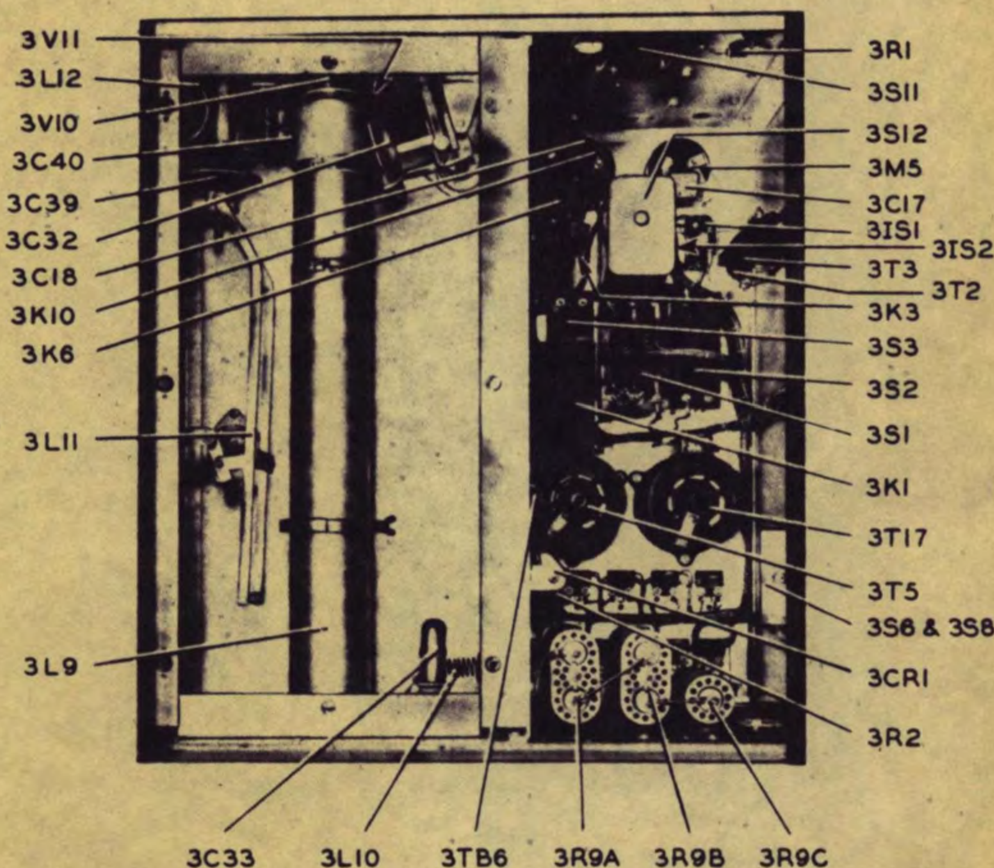


Fig. 8. Rear View, Components in Center Section (Plate Tank and Control Circuits) Identified (SY2067A)

overload relay 3K14. Each is connected in the ground lead of its respective supply.

When 3K15 is energized, it performs three operations:

(a) It opens contact BG, thereby de-energizing relay 3K3 which de-energizes the plate contactor 3K4.

(b) It opens contact BF, which is in series with the plate contactor relay coil, 1K2, of the Exciter Unit.

(c) It closes contact BE which is wired to 3TB2-3 and 2-4 for connection to supervisory lights.

When 3K14 is energized it also performs three similar operations:

(a) It opens contact BJ, thereby de-energizing relay 3K3.

(b) It opens contact BI, thereby de-energizing plate contactor 1K2 of the Exciter Unit.

(c) It closes contact BB which is wired to 3TB2-1 and 2-2 for connection to supervisory lights.

(21) Grid Current Relay, 3K16, controls normally open contact BH in series with the coil of relay 3K3. Thus, plate power cannot be applied or maintained in the Amplifier Unit unless the Exciter Unit is supplying sufficient grid excitation.

(22) Control for Cabinet Heaters, if used, may be obtained by connecting between 1TB11-12 and ground in the Exciter Unit and between 3TB4-10 and ground in the Amplifier Unit.

2. HIGH VOLTAGE POWER SUPPLY

The high-voltage rectifier uses 6 Type GL-8008 hot cathode mercury vapor tubes in a conventional three-phase full-wave circuit. Refer to the Elementary Diagram, Fig. 16.

By means of the Delta-Wye switch, 3S12, which is controlled from the front panel, the primary of the plate rectifier transformer, 3T7, may be instantly switched from wye connection to delta connection and vice versa. When the primary of the transformer is connected in wye, the plate voltage supplied by the rectifier is reduced to 58 per cent of its value when the primary is connected in delta. Thus by means of the Delta-Wye switch it is possible to reduce the power of the amplifier at any time.

The primary of the rectifier transformer is also provided with taps to permit compensation for local line voltage differences. Information regarding the rating and use of these taps is included in the Installation section of this book.

The single section L-C filter consists of capacitors 3C5, 3C6, and 3C7 in parallel, and inductor 3L3. Step start resistor 3R4 is connected in series with filter capacitors, 3C5, 3C6 and 3C7, to limit the charging current when plate voltage is applied. This resistor is shorted out when step start relay 3K13 is energized as discussed in "Explanation of Control Circuits."

Resistors 3R5 and 3R6 are connected across the

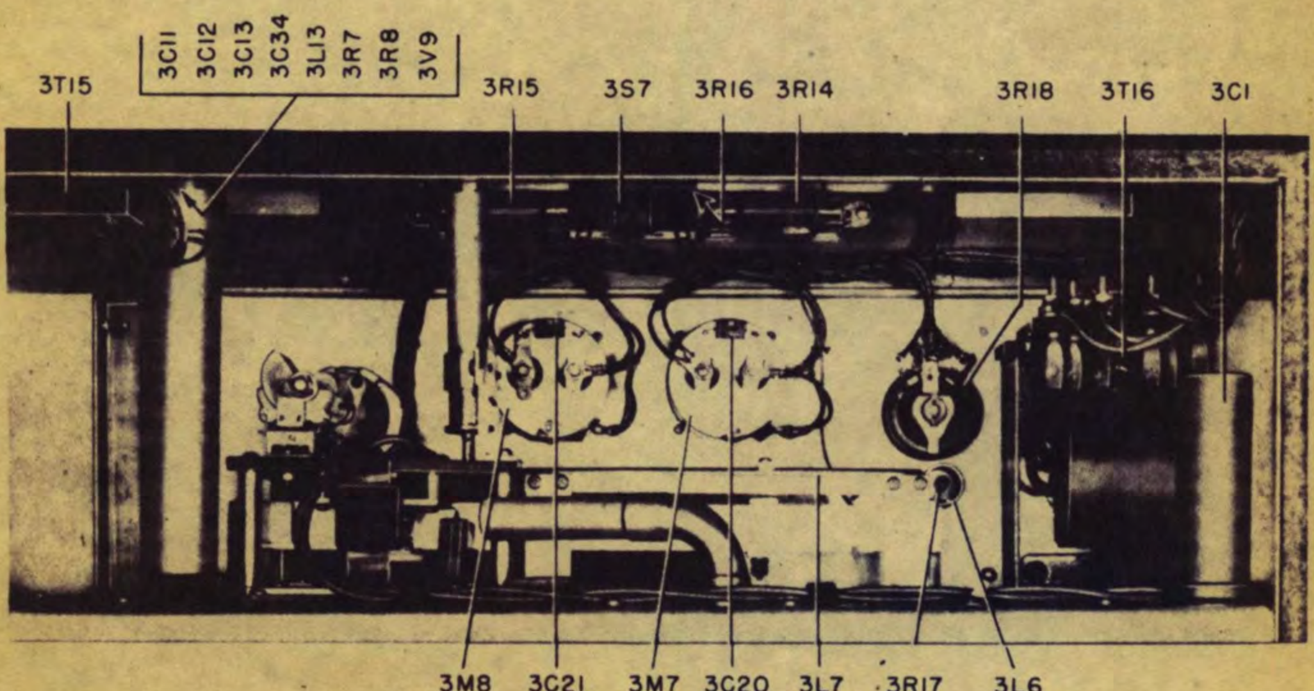


Fig. 9. Rear View, Components in Upper Section Identified (SY5252A)

high voltage supply to serve as bleeders.

To provide overload protection for the equipment the d-c current flows through overload relay 3K15. If an overload occurs in the high voltage circuit, relay 3K15 will be energized and through the action of its contacts in the control circuits, as explained previously, power will be disconnected from the primaries of the plate and screen rectifier transformers.

As explained previously, power to the primary of the plate transformer, 3T7, cannot be applied or maintained if the rear doors of any of the cabinets are open. As a further protection to personnel, shorting switches 3S8 and 3S9 are provided. Switch 3S8 automatically grounds the high-voltage supply when the rear access door of the amplifier cabinet is open and switch 3S9 automatically grounds the high voltage if the rear access door of the power supply cabinet is open.

3. SCREEN VOLTAGE POWER SUPPLY

Screen voltage is supplied by a separate rectifier using a pair of GL-866-A 866 tubes in a single-phase full-wave circuit. Since the screen voltage required is less than 500 volts, considerable power would be wasted if the screen voltage were obtained from a resistance divider connected across the plate voltage supply.

Power for the screen voltage rectifier is obtained from one phase of the three-phase supply to the primary of the plate transformer rectifier. The connection is made in such a way that when the plate transformer primary is switched from delta connection to wye connection, the screen voltage is reduced simultaneously with the plate voltage to 58 per cent of its former value. The power to the primary of the screen voltage rectifier transformer is controlled by a circuit-breaker-type switch, 3S3, and in addition by a variable transformer, 3T17, which permits continuous variation of screen voltage.

To provide overload protection, screen current flows through overload relay 3K14. Excessive d-c current through the screen voltage power supply will energize relay 3K14, and through the action of its contacts in the control circuit, power will be removed from both the plate and screen voltage supplies.

The two section L-C filter consists of 3L1, 3L2, 3C3 and 3C4. Resistor 3R12 serves as a bleeder.

To provide protection to personnel, switch 3S8 grounds the screen voltage supply when the rear access door of the amplifier cabinet is open.

4. POWER AMPLIFIER

Two Type GL-7D21 tubes are used in a push-pull circuit in the final amplifier. Refer to Figs. 6a or 6b and 16. The type GL-7D21 tube is a new air-cooled tetrode employing external anode construction. (For further information regarding the Type GL-7D21 tube, refer to the Tube Bulletin at the back of the book.)

Both the grid and plate tank circuits are of the quarter-wave shorted-transmission-line type. An adjustable shorting bar is provided on both the grid and plate tanks for approximate frequency setting, and a variable capacitor is connected across each tank near the high r-f voltage end for fine tuning adjustment. Both grid and plate tank fine tuning capacitors are adjusted by vernier dials on the front panel.

The grid line, 3L8, is constructed of close-spaced rectangular conductors. See Figs. 9 and 12. Excitation is coupled into the grid tank by means of an unbalanced hairpin loop, 3L7. A Faraday shield is placed between the loop and the grid line to prevent unbalanced electro-static coupling and consequent unbalanced grid drive.

The plate tank, 3L9, consists of a pair of vertically mounted hollow cylinders 3¼ inches in diameter, spaced one inch apart. See Fig. 8. At the top of each cylinder is a telescopic insert. The anode of the Type GL-7D21 tube clamps into this telescopic insert, and the insert with the amplifier tube installed may then be lifted to engage the tube contact surfaces with the fingers of the tube socket. The contact surfaces of the tube socket consist of properly spaced rings with spring finger contacts.

Each vertical cylinder of the plate tank also serves as an air duct to carry cooling air to the anode of the amplifier tube. A low pressure type blower, 3BM1, mounted below the plate tank (see Fig. 11), supplies filtered air with a minimum of air rush noise.

Although the final tubes are tetrodes having very little coupling from plate to grid, improved operation results from the addition of a very small amount of cross-neutralizing capacitance. Feedback through 3C40 from only one of the anodes to the opposite grid is employed. The feedback capacitance is not critical and normally needs no adjustment over the frequency range. The setting of 3C40 is not affected by tube change.

Power is coupled from the plate tank circuit into the 51.5 ohm, 1⅝ inch output transmission line by a series tuned loop, 3L11. See Fig. 8. The tuning capacitor, 3C39, for this loop usually requires no change in setting over the entire FM band. An adjustable shorting bar is provided for decreasing the size of the coupling loop for the higher frequencies. In general, this shorting bar is set at the same vertical level as the shorting bar on the plate tank circuit. Changing both the position of this shorting bar on the coupling loop and the capacity setting of 3C39 provides a means of coupling into badly mis-matched loads as occasionally encountered in interim or emergency operation. The shorting bar and capacitor should be adjusted so that full loading is achieved with as loose a coupling as possible. Coupling between the output coupling loop and the plate tank is controlled from the front panel.

5. RF OUTPUT METER

The r-f voltmeter, 3M4, gives a relative indication of the transmission line r-f input voltage. This indication is affected by standing waves in the line and therefore is not necessarily a direct measure of power output; however it will serve to show any change in predetermined level.

A small amount of r-f energy is coupled from the output transmission line by 3C34 and rectified by diode 3V9. The diode is a peak rectifier with capacitor 3C13 and resistors 3R7 and 3R8 serving as the load. The average load current is measured by 3M4, the RF OUTPUT meter which requires 1 milliampere for full scale deflection. The scale on the RF OUTPUT meter is calibrated in arbitrary units. By adjusting resistor 3R7 the meter may be made to read some value which may be used as a reference.

6. MONITOR COUPLING

Loop 3L12 is inductively coupled to the amplifier p-a plate tank coil. The loop is so located that about 8 volts RMS is produced across 50 ohms when the transmitter is adjusted to 3-kw output. This voltage is used to feed the station modulation monitor. The loop may be adjusted to provide the proper value of voltage to the monitor by bending it to change its coupling to the p-a plate tank coil.

RECOMMENDED OPERATING PROCEDURE

1. GENERAL

The following describes the proper method of placing the over-all Transmitter (250-W Transmitter used as the Exciter and the 3-KW Amplifier) in operation for the first time after installation. The procedure is based on the assumption that the transmitter modulator has been tuned completely to the proper frequency at the factory. 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 the installation of tubes other than those used during test.

The procedure to be used for putting the exciter in operation is given in the 250-Watt Transmitter Instruction Book; therefore it will not be repeated in these instructions. The loading procedure for the 250-Watt Transmitter will be slightly different when the transmitter is used as an exciter; therefore the new loading procedure is included in these instructions.

2. PRELIMINARY ADJUSTMENTS

A. In the Exciter Unit: Change the lead on terminal 3 of 1T46 to terminal 4. (This is the 90 per cent tap of the plate transformer. Full output is not required to drive the 3-KW Amplifier.)

B. In the Amplifier Unit:

(1) First be sure that all POWER circuit-breaker switches (MAIN POWER, FIL POWER and SCREEN POWER) are switched to their OFF positions.

(2) Switch the MAIN POWER breaker to its ON position. The blower should start immediately.

(3) Turn FIL VOLTAGE control as far as it will go in DECREASE direction.

(4) Switch FIL POWER to ON position, and adjust FIL VOLTAGE control until FIL VOLTAGE meter reads 6.3 volts (to red line on meter scale).

(5) Approximately 30 seconds after switching on FIL POWER, the green PLATE ON push button should light, provided the rear door interlocks are closed.

3. PRELIMINARY TUNING OF THE AMPLIFIER

A. Positioning Grid Coupling Loop and Grid Tank Shorting Bars: The distance between the grid-coupling loop and the Faraday screen should be approximately $\frac{3}{32}$-inch. Check this spacing and adjust it if necessary. The line clamp which positions the grid-coupling loop may be loosened slightly to facilitate making the adjustment.

Shorting bars are provided on the grid-tank circuit and grid-coupling loop. These shorting bars should be kept in approximately the same relative positions on their loops and should be clamped somewhere between one inch and six inches from the shorted end of the grid line; nearer to the one-inch position for the low-frequency end of the band; nearer to the six-inch position for the high-frequency end of the band.

The shorting bar on the grid-coupling loop must not touch the Faraday screen. The location of this shorting bar is not critical, and therefore it can always be clamped midway between two of the Faraday screen fingers. *Important: Clamp the shorting bars securely after each adjustment.*

Turn on the Exciter and apply plate power. By increasing the exciter OUTPUT COUPLING, apply a small amount of amplifier-grid excitation (readable amount on PA GRID CURRENT meter).

CAUTION

Screen grid current may flow even though screen voltage has not been applied. Be sure at all times that the SCREEN CURRENT does not exceed 200 ma. The SCREEN CURRENT may be reduced by increasing the amplifier OUTPUT COUPLING (turning control in direction of increasing numbers).

Tune the amplifier grid capacitor (GRID TUNING) through its full range, noting if a maximum grid meter reading is passed through within the range of the capacitor. If the grid meter tends to maximize at the minimum capacitance end (near "100" on the GRID TUNING dial), move the grid-tank shorting bar and grid-coupling-loop shorting bar toward the tubes. Conversely, if the grid meter reading tends to maximize at the maximum capacitance point, move the shorting bars toward the shorted end of the grid line. By the above procedure, find the position of the shorting bars that give a maximum on the grid meter at about the mid-position of the grid tuning capacitor. This position may change somewhat with subsequent adjustments, and the shorting bars may have to be moved slightly to center them up when the remainder of the amplifier is in tune. Leave the grid tuning capacitor in the position which indicates a maximum on the grid meter.

Adjust the exciter OUTPUT COUPLING to give about 100 to 150 ma of amplifier PA GRID CURRENT. Readjust the exciter PA PLATE TUNING for minimum exciter PA PLATE CURRENT.

B. Positioning Plate-Tank and Output Coupling Loop Shorting Bars.

Note that a very small indication is obtained on the amplifier PA PLATE CURRENT meter. The plate-tank shorting bar and output-coupling loop shorting bar (see Fig. 8) should now be adjusted in a manner similar to that used for adjusting the grid-tank shorting bar and grid-coupling loop shorting bar. In this case, the indication will be a slight dip in the amplifier PA PLATE CURRENT as the PLATE TUNING capacitor is tuned through resonance. For the low-frequency end of the FM band, the plate-tank shorting bar will be an inch or two from the bottom of the plate line. For the high-frequency end, it will be approximately seven inches up from the bottom. Set the position of the bar so that the plate-current reaction occurs at about the mid-position of the PLATE TUNING capacitor.

Set the output-coupling loop shorting bar at the same vertical level as the plate-tank shorting bar. *Important: Clamp the shorting bars securely after each adjustment.*

4. APPLYING PLATE POWER

Switch the PLATE TRANSFORMER switch to the WYE position. Push the amplifier PLATE ON button to apply plate voltage and quickly tune the amplifier PLATE TUNING capacitor to give minimum PA PLATE CURRENT indication.

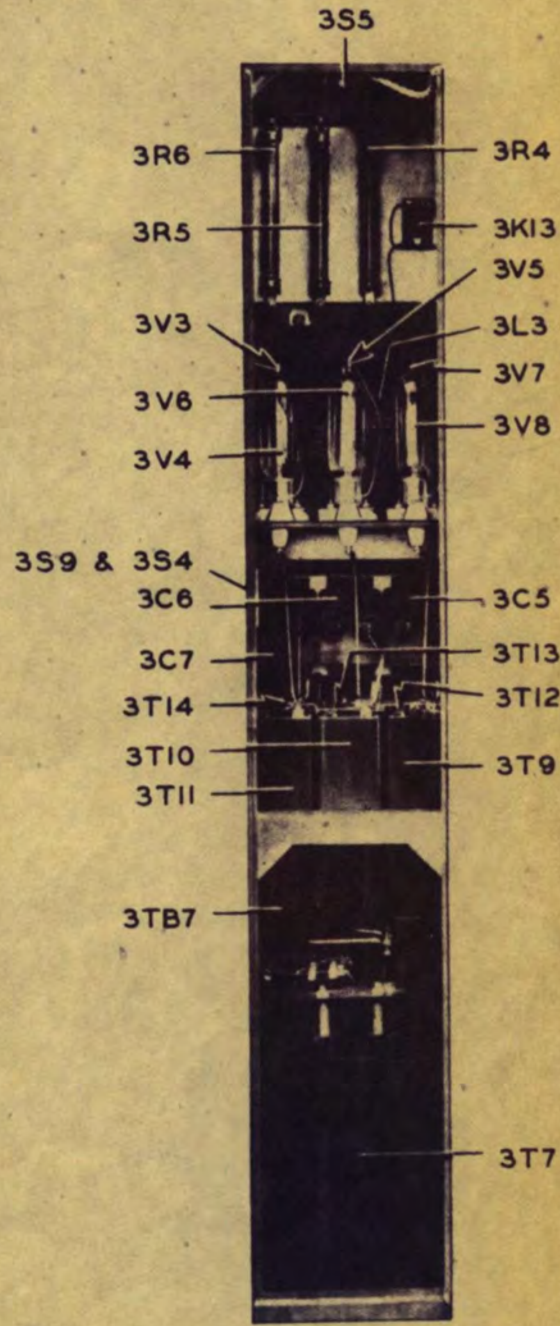


Fig. 10. Rear View, Components of Power Supply Cubicle Identified (SY1170A)

5. APPLYING SCREEN POWER

Turn SCREEN VOLTAGE control as far as it will go in DECREASE direction. Switch SCREEN POWER circuit breaker to ON position. Adjust the SCREEN VOLTAGE control until SCREEN VOLTAGE meter reads approximately 50 volts.

Tune GRID TUNING capacitor for maximum PA GRID CURRENT, and readjust the exciter OUTPUT COUPLING, if necessary, to give 150 ma amplifier PA GRID CURRENT.

CAUTION

Be sure that the SCREEN CURRENT does not exceed 200 ma. The SCREEN CURRENT may be reduced by increasing the amplifier OUTPUT COUPLING (turning control in direction of increasing numbers).

6. LOADING TRANSMITTER

Push red PLATE OFF button to turn off plate power. Turn PLATE TRANSFORMER switch to DELTA position. Push PLATE ON button to reapply plate power.

Check PA PLATE VOLTAGE. It is assumed that the primary terminals of plate transformer 3T7 have been connected for your particular line voltage as described in the INSTALLATION section of these instructions under IMPORTANT. The PA PLATE VOLTAGE should therefore be approximately 3750 volts.

Calculate the following:

$$\text{Transmitter Output Power Required} = \frac{\text{Licensed Effective Radiated Power}}{\text{Transmission Line Efficiency} \times \text{Antenna Power Gain}}$$

and

$$\text{PA PLATE CURRENT} = \frac{\text{Transmitter Output Power Required}}{\text{PA PLATE VOLTAGE} \times \text{PA Plate Efficiency}}$$

PA plate efficiency is found by interpolating on Fig. 13 for your particular "Frequency" and "Transmitter Output Power Required."

For Example:

If operating conditions are as follows:
Licensed Effective Radiated Power = 9 kw
Transmission Line Efficiency = 90 per cent
Antenna Power Gain = 3.6
Frequency = 100 megacycles
PA PLATE VOLTAGE = 3750 volts

then

$$\text{Transmitter Output Power Required} = \frac{9}{.90 \times 3.6} = 2.78 \text{ kw}$$

PA PLATE Efficiency from Fig. 13 is, by interpolation, 68.8 per cent

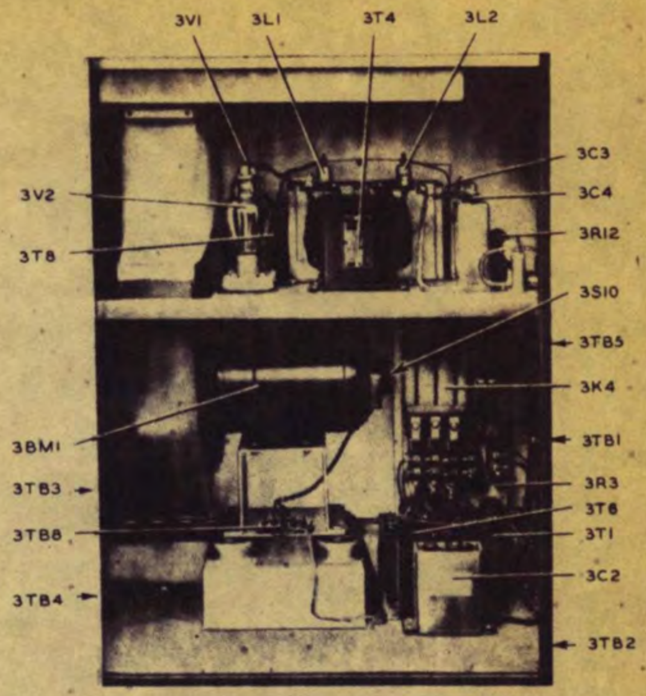


Fig. 11. Rear View, Components in Lower Section (Blower and Low-Voltage Power Supply) Identified (SY1165A)

therefore

$$\text{PA PLATE CURRENT} = \frac{2780}{3750 \times .688} = 1.1 \text{ amps}$$

If the Transmitter Output Power Required is 2.5 kw or less, proceed to the next step. If the Output Power Required is more than 2.5 kw, as in the above example, adjust the exciter OUTPUT COUPLING to give 175 ma amplifier PA GRID CURRENT. After each change in exciter OUTPUT COUPLING, adjust exciter PA PLATE TUNING for minimum exciter PA PLATE CURRENT.

Turn SCREEN VOLTAGE control gradually in INCREASE direction and simultaneously adjust the OUTPUT COUPLING control so that the SCREEN CURRENT meter indicates 185 ma. As the OUTPUT COUPLING control is changed during this loading procedure, keep the plate tank in resonance by adjusting the PLATE TUNING control to give minimum PA PLATE CURRENT indication. Note that maximum SCREEN CURRENT is coincident with minimum PA PLATE CURRENT. Since the SCREEN CURRENT peak is the more sensitive indication it may be used advantageously in adjusting the PLATE TUNING control.

Continue the above loading procedure until the required PA PLATE CURRENT is obtained. The SCREEN VOLTAGE with new tubes should be within the range indicated on Fig. 13 for your particular frequency and transmitter output power. As tubes age, it may be necessary to increase the SCREEN VOLTAGE above this range in order to maintain proper SCREEN CURRENT

(185 ma). NOTE: In general the output coupling loop shorting bar may remain at the same vertical level as the plate tank shorting bar. If you desire to couple into a badly mis-matched load during a period of interim or emergency operation, it may be necessary to change the position of the shorting bar and the setting of capacitor 3C39. The output coupling loop 3L11 and capacitor 3C39 constitute a series tuned loop. The shorting bar and capacitor should be adjusted so that full loading is achieved with as little coupling (lowest number on OUTPUT COUPLING control dial) as possible.

7. CHECKING NEUTRALIZATION

Only a small amount of capacitance is needed to neutralize this 3-KW Amplifier and the adjustment is not very critical. In the majority of cases the adjustment made in the factory will be satisfactory, but the following procedure is given for completeness.

First be sure that the GRID TUNING capacitor is adjusted for maximum PA GRID CURRENT indication, and that the PLATE TUNING control is adjusted for minimum PA PLATE CURRENT.

Vary the PLATE TUNING control through resonance. If the amplifier is properly neutralized, the PA PLATE CURRENT minimum will occur at the same time as the PA GRID CURRENT maximum. If this test indicates that the Amplifier is not neutralized, adjust the neutralizing capacitor.

The neutralizing capacitor 3C40, actually consists of two capacitors in series. See Figs. 8 and 12. One section consists of a plate mounted under the p-a shelf about one-half inch from the plate of the front tube. This section is connected in series with the second section which is mounted on the top of the p-a shelf and which consists of a small plate mounted about three-eighths of an inch from the rear of the open end of the grid line. Adjust this plate adjacent to the grid line, slightly, to change the spacing and therefore its capacitance. An adjustment can easily be made so that neutralization is correct, i.e., the PA PLATE CURRENT minimum corresponds to the PA GRID CURRENT maximum when the PLATE TUNING control is varied.

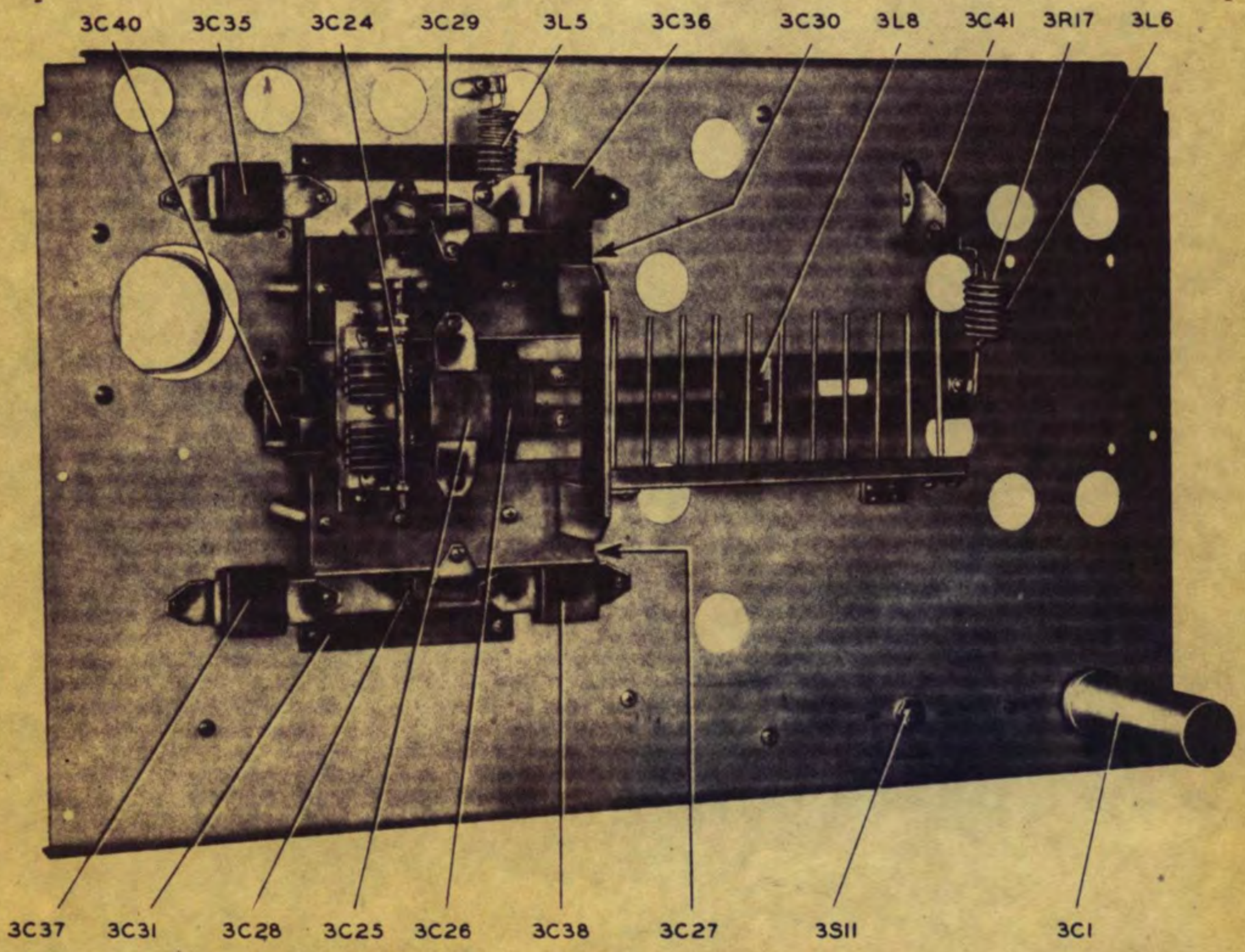


Fig. 12. Grid Tank Shelf, Top View, Components Identified (SY2441A)

8. ADJUSTING RF OUTPUT METER

This meter is to be used as a relative power-output monitoring meter. When the Transmitter has been tuned to give required output, set the reading of the meter to indicate 100 by adjusting potentiometer 3R7. See Fig. 9. This potentiometer is located in a small box attached to the output-transmission line in the top rear section of the cabinet. The screwdriver adjustment for 3R7 is accessible from outside the box.

9. BALANCING POWER AMPLIFIER

Compare the readings of the FRONT and REAR CATHODE CURRENT meters. They should be of approximately the same value when the amplifier is loaded and operating properly. If not, adjust BALANCE potentiometer 3R18, on the front panel. Adjustment of this potentiometer increases the cathode resistance of one tube and simultaneously lowers the cathode resistance of the other tube. Due to the fact that tube characteristics may vary slightly, a new setting of this control will probably be required whenever tubes are changed.

The tube characteristics can vary slightly, and a check may be made by reversing the tubes in their sockets. If the unbalance changes with change of tubes, it is due to slightly different tube characteristics.

After balancing, a slight adjustment of OUTPUT COUPLING may be required.

10. ADJUSTING MONITOR COUPLING

If the r-f input level to the monitor requires adjustment, bend the monitor pick-up loop, 3L12, forward or backward as required; forward increases the level and backward decreases it. 3L12 is located near the amplifier p-a plate tank. See Fig. 8.

11. RECORDING DATA

For future reference, record all dial settings and meter readings.

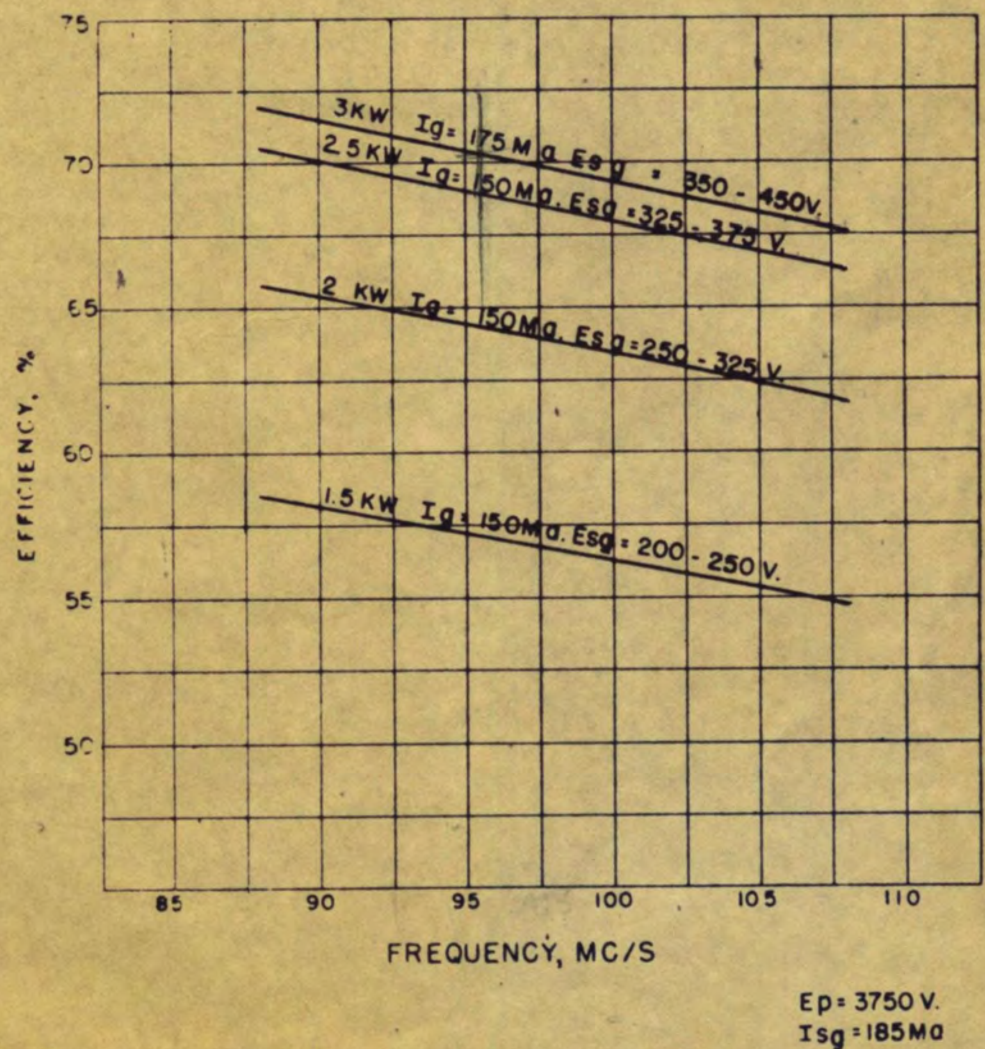
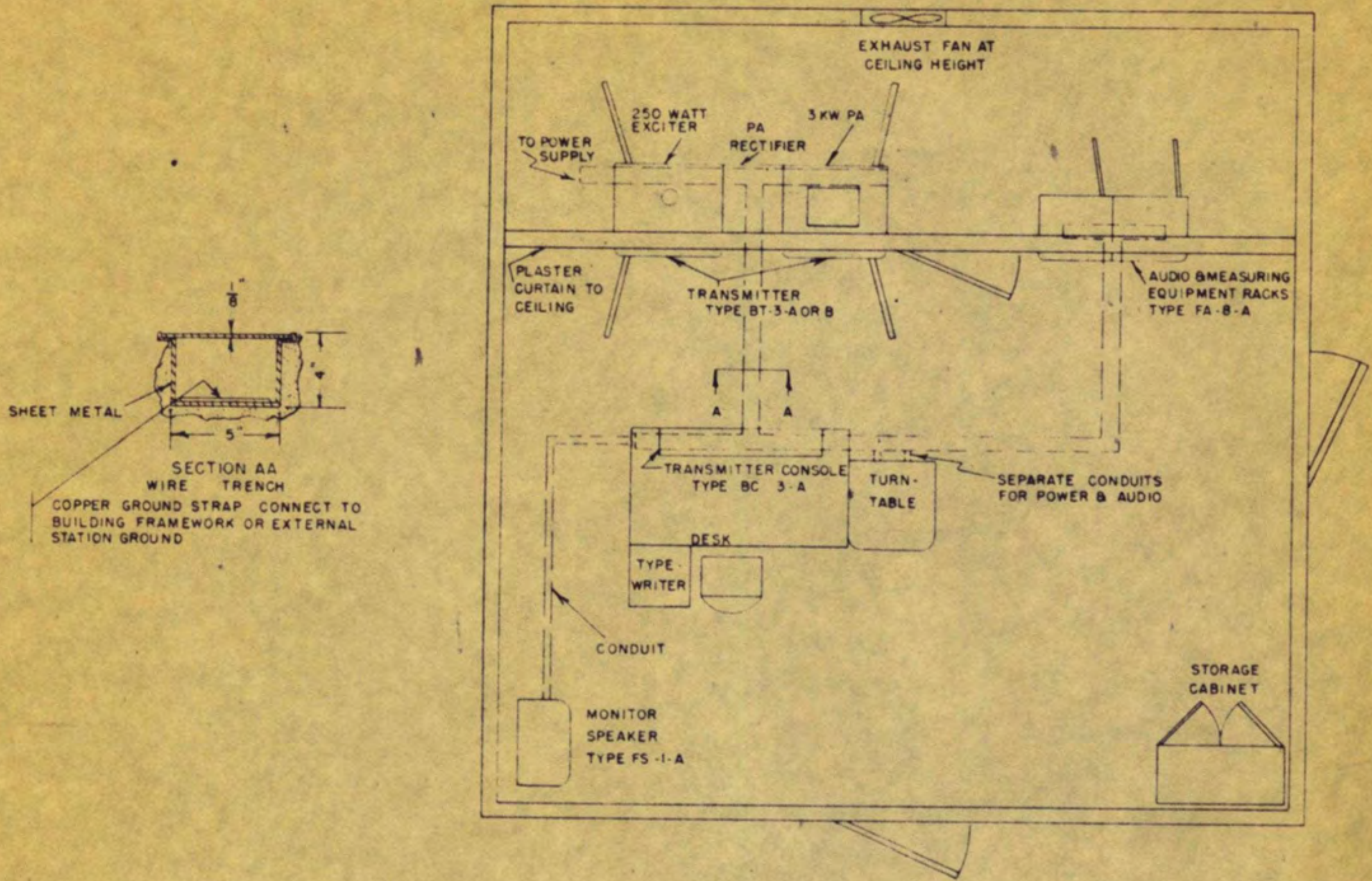


Fig. 13. Efficiency Curves for 3-KW FM Amplifier (K-7988096, Rev. 3)



NOTES

1. 150 CFM AIR OUT OF 4" HOLE IN TOP OF EXCITER & 430 CFM AIR OUT OF RECTANGULAR OPENING TOP OF AMPLIFIER
2. TRANSMITTER NET WEIGHT — EXCITER-765 LBS, AMPLIFIER-715 LBS, RECTIFIER-633 LBS
3. POWER SUPPLY 208/230 VOLTS, 50/60 CYCLE, 3 PHASE, APPROX 8 KW, 90% PF. APPROX 10 WATTS AT 115 VOLTS REQUIRED FOR CRYSTAL HEATER
4. WHEN WIRING TRENCH IS NOT USED ALL WIRES SHOULD BE RUN IN CONDUIT, WITH AUDIO WIRES IN SEPARATE CONDUIT. WHEN WIRING TRENCH IS USED, ONLY AUDIO WIRES SHOULD BE RUN IN CONDUIT

SCALE - $\frac{1}{2}"$ = 1'0"

Fig. 14. Typical Installation Drawing (P-7770605, Rev. 1)

MAINTENANCE

1. PREVENTATIVE MAINTENANCE

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

Routine maintenance requires periodic inspection with immediate repair, where needed, to avoid future trouble. If there is not time for such preventive repair when its need is found, record the work to be done and do it as soon as possible.

A. Routine Inspection and Cleaning: During inspections 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 adjust and clean them if necessary. Tighten any loose components or loose connections at terminal boards.

CAUTION

Do not change adjustments on overload or time-delay relays without following with an operational check.

B. Voltage-adjusting Transformer Brushes: Periodic inspection should be made of these brushes. If dirt or burning is evident, clean the brush with fine sandpaper; never emery paper. Replace the brush if necessary.

C. Blower Motor Lubrication: Routine maintenance of the motor calls for annual dismantling and thorough cleaning of bearings and housings. The bearings should then be repacked with G-E ball-bearing grease, which may be obtained in bulk or in tubes from G-E Distributors.

In repacking the bearings, fill the space between the inner and outer races one-third full. Be careful not to over-grease. When assembling the bearing in the housing, fill the space in back of the housing one-third full of grease, as a reserve supply.

D. Cleaning the Air Filters: The intake air filters, located at the bottom of the rear door, should be cleaned whenever inspection shows appreciable dust. To remove them for cleaning, remove 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 and drain face (smooth side) downward.

2. CHECKING METER READINGS

Note the readings of all meters, daily, and compare to previous readings. A certain amount of day-to-day variation can 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 one or both p-a tubes are losing emission.

TYPICAL METER READINGS AT 3-KW OUTPUT

	FREQUENCY MC/S		
	88	98	108
FIL VOLTAGE	6.3	6.3	6.3
CATHODE CURRENT (FRONT)	0.78	0.80	0.80
CATHODE CURRENT (BACK)	0.82	0.84	0.80
PA GRID CURRENT	175	175	175
PA PLATE CURRENT	1.23	1.25	1.28
PA SCREEN CURRENT	185	185	185
PA SCREEN VOLTAGE	410	420	430
PA PLATE VOLTAGE	3750	3750	3750

3. CHECKING SPARE TUBES AND CRYSTALS

It is recommended that all spare tubes and crystals be checked for proper operation periodically to insure that dependable spares are available at all times.

4. TESTING TYPE GL-8008 RECTIFIER TUBES

Good visibility of the Type GL-8008 Rectifier Tubes in operation is provided to help the transmitter engineer identify faulty tubes. In operation, a clear blue glow is characteristic of a good tube—a greenish yellow color is usually indicative of a faulty one. Some engineers may desire to tape thermometers to the metal part of the tube base. The normal base temperature, which is essentially the condensed mercury temperature, is 40 to 60 C, depending on tube age and ambient. Temperatures substantially above this range indicate that tubes are nearing their life-end point.

Loss of program time due to rectifier arc-backs can be minimized by making a monthly check of each rectifier tube and recording the results. A tube which is becoming faulty will require progressively higher voltage for breakdown and will fire later in its conducting half cycle. A simple testing circuit can be set up to permit checking each rectifier tube in its socket. Two of the methods used are as follows:

A. An isolation transformer with 115-volt 60-cycle output and a 50-ohm current limiting resistor are needed. Remove regular rectifier plate connection and apply filament power. Connect the transformer secondary, the resistor, and the tube in series. Connect the vertical deflection plates of an oscilloscope directly across the tube. The pattern of the tube voltage on the conducting half cycle will show a peak at its start. The amplitude of this peak is a measure of the initial breakdown voltage.

B. An isolation transformer and a variable auto transformer, which will give an isolation winding output adjustable from 0 to 75 volts, are needed. Connect a voltmeter across this output winding. In series with this winding, connect a 50-ohm current-limiting resistor, a 50-milliampere d-c meter, and the tube to be tested. To test the tube, slowly increase the applied voltage from zero to the point where d-c current just begins to flow. The peak value of the RMS voltage read by the voltmeter at this point is the initial breakdown voltage.

Using either method, the peak breakdown voltage for a good tube will average 10 to 15 volts. When the peak break-down voltage reaches 30 volts the tube should be tested at more frequent intervals; a value of 50 volts will generally indicate that it should be replaced.

5. REPLACING COMPONENTS

A. Replacing Type 7D21 Tube: Recommended procedure for removing and installing Type 7D21 tubes is given in the INSTALLATION section of this book under Installation of Tubes.

When a Type 7D21 tube is replaced, the filament voltage should be checked and adjusted if it is not correct.

B. 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 two 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, near each edge. 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.

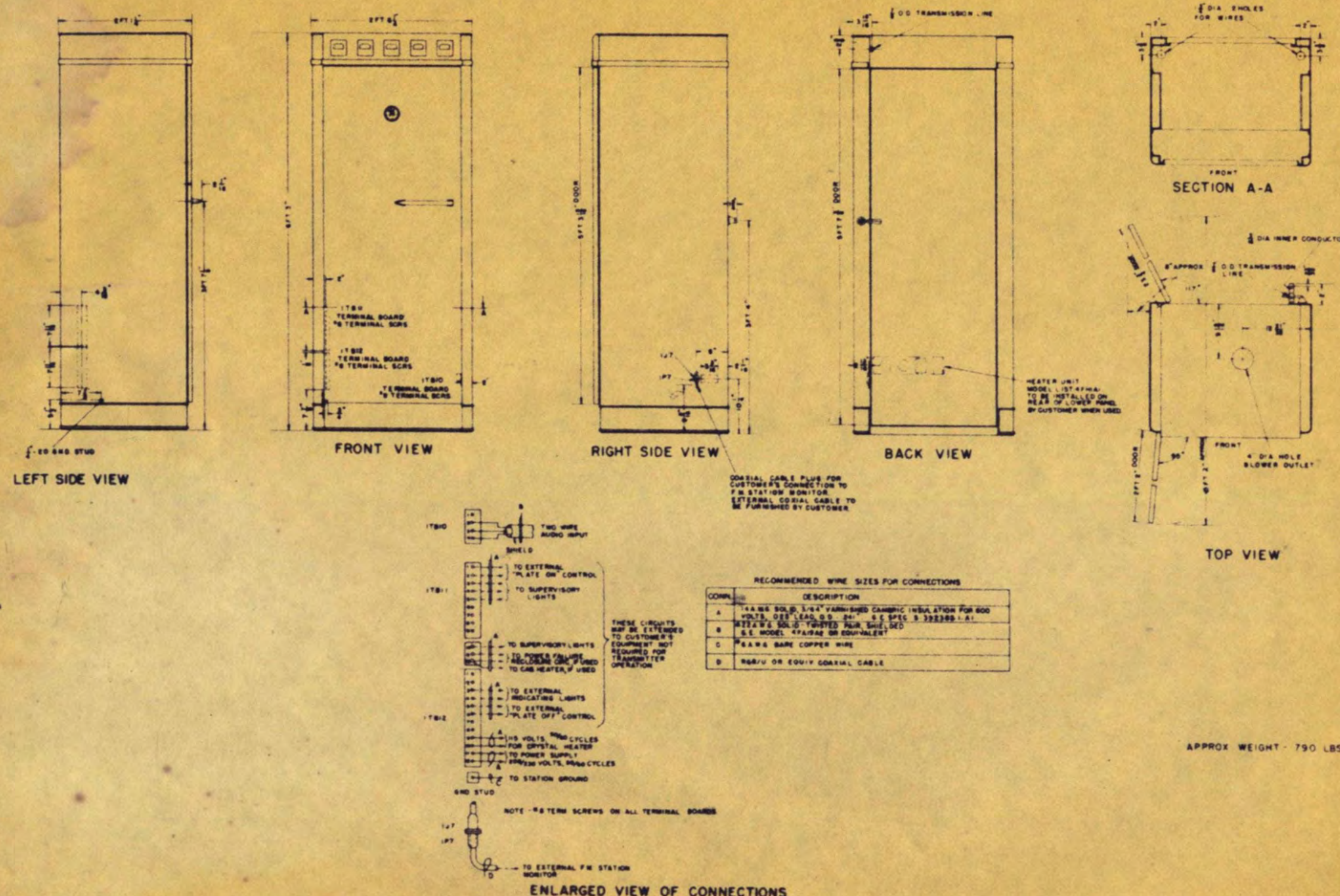
6. TROUBLE SHOOTING TIPS

First, check the meter readings, and compare with previous readings. Replace the tube whose meter readings indicate improper operation. Should the same condition remain, a bad connection or component may be at fault. Refer to the Elementary Diagram, Fig. 16. Check continuity to the various socket terminals or voltages. 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.

7. NAMES AND SYMBOLS OF OPERATING CONTROLS AND METERS ON FRONT PANEL

3S1	MAIN POWER
3S2	FIL POWER
3S3	SCREEN POWER
3S12	PLATE TRANSFORMER (DELTA-WYE)
3IS1	PLATE ON
3IS2	PLATE OFF
3T5	FIL VOLTAGE (INCREASE)
3T17	SCREEN VOLTAGE (INCREASE)
3L11	OUTPUT COUPLING
3C24	GRID TUNING
3C32	PLATE TUNING
3M5	SCREEN VOLTAGE
3M6	SCREEN CURRENT
3M7	CATHODE CURRENT (FRONT)
3M8	CATHODE CURRENT (BACK)
3M10	FIL VOLTAGE
3M3	PA PLATE VOLTAGE
3M9	PA GRID CURRENT
3M2	PA PLATE CURRENT
3M4	RF OUTPUT

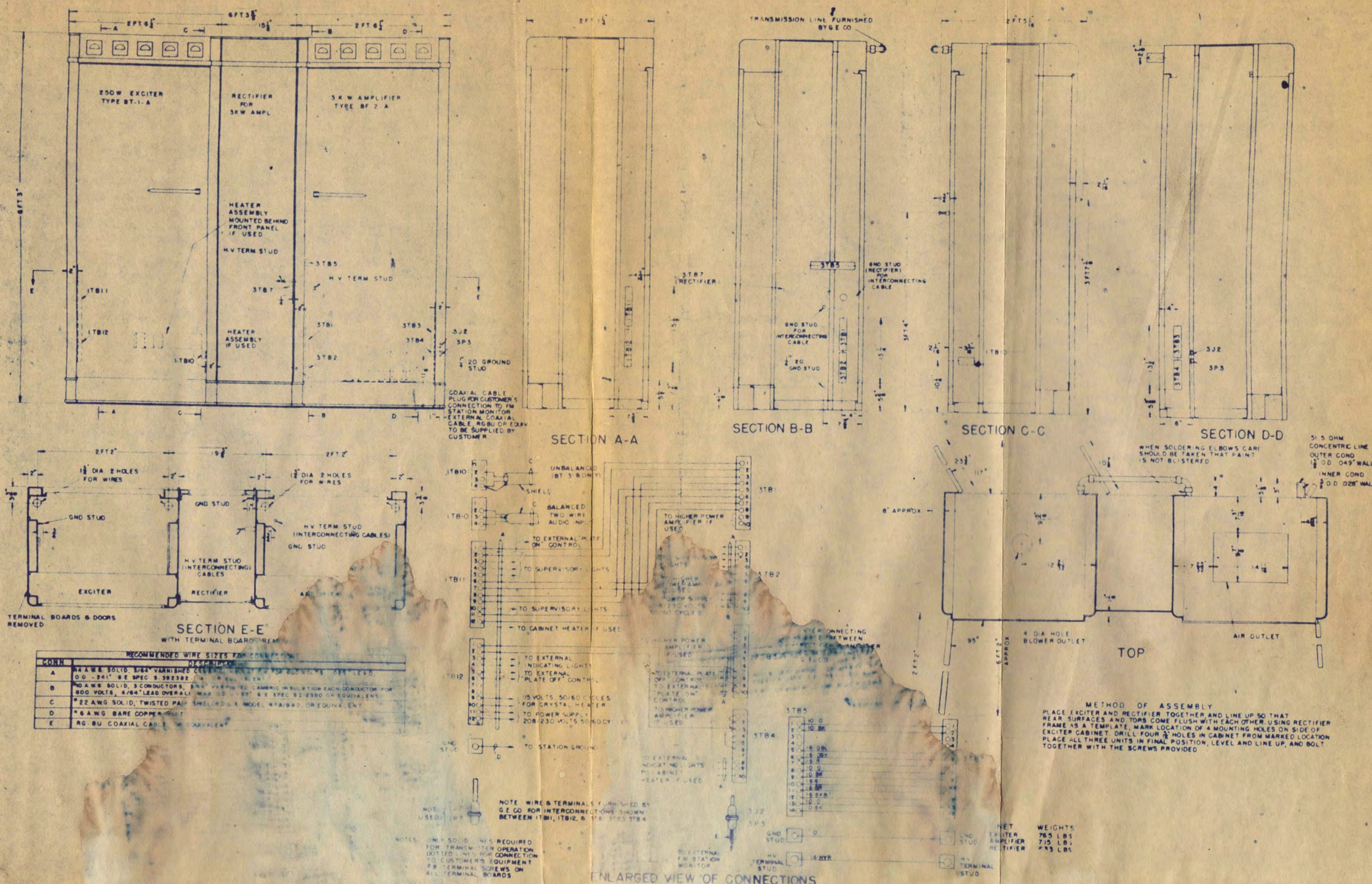


RECOMMENDED WIRE SIZES FOR CONNECTIONS

CONN.	DESCRIPTION
A	14 AWG SOLID, 3/64" VARNISHED CAMBRIC INSULATION FOR 600 VOLTS, [illegible] LEAD O.D. .241" G.E. SPEC. [illegible]
B	#22 AWG SOLID TWISTED PAIR, SHIELDED G.E. MODEL [illegible] OR EQUIVALENT
C	#6 AWG BARE COPPER WIRE
D	RG8/U OR EQUIV COAXIAL CABLE

Fig. 32.

250-Watt Frequency-modulation Broadcast Transmitter, General Electric Type BT-1-A, Installation Diagram (T-7663560, Rev. 4).



RECOMMENDED WIRE SIZES FOR CONNECTIONS

CONN	DESCRIPTION
A	#14 AWG SOLID, 3/64" VARNISHED [illegible] FOR 600 VOLTS .025" LEAD O.D. .241" G.E. SPEC S-392382 [illegible] OR EQUIVALENT
B	#10 AWG SOLID, 3 CONDUCTORS, [illegible] VARNISHED CAMBRIC INSULATION EACH CONDUCTOR FOR 600 VOLTS, 4/64" LEAD OVERALL [illegible] G.E. SPEC S1-2380 OR EQUIVALENT
C	#22 AWG SOLID, TWISTED PAIR SHIELDED G.E. MODEL 4TAI9A2, OR EQUIVALENT
D	#6 AWG BARE COPPER [illegible]
E	RG-8U COAXIAL CABLE OR EQUIVALENT

NET	WEIGHTS
EXCITER	765 LBS
AMPLIFIER	715 LBS
RECTIFIER	[illegible]3 LBS

Fig. 15. Installation Requirements Diagram (T-7665062, Rev. 7)

Fig. 15. Installation Requirements Diagram (T-7665062, Rev. 7)

Amperex® . . . *Tomorrow's Thinking in Today's Products®*

CONVERSION OF 3 KW G.E. FM BROADCAST AMPLIFIER TYPE BF–2A

TO 6076A TUBES

Amperex® Electronic Corporation
A NORTH AMERICAN PHILIPS COMPANY

HICKSVILLE DIVISION

230 Duffy Avenue
Telephone: 516/931-6200
Hicksville, L.I., N.Y. 11802
TWX: 516/433-9045

CONVERSION OF 3 KW G.E. FM BROADCAST AMPLIFIER TYPE BF-2A

TO 6076A TUBES

This modification involves the replacement of the type 7D21 tube used in the BF-2A FM amplifier with the AMPEREX 6076A type tube. These instructions represent a composite of recommendations from AMPEREX and the experience of the American Broadcasting Company.

REASON FOR MODIFICATION

The type 6076A is a modern tube with higher allowable dissipation, longer life and lower cost. Some characteristics of the two tubes are compared in the following table.

	TYPE 6076A	TYPE 7D21
Plate Dissipation	3 KW max.	1.2 KW max.
Screen Dissipation	100 watts max.	60 watts max.
Driving Power Required	30 watts	60 watts

FCC REQUIREMENTS

Authorization must be obtained from the FCC before making this change.

CONVERSION PROCEDURE (Estimated time: 2 men, 10 hours)

Note: List of parts furnished with SD513 Kit is shown on page 4.

1. Remove grill on top of transmitter compartment for access to work space beneath.
2. Remove all tube socket superstructure down to main chassis.
3. Remove all bypass capacitors around tube sockets.
4. Drill out rivets holding screen bypass. (Save screen bypass mica.)
5. Mount screen grid connectors S3706 on mica insulator.
6. Enlarge holes through chassis deck to allow 3/8 inch clearance around screen connectors and mounting screws (square hole recommended).
7. Remount insulating plate with screen grid connectors strapped together on chassis using 3/4 inch copper strips.
8. Cut approximately 1/2 inch from insulating strips on which previous filament connectors were mounted. This leaves enough material to mount grid tuning capacitor and provides better access to filament and grid connectors. (See Figure 1.)
9. Mount four double stacks of CENTRALAB TV-20 door-knob capacitors adjacent to four outside corners of screen connectors. Each lower capacitor is connected by a strap to the screen connector, while upper capacitors are connected by a strap to their respective filament terminals. (See Figure 2.)
10. Replace resistor 3R16 with Ohmite 1362B (set tap at 1300 ohms). Relay 3K16 can be left unchanged.
11. The curvature of the plate tuning capacitors must be changed slightly to accommodate the larger plate line. This can be accomplished by tapping carefully with a hammer. It may be necessary to shorten the insulators which hold the capacitors to their lever. Birnbach 440A, or equivalent may be used. (See Figure 3.)
12. Install 6076A tubes and apply filament voltage of precisely 6.3 volts measured on the tube filament terminals. In installing, it is important that the tubes be inserted carefully so that the tube screen ring does not go beyond the "fingers" of the socket screen connector.

Note: Damage to the "fingers" may result if the tube screen ring passes beyond and is then pulled back.

13. Cold-tune plate line to resonance and perform final amplifier neutralizing and recheck neutralization of driver stage. It will be necessary to increase the size of the neutralizing capacitor on the plate side under the chassis (see Figure 3) by 10% to increase spacing and eliminate the possibility of arcing. (If excessive unbalance between tubes cannot be eliminated, the installation of balanced cross neutralizing is recommended. (See Figure 4.)

14. Apply plate voltage with low screen voltage and adjust for best dynamic neutralization. Slowly increase voltage to licensed plate current or power output.

Typical Operating Parameters

Filament Voltage	6.3 Volts
Plate Voltage	3700 Volts
Grid Current	85-100 Milliamperes
Plate Current	1.2 Amperes
Screen Voltage	460 Volts
Screen Current	90 Milliamperes
Cathode Current, Rear	550 Milliamperes
Cathode Current, Front	650 Milliamperes

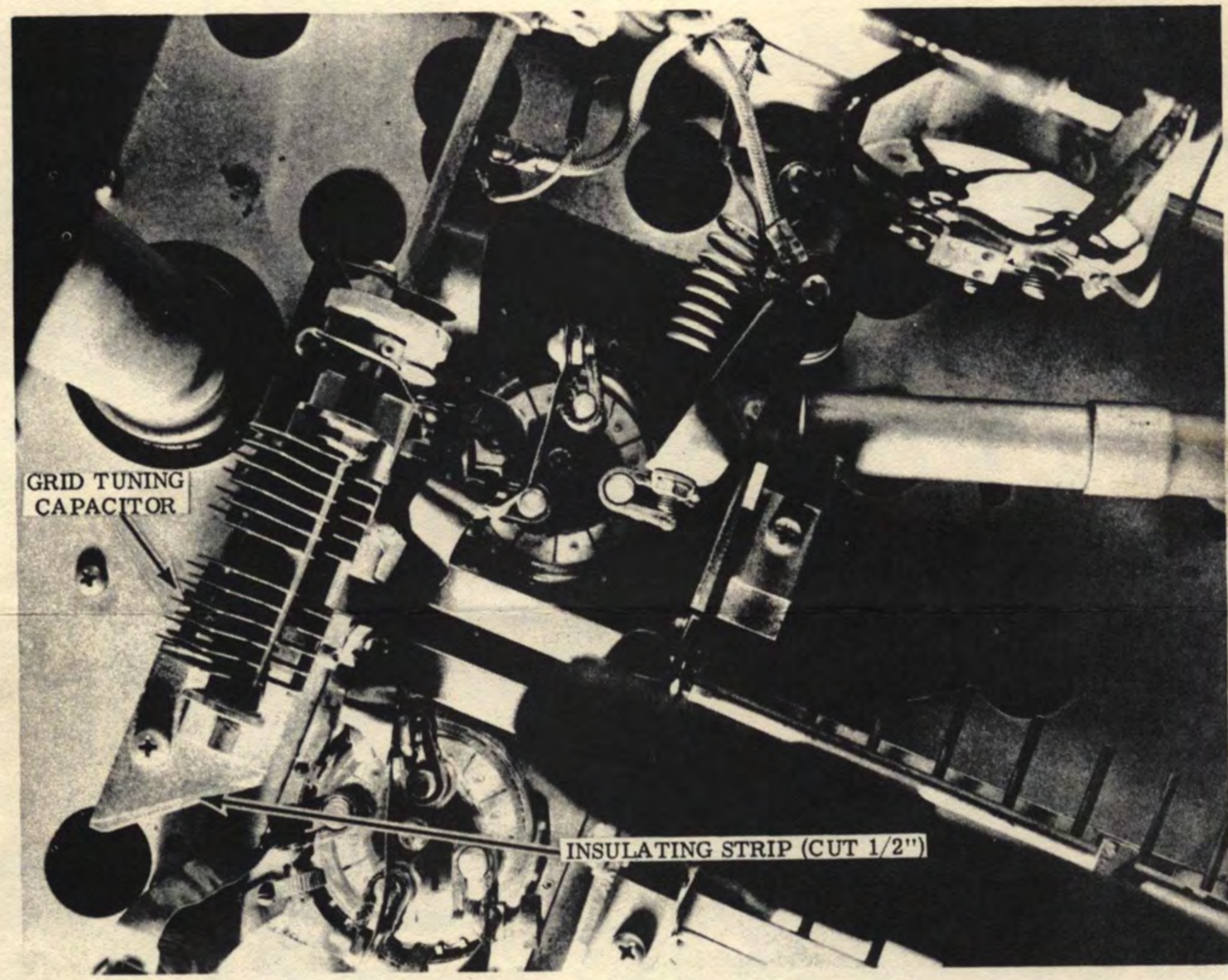


Figure 1. Grid Tuning Capacitor

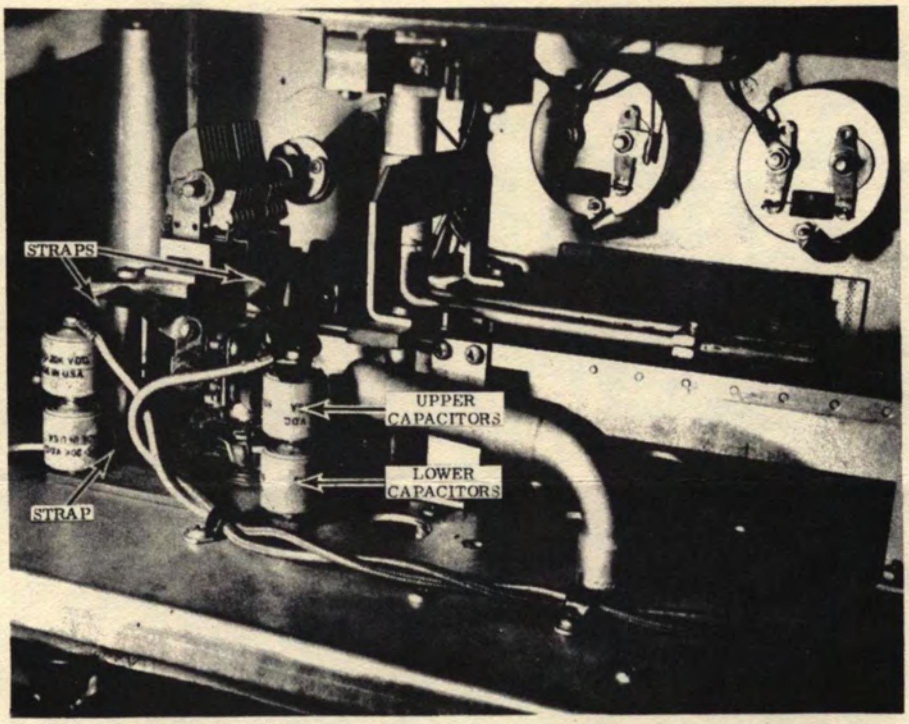


Figure 2. Insulating Strip (Cut 1/2 inch)

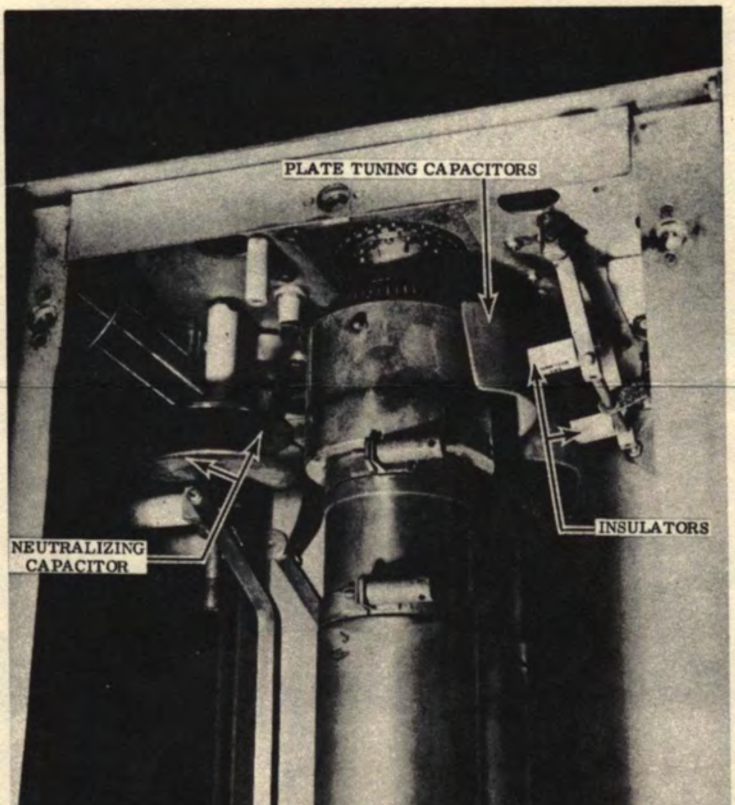
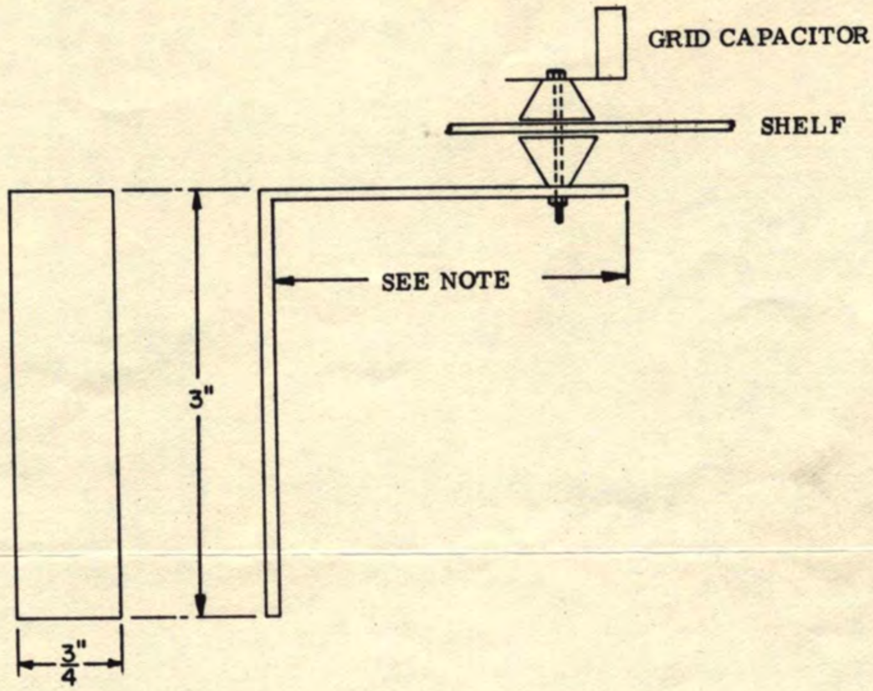


Figure 3. Straps



NOTE:

THIS LENGTH MADE TO SUIT MOUNTING DIMENSIONS.
FORM THIS PART TO ALLOW FREE PASSAGE PAST
PLATE LINE AND OTHER NEUTRALIZING CAPACITOR.

Figure 4. Strap

SD513 KIT OF PARTS FOR BF-2A FM TRANSMITTER CONVERSION

QUANTITY	ITEM DESCRIPTION	MANUFACTURER
3	6076A Tubes (includes required spare)	AMPEREX
2	Plate Line Adapters, S27259	AMPEREX
2	Screen Grid Connectors, S3706	AMPEREX
8	Filament and Grid Connectors, S3707	AMPEREX
8	Type TV-20 500 MMFD. 20 KV DCW Ceramic Capacitors	CENTRALAB
4	Type 445C 3/4 inch round, 1 inch long stand-off insulators tapped for 10/32 thread	BIRNBACH
4	Type 440A 1/2 inch round, 3/4 inch long stand-off insulators tapped for 8/32 thread	BIRNBACH
4	Type 445 1/2 inch round, 1 inch long insulators tapped for 6/32 thread	BIRNBACH
1	Dividohm resistor type 1362B 1500 ohm, 200 watt. (Set tap at 1300 ohms)	OHMITE
9	0.006 inch Phosphor Bronze or copper strips 3/4 inch side.	

NOTE: The two plate line adapters and the strip connectors should be silver-plated. Electronic standard plating (0.0003 to 0.0005 inch thickness) is recommended.

Amperex® Electronic Corporation
TUBE DIVISION
230 Duffy Avenue Hicksville, L.I., N.Y. 11802
Telephone: 516/931-6200 TWX: 516/433-9045

TUBE TYPES
6076
6076A

The 6076A is a ceramic and metal version of the 6076. It is an external anode tetrode for R.F. power amplifier service.

The 6076A is particularly suited for use in broadcast transmitters including VHF television.

The external anode of this tube is capable of dissipating 3.0 kW. The maximum frequency rating is 220 MHz.

GENERAL CHARACTERISTICS

MECHANICAL

Dimensions	see outline drawings
Mounting Position	vertical anode up or down
Control Grid Connection	see note 1
Air Cooling Data	

Plate Dissipation (kw)	Height Above Sea Level (feet)	Inlet Air Temp. (°C)	Min. Air Flow (cu.ft./min.)	Inlet Pressure (inches of water)
1	0	35	65	0.4
1	0	45	80	0.6
1	5,000	35	80	0.5
1	10,000	25	80	0.5
2.5	0	35	160	2.4
2.5	0	45	190	3.4
2.5	5,000	35	190	2.9
2.5	10,000	25	205	3.0
3	0	35	200	3.8

	6076	6076A
Maximum Bulb Temperature	250°C	250°C
Maximum Seal Temperature[2]	180°C	250°C

Accessories

Grid No. 2 Connector	Amperex #S-3706
Filament Connector & Grid No. 1 Connector	Amperex #S-3707
Air Flow Chamber	Amperex #S-11882
Net Weight (approx.)	5 lbs.

ELECTRICAL

Filament Voltage		6.3 volts
Filament Current		32.5 amps
Filament Cold Resistance		0.02 ohm
Amplification Factor (G_2 - G_1 Mu)		8.5
Transconductance (I_b = 2 amps)		19,000 μmhos
Direct Interelectrode Capacitances	6076	6076A
Input	21	22 pf
Output	7	8 pf
Plate to Control Grid	0.2	0.24 pf
Peak Cathode Current (max.)[3]		7 amps

[1] Both pins must be used to make connection to the control grid at frequencies above 30 MHz.

[2] To keep the temperature of the seals below this value, it may be necessary to direct an air flow of sufficient velocity to the seals.

[3] Represents maximum usable cathode current for any condition of operation.

Amperex

Rev. March 1968

Plate and Screen Grid Modulated, RF Power
Amplifier - Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values
(Frequencies up to 110 MHz)

	CCS
DC Plate Voltage	4000 volts
DC Grid No. 2 Voltage	800 volts
DC Grid No. 1 Voltage	-500 volts
DC Plate Current	0.9 amp
Plate Input	3.7 kW
Plate Dissipation	2 kW
Grid No. 2 Dissipation[4]	100 watts
Grid No. 1 Dissipation	30 watts

Typical Operation
(Screen grid supply via a choke of 60 henrys)

	CCS
DC Plate Voltage	4000 volts
DC Grid No. 2 Voltage	800 volts
DC Grid No. 1 Voltage	-375 volts
Peak RF Grid No. 1 Voltage	625 volts
DC Plate Current	0.9 amp
DC Grid No. 2 Current	120 m A
DC Grid No. 1 Current	85 m A
Driving Power	48 watts
Power Output	2.7 kW

RF Power Amplifier
Class C Telegraphy

Key-down conditions per tube without amplitude modulation[5]

Maximum Ratings, Absolute Values
(Frequencies up to 110 MHz)

	CCS
DC Plate Voltage[6]	5000 volts
DC Grid No. 2 Voltage	800 volts
DC Grid No. 1 Voltage	-500 volts
DC Plate Current	1.1 amps
Plate Input	5.5 kW
Plate Dissipation	3 kW
Grid No. 2 Dissipation	100 watts
Grid No. 1 Dissipation	30 watts

Typical Operation

	CCS	CCS	CCS	CCS
Frequency	75	75	110	220 MHz
DC Plate Voltage	4000	5000	5000	4000 volts
DC Grid No. 2 Voltage	800	800	800	800 volts
DC Grid No. 1 Voltage	-250	-250	-250	-250 volts
DC Plate Current	1.1	1.1	1.1	1.1 amps
DC Grid No. 2 Current	120	100	100	120 m A
DC Grid No. 1 Current	80	70	70	80 m A
Peak RF Grid No. 1 Voltage	500	480	480	500 volts
Driving Power	36	30	30	36 watts
Power Output	3.15	4.1	3.9	2.9 kW

[4] For all other modulation methods the grid No. 2 dissipation is 65 watts maximum.
[5] Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.
[6] At 220 MHz the DC plate voltage = 4000 volts max. For other frequencies see derating curve.

R.F. Power Amplifier, Grid Modulated
Class C Television Service

Negative Modulation, Positive Synchronization

Maximum Ratings, Absolute Values
(Frequencies up to 220 MHz)

D.C. Plate Voltage [7]	4000 volts
D.C. Grid No. 2 Voltage	800 volts
D.C. Grid No. 1 Voltage	-500 volts
D.C. Plate Current (sync.)	1.5 amps
Plate Input (sync.)	6 kW
Plate Dissipation (sync.)	3 kW
Grid No. 2 Dissipation (sync.)	100 watts
Grid No. 1 Dissipation (sync.)	30 watts

Typical Operation
Two tubes, Push-Pull

	CCS[8,10]	CCS[9,10]	CCS[7,9]
Frequency	170-220	170-220	88 MHz
D.C. Plate Voltage	4000	4000	5000 volts
D.C. Grid No. 2 Voltage	800	800	800 volts
D.C. Grid No. 1 Voltage			
Synchronization level	-150	-150	-150 volts
Pedestal level	-230	-260	-260 volts
White level	-450	-450	-450 volts
R.F. Grid No. 1 Voltage peak to peak	850	850	900 volts[11]
D.C. Plate Current			
Synchronization level	2.75	2.75	2.7 amps
Pedestal level	2.1	1.5	1.75 amps
D.C. Grid No. 2 Current			
Synchronization level	110	250	145 mA
Pedestal level	50	65	40 mA
D.C. Grid No. 1 Current			
Synchronization level	100	80	82 mA
Pedestal level	50	20	35 mA
Driving Power at Synchronization level	300-400	200-300	200-300 watts [12]
Power Output			
Synchronization level	5	5.9	8 kW
Pedestal level	2.8	3.3	4.5 kW

[7] Up to 88 MHz, a D.C. Plate Voltage of 5000 volts is allowed.
[8] Wide band; 6.5 MHz bandwidth at - 1.5 db or 12 MHz at -3 db.
[9] Narrow band; 7.5 MHz bandwidth at -3 db.
[10] The values of bandwidth are based on measurements on a circuit with a single LC-section.
[11] Measured by slide back method.
[12] Driving Power is accounted for largely by circuit losses. The indicated driving power is required to take care of losses in damping resistors, circuit losses and tube driving power.

Class AB_2 Grounded Grid Linear R.F. Amplifier
Single Sideband Suppressed Carrier Operation

Maximum Ratings, Absolute Values
(Frequencies up to 110 MHz)

	CCS
DC Plate Voltage	5000 volts[6]
DC Grid No. 2 Voltage	600 volts
DC Grid No. 1 Voltage	-500 volts
DC Plate Current	1.8 amps
Plate Input	8.2 kW
Plate Dissipation	3 kW
Grid No. 2 Dissipation	100 watts
Grid No. 1 Dissipation	30 watts

Typical Operation
Single Tone and/or Two Tone Modulation

	CCS	CCS	CCS	CCS	CCS
DC Plate Voltage	5000	4500	4000	3500	3000 volts
DC Grid No. 2 Voltage	600	600	600	600	600 volts
DC Grid No. 1 Voltage	-50	-50	-50	-50	-50 volts
Zero Signal DC Plate Current	350	330	310	300	280 mA
Zero Signal DC Grid No. 2 Current	2	2	2	3	3 mA
Effective RF Load Resistance	1600	1600	1300	1400	1500 ohms

Single Tone Modulation

Max Signal DC Plate Current	1.63	1.43	1.45	1.25	1.06 amps
Max Signal DC Grid No. 2 Current	110	95	95	93	103 mA
Max Signal DC Grid No. 1 Current	95	71	76	57	41 mA
Max Signal Peak RF Cathode Voltage	275	250	240	220	190 volts
Max Signal Driving Power Output	475	374	365	298	211 watts
Max Signal Plate Power	5350+428	4100+340	3500+320	2700+260	1975+186 watts
Max Signal Driver Feedthru Power	428	340	320	260	186 watts
Cathode Impedance	80	82	83	85	88 ohms

Two Tone Modulation

Average DC Plate Current	1110	990	1000	830	710 mA
Average DC Grid No. 2 Current	42	37	30	29	29 mA
Average DC Grid No. 1 Current	44	34	32	24	19 mA
Max Resultant Peak RF Cathode Voltage	275	250	240	220	190 volts
Average Plate Power Output	2675+214	2050+170	1750+160	1350+130	988+93 watts
Peak Envelope Plate Power Output	5350+428	4100+340	3500+320	2700+260	1975+186 watts
Average Driver Feedthru Power	214	170	160	130	93 watts
Peak Envelope Feedthru Power	428	340	320	260	186 watts
3rd Order Intermodulation Distortion	-37	-38	-40	-40	-40 db

R.F. Power Amplifier
Class B - Television Service [13]

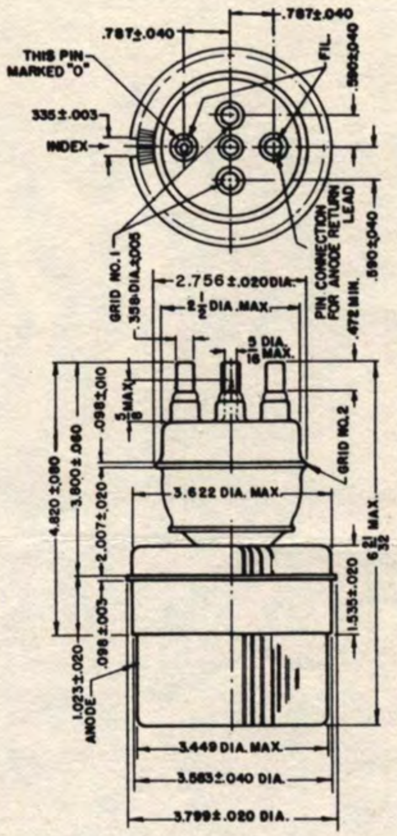
Maximum Ratings, Absolute Values
(Frequencies up to 220 MHz)

	CCS
D.C. Plate Voltage [7]	4000 volts
D.C. Grid No. 2 Voltage	800 volts
D.C. Plate Current (sync.)	1.5 amps
Plate Input (sync.)	6 kW
Plate Dissipation (sync.)	3 kW
Grid No. 2 Dissipation (sync.)	100 watts
Grid No. 1 Dissipation (sync.)	30 watts

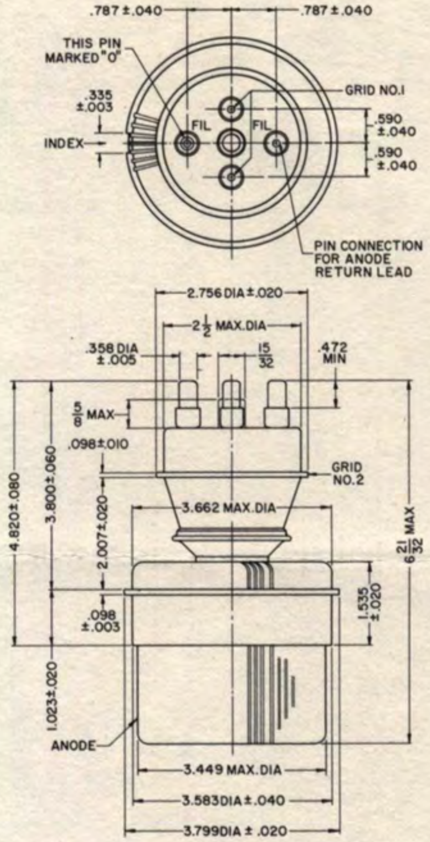
Typical Operation
Two Tubes Push-Pull

	CCS
Frequency	170-220 MHz
D.C. Plate Voltage	4000 volts
D.C. Grid No. 2 Voltage	800 volts
D.C. Grid No. 1 Voltage	-150 volts
R.F. Grid No. 1 Voltage peak to peak	
Synchronization level [14]	850 volts
Pedestal level [14]	700 volts
D.C. Plate Current	
Synchronization level	2.75 amps
Pedestal level	2.1 amps
D.C. Grid No. 2 Current	
Synchronization level	110 mA
Pedestal level	50 mA
D.C. Grid No. 1 Current	
Synchronization level	100 mA
Pedestal level	50 mA
Driving Power at Synchronization level [12]	300-400 watts
Power Output	
Synchronization level	5 kW
Pedestal level	2.8 kW

[13] Bandwidth; 6.5 MHz at -1.5 db or 12 MHz at -3 db.
[14] Measured by increasing fixed bias until no grid current flows.



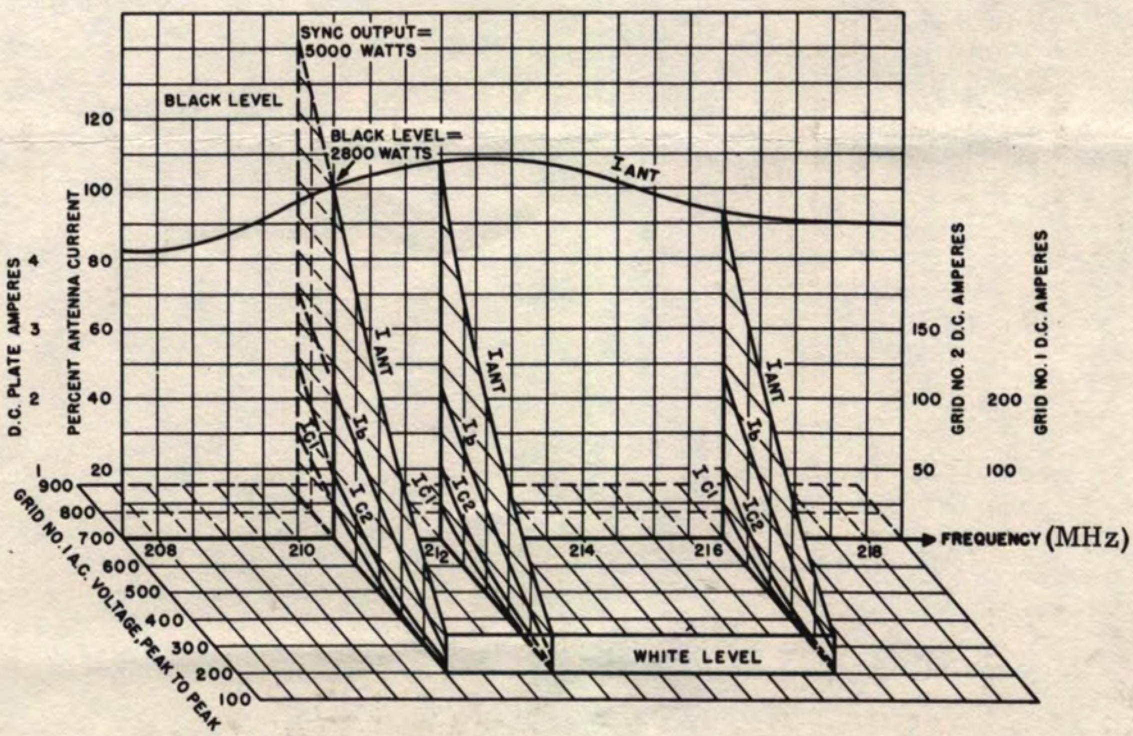
6076



6076A

GRID MODULATED H.F. CLASS B AMPLIFIER–T.V. SERVICE (2 TUBES, PUSH–PULL)

PLATE VOLTAGE = 4000 VOLTS
GRID NO. 2 VOLTAGE = 800 VOLTS
GRID NO. 1 BIAS = 150 VOLTS



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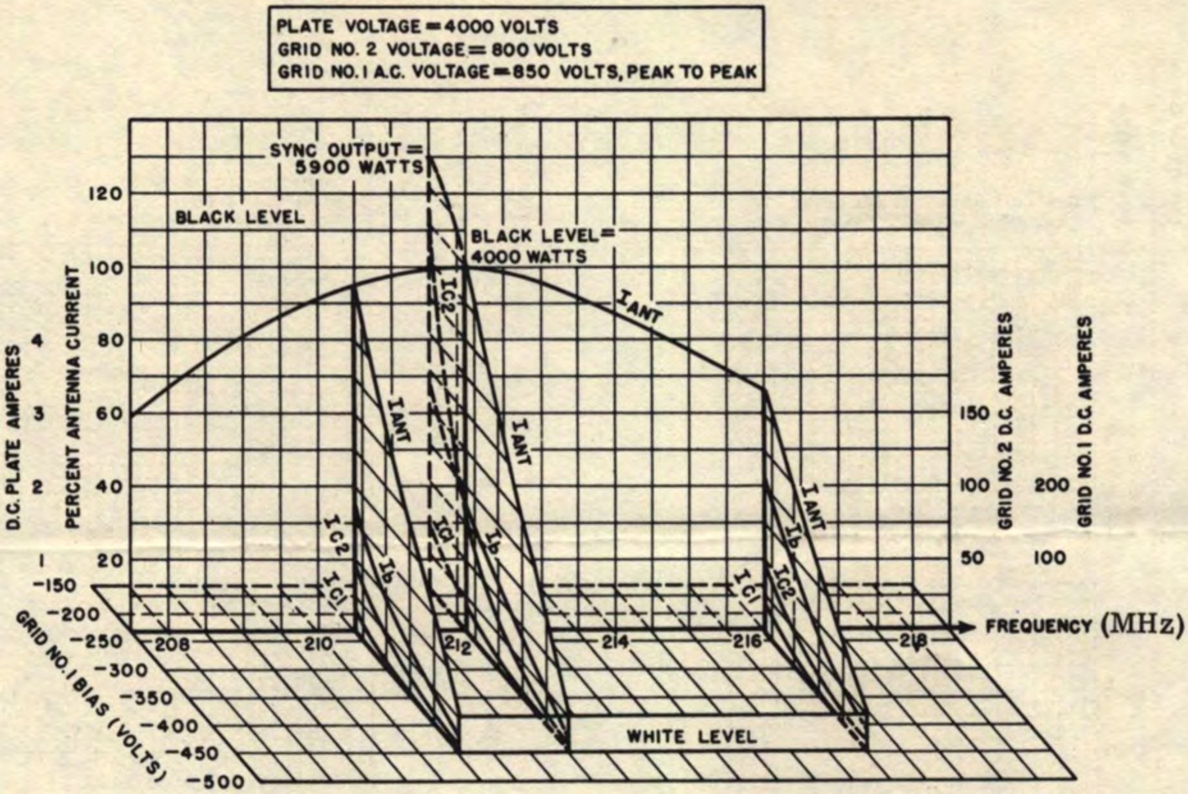
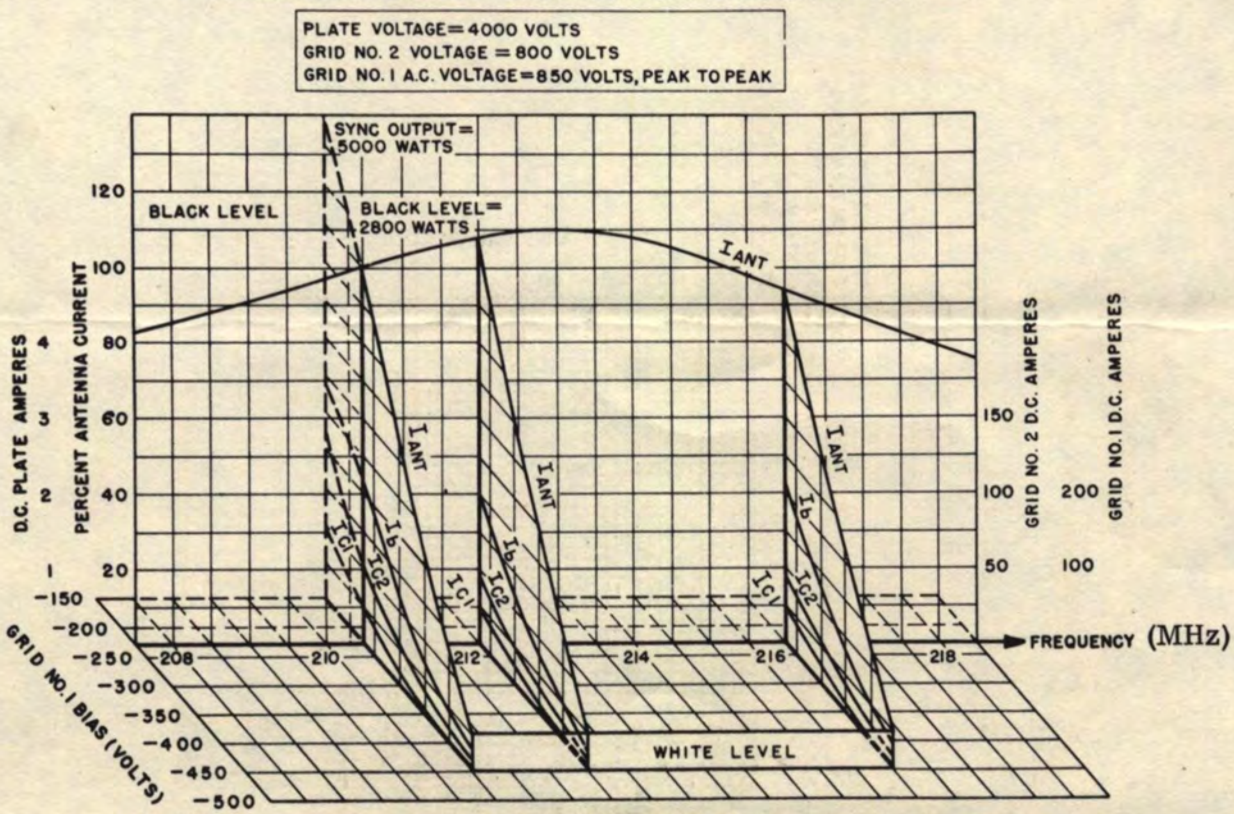
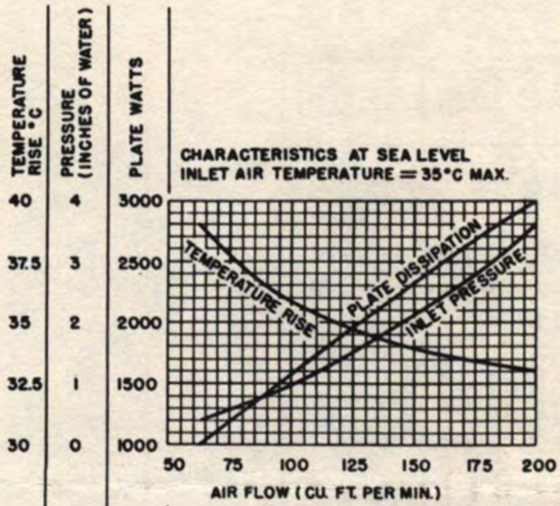
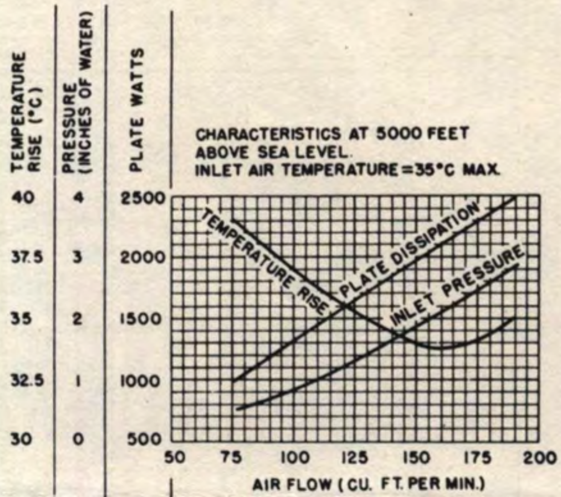
GRID MODULATED H.F. CLASS C AMPLIFIER—T.V. SERVICE (2 TUBES, PUSH-PULL)

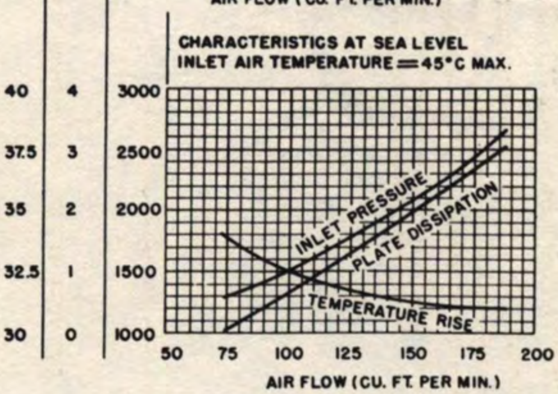


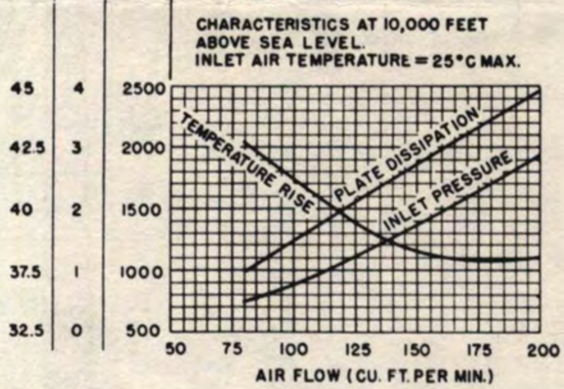
GRID MODULATED H.F. CLASS C AMPLIFIER—T.V. SERVICE (2 TUBES, PUSH-PULL)

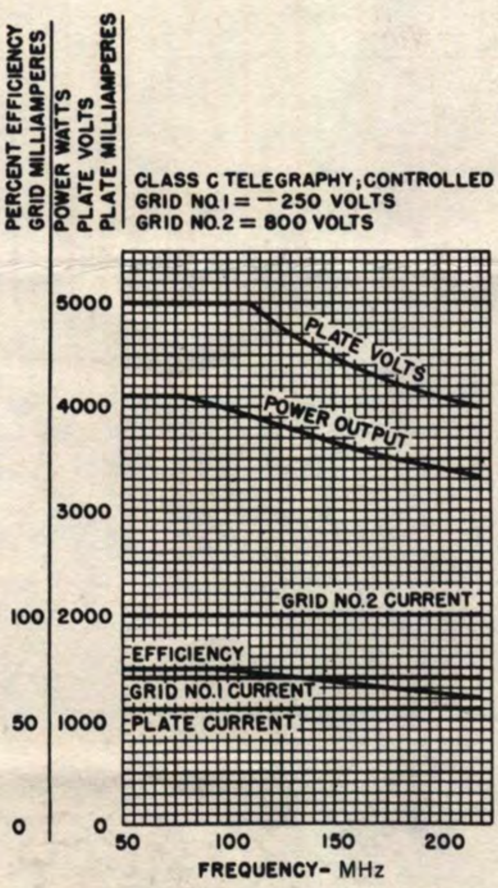



TEMPERATURE RISE °C
PRESSURE (INCHES OF WATER)
PLATE WATTS
CHARACTERISTICS AT SEA LEVEL
INLET AIR TEMPERATURE = 35°C MAX.
40 4 3000
37.5 3 2500
35 2 2000
32.5 1 1500
30 0 1000
TEMPERATURE RISE
PLATE DISSIPATION
INLET PRESSURE
50 75 100 125 150 175 200
AIR FLOW (CU. FT. PER MIN.)


TEMPERATURE RISE (°C)
PRESSURE (INCHES OF WATER)
PLATE WATTS
CHARACTERISTICS AT 5000 FEET
ABOVE SEA LEVEL.
INLET AIR TEMPERATURE = 35°C MAX.
40 4 2500
37.5 3 2000
35 2 1500
32.5 1 1000
30 0 500
TEMPERATURE RISE
PLATE DISSIPATION
INLET PRESSURE
50 75 100 125 150 175 200
AIR FLOW (CU. FT. PER MIN.)


CHARACTERISTICS AT SEA LEVEL
INLET AIR TEMPERATURE = 45°C MAX.
40 4 3000
37.5 3 2500
35 2 2000
32.5 1 1500
30 0 1000
INLET PRESSURE
PLATE DISSIPATION
TEMPERATURE RISE
50 75 100 125 150 175 200
AIR FLOW (CU. FT. PER MIN.)


CHARACTERISTICS AT 10,000 FEET
ABOVE SEA LEVEL.
INLET AIR TEMPERATURE = 25°C MAX.
45 4 2500
42.5 3 2000
40 2 1500
37.5 1 1000
32.5 0 500
TEMPERATURE RISE
PLATE DISSIPATION
INLET PRESSURE
50 75 100 125 150 175 200
AIR FLOW (CU. FT. PER MIN.)


PERCENT EFFICIENCY
GRID MILLIAMPERES
POWER WATTS
PLATE VOLTS
PLATE MILLIAMPERES
CLASS C TELEGRAPHY; CONTROLLED
GRID NO. 1 = −250 VOLTS
GRID NO. 2 = 800 VOLTS
5000
4000
3000
100 2000
50 1000
0 0
PLATE VOLTS
POWER OUTPUT
GRID NO. 2 CURRENT
EFFICIENCY
GRID NO. 1 CURRENT
PLATE CURRENT
50 100 150 200
FREQUENCY- MHz

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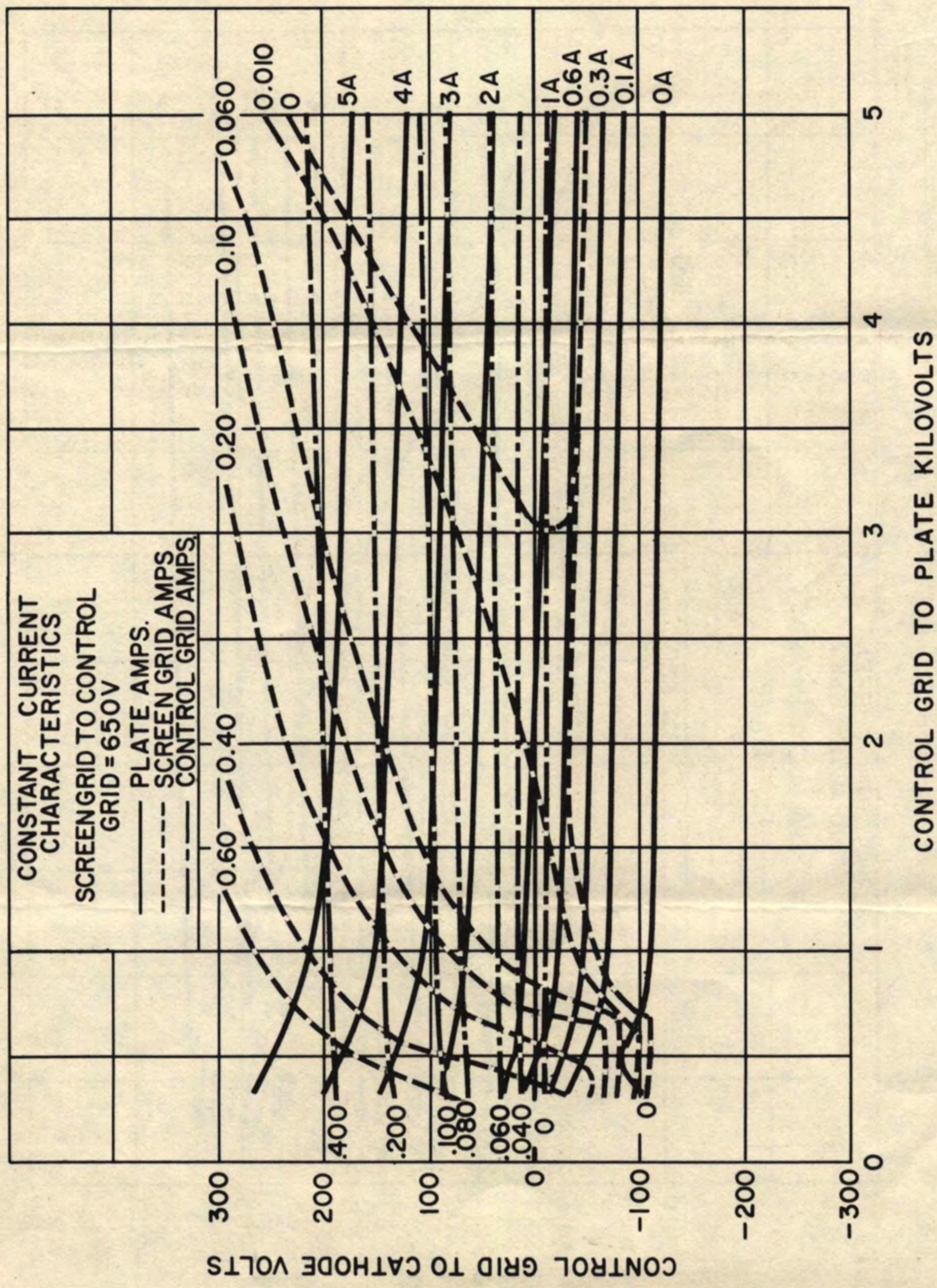
CONSTANT CURRENT CHARACTERISTICS
SCREENGRID TO CONTROL GRID = 650V
PLATE AMPS.
SCREEN GRID AMPS
CONTROL GRID AMPS
0.010
0
0.060
0.10
0.20
0.40
0.60
5A
4A
3A
2A
1A
0.6A
0.3A
0.1A
0A
.400
.200
.100
.080
.060
.040
0
0
300
200
100
0
-100
-200
-300
CONTROL GRID TO CATHODE VOLTS
0
1
2
3
4
5
CONTROL GRID TO PLATE KILOVOLTS

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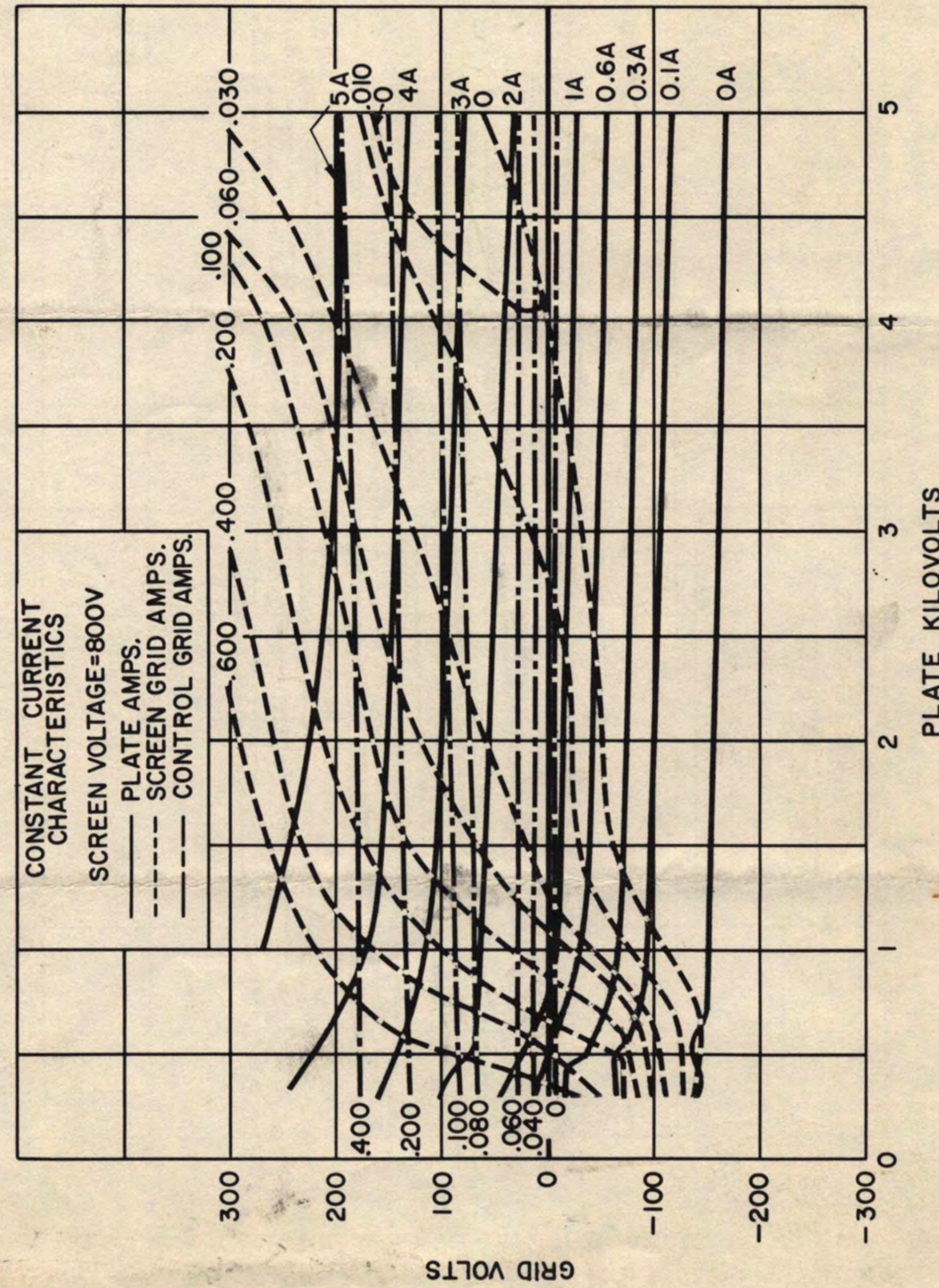

CONSTANT CURRENT CHARACTERISTICS
SCREEN VOLTAGE=800V
PLATE AMPS.
SCREEN GRID AMPS.
CONTROL GRID AMPS.
PLATE KILOVOLTS
GRID VOLTS
5A
4A
3A
2A
1A
0.6A
0.3A
0.1A
0A
.030
.060
.100
.200
.400
.600
.010
.400
.200
.100
.080
.060
.040
300
200
100
0
-100
-200
-300
1
2
3
4
5

Rev. 3/68

EIMAC

A Division of Varian Associates

SAN CARLOS, CALIFORNIA

8438
4-400A

RADIAL-BEAM POWER TETRODE

•

**MODULATOR
OSCILLATOR
AMPLIFIER**

The Eimac 8438/4-400A is a compact, ruggedly constructed power tetrode having a maximum plate dissipation rating of 400 watts. It is intended for use as an amplifier, oscillator or modulator. The low grid-plate capacitance of this tetrode coupled with its low driving-power requirement allows considerable simplification of the association circuit and driver stage.

The 8438/4-400A is cooled by radiation from the plate and by circulation of forced-air through the base, around the envelope, and over the plate seal. Cooling can be greatly simplified by using an Eimac SK-400 Air-System Socket and its accompanying glass chimney. This socket is designed to maintain the correct balance of cooling air between the component parts of the tube.†

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten

Voltage	5.0 volts
Current	14.5 amperes
Grid-Screen Amplification Factor (Average)	5.1
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.12 $\mu\mu$fd
Input	12.5 $\mu\mu$fd
Output	4.7 $\mu\mu$fd
Transconductance (I_b=100ma., E_b=2500V., E_{c2}=500V.)	4,000 μmhos
Frequency for Maximum Ratings	110 Mc.

MECHANICAL

Base	See drawing
Basing	See drawing
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat Dissipating Plate Connector	Eimac HR-6
Recommended Socket	Eimac SK-400 Air System Socket
Maximum Over-all Dimensions	
Length	6.38 inches
Diameter	3.56 inches
Net Weight	9 ounces
Shipping Weight	2.5 pounds

If an Air-System Socket is used, mounted on a 1/4 inch deck, the over-all dimensions of the system including chimney and HR-6 Heat Dissipating Plate Connector are:

Length	8.0 inches
Diameter	5.5 inches

Note: Typical operation data are based on conditions of adjusting the r-f grid drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR
Class-C Telegraphy or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc., one tube)

D-C Plate Voltage	2500	3000	4000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—200	—220	—220	volts
D-C Plate Current	350	350	350	ma
D-C Screen Current	46	46	40	ma
D-C Grid Current	18	19	18	ma
Screen Dissipation	23	23	20	watts
Grid Dissipation	1.8	1.9	1.8	watts
Peak R-F Grid Input Voltage	300	320	320	volts
Driving Power*	5.4	6.1	5.8	watts
Plate Power Input	875	1050	1400	watts
Plate Dissipation	235	250	300	watts
Plate Power Output	640	800	1100	watts

*Driving Power increases as frequency is increased. At 75 Mc. the driving power required is approximately 12 watts.

TYPICAL OPERATION (110 Mc., two tubes)

D-C Plate Voltage	3500	4000	volts
D-C Screen Voltage	500	500	volts
D-C Grid Voltage	—170	—170	volts
D-C Plate Current	500	540	ma
D-C Screen Current	34	31	ma
D-C Grid Current	20	20	ma
Driving Power (approx.)	20	20	watts
Plate Power Output (approx.)	1300	1600	watts
Useful Power Output	1160	1440	watts

†Guarantee applies only when the 4-400A is used as specified with adequate air in the SK-400 Air-System Socket or equivalent.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions unless otherwise specified. One tube)

MAXIMUM RATINGS (Frequencies below 75 Mc. Continuous Service)

D-C PLATE VOLTAGE	3200 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	275 MAX. MA
PLATE DISSIPATION	270 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc. Continuous Service)

D-C Plate Voltage	2000	2500	3000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	volts
D-C Plate Current	275	275	275	ma
D-C Screen Current	30	28	26	ma
D-C Grid Current	12	12	12	ma
Screen Dissipation	15	14	13	watts
Grid Dissipation	1.1	1.1	1.1	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	volts
Driving Power	3.5	3.5	3.5	watts
Plate Power Input	550	688	825	watts
Plate Dissipation	170	178	195	watts
Plate Power Output	380	510	630	watts

MAXIMUM RATINGS (Frequencies below 30 Mc., Intermittent Service)

D-C Plate Voltage	4000 MAX. VOLTS
D-C Screen Voltage	600 MAX. VOLTS
D-C Grid Voltage	—500 MAX. VOLTS
D-C Plate Current	275 MAX. MA
Plate Dissipation	270 MAX. WATTS
Screen Dissipation	35 MAX. WATTS
Grid Dissipation	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 Mc., Intermittent Service)

D-C Plate Voltage	2000	2500	3000	3650	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	—225	volts
D-C Plate Current	275	275	275	275	ma
D-C Screen Current	30	28	26	23	ma
D-C Grid Current	12	12	12	13	ma
Screen Dissipation	15	14	13	12	watts
Grid Dissipation	1.1	1.1	1.1	1.2	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	315	volts
Driving Power	3.5	3.5	3.5	4.0	watts
Plate Power Input	550	688	825	1000	watts
Plate Dissipation	170	178	195	235	watts
Plate Power Output	380	510	630	765	watts

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	800 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	350 MAX. MA.
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION CLASS AB_1

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	750	750	750	750	volts
D-C Grid Voltage (approx.)*	—130	—137	—145	—150	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	635	635	610	585	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	28	26	32	40	ma
Effective Load, Plate-to-Plate	6800	8900	11,500	14,500	ohms
Peak A-F Grid Input Voltage (per tube)	130	137	145	150	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	370	400	400	400	watts
Max-Signal Plate Power Output	850	1110	1330	1540	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage (approx.)*	—75	—80	—85	—90	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	700	700	700	638	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	50	40	38	32	ma
Effective Load, Plate-to-Plate	7200	9100	10,800	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	133	140	145	140	volts
Max-Signal Peak Driving Power	8.6	9.0	10.2	7.0	watts
Max-Signal Nominal Driving Power	4.3	4.5	5.1	3.5	watts
Max-Signal Plate Dissipation (per tube)	320	363	400	400	watts
Max-Signal Plate Power Output	1110	1375	1650	1750	watts

*Adjust for stated zero-signal plate current.

Pulse Service—For information on Pulse Service Ratings, "Application Bulletin No. 3, Pulse Service Notes", will be furnished free on request.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EIMAC, DIVISION OF VARIAN ASSOCIATES, FOR INFORMATION AND RECOMMENDATIONS

APPLICATION

MECHANICAL

Mounting—The 4-400A must be mounted vertically, base up or base down. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube and must also provide clearance for the glass tip-off which extends from the center of the base. The metal tube-base shell should be grounded by means of suitable spring fingers. The above requirements are met by the Eimac SK-400 Air-System Socket. A flexible connecting strap should be provided between the Eimac HR-6 cooler on the plate terminal and the external plate circuit. The tube must be protected from severe vibration and shock.

Cooling—Adequate forced-air cooling must be provided to maintain the base seals at a temperature below 200°C., and the plate seal at a temperature below 225°C.

When the Eimac SK-400 Air-System Socket is used, a minimum air flow of 14 cubic feet per minute at a static pressure of 0.25 inches of water, as measured in the socket at sea level, is required to provide adequate cooling under all conditions of operation. Seal temperature limitations may require that cooling air be supplied to the tube even when the filament alone is on during standby periods.

In the event an Air-System Socket is not used, provision must be made to supply equivalent cooling of the base, the envelope, and the plate lead.

Tube temperatures may be measured with the aid of "Tempilaq", a temperature-sensitive lacquer manufactured by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated voltage of 5.0 volts. Variations in filament voltage must be kept within the range from 4.75 to 5.25 volts.

Bias Voltage—The d-c bias voltage for the 4-400A should not exceed 500 volts. If grid leak bias is used, suitable means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation, and the grid-leak resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube. In operation above 50 Mc., it is advisable to keep the bias voltage as low as is practicable.

Screen Voltage—The d-c screen voltage for the 4-400A should not exceed 600 volts in r-f applications. In audio applications a maximum d-c screen voltage of 800 volts may be used. The screen voltages shown under "Typical Operation" are representative voltages for the type of operation involved.

Plate Voltage—The plate-supply voltage for the 4-400A should not exceed 4000 volts in CW and audio applications. In plate-modulated telephony service the d-c plate-supply voltage should not exceed 3200 volts, except below 30 Mc., intermittent service, where 4000 volts may be used.

Grid Dissipation—Grid dissipation for the 4-400A should not be allowed to exceed 10 watts. Grid dissipation may be calculated from the following expression,

$$P_g = e_{cmp} I_c$$

where P_g = Grid Dissipation
e_{cmp} = Peak positive grid to cathode voltage, and
I_c = D-c grid current

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. (For suitable peak v.t.v.m. circuits see Eimac Application Bulletin Number 6, "Vacuum Tube Ratings." This bulletin is available on request.)

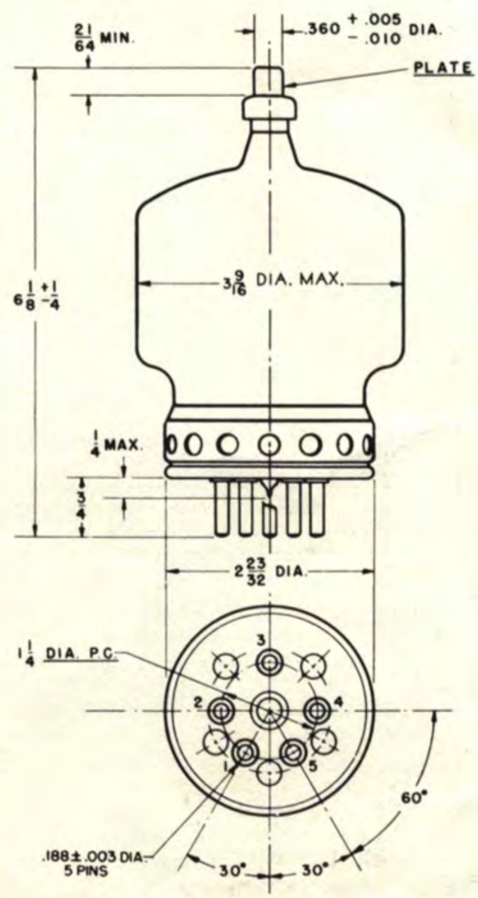
Screen Dissipation—The power dissipated by the screen of the 4-400A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in event of circuit failure.

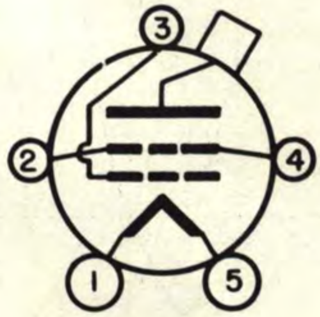
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-400A should not be allowed to exceed 400 watts.

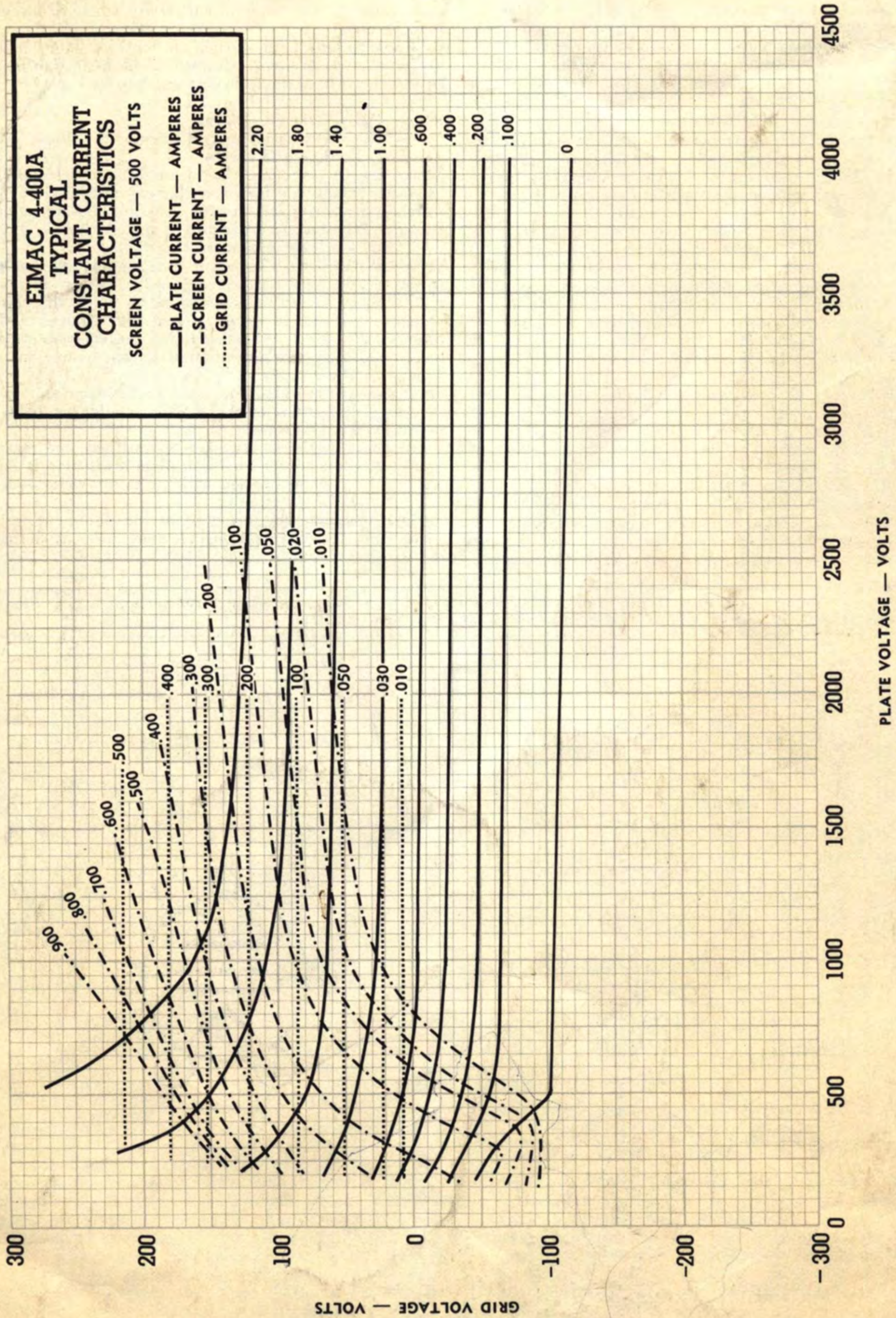
In plate modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 270 watts. The plate dissipation will rise to 400 watts under 100% sinusoidal modulation.

Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

GENERAL INFORMATION PERTAINING TO THE OPERATION OF THE 4-400A MAY BE FOUND IN APPLICATION BULLETIN NO. 8, "THE CARE AND FEEDING OF POWER TETRODES." THIS BULLETIN IS AVAILABLE UPON REQUEST.







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