E-80

50 KW AM BROADCAST TRANSMITTER

K C B S

ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SYRACUSE, NEW YORK

Instructions

for

50-Kilowatt Standard Broadcast

Transmitter

G-E Type BT-25-A

General Electric Company

Electronics Department

Syracuse, New York

4/48 (200)

Printed in USA

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

-INTRODUCTION-

The General Electric Type BT-25-A 50 KW Standard Broadcast Transmitter is designed to provide the commercial broadcaster with modern equipment capable of high quality performance at low operating cost.

In the design of this equipment the best features of contemporary 50 KW transmitters have been carefully weighed. The opinions of many of the most experienced broadcasters have been thoughtfully considered. All of this, combined with the wealth of first hand information and experience accumulated by the General Electric Company in building many of the world's high powered radio transmitters, has resulted in a design which we believe comes as close as possible to being the ideal broadcast transmitter in its power class.

The information contained in these instructions is designed to familiarize you with your equipment and enable you to maintain top efficiency in performance.

-SPECIFICATIONS-

1. Electrical

Type of Emission:	A3 (Telephone)
Carrier Power Output(40-250 ohm load):	50,000 watts

(Transmitter is designed for 53 kw output to provide for directional antenna systems.)

Carrier Frequency Range:	540—1600
R.F. Harmonic Power: (max)	70 db below fundamental
Carrier Frequency Stability:	assigned frequency ± 10 cycles
Main Power Supply:	460 volts ± 5 per cent, three phase, 50/60 cycles
Approximate Power Input:	

Unmodulated ....110 KW
Average program level (25 per cent Mod.) ....120 KW
100% Modulation ....157 KW
Power Factor ....90 per cent

Crystal Heater Supply:	115 volts, single phase, 50/60 cycles, 25 watts
Type modulation:	High Level - Class B
Audio Input for 100 per cent Modulation, sine wave:	10 dbm (10 milliwatts) ± 2 db
Audio Input Impedance:	600/150 ohms
Audio Frequency Response: (at 60 per cent modulation)	Uniform within ±1 db, 30-10,000 cycles
Audio Frequency Distortion (to 95 per cent modulation):	less than 3 per cent RMS, 50-7500 cycles

Residual Noise and Hum: 60 db below 100 per cent modulation, unweighted

Performance meets all FCC Standards of Good Engineering Practice Methods and conditions of measurement conform with latest proposed RMA Standards.

2. Tube Complement

Radio Frequency

Crystal Oscillator 1-GL-837
1st IPA 1-GL-828
2nd IPA 1-GL-810
3rd IPA 3-GL-833A
Power Amplifier 2-GL-895-R

Rectifiers

High Voltage 6-GL-857-B
Intermediate 4-GL-8008
Low Voltage 2-GL-866-A/866
Power Amp. Bias ...2-GL-866-A/866
A-F Bias 2-GL-8008

Audio Frequency

1st Audio 2-GL-837
2nd Audio 2-GL-5C24
3rd Audio 4-GL-5C24
Modulator 2-GL-895-R

3. Mechanical

Overall Dimensions of Transmitter

Height ------------7 feet
Width -------------29 feet
Depth -------------5 feet

For Dimensions of External Equipment refer to the Installation Diagram, Fig. 39.

Approximate net weight

Transmitter -------------16,500 pounds
External Equipment ------25,000 pounds

-FCC FILING DATA-

In applying for a license, the following information may be entered on pages 1 and 2 of Section II-A on FCC Form 302.

2. Facilities authorized in construction permit:

Transmitter make	Type No.
General Electric	BT-25-A

4. Operating constants:

Class of operation of last radio frequency amplifier stage. (See Section 8 Standards of Good Engineering Practice Concerning Standard Broadcast Stations.)	A x B BC	C D
Manufacturer's recommended operating efficiency for the last radio frequency amplifier stage in per cent.	78%	

Tubes:

Make	Type	No.
General Electric	GL-895R	2

Is inverse feedback utilized? Yes x No

If "Yes", to what value of feedback power is transmitter adjusted (in d.b.) 14 d.b.

5. Indicating instruments in last radio stage:

	Manufacturer's name and type	Full scale reading
Plate voltmeter	G-E TYPE DB-4	15 KV
Plate ammeter	G-E TYPE DB-4	10 Amp
Antenna ammeter		
Remote antenna ammeter	G-E TYPE DB-4	

9. Give method of varying power to compensate for variation of line voltage: continuously variable r-f output coupling control on front panel. (± 20 per cent power range)

Note:
(1) Under Section 5, the full scale Antenna Ammeter reading must correspond with that of your particular Antenna Ammeter.

(2) If main rectifier voltage regulator 6VR1 is used, insert the following additional data under Section 9:

"Automatic induction voltage regulator of ± 10 per cent range compensates for line voltage variations."

-DESCRIPTION-

1. Construction

The G-E type BT-25-A Transmitter consists of the transmitter proper and several external auxiliary units.

Five main cubicles (Control Unit, Exciter Unit, Audio-Modulator Unit, Power-Amplifier Unit and Rectifier Unit), are bolted together to form the transmitter proper. The rugged, attractively-styled cabinets are finished in two-tone blue with bright trim. Particular attention was given to providing complete accessibility for ease of maintenance.

Heavy power equipment such as modulation and plate transformers, filter and modulation reactors, external Power Cabinet, etc. is located either in the basement or directly behind the transmitter. Since General Electric Pyranol* filled equipment is used, no fire-proof vault is necessary.

The transmitter is completely air-cooled from a central blower system located external to the transmitter cabinets. The installation can be readily arranged to permit utilization of the transmitter heat during cold weather.

All small tubes may be easily changed. Spare power amplifier and modulator tubes are mounted so that they can be quickly switched into the circuit to reduce to a minimum the time off the air due to tube failure. A spare main rectifier tube can be electrically switched into the circuit by means of contactors with only a momentary carrier break.

*G-E trade-mark

Large meters of the latest type, having 240-degree scales, located along the top of the transmitter cabinet are used for the more important functions. Smaller meters used for frequency adjustments are mounted on the panels for convenience in tuning.

Large tuning controls are motor-driven; smaller ones are hand-operated through vernier controls.

Windows are provided on doors and panels at approximately eye-level for the purpose of observing small meters, rectifier tubes, and other equipment. Two lamps in each cubicle provide adequate lighting for maintenance. At least one 115-volt convenience outlet is provided in each cubicle. Additional outlets are placed in the front of the Modulator and Power Amplifier cubicles.

A recessed opening or "kick cove" is provided along the base of the cabinet at the front to prevent scuffing of the finish.

Particular attention has been given to safety of personnel and equipment. All access doors leading to areas employing dangerous voltages are fully interlocked to automatically remove such voltages when opened. In addition, the doors when opened operate switches which ground directly all high voltage circuits in that particular compartment. All control panels are of the dead-front type. High speed overload relays, contactors and magnetic circuit breakers protect the equipment.

For ease of reference, the circuit symbols of the components located in the various transmitter sections are prefixed as follows:

First Digit of Symbols	Location of Item
1	Transmitter Exciter Unit
2	Transmitter Power Amplifier Unit
3	Transmitter Audio-Modulator Unit

First Digit of Symbols	Location of Item
4	Transmitter High-Voltage Rectifier Unit
5	Transmitter Control Unit
6	External Items Including Power Cabinet
7	Monitor Rectifier Unit
8	Supervisory Console
9	Supervisory Clock Panel (if used)

2. Equipment Furnished

A. Transmitter:

Item	Quantity
Control Cubicle	1
Audio-Modulator Cubicle	1
Exciter Cubicle	1
Power Amplifier Cubicle	1
Rectifier Cubicle	1
Inter-Cubicle Installation Material (wire, terminals, etc.)	1

B. External Equipment:

Item	G-E Dwg. No.	Symbol	Quantity
Main Rectifier Plate Transformer	M-7478467	6T7 6T8 6T9	3
Modulation Transformer	M-7477982	6T10	1
Auto-Transformer	M-7478468	6T1 6T2 6T3	3
Breaker Control Transformer	M-7478473	6T4	1
Modulation Reactor	M-7477981	6L1	1
Filter Reactor	M-7477980	6L2	1

Item	G-E Dwg. No.	Symbol	Quantity
Main Blower and Motor	P-7770293	6B1	1
Main Blower Starter	M-7478861	6K1	1
Circuit Breaker	M-7478786P2	6S1	1
Circuit Breaker	M-7478786P1	6S2	1
Air Flow Switch	P-7770288P1	6S3	1
Breaker Control Power Switch	P-7770225P1	6S4	1
Door Interlock	M-7460330G4	6S5	1
Door Interlock	K-7116627P1	6S6	1
Air-Filter Panel	M-7480711	-	15
Filter Panel Holding Frame	P-7771221	-	1
External Power Cabinet		-	1
Monitor Rectifier Unit	Type FZ-2-A	-	1
Hum Bucking Unit	Type FZ-1-A	-	1

3. Available Accessories List *

Item

Complete Set of Tubes

Set of Spare Tubes

Portable Tube Hoist, Type FZ-3-A

Audio Input Monitoring and Test Equipment

Supervisory Console, Type BC-3-A
or
Deluxe Supervisory Console, Type BC-13-A

Installation Material (wire, terminals, etc. for use between transmitter and external equipment)

Antenna Tuner (230-ohm line)

Antenna Tuner (70-ohm line)

Antenna Phasing Equipment

* Consult nearest G-E office for particulars.

Item

RF Transmission Line

Main Rectifier Induction Regulator, G-E Dwg. M-7478780, Symbol 6VR1

Water Cooled Load, Type FY-13-A

Spare Blower Equipment (Blower per G-E Dwg. P-7770293 and motor starter per G-E Dwg. M-7478861)

Spare Parts

4. Recommended Test Equipment

Item

Audio-Frequency Oscillator

Noise and Distortion Meter

Cathode-Ray Oscilloscope

Vacuum Tube Voltmeter

Radio-Frequency Bridge

Radio-Frequency Oscillator

500-Volt Portable Megger

Multimeter

-INSTALLATION-

General Information

Upon receiving and unpacking the transmitter, inspect it thoroughly for possible shipping damage.

The following instructions for reassembly of the Type BT-25-A Broadcast Transmitter are provided as a guide for installing and wiring the transmitter after it has been dismantled for shipment. It is assumed that the layout of the transmitter and its auxiliary equipment has been planned with due reference to the Installation Drawings Fig. 39, Sheets 1, 2 and 3. Typical layouts for both single and double floor installations are shown.

The five cubicles comprising the transmitter proper, the four sections comprising the base for the cubicles, the external power cabinet, and the external transmitter items are separately crated.

Transmitter Items

Assemble the four sections of the base as marked, bolting them firmly together. The base should be leveled carefully with use of shims as necessary. Be particularly careful to obtain a flat plane along the top of the bases. (A stretch-cord may be used to advantage). Locate the cubicles on the base, allowing them to lock into place. Bolt the cubicles together (it is not necessary that all of the bolts be used). Attach the two end pieces by means of machine screws provided.

After the transmitter cubicles are lined up, attach the trim strips. This is done by placing the strip against the retainers and applying hand pressure.

Remove all shipping blocks and cords from contactors, relays, etc. Remove the red-tipped shipping screws from the two contact-making voltmeters (5A1, 5A2).

The following items were removed from the transmitter cubicles for shipment; reinstall them in their locations (as indicated on Fig. 39, Sheet 1) after the cubicles have been located in their final positions.

Control Voltage Transformer (5T25) - Control Cubicle

Filament Voltage Regulator (5VR1) - Control Cubicle

Power Factor Correction Capacitors - Exciter Cubicle
(1C80 through 1C83)

Intermediate Rectifier Filter Reactors - Exciter Cubicle
(1L24 and 1L25)

Intermediate Rectifier Plate Transformer - Exciter Cubicle
(1T9)

Modulator Filament Transformer - Audio-Modulator Cubicle
(3T13 through 3T18)

Third Audio Reactor (3L1) - Audio-Modulator Cubicle
(Use lift rope through hole provided in cubicle roof).

Blocking Capacitors (3C24 and 3C25) - Audio-Modulator Cubicle

Choke Coil (2L10) - PA Cubicle

Tank Coil (2L4) - PA Cubicle

Harmonic Filter Coils (2L6 and 2L7) - PA Cubicle

Neutralizing Coils (2L2 and 2L3) - PA Cubicle

Power Amplifier Filament Transformer - PA Cubicle
(2T12 through 2T17)

Gas-Filled Capacitors (2C1, 2C2) - PA Cubicle

Filter Capacitors (4C1 through 4C6) - Rectifier Cubicle

Modulator Coupling Capacitors - Rectifier Cubicle
(4C7 through 4C12)

The gas-filled capacitors (2C1 and 2C2) are shipped with 5 to 50 psi pressure of Freon F12. Before installing, the gas should be released in a well-ventilated location to about 5 psi pressure. After installing the capacitors, the pressure should then be increased to 200 psi by adding dry nitrogen.

The output post in the Power Amplifier cubicle has been mounted in an inverted position for shipping. This should be placed on top of the cubicle as indicated on the Installation Drawing, Fig. 39, Sheet 1.

If the transmitter is to be operated on a frequency below 1081 kc, remove the jumper between 2C17 and 2L3.

When the GL-895-R tubes are inserted in their sockets, locate the six seal-cooling air-deflectors on the filament pins before placing the filament and grid connectors in position. Train the filament leads away from the grid lead in both Modulator and Power Amplifier.

External Items

The external items, with their dimensions and weights, are indicated on Fig. 39, Sheet 2. The transformers, reactors and optional plate regulator are filled with non-inflammable Pyranol* and vaults are not ordinarily required; a fenced interlocked enclosure is sufficient. Check the level of the Pyranol*.

In some localities if transformers are placed in a poorly ventilated area, it may be necessary to install gas absorbers or connecting flues from the pressure-relief vents to the outside. (1940 National Electric Code). For detailed information, see pages 16 and 17 of Instruction Bulletin GEH-1093A.

If the optional plate regulator (6VR1) is used, it may be readily wired to the contact-making voltmeter (5A2) in the Control Cubicle and to the panel controls in the Rectifier Cubicle. (See Wire Running List, Fig. 37).

*G-E trade-mark

If the user desires a manual HV Rectifier plate supply disconnect switch, it may be wired into the circuit as indicated on the Control and Power Distribution Diagram, Fig. 41.

Be sure all external items and their protecting enclosures are positively grounded. Check settings of all arc-gaps (see MAINTENANCE Section). Circuit breakers 6S1 and 6S2 should be mounted firmly, as on a pipe frame. The front of the breakers should be accessible during operation, as indicated on Fig. 39, Sheet 3.

For mounting and wiring breakers 6S1 and 6S2 it is necessary to remove the units from their enclosing cases. This is accomplished (after first removing the front cover) by removing the upper two screws and tilting the breaker forward. (Refer to page 1 of Bulletin GEI-10982B). In replacing breakers into their cases, make certain that the contact fingers are properly aligned. When replacing cover be sure to line up manual trip button with its opening in the cover; after cover is in place tighten the locking device on the threaded stud. This locking feature is a safety device which prevents operation of the breaker with the cover off. After mounting 6S1 and 6S2, replace the oil in the dash-pots.

The External Power Cabinet is normally located in the fenced enclosure with the other external items. Access is provided through front and rear doors. The cabinet is usually located with its front door flush with the enclosure to permit observation of the large contactors. The doors are provided with locks. The front door should be kept locked in operation. If desired, the cabinet can be located entirely within the fenced enclosure.

Outgoing Transmission Line

If coaxial line is used, it is customary to run this direct to the top of the Power Amplifier Unit.

If 230-ohm open wire line is used, this will normally terminate at the feed-through wall-bushings as indicated on Fig. 39, Sheet 3. The feeder from the transmitter to the feed-through can be conveniently run inside the extended air-exhaust duct as indicated. The feeder can consist of three wires (#6 stranded or 1/4-inch copper tubing) mounted on insulators and run parallel in the same plane. The spacing between adjacent wires should be 2.6 inches. The outer two conductors are connected together and grounded. The center conductor is the high r-f voltage lead.

With open wire line, a horn gap should be provided from the building feed-through bushing to ground. A choke consisting of two turns wound to 4 inch diameter should be used in series with the "hot" line on the transmitter side of the horn gap. See Bulletin EBR-95 "Protecting Against Carrier Failure."

Monitor Rectifier Unit

This unit should be installed in the antenna tuning house at the base of the tower. The coil assembly is located near the antenna ammeter inside the high r-f voltage fenced enclosure, and may be mounted in any position. The primary loop (7L2) is connected in series with, and just below, the antenna ammeter. The rectifier unit should be mounted outside of the fenced enclosure so that adjustment (7R3) may be made during operation while watching the r-f antenna ammeter. The rectifier should be within easy reach of the mag-phone for communication with the transmitter operator while making adjustments.

Fifteen feet of flexible co-axial cable is provided for connecting the rectifier unit to its pick-up coil.

Air Circulating System

See Fig. 39, Sheet 3.

An air duct is required between the Main Blower equipment and the transmitter cubicles. An exhaust air duct along the top of the transmitter is required for carrying exhaust air to the outside. The exhaust air duct is usually used also for enclosing outgoing transmission lines, if open wire, and high voltage buses (with single floor installations). The suggested exhaust vent is designed to be wind- and rain-proof. It should be covered with a bird screen of suitable mesh. An air-mixing room is desirable, as indicated in the drawings. However, in locations where space is limited, the air filter panels may be located directly in the wall of the blower room which is then used also as the air-mixing room. Mechanically connected adjustable intake louvers permit mixing of inside and outside air for building ventilation and control of incoming air temperature. Louvers with adjustable shutters are usually provided for building heating. Positions of the cut-outs beneath the transmitter for locating vertical risers from the intake duct are indicated on Fig. 39, Sheet 1. It is desirable to have a damper in the air flow to the Rectifier Cubicle capable of being adjusted during operation to permit control of air temperature to the GL-857-B rectifier tubes.

The air interlock switch, 6S3, is normally located on the intake air duct near the end away from the blower. It is desirable for this to be accessible with power on. See Section XI for adjustment.

For maximum reliability, two blowers are often used as indicated on Fig. 39, Sheet 3, suitable dampers being provided to prevent air from the blower in use escaping through the idle one.

The air filter frame is shipped in five sections; each section consists of three unit frames welded together. In installation, the five frames are bolted together as indicated on Fig. 39, Sheet 2. A felt seal should be provided between frames (felt and bolts are supplied). In addition, the user should provide a felt or caulk seal between the frames and the wall. Note that the frames are to be mounted so that the standard filter panels may be changed from the incoming-air side. If it is required, for reasons of accessibility, to change filter panels from the leaving-air side, it is necessary to specify "Reverse Flow" Filter panels. The air must always enter the coarse-mesh side of a filter.

The Main Blower, the Blower Motor, and floating base are shipped separately. The Blower is usually supplied for "upblast" discharge for a two-floor installation, but may be rotated 90 degrees for horizontal discharge for a single-floor installation. The sheaves supplied for the motor are adjustable from 8.4 inches to 7 inches diameter. For a line frequency of 60 cps adjust the motor sheave for 7 inch diameter. For 50 cps adjust the motor sheave for 8.4 inch diameter; connect the motor for 220 volt operation as indicated on the instruction plate. For safety, the belt drive assembly should be protected by a wire guard and a protective mesh should be mounted over the blower air-intake.

The motor starter, 6K1, should be mounted vertically in a location convenient to the blowers. Remove excess grease which may have been applied to the armature for rust prevention during shipment. The coil normally included in 6K1 is for 60 cps operation (22D112G3). An extra 50 cps coil (22D112G8) is supplied and should be installed if 50 cps operation is used.

Wiring

Consult Wiring Running List, Fig. 37.

Wire and terminals are supplied for all inter-cubicle connections of the transmitter proper. Wiring between Transmitter and external power equipment is to be furnished by the user, the quantities required depending on the particular installation. External wiring trenches are usually employed for major runs with conduit for minor runs as indicated on Fig. 39, Sheet 3. Inter-cubicle wiring is to be run in the built-in trench provided in the Transmitter base.

The PA and Modulator cubicles are so arranged that the high voltage busses may enter from the bottom for a two-floor installation or through the top for a single-floor installation. The set is normally shipped with the two-floor arrangement of parts. Refer to Installation Diagram, Fig. 39, Sheet 1. In the case of the Modulator Unit, to adapt to a single-floor installation, relocate resistors 3R14, 3R15, 3R16, 3R17. Mount two insulators having at least four inches creepage path on the cubicle roof using tubing to connect them to the resistors through the two rear exhaust air openings. In the case of the PA cubicle, transfer the feed-through bowl, P03, to the top of the tube air box as indicated on the drawing. Mount an insulator on the cubicle roof and connect this to P03 with tubing supported by insulators as required.

-POWER REQUIREMENTS, DISTRIBUTION, AND CONTROL SEQUENCE-

POWER REQUIREMENTS

General

The main power supply is three phase, three wire, 460 volts $\pm$ 5 per cent, 50/60 cps of good regulation. The load varies approximately from 110 kw to 157 kw as the Transmitter modulation varies from 0 to 100 per cent. At average program level (25 per cent modulation) nominal power input is 120 kw and power factor approximately 90 per cent.

460 volt power is supplied to the HV (high voltage) rectifier plate transformers 6T7, 6T8 and 6T9. Auto-transformers 6T1, 6T2 and 6T3, with grounded neutral, step down the 460 volts to 230 volts line to line (133 volts to ground), which feeds the Transmitter proper. Transformer 6T4 steps down the 460 volts to 230 volts (with grounded mid-point) for breaker control.

115 volts single phase is required for the crystal heaters, cubicle lighting, convenience outlets and the carrier off alarm. This is normally obtained from the building lighting circuit.

50 CPS Operation

The Transmitter as shipped is normally connected for 60 cps operation. Conversion to 50 cps operation requires the following internal reconnections:

(1) Move the connecting terminal with the red paint marker from terminal X4 on transformer 5T25 to terminal X3.

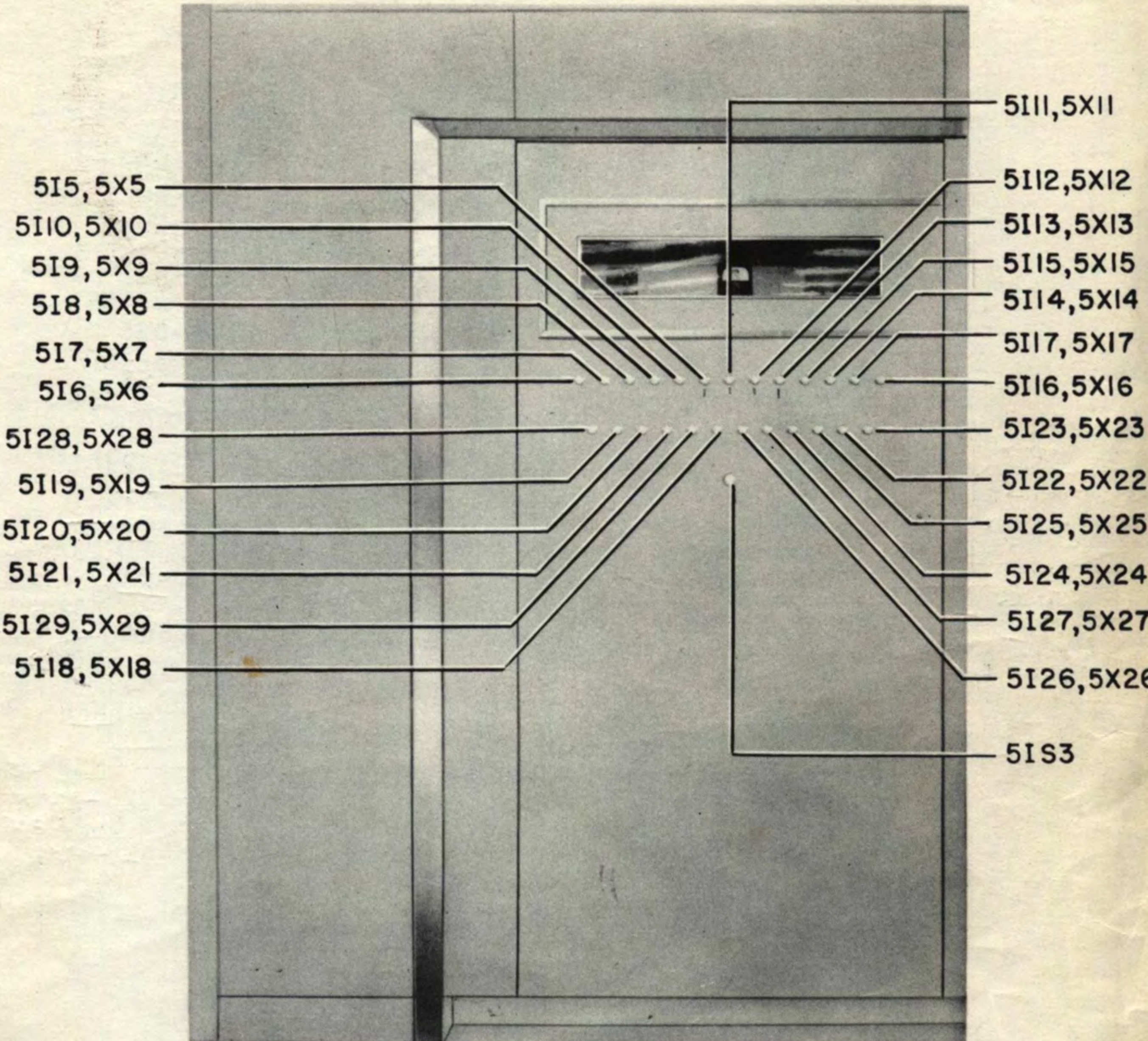


Fig. 1 Control Cubicle, Front View, Door Closed, Parts Identified (SY5260A)

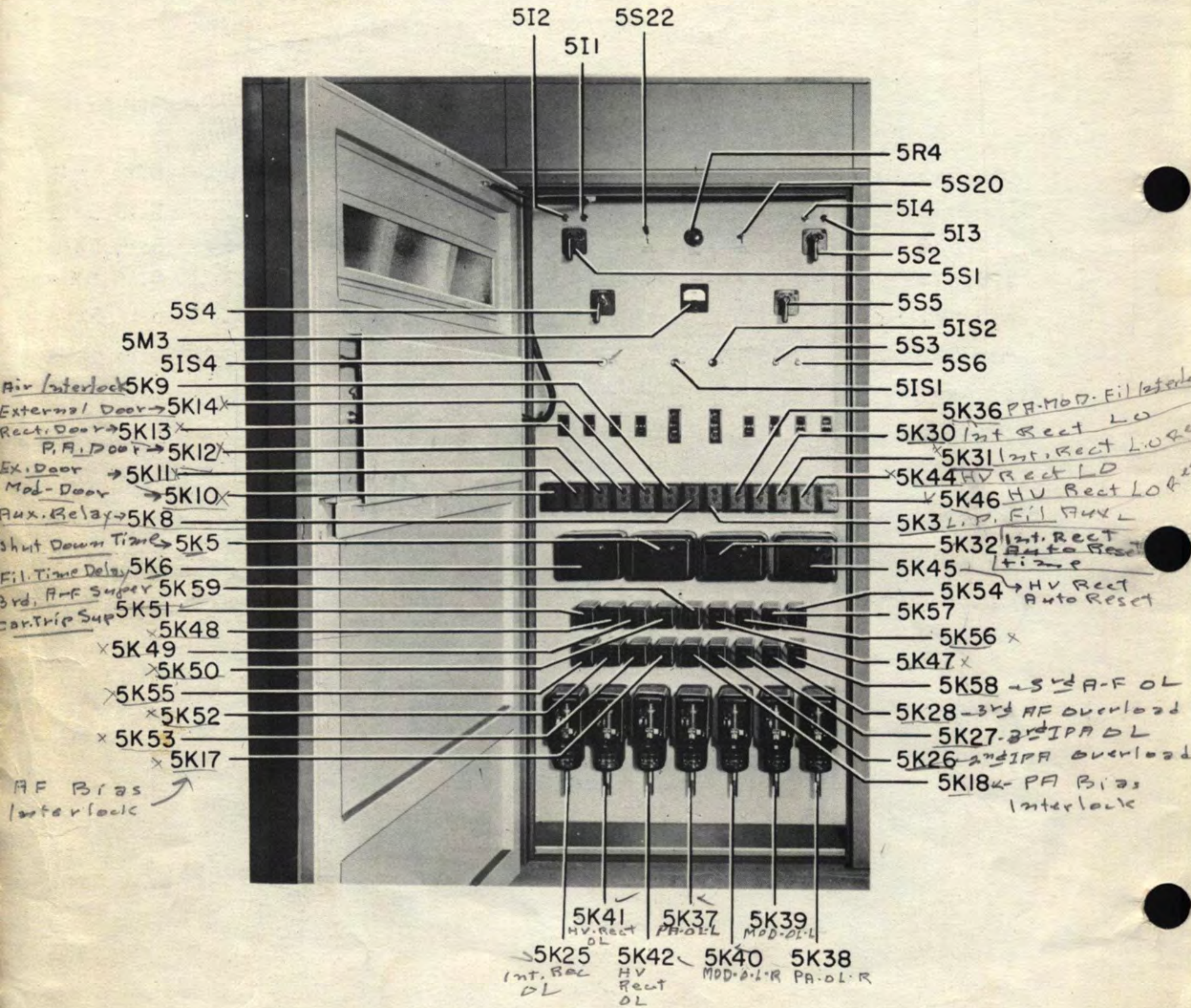


Fig. 2 Control Cubicle, Front View, Door Open, Parts Identified (SY5259A)

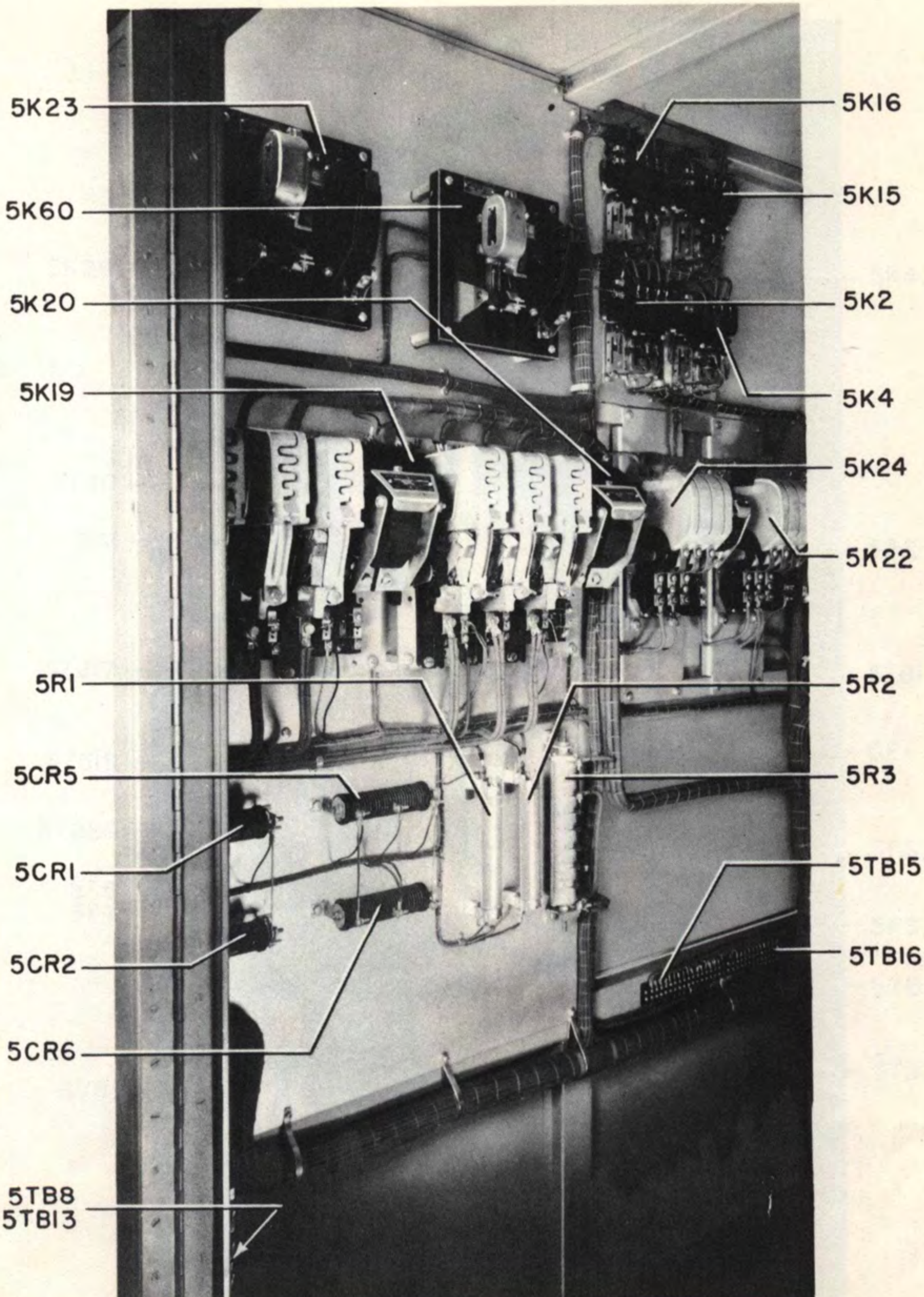


Fig. 3 Control Cubicle, Rear View, Parts on Right Side Identified (SY5047A)

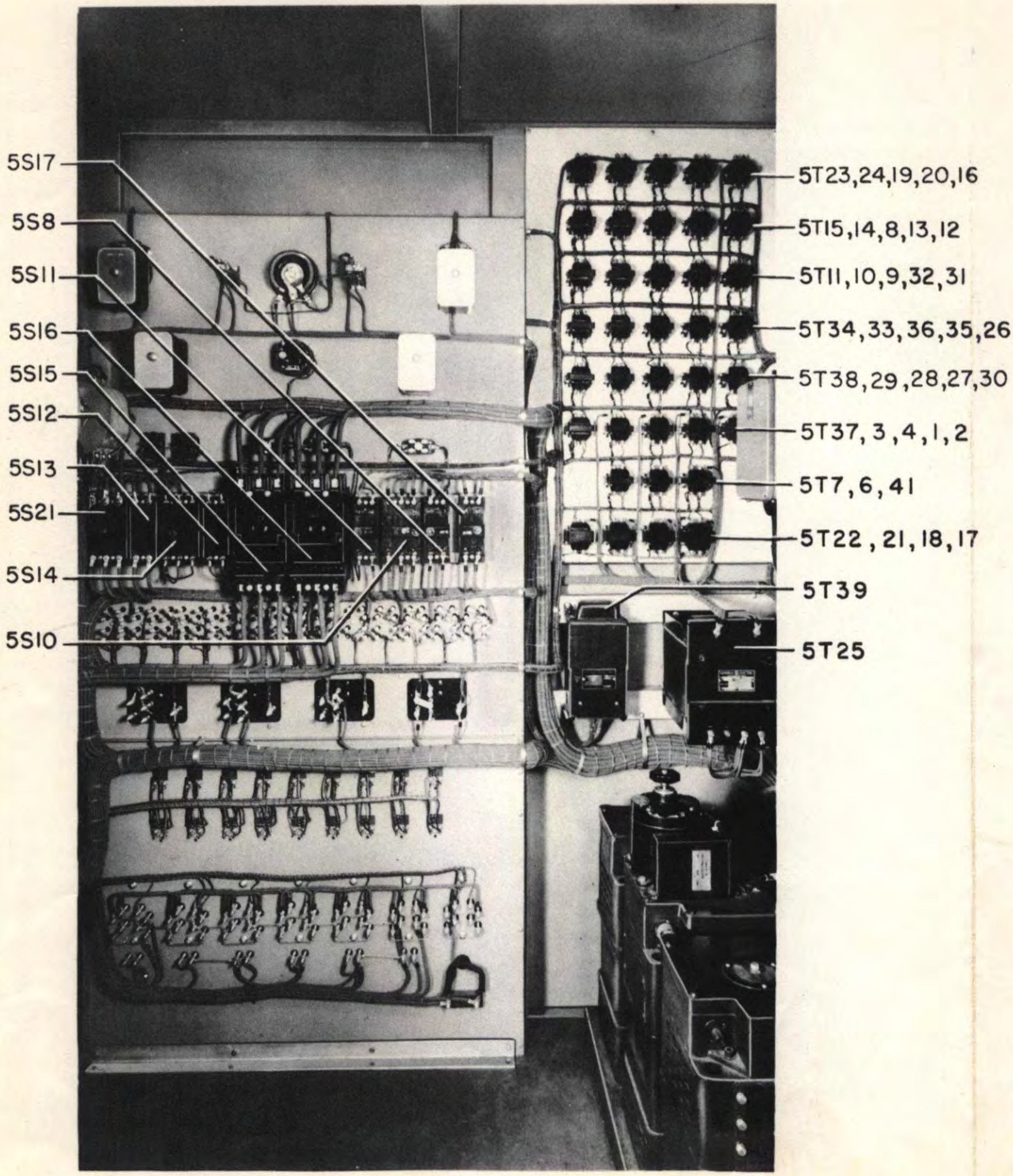


Fig. 4 Control Cubicle, Rear View, Parts in Center Section Identified (SY5046A)

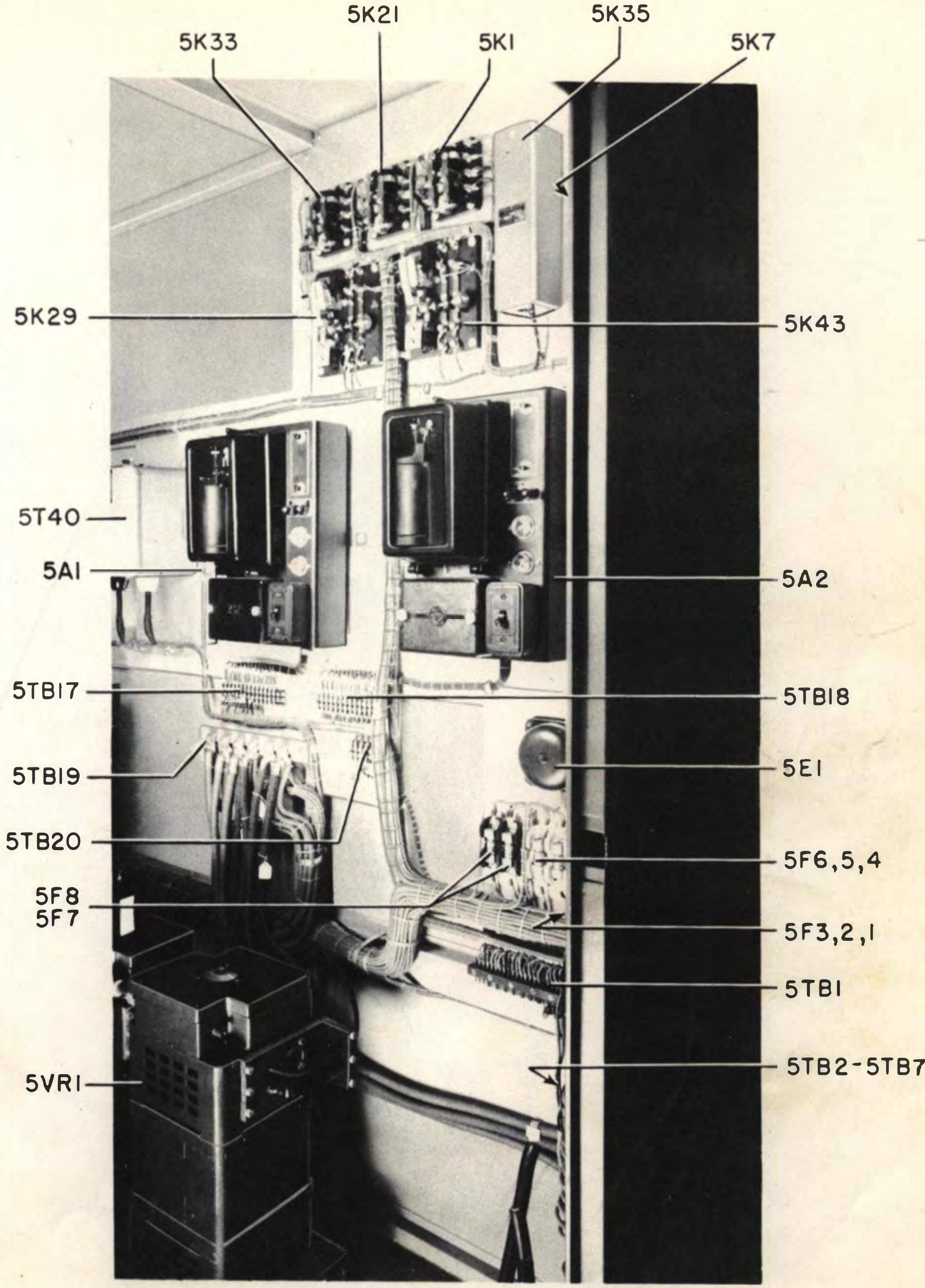


Fig. 5 Control Cubicle, Rear View, Parts on Left Side Identified (SY5041A)

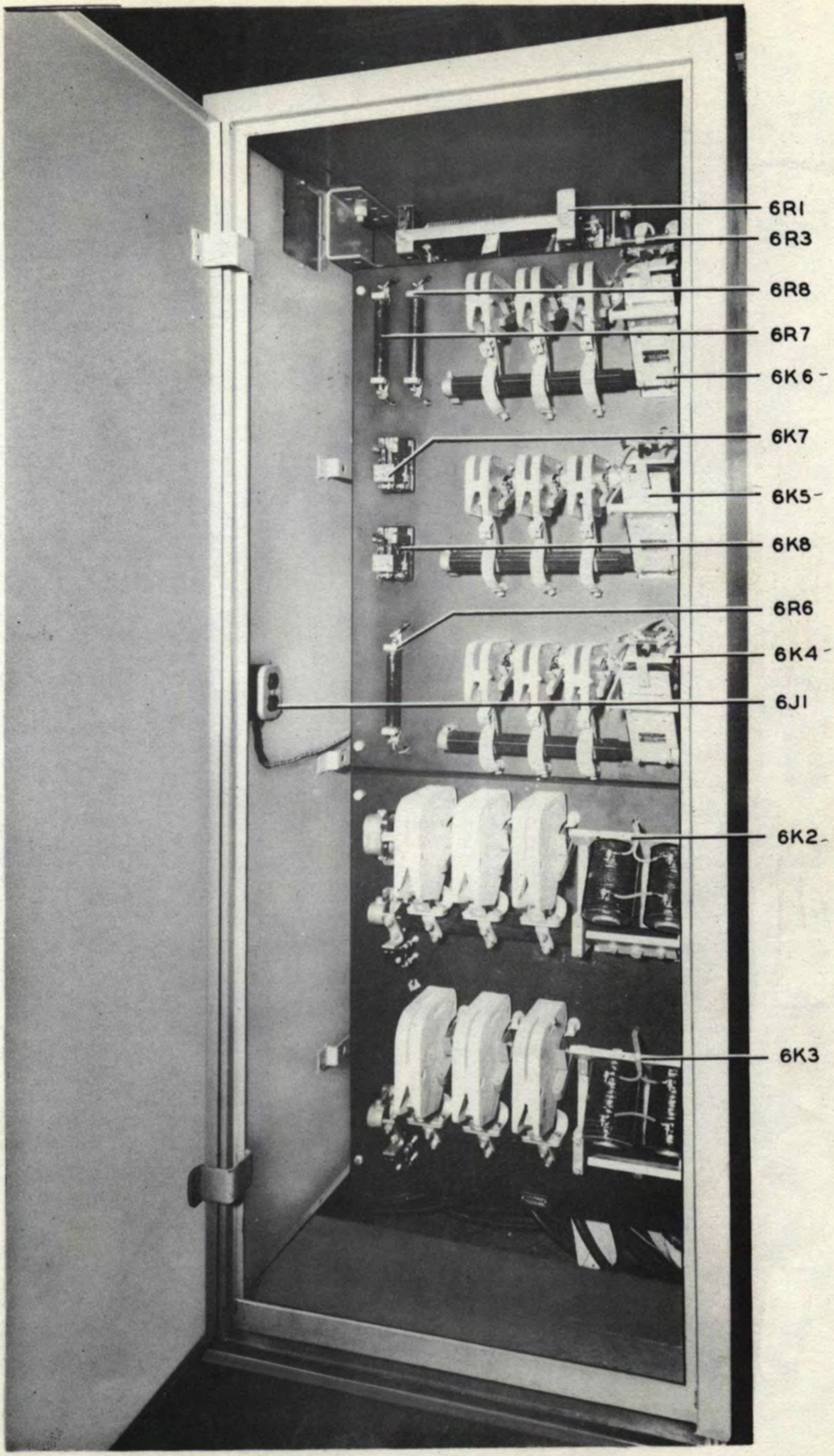
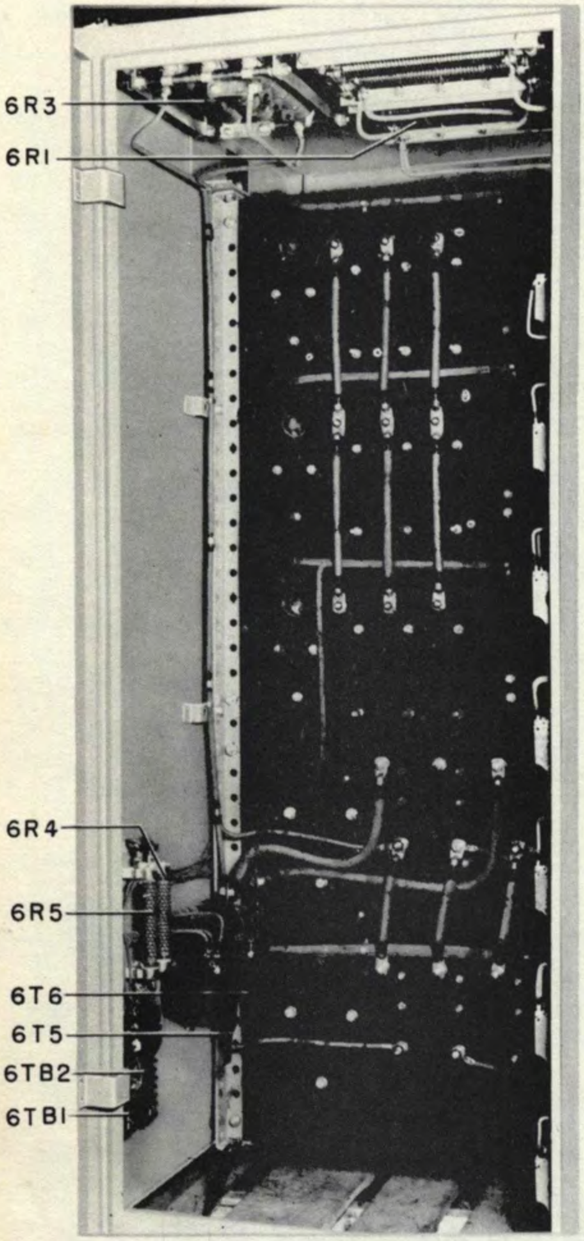


Fig. 6 External Power Cabinet, Front View, Door Open, Parts Identified (SY5267A)



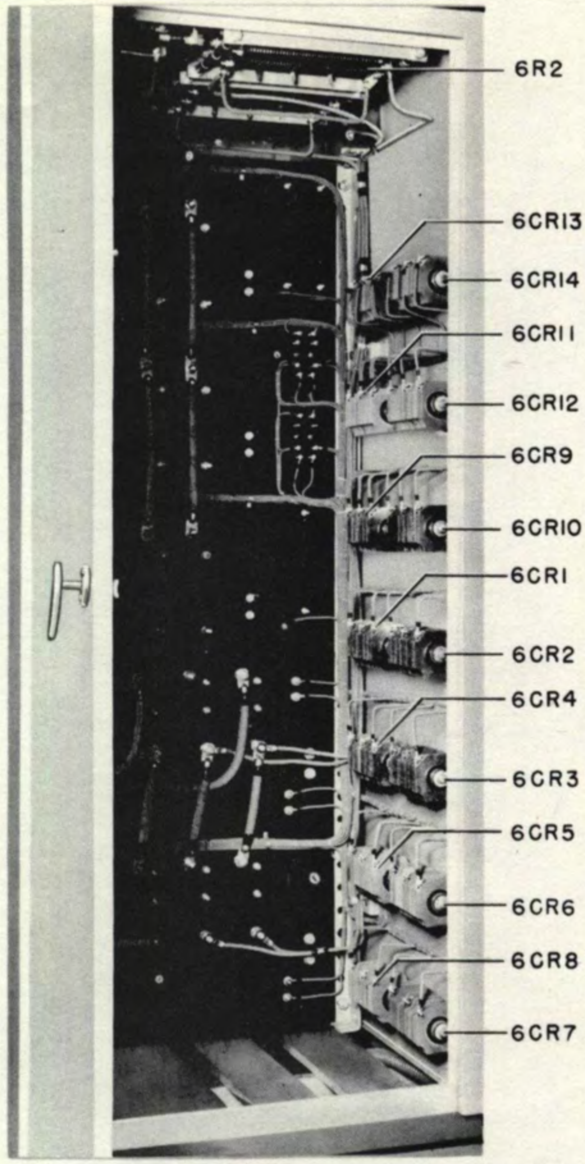


Fig. 7 External Power Cabinet, Rear View, Parts on Right Side Identified (SY5982A)

Fig. 8 External Power Cabinet, Rear View, Parts on Left Side Identified (SY5981A)

(2) Change FILAMENT hour meter 5M3 on the Control Unit panel from the 60 cps model (P3R66-P3) to the 50 cps model (P3R66-P8).

(3) The "time of operation" of timing relays 5K5, 5K6, 5K32 and 5K45 will be 20 per cent longer than the values indicated on their calibrating dials. This should be taken into consideration if these relays are adjusted.

(4) The blower motor starter, 6K1, has a coil (22D112G3) for 60 cps operation. For 50 cps operation replace this with coil 22D112G8 supplied with the starter.

(5) Change the ratio of the adjustable sheaves on Blower Motor 6BM1 (see Section XI on MAIN AIR CIRCULATING SYSTEM).

(6) Change the taps on PA filament transformers 2T12, 2T13, 2T14, 2T15, 2T16, 2T17 and on modulator filament transformers 3T13, 3T14, 3T15, 3T16, 3T17, and 3T18 (move all leads on primary terminal H_2 over to H_1). See Section VIII on POWER AMPLIFIER and Section IX on AUDIO-MODULATOR UNIT.

POWER DISTRIBUTION

Main Breakers

The incoming power connects directly to customer's main switch. See Fig. 41. WARNING - THIS SWITCH SHOULD BE OPENED BEFORE ENTERING THE 460 VOLT AREAS.

Air circuit breaker 6S1 controls all power to the Transmitter except that to the HV rectifier plates. This breaker (6S1) can be closed or opened directly from the breaker position, or remotely by means of control switch 5S1 (MAIN BREAKER) on the Control Unit (indicating lights 5I1 and 5I2 show status of the breaker). This breaker has an interrupting rating of 15,000 amperes which is more than adequate for any normal requirement. The trip-out adjustment can be set between 125 and 250 amperes. The breaker has an inverse time characteristic for overcurrents of up to ten times the normal setting, and instantaneous trip-out for overloads exceeding this value.

Power for the HV rectifier plates is supplied through circuit breaker 6S2 (HV RECT) which can be operated at the breaker or by means of control switch 5S2 on the Control Unit panel (5I3 and 5I4 show the breaker status). This breaker also is rated at 15,000 amperes interrupting capacity and is adjustable for trip-out from 225 to 450 amperes. The inverse time feature is very desirable as it assures that ordinary overloads such as tube gas-kicks will be handled automatically by the overload relays and contactors without tripping the breaker. Instruction Bulletin GEI-10982B included in Section XVII gives maintenance and operational information on these breakers.

Power for breaker control is supplied through enclosed switch 6S4 and associated fuses 6F1 and 6F2.

If desired, a disconnect switch can be connected in the circuit between the output of plate regulator 6VR1 and the plate transformer, as indicated on Fig. 41. This provides a positive, visual disconnect which can be opened before entering the plate transformer enclosure.

Power Distribution Circuit Breakers

Each branch circuit is protected by means of a magnetic or thermal-magnetic manually operated air breaker. Fig. 41 clearly indicates the function of each breaker. They are rated at 5000 amperes interrupting capacity. When operated by an overload, the handle moves to a neutral position giving positive indication of tripping.

Induction Regulators

Filament regulator 5VR1 and contact-making voltmeter assembly 5A1 located in the non-interlocked Control Cubicle hold the bus voltage at 230 volts. Adjustments for the contact-making voltmeter are covered by Instruction Bulletin GEH 1085B in Section XVII. Switch 5S22 on the Control Unit panel allows MANUAL control of the regulator as switch 5S20 on the same panel is thrown to RAISE or LOWER. When 5S22 is thrown to AUTOMATIC, the regulator is controlled by contact-making voltmeter assembly 5A1. Variable resistor 5R4 (FIL VOLTAGE ADJUSTMENT) permits panel-control of the regulated voltage. When 5S22 is in the TEST position, both the switch and the contact-making voltmeter control the regulator as explained in the Instruction Bulletin. The regulator will correct for input voltage variations of $\pm$ 10 per cent.

Plate regulator 6VR1, if used, is normally located in the external power enclosure. Its contact-making voltmeter 5A2 is located in the Control Unit. The MANUAL-TEST-AUTO SWITCH 4S6, the RAISE-LOWER Switch 4S7, and regulated PLATE VOLTAGE ADJUSTMENT 4R11 are located on the HV Rectifier Unit Panel. Bulletin GEI-21709 describes this regulator. The range of this regulator is also $\pm$ 10 per cent. See Section X for transformer ratio-adjuster settings when 6VR1 is used.

Relays and Contactors

The larger contactors are d-c energized by means of metallic rectifiers for reducing audible hum to a low value. These rectifiers are supplied control power at 220 volts for either 60 cps or 50 cps operation. The d-c operated contactors are listed as follows:

Symbol	Function	Associated Rectifier
5K19	PA Filaments	5CR1, 5CR2
5K20	Modulator Filaments	5CR5, 5CR6
6K2	HV Rectifier Start	6CR1, 6CR2 6CR3, 6CR4
6K3	HV Rectifier Run	6CR5, 6CR6 6CR7, 6CR8
6K4	HV Rectifier Tap Change (60 per cent)	6CR9, 6CR10
6K5	HV Rectifier Tap Change (80 per cent)	6CR11, 6CR12
6K6	HV Rectifier Tap Change (100 per cent)	6CR13, 6CR14

Smaller contactors and relays are a-c operated. With most of these, when the power supply is 50 cps, the coil voltage must be reduced to 5/6 of the 60 cps value. This is accomplished by changing a tap on control transformer 5T25. A few other relays in the following list operate on full line voltage (220 volts) for either 50 or 60 cps; these are indicated by an asterisk.

Symbol	Function
*3K1	Audio Bias Change Relay
*3K2	Audio Bias Change Relay
*3K3	Audio Bias Change Relay
5K1	Transmitter Start Latching Relay
5K2	LP Filament Contactor
*5K3	Low Power Filament Auxiliary
5K4	Blower Start Auxiliary
5K8	Auxiliary to Filament Time Delay
5K9	Air Interlock Auxiliary
5K10	Modulator Unit Door Interlock Auxiliary
5K11	Exciter Unit Door Interlock Auxiliary

Symbol	Function
5K12	Power Amplifier Unit Door Interlock Auxiliary
5K13	Rectifier Unit Door Interlock Auxiliary
5K14	External Enclosure Door Interlock Auxiliary
5K15	Door Interlock Relay
5K16	LV and Bias Rectifier Contactor
5K17	AF Bias Interlock
5K18	Power Amplifier Bias Interlock
5K21	Intermediate Rectifier Start Latching Relay
5K22	Intermediate Rectifier Start Contactor
5K24	Intermediate Rectifier Run Contactor
5K29	Intermediate Rectifier Automatic Reclosure Relay
5K30	Intermediate Rectifier Lockout Relay
5K31	Intermediate Rectifier Lockout-Reset Relay
5K33	HV Rectifier Start Latching Relay
*5K36	PA and Modulator Filament Auxiliary Relay
5K43	HV Rectifier Automatic Reclosure Relay
5K44	HV Rectifier Lockout Relay
5K46	HV Rectifier Lockout-Reset Relay
5K47	Intermediate Rectifier Overload Supervisory Relay
5K48	Exciter (2nd IPA) Overload Supervisory Relay
5K49	Exciter (3rd IPA) Overload Supervisory Relay
5K50	Audio (3rd AF, LH) Overload Supervisory Relay
5K51	Carrier Trip Circuit Supervisory Relay

Symbol	Function
5K52	PA (LH) Overload Supervisory Relay
5K53	PA (RH) Overload Supervisory Relay
5K54	Modulator (LH) Overload Supervisory Relay
5K55	Modulator (RH) Overload Supervisory Relay
5K56	HV Rectifier AC Overload Supervisory Relay
5K57	HV Rectifier AC Overload Supervisory Relay
5K59	Audio (3rd AF, RH) Overload Supervisory Relay
6K1	Main Blower Starter (change coil for 50 cps)
*6K7	HV Rectifier Start Auxiliary
*6K8	HV Rectifier Run Auxiliary

Timing Relays

Symbol	Type	Function	Normal Timing
5K5	Telechron Motor	Shut-Down Timing	5 minutes TO
5K6	Telechron Motor	Filament Time Delay	2 minutes TC
5K7	Escapement	Filament Time Delay Bypass	3 seconds TRO
5K23	Escapement	Intermediate Rectifier Plate Step-Start Timing	1 second TC
5K32	Telechron Motor	Intermediate Rectifier Reclosure Circuit Auto-Reset Timing	10 seconds TC
5K35	Escapement	HV Rectifier Reclosing Timing	1 second TRC
5K45	Telechron Motor	HV Rectifier Reclosure Circuit Auto-Reset Timing	10 seconds TC
5K60	Escapement	Intermediate & HV Rectifier Start Circuit Auxiliary	1 second TC
4K8	Magnetic Flux	HV Rectifier Tube change Auxiliary	1 second TRC
6K2	Escapement	HV Rectifier Start	1.5 seconds TC

Abbreviations:

TO.	-	Time delay opening
TC	-	Time delay closing
TRO	-	Time delay re-opening
TRC	-	Time delay re-closing
NO.	-	Normally open
NC	-	Normally closed
CW	-	Clockwise
CCW	-	Counter-clockwise
LH	-	Left Hand
RH	-	Right Hand

Overload Relays

Symbol	Function	Normal trip-out Adjustment
5K25	Intermediate Rectifier OL	40 amp
5K26	Exciter (2nd IPA) OL	275 ma
5K27	Exciter (3rd IPA) OL	1.75 amp
5K28	Audio (3rd AF, LH) OL	600 ma
5K37	PA (LH) OL	5.0 amp
5K38	PA (RH) OL	5.0 amp
5K39	Modulator (LH) OL	6.0 amp
5K40	Modulator (RH) OL	6.0 amp
5K41	HV Rectifier OL	6.0 amp
5K42	HV Rectifier OL	6.0 amp
5K58	Audio (3rd AF, RH) OL	600 ma

CONTROL SEQUENCE

General

Refer to Fig. 41.

Although the control circuits may at first appear complex, they are actually quite straightforward. In arranging the circuits, particular attention was given to safety of personnel, protection of equipment and reliability of operation. The operator may choose either manual or automatic operation.

Control Circuit Operating Voltages

220 volts is supplied by transformer 5T25 through CONTROL CIRCUIT breaker 5S8. The terminal on one of the wires to this transformer is red-enamelled. This terminal connects to X4 on 5T25 for 60 cps operation and to tap X3 on 5T25 for 50 cps operation. Tap X2 connects to ground so that the maximum voltage from the control circuit to ground does not exceed 150 volts rms.

Color-Coding of Indicator Lights

The Transmitter employs pushbuttons with internal indicating lights. The button which is illuminated is always the one to be depressed to perform the indicated operation. Depressing the button which is not illuminated will have no effect.

The indicating-light color selection is such that green always indicates "ready", showing that power is available, and the starting sequence has been completed up to the indicated point. Red indicates that the circuit is energized and in operation. White always indicates an abnormal condition, such as overload, open door, etc. During normal operation, only red lights are illuminated.

Starting Sequence, Low Power Filaments, Blower Starting, Shut-Down Timing

With breakers 6S1 and 5S8 closed, the green pushbutton, 5IS1, lights. White lights, 5I5, 5I11, 5I12, 5I13 and white pushbutton 5IS4, will also be lighted if all doors are closed. Depressing

5IS1 causes transmitter start latching relay 5K1 to "latch in." This causes the green light of 5IS1 to go out, the red pushbutton, 5IS2 to light and the low power filament contactor 5K2 which applies power through breaker 5S14 to all low power filaments to be energized. Another finger on 5K2 energizes blower start auxiliary 5K4 which closes the starting circuit of main blower starter 6K1 and also feeds through breaker 5S11, power to the rectifier blowers in the HV rectifier unit. When 5K2 picks up, the circuit to the coil of shut down timing relay 5K5 is opened.

On shut down, when 5IS2 is depressed, 5K2 falls out and its normally closed finger closes, applying power to shut down timing relay 5K5. 5K5 requires 5 minutes for its TO. contact to open. During this time, 5K4 remains energized and the Main and Small Blowers are kept running.

Filament Time Delay, Air Interlocks, High Power Filaments

When power is applied (by 5K2) to low power filaments and to HV rectifier tube filaments, low power filament auxiliary relay 5K3 picks up and one of its NO. fingers closes and starts filament time delay relay 5K6 operating. Another NO. finger of 5K3 closes and if air interlock relay 5K9 is closed (air interlock 6S3 and p-a air box switch 2S14 being closed as indicated by white light 5I3 being out) power is supplied through an interlock finger of main blower starter 6K1 and p-a switch 2S13 and modulator switch 3S10 to the metallic rectifier associated with p-a filament contactor 5K19 and modulator filament contactor 5K20. These contactors close applying power through breakers 5S16 and 5S15 respectively to p-a and modulator filaments. At the same time supervisory white lights 5I12 and 5I13 go out.

Filament Time Delay, Power Failure Relay, Door Interlocks and Relays, Low Voltage and Bias Power, Bias Interlock

Two minutes after filament time delay relay 5K6 has been energized, its TC finger closes applying power to time delay bypass relay 5K7 which picks up instantaneously energizing auxiliary relay 5K8. When 5K8 picks up, the white light in 5IS4 goes out. Time delay bypass relay 5K7 requires 3 seconds TRO (time re-opening) when de-energized. In case of a brief (up to 3 seconds) power failure 5K7 holds in during the period of no voltage so that on return of power, the Transmitter returns to operation without requiring the usual 2 minute wait for 5K6 to operate. For emergency re-start following a failure of over 3 seconds, EMERG START button 5IS4 (whose white light will then be illuminated) can be depressed. See paragraph on Installation and Operation of Tubes (Section X) for further information.

All cubicles are interlocked except the Control Unit. (White indicating lights 5I5, 5I6, 5I7, 5I8, 5I9, 5I10 indicate which interlocked unit has doors open. However, if two units have doors open, only one light will indicate until the doors in that corresponding unit are closed. Then the light for the other unit will come on.)

If all interlocked doors are closed, door interlock relay 5K15 picks up. Closing of this relay removes the shorts from the INT PLATE and HV PLATE OFF buttons and closes the circuits to the corresponding latching coils of 5K21 and 5K33. (The circuit is so arranged that INT PLATE and HV PLATE "Off" buttons are automatically operated in case an interlocked door is opened. TC Relay 5K60 assures that this circuit will not defeat the automatic power failure circuit). 5K8 having closed and 5K15 now being closed, low voltage and bias contactor 5K16 picks up. This applies power through breaker 5S12 to the low voltage rectifier and to the p-a and a-f bias rectifiers. Bias interlocks 5K17 and 5K18 pick up when bias is normal and cause the bias white indicating light 5I11 to go out.

Intermediate Rectifier Circuit, Automatic Reclosure, Lockout

Low voltage and bias contactor 5K16 and bias interlock relays 5K17 and 5K18 being closed, the circuit is now closed as far as the contacts of intermediate rectifier start latching relay 5K21. The green "ready" lights in INT PLATE ON pushbuttons 1IS1, 2IS4, 3IS2, 8IS1 come on. Pushing any of these causes 5K21 to "latch-in", closing the circuit to intermediate rectifier start contactor 5K22 which applies power through breaker 5S13, coil of overload relay 5K25 and starting resistor 5R3 to the intermediate rectifier plate transformer 1T9. An NC finger on 5K22 opens, extinguishing the green lights in the INT PLATE ON pushbuttons. At the same time relay 5K23 starts to operate and after 1 second its TC finger closes and operates intermediate rectifier run contactor 5K24 which shorts starting resistor 5R3, allowing normal intermediate rectifier voltage. When 5K24 closes, one of its fingers applies voltage to the red lights in INT PLATE OFF buttons 1IS2, 2IS3, 3IS1, 8IS2.

Normally closed contacts of overload relays 5K25, 5K26, 5K27, 5K28, 5K58 are in series with the coil circuits of intermediate rectifier contactors 5K22 and 5K24; if an overload occurs which trips any of these relays, the contactors remove power. If INT LOCKOUT switch, 5S3, is placed in the "lockout" (up) position for testing (in which case white light 5I15 is lighted) and an overload occurs, the NO. contact of the associated relay closes momentarily and applies power to the coil of reclosure relay 5K29. The NO. instantaneous contact of 5K29 closes and causes intermediate rectifier lockout relay 5K30 to be energized and to seal itself in. This opens the circuit to contactors 5K22 and 5K24, thereby removing and "locking-out" intermediate rectifier plate power. When this "lockout" occurs, white intermediate rectifier lockout light 5I14 is illuminated. The green lights in the INT PLATE ON pushbuttons also are illuminated. Pushing any of these energizes lockout reset relay 5K31 whose NC contact opens, permitting lockout relay 5K30 to fall out, lose its seal, and to reapply intermediate rectifier plate power in the sequence outlined in the preceding paragraph.

During normal operation INT RECTIFIER LOCKOUT switch 5S3 will be in its OFF position (white intermediate rectifier lockout switch position light 5I15 will not be lighted). Reclosure Relay 5K29 is a "notching" type which has a closing coil, a reset coil, a NO. instantaneous contact (which closes while the closing coil is energized), one contact designated OOOC and a contact designated OCCO. Operation of the relay is such that, as the closing coil is successively energized three times, the OOOC contact moves from Open, to Open, to Open, and to Closed: simultaneously the OCCO circuit changes from Open, to Closed, to Closed, to Open. With this arrangement a first and a second overload will permit power to be automatically reapplied but a third will leave power on 5K30 which will "lockout" the circuit as described above. Depressing an INT PLATE ON pushbutton energizes the reset coil of lockout relay 5K29 through 5K31 and returns the relay to its initial position, permitting intermediate rectifier to come on. To prevent an accumulation of operations on 5K29, an automatic reset timing relay 5K32 closes after 10 seconds (providing not more than 2 overloads have occurred) and automatically resets 5K29 to its initial position. However, if the third overload occurs before 5K32 has operated, power is removed from 5K32 and an INT PLATE ON pushbutton must be pushed to restore operation.

HV Rectifier Circuit, Automatic Reclosure, Lockout

When intermediate rectifier run contactor 5K24 goes in, its NO. interlock finger in the HV rectifier contactor coil circuit closes and, assuming plate transformer tap change switch 4S1 is not in an OFF position, the green lights in HV PLATE ON pushbuttons 4IS1, 2IS2, 3IS4, 8IS3 come on. Pushing any of these causes 5K33 to "latch-in" thereby applying power to auxiliary relays 6K7 and 6K8 and to copper oxide rectifiers 6CR1, 6CR2, 6CR3 and 6CR4, and energizing HV rectifier start contactor 6K2. 6K2 applies power, through starting resistors 6R1, 6R2 and 6R3 to the HV rectifier plate transformers. After approximately 1 second the TC finger of 6K2 closes, causing the HV rectifier run contactor 6K3 to close. The red lights in HV PLATE OFF buttons 4IS2, 2IS1, 3IS3, 8IS4 are now lighted.

Normally closed contact of overload relays 5K37, 5K38, 5K39, 5K40, 5K41, 5K42 are in the coil circuit of HV rectifier contactors 6K2 and 6K3 and their auxiliary relays 6K7 and 6K8 (these break the d-c coil circuit for faster operation). If an overload occurs to trip any of these relays the contactors remove power. If HV lockout switch 5S6 is placed in the "lockout" position for testing (in which case white light 5I17 is lighted), and an overload occurs, the NO. contact of the associated overload relay closes momentarily and applies power to the coil of reclosure relay 5K43. The NO. instantaneous contact of 5K43 closing energizes HV rectifier lockout relay 5K44 which seals itself in and opens the circuit to contactors 6K2 and 6K3, thereby removing and "locking-out" the HV rectifier. When the "lock-out" occurs, white HV rectifier lockout light 5I16 is illuminated. The green lights in the HV PLATE ON pushbuttons also are lighted. Pushing any of these momentarily energizes lockout reset relay 5K46 whose NC contact opens, permitting lockout relay 5K44 to fall out, lose its seal, and allow the HV rectifier plate power to be reapplied in the proper sequence.

During normal operation HV rectifier lockout switch 5S6 will be in its OFF Position (white main rectifier lockout switch position light 5I17 will not be lighted). Reclosure relay 5K43 is similar to 5K29 previously described and has the same contact arrangement (1-NO., 1-OOOC, 1-OCCO). On a third overload 5K43 leaves power on lockout relay 5K44 which will "lock-out" the circuit. Pushing an HV PLATE ON button energizes the reset coil of lockout relay 5K43, by means of 5K46, and returns the relay to its initial position permitting HV rectifier to come on. To prevent an accumulation of operations on 5K43, an automatic reset timing relay, 5K45, closes after ten seconds, providing not more than two overloads have occurred, and automatically resets 5K43 to its initial position. However, if the third overload occurs before 5K45 has operated, power is removed from 5K45 and an HV PLATE ON pushbutton must be pushed to restore operation. On each overload relay 5K35 is energized. This relay requires one second for TRC (time re-closing) and prevents too rapid re-application of power in case of a severe overload.

<u>HV Rectifier Plate Voltage Change Circuit</u>

Switch 4S1 controls selection of the desired voltage taps on HV rectifier plate transformers 6T7, 6T8, 6T9. As this switch is turned, the "a" section opens the HV rectifier plate contactor's coil circuit removing plate power; at the same time the "b" section drops out the operating tap change contactors (either 6K4, 6K5, 6K6). Then as the switch is turned further to the selected position, the desired tap change contactor picks up and the plate voltage is re-applied in proper sequence. These tap change contactors are d-c operated by means of copper oxide rectifier 6CR9, 6CR10, 6CR11, 6CR12, 6CR13, 6CR14. A running resistor (6R6, 6R7 or 6R8) is inserted in the circuit when a tap change contactor closes to reduce its holding current. Tap change switch 4S1b also selects the proper bias change relay (either 3K1, 3K2, 3K3) to automatically adjust the modulator bias for the plate voltage.

Supervisory Light Relays

When an overload relay (or the carrier trip relay 1K1, described later) operates, power is applied to its corresponding supervisory light relay (5K47, 5K48, 5K49, 5K50, 5K51, 5K52, 5K53, 5K54, 5K55, 5K56, 5K57, or 5K59). When one of these relays is energized one of its NO. contacts closes permitting it to seal itself in so that it remains energized even after removal of the overload. When this occurs, the corresponding white supervisory light (5I18, 5I19, 5I20, 5I21, 5I22, 5I23, 5I24, 5I25, 5I26, 5I27, 5I28, or 5I29) is illuminated. Whenever one or more of the above relays is energized, power is applied to the white indicator lamp in supervisory light reset pushbutton 5IS3; pushing this resets all supervisory relays.

Carrier Trip Circuit, Audio Dropping Relay

When 5K16 closes, if carrier trip circuit switch 1S4 is closed, power is applied to selenium rectifier 1CR1. Red light in carrier trip TEST pushbutton 1IS3 lights. Approximately 60 volts d-c feeds through carrier trip relay 1K1 and resistor 1R50 to the p-a grid tank, p-a neutralizing coil, p-a plate tank, harmonic filter, transmission line, antenna terminating equipment and antenna. If an arc-over occurs at any of these points, a ground circuit is established which permits 1K1 to operate; this applies negative bias to the first i-p-a screen, reducing the r-f output to extinguish the arc, after which operation is automatically restored. Whenever 1K1 operates, audio drop relay 3K4 is energized. This inserts a 15 db pad in the transmitter audio input to reduce the modulation transformer voltage. 3K4 is also energized until the HV rectifier contactors close. This prevents the 3rd audio stage from overloading during starting. Power switch 1S4 should be closed during normal operation. 1IS3 is used to test the operation of the system by simulating an antenna arc-over.

Carrier Alarm Circuit

Carrier off bell 5E1 is wired in series with an NC contact of carrier off relay 7K1 and the carrier alarm switch on the customers operating console. Whenever the carrier drops to approximately 20 per cent of normal voltage, 7K1 falls out and 5E1 rings to warn the operator.

HV Rectifier Tube Change

Refer to Fig. 40.

Rectifier tube change contactors 4K1, 4K2, 4K3, 4K4, 4K5, 4K6 are mechanically held in the position in which their coils are de-energized. To connect the spare rectifier tube into a tube position, the TUBE CHANGE SELECTOR switch 4S2 is first set for that position. When TUBE CHANGE pushbutton 4IS3 (whose red light is illuminated if the HV rectifier is "on") is pushed, 4K7 is energized, and when it picks up the HV rectifier plate contactors drop out removing plate voltage. When the plate contactors drop out, voltage is removed from the TRC relay 4K8; after approximately 1 second 4K8 falls out applying power to the reset coils of all tube change relays except the one selected, and to the latch coil of the selected one. The white indicating light (4I1, 4I2, 4I3, 4I4, 4I5, or 4I6) for the selected position then lights. Removing pressure from 4IS3 then permits plate voltage to be reapplied in the proper sequence and with the desired rectifier tube change.

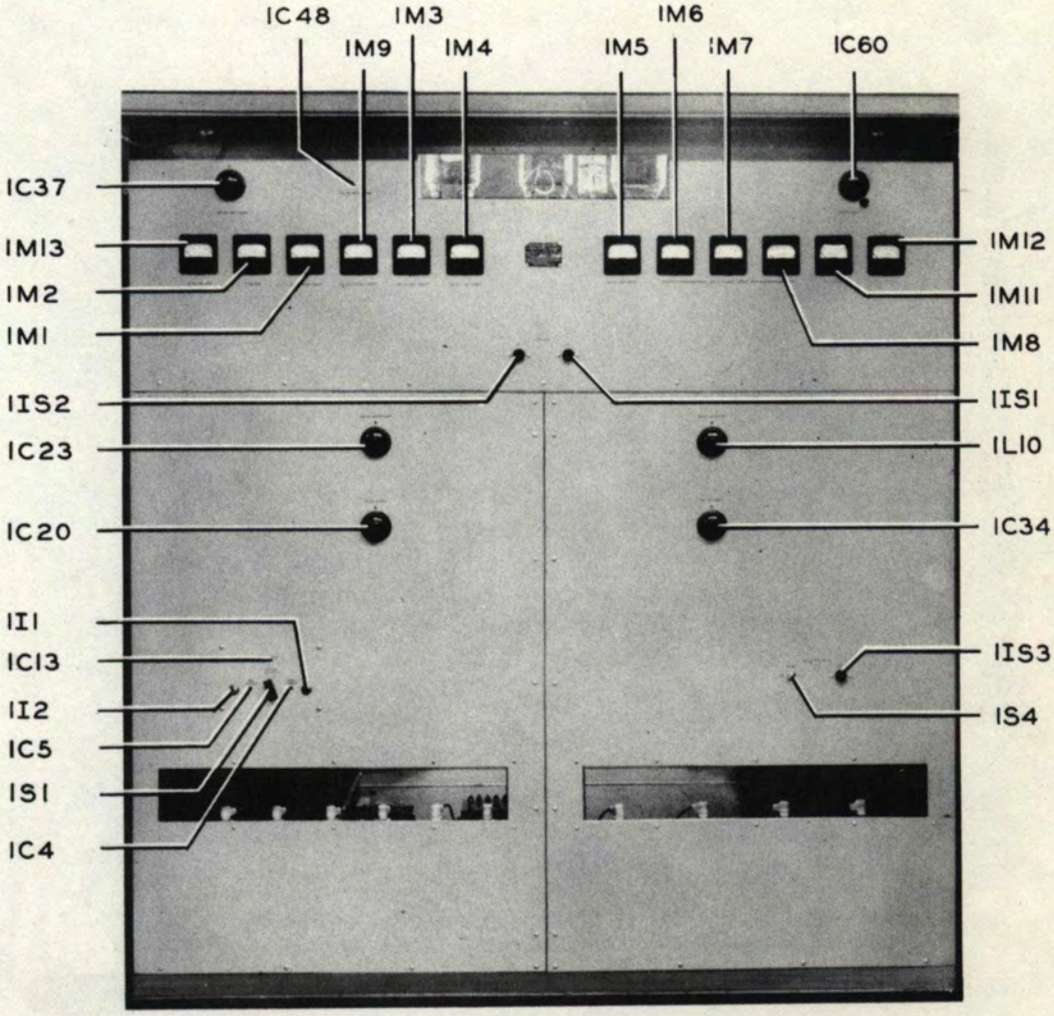


Fig. 9 Exciter Cubicle, Front View, Doors Open, Parts Identified (SY5256A)

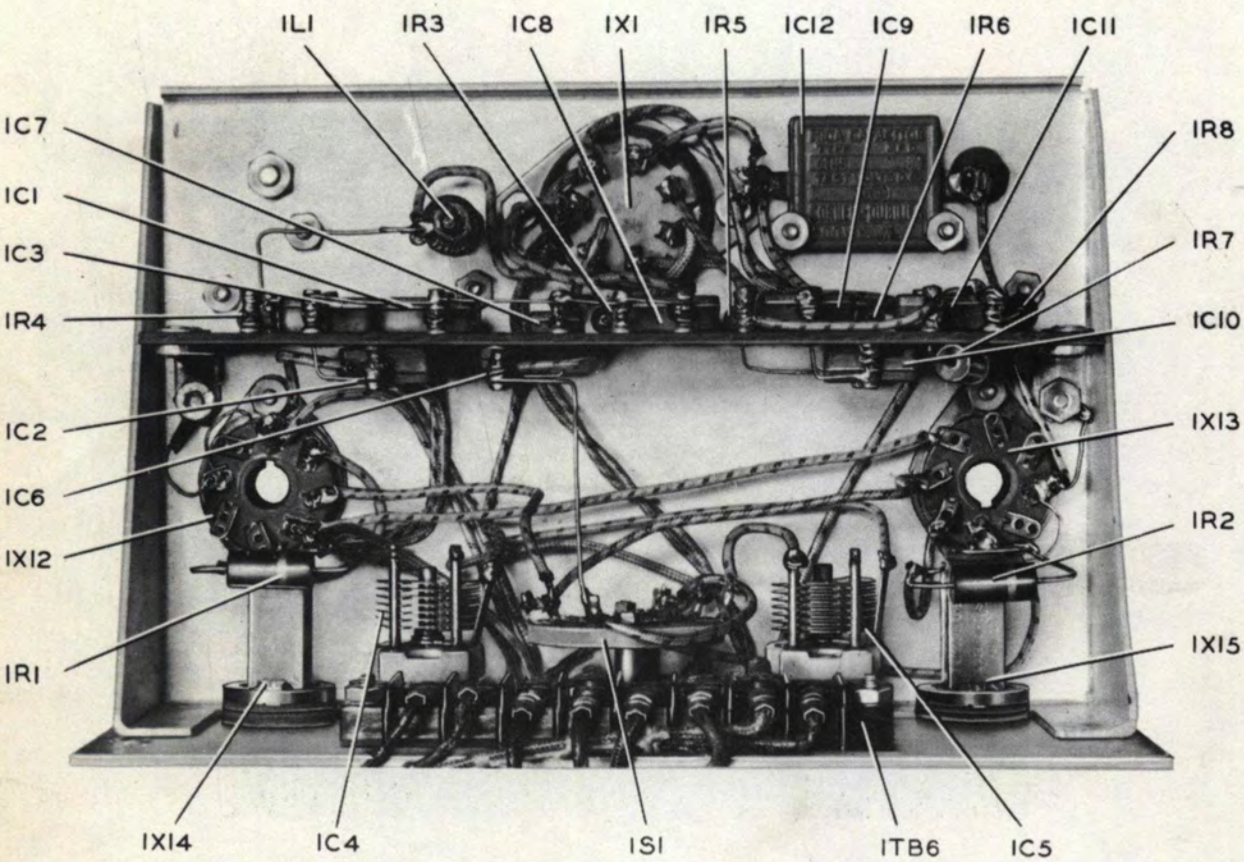


Fig. 9a Exciter Cubicle, Crystal Oscillator (1A1), Bottom View, Parts Identified (SY2070A)

-EXCITER-

General

The Exciter cubicle contains the following circuits:

Crystal Oscillator	Type GL-837
1st IPA	Type GL-828
2nd IPA	Type GL-810
3rd IPA	3 Type GL-833A
Low Voltage Rectifier (750 volts)	2 Type GL-866-A/866
Intermediate Rectifier (2800/1400 volts)	4 Type GL-8008
AF Bias Rectifier (560 volts)	2 Type GL-8008
PA Bias Rectifier (300 volts)	2 Type GL-866-A/866
Power Factor Correction Capacitors	

All transformers in this unit are designed for 50/60 cps and may be used on either frequency without re-connection. The filament transformers are designed for either 230 or 208 volt primary (terminals 1 and 3 for 230 volts, and terminals 1 and 2 for 208 volts). In this transmitter only the 230 volt connection is used.

Besides the normal door interlock switch (1S3), safety grounding switches 1S2 and 1S6 operate to ground both d-c and a-c leads of the 2800- 1400- and 750-volt supplies whenever the door is opened.

Crystal Oscillator

The crystal-controlled oscillator is housed in a separate shielded compartment. It uses one Type GL-837 tube (1V1) in an electron-coupled circuit of exceptionally high stability. Two low temperature coefficient crystals in individual thermocells (1Y1 and 1Y2) are provided, either of which may be switched into the circuit by the CRYSTAL SELECTOR control 1S1. Indicator lamps 1I1 and 1I2 associated with the Thermocells are located on the exciter front panel. Supply voltage for the crystal heaters is normally obtained from the station's lighting supply (115 volts 50/60 cps) and is usually left on continuously, to maintain the crystals in a ready condition. FREQ TRIMMER capacitors 1C4 and 1C5 are for the purpose of providing a few cycles of frequency adjustment. (Use an insulated screwdriver.)

Coil 1L2 and variable capacitor 1C13 (OCC PLATE) permit peaking of the crystal stage output, this adjustment having negligible effect on the oscillator frequency. Coil 1L2 has three sections for covering the Standard Broadcast range (540 to 1600 KC).

Adjustments

Adjust the value of 1L2 by removing the cover from the oscillator unit and soldering the connecting wire to the proper terminal as indicated by the following table:

1L2

Frequency Range	Connection
540-700 KC	Remove flexible jumper from term.1
701-1100 KC	Connect 1 to 2
1101-1600 KC	Connect 1 to 3

After adjusting 1L2, replace the cover on the oscillator unit and insert the GL-837 tube and the two crystal Thermocells. Apply power to the crystal heaters. Intermittent flashing of indicators 1I1 and 1I2 (cycling of their thermostats) shows that the crystals have reached operating temperature. Start the transmitter by pressing the TRANS ON pushbutton, which allows filaments to come on followed two minutes later by the LV and bias rectifiers. 1R11, 1R12, and 1R14 are slotted-shaft type potentiometers located on the rear of the panel near the oscillator compartment. Set 1R14 for 375 volts as measured from ground to crystal unit terminal 1-7-7. Set 1R11 for 125 volts measured from ground to the moving arm of 1R11. Adjust 1R12 for 175 volts from ground to exciter unit terminal 1-1-12. Tune 1C13 for minimum plate current (approximately 13 ma) as read on 1M1. Check operation of the spare crystal by turning 1S1 to the other position. 1R11, 1R12, and 1R14 are later adjusted to their final settings (3rd IPA TUNING).

1st IPA (GL-828)

The 1st IPA stage uses one Type GL-828 tube (1V2) so operated as to place negligible load on the oscillator. The plate tank circuit consists of 1C20 and 1L3, which must be initially adjusted as follows:

1L3

Frequency Range	Connection
540-970 KC	Use entire coil
971-1600 KC	Short out rear (larger) coil section

This stage is biased by a combination of grid-leak and cathode bias (1R9 and 1R21). Proper adjustment of 1C20 is indicated by a minimum reading on 1st IPA CATHODE CURRENT meter 1M9.

Coil 1L4, consisting of several turns supported in a loop of copper tubing, provides unmodulated r-f output for the station frequency monitor. Coupling to 1L3 may be varied (by shifting the position of 1L4) to give the desired voltage. On initial adjustment of 1L4, start with loose coupling and increase it gradually until sufficient output for the frequency monitor is obtained.

Carrier Trip Circuit

In normal operation the screen of the GL-828 is at a positive potential. On actuating of the carrier trip circuit, relay 1K1 reduces the plate current by applying negative screen voltage. This drops the transmitter output to a low value permitting an antenna arc to be extinguished, whereby 1K1 is de-energized and the carrier is restored. 1C73 and 1R18 constitute a shaping circuit for preventing too rapid a rate of change of plate current during operation of 1K1. The transmitter should normally be operated with the carrier trip circuit energized (POWER SWITCH 1S4 closed and 1IS3 lighted.) The circuit can be tested by depressing TEST button 1IS3 in which case carrier output should drop. (Bulletin EBR-95 gives interesting information on Protection Against Carrier Failure).

Tuning Procedure

Before applying plate power remove the plate caps from 1V4, 1V5 and 1V6 (GL-833A tubes), and remove the ≠ B voltage from the GL-810 stage by disconnecting from 1C27 the bus which connects it to 1L8. Also, rotate the 3rd AF BIAS controls (3R29, 3R30) to their extreme CCW position.

Assuming that the oscillator has been tuned and LV rectifier is turned on, depress the INT PLATE ON pushbutton. Adjust 3RD AF BIAS controls (3R29, 3R30) for 125 ma as indicated on the respective 3RD AF PLATE CURRENT meter, (3M10, 3M11) Tune capacitor 1C20 (1ST IPA TUNING) for minimum cathode current (approximately 60 ma) as indicated on 1M9. Adjust the position of 1L3 for proper input to the station frequency monitor and trim each crystal for the precise frequency by means of FREQ TRIMMER 1C4 and 1C5.

2nd IPA (GL-810)

The 2nd IPA uses 1 Type GL-810 tube (1V3). Its tank circuit consists of inductor 1L9, variable capacitor 1C34 and fixed vacuum capacitors 1C28 through 1C33. Make preliminary plate circuit tuning adjustments in accordance with the following table:

FREQ RANGE (KC)	NUMBER OF VACUUM CONDENSERS USED (1C28-1C33)	SHORT BETWEEN TAPS (1L9)
540-680	6	None
*681-700	5	None
701-800	5	11-12
801-840	5	13-12
841-870	4	11-12
871-1000	4	13-12
1001-1150	3	13-12
1151-1300	3	14-12
1301-1350	2	14-12
1351-1450	2	15-12
1451-1600	2	15-12

* For this range only, connect the incoming lead to terminal 0 with a length of tinned copper wire.

Coil neutralization is used in this stage (GL-810). Inductance 1L7 is resonated with the grid-plate tube capacity and 1C23. This results in high grid-to-plate impedance and negligible feedback. Adjust the inductance of 1L7 as follows:

1L7

Frequency Range	Connect shorting wire to indicated terminal (numbered from the bottom of the coil).
540-800 KC	*
801-980 KC	2
981-1160 KC	3
1161-1400 KC	4
1401-1600 KC	5

* Remove shorting wire so entire coil is used.

Bias for the GL-810 tube is obtained from grid-leak resistor 1R19 and self-bias resistor 1R20. Overcurrent relay 5K26 (with its protective shunt 1R30) protects the stage from overload. Meter 1M3 indicates 2ND IPA GRID CURRENT AND 1M4, 2ND IPA PLATE CURRENT.

Tuning Procedure

Note that the GL-833A plate caps and the +B lead from 1C27 (taken off during 1st i-p-a tune-up) are still removed. To prevent excessive voltages from being induced in 1L4, reduce its coupling to 1L3 to a minimum for initial tune-up. The lead from X3 on 1T9 should be connected to X1. This provides approximately half of normal INT RECT voltage for testing.

Start the transmitter by pressing the TRANS ON button. If the oscillator and the GL-828 stage are operating properly, 1M3 will indicate 2ND IPA GRID CURRENT. Reduce capacity of 1C23 (2ND IPA NEUTRALIZING) to a minimum to assure off-neutralization. Rotate 1C34 (2ND IPA TUNING) until a "kick" of 2ND IPA GRID CURRENT (1M3) is obtained. This should occur at some setting between minimum and maximum capacity of 1C34. This procedure locates the plate circuit tuning point. Make fine adjustment of 1L9 by moving the jumper from the plate end of the coil to any tap from 1 to 11 to give a desirable setting of 1C34.

Neutralization is then performed by adjusting 1C23 to that setting which gives minimum "kick" on 1M3 as 1C34 is tuned through resonance. Reconnect the +B lead on 1L8 and press the INT PLATE ON button. As a further check on neutralization note that, as 1C34 is tuned through resonance, minimum 2ND IPA PLATE CURRENT (1M4) and maximum grid current (1M3) occur at the same setting - if not, readjust 1C23 slightly.

3rd IPA

This stage uses three GL-833A tubes (1V4, 1V5, 1V6) operated in parallel. The grid tank circuit consists of inductance 1L11, 3RD IPA GRID TUNING capacitor 1C37 and fixed capacitors 1C35 and 1C36. Insert the proper capacitors and make initial adjustments of the two taps on 1L11 as indicated below:

Frequency Range	No. Turns included in ground (coupling) end of 1L11	No. turns shorted out on grid end of 1L11	1C35 Mfds	1C36 Mfds
540-680 KC	10 to 12	0, or 4 to 12 *	.001	.001
681-840 KC	7 to 9	12 to 19	.001	.001
841-1000 KC	8	19 to 22	.001	.00068
1001-1150 KC	6 to 10	19 to 24	.00068	.00068
1151-1300 KC	5 to 6	23 to 26	.00068	.00047
1301-1450 KC	5	24 to 26	.00047	.00047
1451-1600 KC	4 to 5	26 to 28	.00047	.00047

* Do not short less than 4 turns

The plate tank circuit consists of 1L18, fixed capacitors 1C50 through 1C59, 1C88-1C91 and 3RD IPA PLATE TUNING capacitor 1C60. Make initial adjustments as follows:

Frequency Range	Number of 100 mmf Vacuum condensers used (1C50 through 1C59) (1C88 through 1C91)	Number of Active turns in 1L18
540-590 KC	14	26 to 28 **
591-680 KC	10	23 to 28 **
681-840 KC	9	18 to 24 **
841-1000 KC	8	14 to 19
1001-1150 KC	8	12 to 14
1151-1300 KC	7	10 to 12
1301-1450 KC	7	9 to 10
1451-1600 KC	6	8 to 10

** For these ranges only, remove the link on the high-voltage end of 1L18 so the unused turns are not shorted. For the other ranges, allow the link to remain in place so that unused turns are shorted out.

PA grid circuit drive is obtained by inductive coupling to 1L19. Coarse adjustment of loading is provided by varying the number of active turns on 1L19 and fine adjustment by varying its coupling to 1L18. Make initial adjustments as follows:

Frequency Range	No. of Active Turns used on 1L19
540-680 KC	20
681-920 KC	16
921-1140 KC	12
1141-1410 KC	10
1411-1600 KC	8

Procedure for making final adjustment of coupling is given in Section VIII on the Power Amplifier.

Coil neutralizing is used in the 3rd IPA stage, taps on coil 1L16 providing coarse adjustment, and 3RD IPA NEUTRALIZING capacitor 1C48 permitting fine adjustment. Make the following preliminary adjustments of 1L16:

Frequency Range	Connect shorting lead to indicated tap (numbered from upper end of coil)
540-660 KC	-
661-750 KC	1
751-860 KC	2
861-980 KC	3
981-1100 KC	4
1101-1225 KC	5
1226-1365 KC	6
1366-1500 KC	7
1501-1600 KC	8

Approximately 80 volts of holding grid bias is obtained from the AF Bias Rectifier through 1R48 to limit the plate current to about 10 to 20 ma due to loss of excitation. This is needed during carrier trip circuit operation. During normal operation, the grid leak bias overrides the holding bias. Meter 1M5 indicates total 3RD IPA GRID CURRENT and meters 1M6, 1M7, and 1M8 indicate 3RD IPA CATHODE CURRENT for 1V4, 1V5, and 1V6 respectively. Resistors 1R24, 1R26, 1R31 protect the meters from intermediate rectifier voltage in the event of an open-meter. Over current relay 5K27 located in the Control Unit protects the stage from overload.

<u>Tuning Procedure</u>

Replace the plate caps on the three GL-833A tubes and remove +B voltage by disconnecting from 1C49 the wire which comes from 1R43. For first tune up, it is advisable to allow the lead from X3 of 1T9 to remain on terminal X1.

Start the transmitter and turn on intermediate plate power. Tune 3RD IPA GRID TUNING capacitor 1C37 for maximum grid current on 1M5 and adjust the 3RD IPA EXCITATION (1L10) so that 1M5 reads approximately 100 ma. If necessary, readjust the 2ND IPA TUNING and 1C37.

Reduce the capacity of 1C48 to minimum to assure off-neutralization. Rotate 1C60 (3RD IPA PLATE TUNING) until maximum reaction on grid current (1M5) is obtained. This tuning point should appear at some position between minimum and maximum capacity (the tap on 1L18 may require slight readjustment). This procedure determines the tuning position of 1C60.

Neutralization is then performed by adjusting 1C48 to the value which permits a minimum of grid current deflection (1M5) as the plate tuning condenser (1C60) is tuned through resonance.

Reconnect the +B lead to 1C49 and apply intermediate rectifier power. Check neutralization by noting whether or not maximum grid current and minimum plate current occur at the same setting of 1C60 (if not, readjust 1C48 slightly).

Replace the lead from X1 of 1T9 on terminal X3 to permit the application of normal voltage on all exciter stages. Recheck tuning and neutralizing with the coupling between 1L9 and 1L10 (3RD IPA EXCITATION) adjusted for approximately 240 ma of 3RD IPA GRID CURRENT (1M5). If necessary, readjust inductances 1L9, 1L11 and 1L18 slightly to give approximately midscale setting of their corresponding capacitors.

On initial installation check circuit stability by removing the crystal in use and noting that all grid currents fall to zero even when the tank circuits are detuned about the operating point. Further stability checks can be made by depressing the Carrier Trip circuit TEST Button 1IS3. With the intermediate rectifier turned on, readjust 1R11, 1R12, and 1R14 as described in the section on the Crystal Oscillator.

Low-Voltage Rectifier

Two GL-866-A/866 rectifier tubes (1V7, 1V8) in a single phase full-wave circuit operate into the choke input filter consisting of 1L20, 1C64, 1L21, and 1C65. This supply furnishes d-c for the crystal oscillator, for the screen and the suppressor of the GL-828, and for the 1st audio stage. Voltage divider circuit (1R10 through 1R15) permits adjustment of the output voltages as indicated by Fig. 40. LV RECTIFIER meter (1M2) indicates d-c voltage output (approximately 750). Primary taps permit $\pm$ 5 per cent adjustment of voltage. This rectifier is protected from overload by breaker 5S12.

Intermediate Rectifier

The intermediate rectifier uses four GL-8008 tubes (1V9, 1V10, 1V16, 1V17) in a duplex circuit providing output at two voltages. All four tubes operate in a full-wave bridge circuit supplying approximately 2800 volts (filtered by 1L24, 1L25, and 1C68 through 1C71). Rectifier tubes 1V9 and 1V10 also operate as a single-phase full-wave rectifier supplying approximately 1400 volts (filtered by 1L22, 1L23, 1C66, 1C67, 1C86 and 1C87). Primary taps on 1T9 permit output voltage adjustment of ± 5 per cent and also a 50 per cent voltage reduction to be used in testing (tap X4 for +5 per cent, X3 normal, X2 for -5 per cent, X1 for -50 per cent).

The 1400-volt section supplies plate power to the GL-828 and GL-810 stages and to the 3rd audio. The 2800-volt section is used for the 3rd i-p-a (GL-833A) and for the 2nd audio stage. Overcurrent relay 5K25 and breaker 5S13 protect the intermediate rectifier from overload. INT RECTIFIER meter 1M11 provides indication of output voltage.

Audio-Frequency Bias Rectifier

The AF bias rectifier provides bias for the modulator driver and for the modulator. It also provides holding bias for the GL-833A tubes. Two GL-8008 rectifier tubes (1V20, 1V21) in a single-phase full-wave circuit provide an output of approximately -562 volts (1M13) through a choke input filter to the bias network in the modulator cubicle. Primary taps permit ± 5 per cent and ± 10 per cent voltage adjustment. 1R47 drops the voltage to the correct value for holding bias. Undervoltage relay 5K17, located in the Control cubicle, prevents application of intermediate rectifier voltage in case of bias failure.

Power Amplifier Bias Rectifier

Two GL-866-A/866 tubes (1V18, 1V19) in a single-phase full-wave circuit provide holding bias for the p-a stage. Under-voltage relay 5K18, in the Control cubicle, is energized through resistors

1R44 and 1R45. This relay prevents application of p-a plate voltage without protective bias. PA BIAS RECTIFIER meter 1M12 will indicate approximately 300 volts with no p-a grid excitation. On application of grid drive to the p-a, 1M12 will indicate approximately 540 volts due to the greater voltage developed by the p-a grid leak. Under this normal condition, the bias rectifier is not delivering any current.

-POWER AMPLIFIER-

General

The Power Amplifier uses two Type GL-895-R tubes operated in parallel and coil neutralized. The cubicle is separated into front and rear sections by a vertical panel. The three GL-895-R power amplifier tubes (2V1, 2V3 and spare 2V2), the grid tank circuit, and the filament voltage-adjusting transformers are located in the front section. The plate tank circuit, the harmonic filters, and the filament transformers are in the rear section. The plate choke coil, its bypass condenser, and the HV voltmeter multiplier are located in the air box (below the tubes). All access doors have interlock switches (2S15, 2S16, 2S17) which operate to remove plate voltages whenever a door is opened. In addition, safety switches (2S6, 2S20, 2S21) positively ground all high voltage circuits.

Motor drive is used for tuning the grid tank, the plate tank, and the plate loading circuit. The associated key switches 2S1, 2S2, 2S3 are located on the left front door. Switch 2S9 permits removal of power from the tuning switches to prevent inadvertent operation. Indicating light 2I1 (green) indicates voltage to the tuning switch. Indicating light 2I2 (white) indicates operation of the end-of-travel limit switches (2S11, 2S12) of the grid tank coil. On the right front door are located the pushbutton controls (2IS1, 2IS2, 2IS3, 2IS4) for the intermediate and HV rectifier. The filament voltmeter transfer switches 2S4, 2S5 permit measurement of filament voltages (2M5) to neutral.

Four large meters are located across the top of the Power Amplifier cubicle and read ANTENNA CURRENT, PA GRID CURRENT, PA PLATE CURRENT, and PA PLATE VOLTAGE (2M4, 2M1, 2M2, 2M3 respectively.) The ANTENNA CURRENT meter (2M4) is operated from the monitor rectifier located in the antenna tuning house. Smaller meters 2M6, 2M7, 2M5 read LEFT CATHODE CURRENT, RIGHT CATHODE CURRENT, and FIL VOLTAGE, respectively.

Interlock switches 2S14 and 2S19 prevent application of filament power if the removable air box panels are not in place. CAUTION: <u>Never operate the transmitter with the spare tube removed from its socket.</u> 5K37 and 5K38 in the Control Unit protect the tubes in this stage from overload.

<u>Filament Circuit</u>

One group of filament transformers (2T12, 2T13, 2T14) is connected with delta primary and wye secondary while the other group (2T15, 2T16, 2T17) is connected with wye primary and wye secondary. This connection produces a 180 degree phase difference between the 360 cps hum frequency components in the LH and RH tubes and obtains a considerable degree of filament hum cancellation. Filament transfer switches 2S7 and 2S8 permit connecting the spare GL-895-R into either the LH or RH position (the proper grid and plate links are likewise transferred). The "down" position of the two transfer switches is normal. Throwing <u>one</u> switch to the "up" position connects the spare tube filaments into the circuit. To prevent application of filament power with <u>both</u> switches in the "up" position, interlock switches 2S25 and 2S26 are provided. FIL VOLTAGE switch 2S13, conveniently located on the p-a sub-panel, permits deenergizing of the p-a filament contactor. This switch should be operated before throwing a filament transfer switch or adjusting a filament voltage-adjusting transformer.

Filament voltage-adjusting transformers 2T3, 2T4, 2T5 permit adjustment of the magnitude and balance of filament voltage of the LH tube. 2T6, 2T7, 2T8, permit corresponding control for the RH tube. Refer to Section IX on the AUDIO-MODULATOR for the procedure to be used in setting the filament voltage. Due to the more than adequate emission capabilities of the GL-895-R, it is not necessary to operate the filaments at rated voltage (19 volts). It will usually be found that filament voltage of approximately 18 volts is sufficient. It may be necessary to increase this value slightly after the tube has been in service for several thousand hours. Operation at reduced filament voltage results in increased tube life (operation at 95 per cent giving approximately 200 per cent and at 90 per cent approximately 400 per cent of normal life). See also Section XV on MAINTENANCE.

Plate Choke Coil

The plate r-f choke coil (2L10) installed in the transmitter depends on the customer's frequency. Selection of this coil is made as indicated in the following table:

2L10

Frequency Range	G-E Drawing No.	Diameter; No. of turns
540-760 KC	ML-7768791G1	6" Dia., 356 turns
761-1200 KC	ML-7768793G1	5" Dia., 286 turns
1201-1600 KC	ML-7768795G1	4" Dia., 250 turns

Grid Circuit

The grid tank circuit consists of fixed capacitors 2C31, 2C32, 2C33 and variable inductor 2L1. The inductance of 2L1 is adjustable in coarse steps by means of taps. Fine control is obtained by a motor-driven adjustment of the position of a movable copper cylinder.

The grid-leak 2R1, consists of four 240-ohm resistors in series, one of which is tapped in 40-ohm steps to permit adjustment. For initial tuning, a grid leak value of approximately 920 ohms is satisfactory. This produces 920 volts of operating bias with 1.0 amperes grid current. The exact value is not critical.

Holding (zero excitation) bias is obtained from the p-a bias rectifier in the Exciter Unit and is applied through resistor 2R15 across 480 ohms of 2R1. 2R15 is tapped in 10 per cent steps to permit adjusting of the resting bias. For initial adjustment it should be varied to produce about 225 volts of bias as measured (at zero excitation) from the p-a tube grids to ground. This bias is sufficient to reduce the p-a plate current (2M2) to approximately 1.5 ampere when the Carrier Trip circuit operates.

Make initial selection of capacitors as follows:

PA GRID CAPACITORS

Frequency Range	2C31	2C32	2C33
540-590 KC	M-2R48P14 (.002 mfd)	M-2R48P14 (.002 mfd)	M-2R48P14 (.002 mfd)
591-770 KC	M-7479203P1 (.0016 mfd)	M-7479203P1 (.0016 mfd)	M-2R48P14 (.002 mfd)
771-950 KC	"	"	M-7479203P1 (.0016 mfd)
951-1050 KC	"	"	M-2R48P12 (.0012 mfd)
1051-1200 KC	"	M-2R48P12 (.0012 mfd)	M-2R48P11 (.001 mfd)
1201-1325 KC	M-2R48P12 (.0012 mfd)	"	"
1326-1475 KC	M-2R48P11 (.001 mfd)	M-2R48P11 (.001 mfd)	"
1476-1600 KC	"	"	M-2R48P10 (.008 mfd)

Make initial adjustment of taps on 2L1 as follows:

- 2L1 -		
Frequency Range	Approximate No. of turns shorted out	Approximate No. of coupling turns above shorting tap
540-575 KC	0	7
576-630 KC	0	6
631-700 KC	2	5
701-800 KC	4	5
801-960 KC	7	4
961-1100 KC	10	3
1101-1340 KC	12	2
1341-1600 KC	13	$1\frac{1}{2}$

Neutralizing Circuit

Coil neutralizing is employed; the grid-to-plate capacities of the two operating tubes plus stray capacities tune to the operating frequency with coils 2L2 and 2L3. This type of neutralizing circuit is employed because of its effectiveness, comparative freedom from parasites, and broadness of adjustment. Coil 2L3 is provided with a slider which permits single turn adjustments, while coil 2L2 may be adjusted in increments of 12 turns. For the higher frequencies 2L2 is omitted. The settings are sufficiently broad so as to make readjustment unnecessary when changing tubes.

Make preliminary adjustments as follows:

2L2 and 2L3		
Frequency Range	Approximate No. of Turns Shorted out on 2L2	Approx. No. of Turns Shorted out on 2L3
540-590 KC	0	6 to 26
591-650 KC	12	6 to 26
651-720 KC	24	6 to 26

2L2 and 2L3 CONTINUED		
Frequency Range	Approximate No. of Turns Shorted out on 2L2	Approximate No. of Turns Shorted out on 2L3
721-790 KC	36	6 to 26
791-890 KC	48	6 to 26
891-970 KC	60	6 to 26
971-1080 KC	72	6 to 26
1081-1600 KC	OMIT COIL 2L2	6 to 32

Plate Tank Circuit

The plate tank circuit consists of motor-driven tuning capacitor 2C1, inductance 2L4 and motor-driven variable output-coupling capacitor 2C2 connected as a "Pi" network. The load impedance across 2C2 is normally approximately 230 ohms. The variable capacitors (2C1 and 2C2) are gas filled (increase pressure to 175-200 psi by adding dry nitrogen, see Section XV on MAINTENANCE) and are controlled by motors 2B1 and 2B2 respectively. Enough range is provided in 2C1 and 2C2 to permit at least $\pm$ 25 per cent change in output power by varying loading if desired. For small changes in loading (2C2), the change in tuning (2C1) is negligible.

Figure 18 shows the variations of effective plate tank-circuit Q, approximate capacitance values of 2C1 and 2C2, and approximate inductance value of 2L4 over the frequency range.

Figure 19 shows the approximate capacitance of 2C1 and 2C2 vs. their scale readings, and the inductance value of 2L4 vs. its number of turns. At frequencies above 650 KC the unused turns on the end of 2L4 nearest 2C1 should be shorted out by means of the strap provided.

Harmonic Filters

The filter consisting of inductances 2L6 and 2L7 and vacuum capacitors 2C18 through 2C29 (the number depends on frequency and

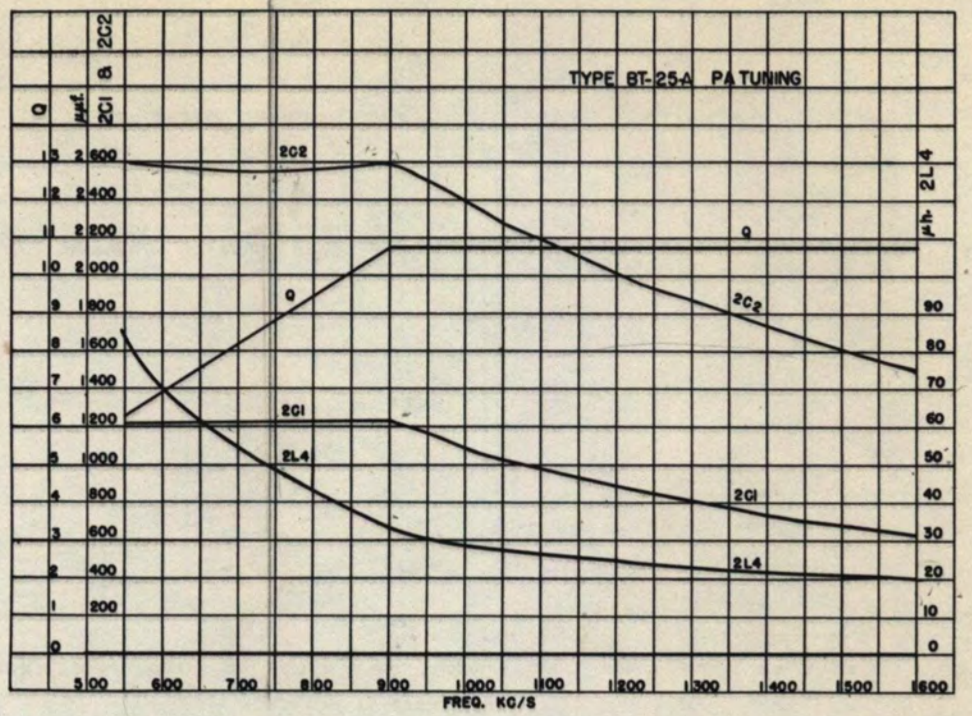


Fig. 18 Plate Tank Circuit Q and Values of 2C1, 2C2, 2L4 vs Number of Turns

2L4 = 90 μh
2C1 = 475-1500 μμf
2C2 = 1450-3250 μμf

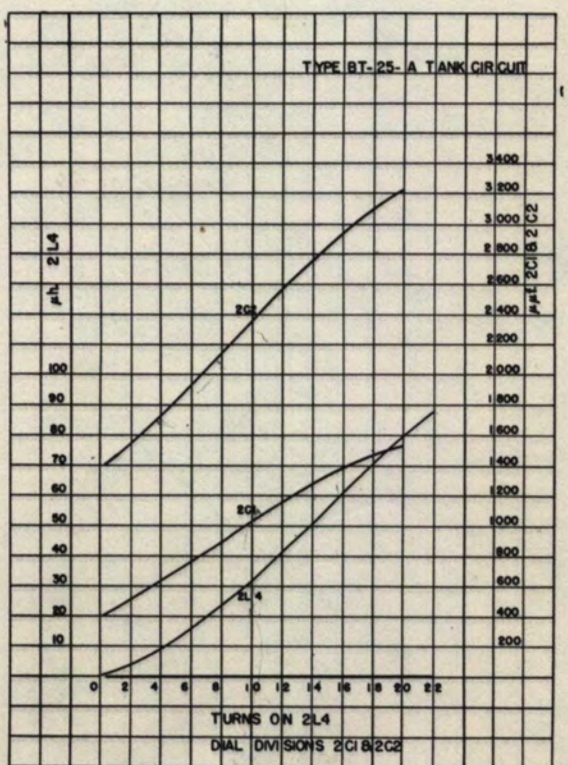


Fig. 19 Values of 2C1, 2C2 vs Dial Divisions and Value of 2L4 vs Number of Turns

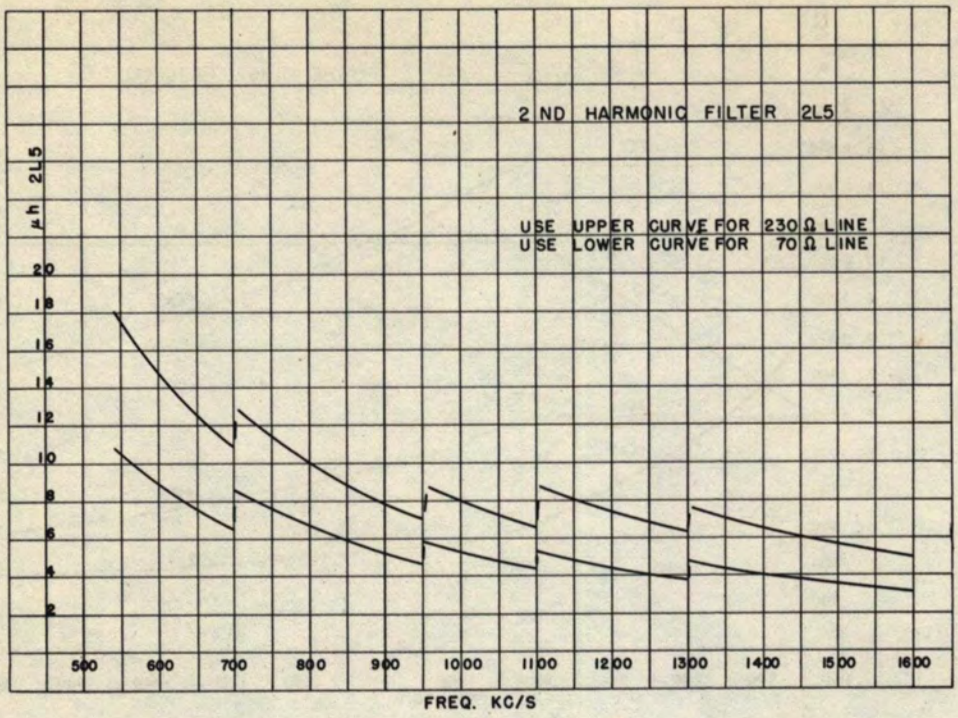


Fig. 20 Value of 2L5 vs Frequency

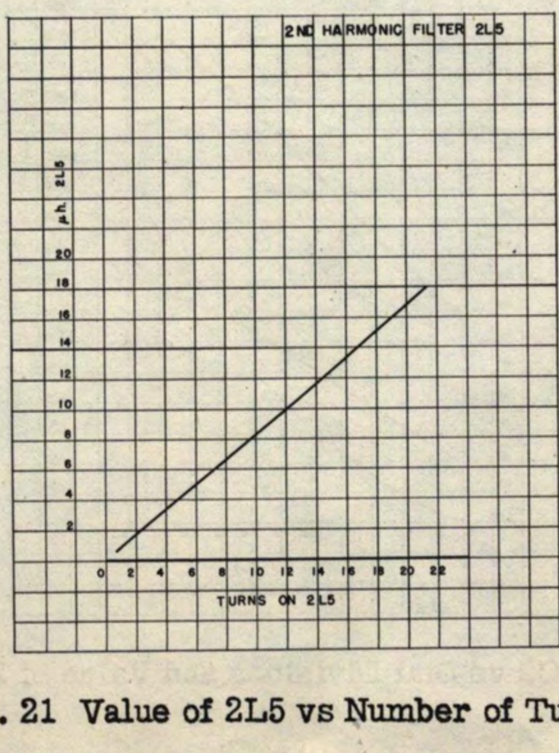


Fig. 21 Value of 2L5 vs Number of Turns

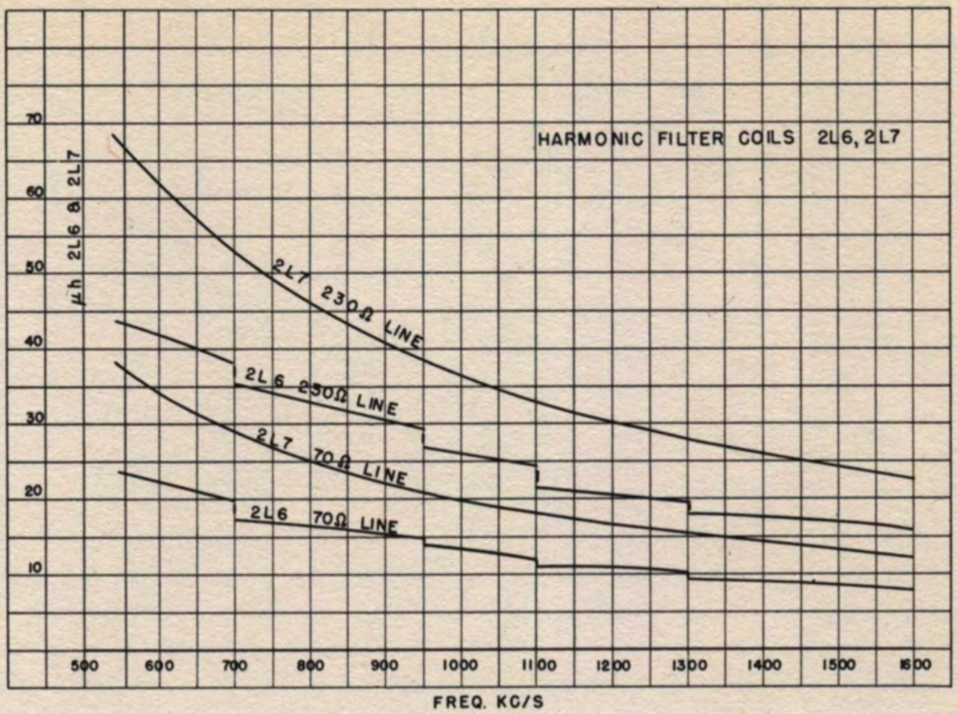


Fig. 22 Values of 2L6, 2L7 vs Frequency

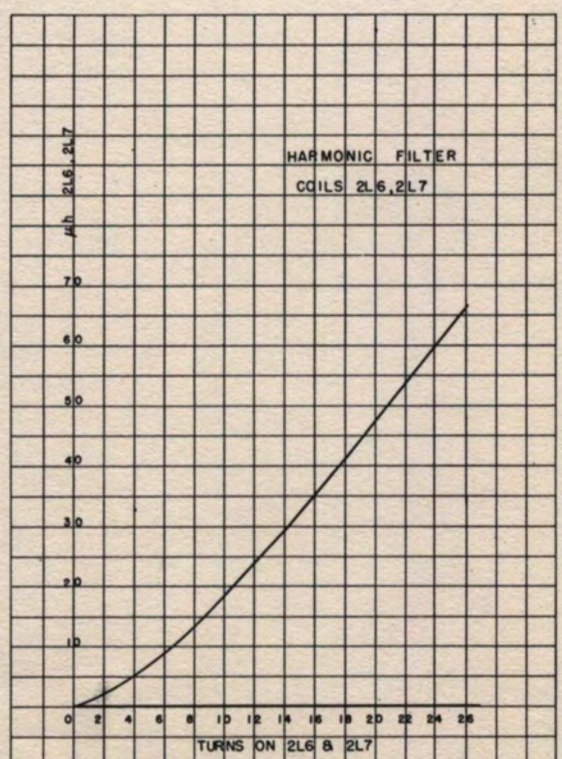


Fig. 23 Values of 2L6, 2L7 vs Number of Turns

transmission line impedance) mounted in the upper rear section of the PA cubicle is used to attenuate r-f harmonics, and to change the transmission line impedance to the proper value (230 ohms) for the p-a tank circuit. The connection used is the conventional "T" network.

For a 230-ohm transmission line, the characteristic impedance of the filter is adjusted to 230 ohms.

$Z_i =$	230 ohms	$Z_i =$	characteristic impedance of filter
$Z_1 =$	$+ j\ 230$ ohms	$Z_1 =$	reactance of each series leg
$Z_c =$	$-j\ 230$ ohms	$Z_c =$	reactance of shunt leg

Values of shunt leg capacity corresponding to 230-ohm and 70-ohm transmission lines are given in the following tables.

For feeding a transmission line of surge impedance other than 70 or 230 ohms, the characteristic impedance of the filter is determined as follows:

$Z_i = \sqrt{230\ Z_o}$, where Z_o is the surge impedance of the transmission line.

Then, $Z_1 = + j \sqrt{230\ Z_o}$

$Z_c = - j \sqrt{230\ Z_o}$

To increase the effectiveness of the harmonic filter at the second harmonic frequency, an anti-resonant circuit (2L5, 2C30) is provided in series with the input leg of the "T" filter. When properly adjusted, the circuit greatly increases the attenuation of this harmonic. Inasmuch as the combination 2L5-2C30 presents an inductive reactance at the fundamental frequency, the value of 2L6 is decreased below the value of 2L7 by this amount. Figs. 20, 21, 22, 23 give the data for determining the approximate number of turns to be used on 2L5, 2L6 and 2L7.

Select the value of 2C30 from the following table:

2C30		
Frequency Range	230-ohm line	70-ohm line
540-700 KC	M-2R48P12 (.0012 mfd)	M-2R48P14 (.002 mfd)
701-950 KC	M-2R48P11 (.001 mfd)	M-2R48P13 (.0015 mfd)
951-1100 KC	M-2R48P10 (.0008 mfd)	M-2R48P12 (.0012 mfd)
1101-1300 KC	M-2R48P9 (.0006 mfd)	M-2R48P11 (.001 mfd)
1301-1600 KC	M-2R48P8 (.0005 mfd)	M-2R48P10 (.0008 mfd)

The shunt leg of the harmonic filter consists of a bank of vacuum capacitors (2C18 through 2C29), the number used and their values depending on frequency and the surge impedance of the transmission line. Make selection of capacitors using the following tables:

For Transmission Line Z_o = 230 ohms

Symbol	540-630 KC	631-730 KC	731-810 KC	811-920 KC	921-1070 KC	1071-1280 KC	1281-1600 KC
2C18	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)
2C19	"	"	"	"	"	"	"
2C20	"	"	"	"	"	"	"
2C21	"	"	"	"	"	"	"
2C22	"	"	"	"	"	"	"
2C23	"	"	"	"	"	"	Omit
2C24	"	"	"	"	"	Omit	"
2C25	"	"	"	"	Omit	"	"
2C26	"	"	"	Omit	"	"	"
2C27	"	"	Omit	"	"	"	"
2C28	"	Omit	"	"	"	"	"
2C29	Omit	"	"	"	"	"	"

For Transmission Line Z_o = 70 ohms

Symbol	540-630 KC	631-730 KC	731-810 KC	811-920 KC	921-1070 KC	1071-1280 KC	1281-1600 KC
2C18	P7767477P25 (.00015 mfd)	P7767477P25 (.00015 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)	P7767477P21 (.0001 mfd)
2C19	"	"	"	"	"	"	"
2C20	"	"	"	"	"	"	"
2C21	"	"	"	"	"	"	"
2C22	"	"	P7767477P25 (.00015 mfd)	"	"	"	"
2C23	"	"	"	"	"	"	"
2C24	"	"	"	"	"	"	"
2C25	"	"	"	"	"	"	"
2C26	"	"	"	P7767477P25 (.00015 mfd)	"	"	"
2C27	"	"	"	"	"	"	Omit
2C28	"	"	"	"	"	"	"
2C29	"	"	"	"	"	Omit	"

Pickup Coils

Pickup coil 2L13 is loosely coupled to the p-a tank coil 2L4. One half of 2L13 provides r-f voltage for operation of the modulation monitor while the other half provides voltage for operation of distortion measuring equipment. Taps are provided on 2L13 so that the voltages of the two halves can be independently adjusted. To adjust for correct input to monitoring equipment, start with a minimum number of turns. Increase (by changing taps) until sufficient voltage is obtained.

Tuning and Neutralizing Procedure

The following instructions are written on the basis that the exciter has been tuned, the transmission line is properly terminated (see Section XIV) and that the proper capacitors and approximate number of coil turns have been selected in accordance with the curves and tables in this section.

Proceed with p-a tuning and neutralizing as follows:

(1) Disconnect the output connection (only) from 2C2. Reduce exciter plate voltage by moving lead on 1T9 to X1. Open the HV RECT BREAKER (5S2).

(2) Push the INT PLATE ON button and tune the p-a grid coil (key switch 2S1) for a peak in grid current (2M1). It may be necessary to change the number of active turns on 2L1 slightly to obtain a definite peak. Adjust the coupling between 1L18 and 1L19 (Exciter cubicle) for approximately 0.7 amperes of PA GRID CURRENT (2M1).

(3) Set the number of turns on 2L4 according to the curve on Fig. 19. (Tap in from each end). It will be noticed that, as 2C1 tunes through resonance, a pronounced dip occurs in p-a grid current due to lack of neutralization. Adjust the

the filter circuit (2L5, 2C30, 2L6, 2L7, 2C18 to 2C29) connected to the transmission line as indicated on Elementary Diagram Fig. 40, connect an r-f bridge to this lead. Adjust the taps on 2L7 and 2L6 until a reading of approximately 230-ohms resistance and zero reactance is obtained. It will be noted that adjusting 2L7 has greater effect on the resistance value while 2L6 has greater effect on the reactance value.

(7) Reconnect the output lead to 2C2; re-close the HV RECT BREAKER (with 5S2) and set the HV TRANSFORMER TAP Switch 4S1 to the 60 per cent setting. Push the HV PLATE ON button.

(8) Tune the plate capacitor 2C1 (key switch 2S2) for minimum PA PLATE CURRENT (2M2). Adjust loading capacitor 2C2 (while readjusting 2C1 for minimum plate current) for approximately 18 kw output (approximately 3.7 amps on 2M2).

(9) Check grid tuning for maximum grid current (approximately 1.2 amps). Check neutralizing by tuning the plate tank condenser (2C1) back and forth through resonance and noting whether or not the PA GRID CURRENT peak occurs at the same setting as the PA PLATE CURRENT minimum. If not, the number of turns on 2L3 should be changed slightly until this condition exists. A further check on completeness of neutralizing may be made later at full power while applying 100 per cent sine wave modulation and adjusting 2L3 slightly to produce the thinnest oscilloscope line on negative peaks (0 voltage with complete neutralization).

(10) Set 4S1 to the 100 per cent HV TRANSFORMER TAP. Apply power and adjust 2C2 (with 2C1 tuned for minimum plate current) for 50 kw output. Grid current should be approximately 1.0 amps. If necessary, adjust coupling between 1L18 and 1L19 to

give this value, and lock the position of 1L19 on its shaft by means of the set screw provided. A considerable variation in loading can be made with negligible effect on plate tuning. However, optimum efficiency will be obtained with 2C1 tuned slightly to the low capacity side of the minimum plate current point. The proper point is readily obtained by adjusting 2C1 and 2C2 so as to obtain the correct output with lowest input. This tuning point also produces lowest carrier hum level.

-AUDIO-MODULATOR-

General

The Audio-Modulator cubicle is separated into front and rear sections by a vertical panel. In the front section are located the three GL-895R modulator tubes (one a spare). These are readily visible through windows in the front doors. The three lower-powered AF stages are mounted on the rear of the vertical panel and are visible through the rear door window. They employ tubes as follows:

1st Audio Stage	2 Type GL-837
2nd Audio Stage	2 Type GL-5C24
3rd Audio Stage (Modulator Driver)	4 Type GL-5C24

All access doors have door interlock switches (3S12, 3S13, 3S14) which operate to remove plate voltages when a door is opened. In addition, safety switches (3S5, 3S16, 3S17, 3S18) positively ground all circuits of 750 volts and over.

The controls which are desirable for occasional adjustments, such as modulator and 3rd AF stage bias controls and modulator filament voltmeter transfer switches, are conveniently located on the front doors. Meters 3M4, 3M5, 3M2 and 3M1 which indicate incoming LINE VOLTAGE, regulated BUS VOLTAGE, LH MOD PLATE CURRENT and RH MOD PLATE CURRENT respectively are of the latest 240 degree type and are easily readable from a distance. Other meters are easily read through the front door windows.

1st AF Stage

This stage uses two type GL-837 pentodes (3V1, 3V2) operating push-pull Class A, resistance-coupled. The 750 volt plate supply and the 175 volt screen voltage are obtained from the LP rectifier in the Exciter cubicle. Variable resistors 3R59 and 3R60 provide cathode feedback for this stage. Variable resistor 3R61 permits variation of GL-837 bias for proper cathode current on 3M8 and 3M9 (22.5 ma). Capacitors 3C5, 3C6, 3C17, 3C18 and resistors 3R51, 3R52 comprise a high-frequency attenuation circuit which provides a desirable amplifier characteristic for use with overall feedback.

Normal transmitter audio input level is 10 dbm ± 2 db. This connects to terminals 3TB7-1 and 3TB7-2 (with shielded wire). Input transformer 3T12 is normally connected for 600-ohms input impedance. If desired 3T12 can be reconnected for 150-ohms input impedance (by moving the connection on transformer terminal 1 to terminal 9, and the connection on terminal 4 to terminal 10).

This transformer has an electrostatic shield between its primary and secondary windings. The secondary winding is in two sections to permit insertion of the feedback voltage from the modulator plates. Resistors 3R62 and 3R63 terminate the secondary to give correct input impedance.

Relay 3K4 (de-energized during normal operation) operates to insert in the audio input a pad (3R84, 3R85, 3R86) of approximately 15-db attenuation. The relay is energized during two conditions:

(A) Prior to the closing of HV run contactor 6K3. Otherwise the 3rd audio stage might be overloaded during starting periods due to the absence of feedback voltage from the modulator plates.

(B) During operation of carrier trip relay 1K1. Otherwise the increase of modulator load impedance could cause abnormally high modulation transformer voltages.

Adjustments

Before inserting the GL-837 tubes in their sockets set 3R59 and 3R60 to 90 ohms each and tighten their locking nuts. Insert the GL-837 tubes and permit the LV rectifier to come on. Read 3M8 and 3M9 (1ST A-F CATHODE CURRENT) and adjust 3R61 for approximately 22.5 ma each.

2nd AF Stage

This stage uses two Type GL-5C24 triodes (3V3, 3V4) operating in push-pull Class A. Cathode bias is provided by fixed resistor 3R40 and variable resistor 3R39. 2ND A-F PLATE CURRENT is indicated on 3M6 and 3M7 (normally 95 ma each). Variable resistors 3R80 and 3R81, adjustable from the rear of the cubicle with power on, permit accurate setting of filament supply center-tap for minimum 60 cps hum. The cases of input and output blocking capacitors (3C19, 3C20, 3C10, 3C11) are insulated from ground for lowest phase shift at high frequencies. Capacitors 3C7, 3C8, 3C15, 3C16, 3R49, 3R50 comprise a low-frequency attenuation circuit which provides a desirable amplifier characteristic for use with feedback.

Adjustments

Set 3R80, 3R81 and 3R39 to their approximate mid-positions. Press INT PLATE ON button and read 3M6 and 3M7. Adjust 3R39 so these meters read approximately 95 ma each.

3rd AF Stage (Modulator Driver)

This stage uses four Type GL-5C24 triodes operating Class AB_1 in a push-pull parallel direct-coupled circuit.

The type GL-5C24 is particularly suitable for the direct coupled circuit due to its low internal plate resistance.

Meter 3M10 indicates the total plate current of tubes 3V7 and 3V8. Meter 3M11 reads the plate current for 3V5 and 3V6. These meters are readily visible through the window in the left hand front door. Bias controls 3R30 and 3R29 (3rd AF bias) permit adjustment from the front door. Normal reading of meters 3M10 and 3M11 is 100 ma each at zero modulation. Plate voltage for this stage is obtained from the half-voltage tap of the intermediate rectifier.

Output of the driver stage is impressed across reactor 3L1. This reactor has two windings tightly coupled together. Resistors 3R22 and 3R23 serve to present a more constant load to the 3rd AF stage.

Overload relays 5K28 and 5K58 located in the control cubicle protect the tubes and circuit.

Adjustments

Turn front door bias controls 3R29 and 3R30 to their extreme CCW positions. Replace the caps on 3V5, 3V6, 3V7 and 3V8 and apply plate voltage. Rotate bias controls for 100 ma plate current as indicated on meters 3M10, 3M11. If there is reason to suspect that the two tubes on each side of the circuit are not sharing the load equally, this can be readily checked by measuring the plate currents, taken one tube at a time, for a fixed position of the bias control. The tubes can then be paired for similar characteristics. An occasional check will show whether or not a tube is losing emission.

Modulator

This stage uses Two Type GL-895-R forced air-cooled tubes (3V9, 3V11). A position is supplied for an additional tube (3V10) used as a spare. Filament switches permit transfer of the spare tube to either

LH or RH position. Disconnecting links permit transfer of spare tube grid and plate connectors to LH or RH. Proper positioning of the grid and plate links is apparent upon inspection. MOD FIL VOLTAGE switch 3S10, conveniently located on the modulator sub-panel, permits de-energizing of the modulator filament contactor. Switch 3S10 should always be operated before throwing a filament transfer switch or setting the tap on a filament-adjusting transformer. The "down" position of the two filament transfer switches (3S8, 3S9) is the normal position. Throwing <u>one</u> switch to the upper position (after operating 3S10) disconnects the filament transformer from the original tube and connects them to the spare tube.

To prevent application of filament power with <u>both</u> switches (3S8, 3S9) in the "up" position, interlock switches, 3S19 and 3S20, are provided.

Bias adjustments are available by means of front door controls 3R26 and 3R27. 3R26 is a balancing adjustment used for setting the LH and RH plate currents to the same value. 3R27 controls the bias to both tubes and is used for adjusting the value of resting (zero modulation) plate current. Relays 3K1, 3K2, 3K3 automatically adjust the bias for the proper plate voltage as determined by the position of HV rectifier switch 4S1. Horn gaps 3E1, 3E2, 3E3 are provided for protection of the grid circuit in case of "arc-back." Adjustment of these is covered in Section XV, MAINTENANCE.

Filament voltmeter transfer switches 3S6 and 3S7 permit measurement of filament voltages to neutral. Filament voltage-adjusting transformers 3T3, 3T4 and 3T5 permit adjustment of the magnitude and balance of filament voltages of the LH tube. 3T6, 3T7 and 3T8 permit corresponding control for the RH tube. Due to the more than adequate emission capabilities of the GL-895R it is not necessary to operate the filament at rated voltage (19 volts). It will usually be found that a filament voltage of approximately 17.5 volts is sufficient for the modulator. It may be necessary to increase this value slightly after the tube has been in service for several thousand hours. Operation at reduced filament voltage results in increased tube life (operation at 95 per cent giving approximately 200 per cent and at 90 per cent approximately 400 per cent of normal life). See also Section XV, MAINTENANCE.

The modulation transformer (6T10) and modulation reactor (6L1) are located externally. The d-c blocking capacitors (4C7 through 4C12) are located in the Rectifier cubicle.

Feedback voltage is derived from the modulator plate circuit. Capacitors 3C24 and 3C25 block the d-c from the feedback voltage divider (fixed resistors 3R64 through 3R73 and variable resistors 3R74 and 3R75). 3R41 and 3R48 prevent static charges from accumulating on the cases of 3C24 and 3C25 respectively.

General Adjustments

With normal air flow to the modulator tubes, with tube seal air deflectors in place, and with filament switches and grid and plate transfer links properly thrown, turn on filaments. WARNING. Never operate the tubes with the spare tube socket open (tube removed) or with the front plates off the air box. Adjust the filament voltages to approximately 17.5 volts to neutral with good balance between phases. This adjustment is made (after first turning filaments off by means of 3S10) by rotating the links on the proper voltage-adjusting transformers. The filament voltage increases in approximately 3 per cent increments as the links are moved CW from tap 5 to tap 14.

Moving the other links (tap 17 to 21) permits approximately 1 per cent adjustment.

Rotate bias control 3R27 to its extreme CCW position. The p-a having been properly tuned and loaded, turn on the HV rectifier. Adjust 3R26 and 3R27 for resting (zero modulation) MOD PLATE CURRENT (3M1 and 3M2) of 0.1 to 0.2 amperes each. Adjust 3R80 and 3R81 slightly for lowest 60 cps carrier hum.

Adjustment of Feedback

The value of feedback voltage is determined by the resistor values of 3R74 and 3R75. Adjust 3R74 and 3R75 to 400 ohms each and tighten the locking nuts. With 3R59 and 3R60 each locked at 90 ohms, the overall audio feedback is then 14 db. This value gives an optimum balance between distortion and noise level.

Adjustment of Bias Network

Refer to Fig. 40.

When the HV TRANSFORMER TAP selector switch, 4S1, is in the 100 per cent position, bias relay 3K1 is energized. This shorts out 3R55 and 3R56 and applies full bias to the modulator. 3R27 is then adjusted as outlined under General Adjustments for proper modulator resting plate current.

With switch 4S1 in the 80 per cent position bias relay 3K2 is energized. This relay shorts out only a portion of 3R55 and 3R56, and also shorts out a portion of 3R25. In adjusting the taps on these resistors, the amount inserted in the circuit by 3R55 and 3R56 is made the same as the amount shorted out of 3R24 and 3R25. (This keeps the total resistance constant so the bias of the 3rd AF stage is not changed). With proper adjustment of the taps, the setting of 3R27 will not require changing when the plate voltage is dropped to 80 per cent.

With switch 4S1 in the 60 per cent position bias relay 3K3 is closed. This shorts out a greater portion (than does 3K2) of resistors 3R24 and 3R25 and a lesser portion of 3R55. Again the total resistance is kept constant, and with proper settings it becomes unnecessary to readjust 3R27 when running at 60 per cent of normal plate voltage.

The circuit is so arranged that with 4S1 in a mid-position, the modulator bias goes to the 100 per cent value and the 3rd AF bias still remains at its proper value.

The taps on 3R24, 3R25, 3R55, and 3R56 are set in the factory.

Adjustment for Lowest Carrier Hum Level

Due to the phasing of the p-a filament transformers and to the ample excitation available at the p-a grids, carrier hum level of this Transmitter is low.

It is advisable to employ low resting modulator plate current (.1 to .2 amps) and to balance plate currents at zero modulation. This operation is also most economical. Due to the use of feedback and the initial low distortion of the audio channel, operation with low resting plate current produces negligible distortion.

Operating the p-a filaments at reduced voltage (desirable also for long tube life) helps maintain low hum level. With the transmitter properly adjusted, the carrier hum level should be approximately 58 db below 100 per cent modulation without use of hum bucking. With the use the General Electric Model 4FZ1A1 Hum Bucking Unit, the predominant hum frequencies are removed and the hum level should be better than 60 db below 100 per cent modulation.

-HIGH VOLTAGE RECTIFIER-

General

The HV Rectifier uses six GL-857B mercury vapor rectifier tubes in a three-phase full-wave circuit. These are designated 4V1, 4V2, 4V3, 4V4, 4V5, 4V6. A seventh tube designated 4V7 is connected as a pre-heated spare which can be quickly switched into service from the front panel, replacing any of the other tubes. The rectifier operates at a primary voltage of 460 volts, 3 phase. The filter reactor 6L2 (1 henry) and the filter capacitors 4C1 through 4C6 (18 mfds total) are sufficient to reduce the 360 cps ripple to a negligible value. The rectifier is designed to have good regulation. The plate transformers have 3.3 per cent impedance.

Filament transformer primary voltage is taken from the 230 volt, 3 phase bus, regulated by 5VR1. This regulator holds the filament voltage to close limits, assuring long tube life. Phasing is such that the filament voltage of each tube is in quadrature with its plate voltage. This type of operation gives best tube life and highest current rating with tubes having a filamentary cathode (such as the GL-857B) by permitting uniform utilization of the cathode. The GL-857B filament transformers (4T1 through 4T7) are rated for 50/60 cps and can be operated at either frequency without reconnection.

The filter capacitors 4C1 through 4C6 and the modulation transformer d-c blocking capacitors 4C7 through 4C12 are located in the Rectifier cubicle.

When the rear door of this cubicle is opened, door interlock 4S3 causes removal of power. In addition, for complete protection safety grounding switches 4S4 and 4S8 operate. These ground the d-c bus, the blocking capacitors and the three incoming high voltage a-c leads.

Operation

To substitute the spare rectifier tube for one of the six operating tubes, set TUBE CHANGE SELECTOR switch 4S2 to the desired tube position and depress TUBE CHANGE pushbutton 4IS3. This removes plate voltage. After approximately 1 second (determined by 4K8) power is automatically applied to the tube change contactors (4K1 through 4K6). The proper contactor operates and its indicator light (4I1 through 4I6) comes on. The operator notes that only one indicator light (or none if the spare tube is being taken out of service) is illuminated; removing pressure from 4IS3 then reapplies plate voltage.

Changing rectifier plate transformer primary taps is accomplished by merely switching 4S1 to the desired voltage percentage (60 per cent, 80 per cent, 100 per cent position). This switch automatically causes the plate contactors to drop out so the smaller tap change contactors do not interrupt the line current. When operating 4S1, the switch should be held in its intermediate position for at least one second to permit the associated contactors to operate in their proper sequence.

If a plate regulator is employed, the Contact Making Voltmeter 5A2 in the Control cubicle permits accurate, automatic regulation of plate voltage over a $\pm$ 10 per cent range. PLATE VOLTAGE ADJUSTMENT 4R11 on the Rectifier control panel permits precise control of the regulated voltage. If manual voltage control is desired, throw key switch 4S6 from AUTOMATIC to MANUAL and operate RAISE-LOWER key switch 4S7. If 4S6 is thrown to the TEST position, both the contact-making voltmeter and the raise-lower buttons (on 5A2) control the regulator -

this position is desirable when making adjustments on 5A2.

Filament regulator 5VR1 and its Contact-Making Voltmeter 5A1 are located in the Control cubicle. Resistor 5R4 permits adjustment of the controlled voltage and key switches 5S20 and 5S22 permit manual or automatic operation in a manner similar to that outlined above. 5R4, 5S20, and 5S22 are located on the Control Unit Panel. Adjust 5R4 to hold the regulated voltage at such a value that 5 volts is measured across the GL-857B filaments.

Installation and Operation of Tubes

When mercury vapor rectifier tubes are first received, they should be operated with filament voltage only for at least 15 minutes. This vaporizes metallic mercury which has been splashed on the tube elements. The tube should then be tested with plate voltage applied before being placed in stock. When handled or stored the tube should be kept in an upright position and care should be taken to avoid splashing of the mercury. The glass envelopes of the tubes should be kept clean to maintain low operating temperature. It is recommended that during maintenance periods they be occasionally cleaned with an alcohol-moistened cloth. It is good practice to repeat the above procedure each six months with the tubes in stock to assure that they are in satisfactory operating condition.

Following the initial preheat described above, the tubes require only the heating time provided by time-delay relay 5K6 (normally adjusted to 2 minutes) located in the Control unit. After the tubes have been initially heated, if a power failure occurs so that 5K6 drops out, it is, of course, not necessary to wait for 5K6 to recycle before reapplying plate power. For power failures of not exceeding 3 seconds (as determined by 5K7) the plate power is automatically reapplied. For power failures of more than 3 seconds, the power may be reapplied without waiting for 5K6 to operate by depressing EMERG START button 5IS4. The transmitter engineer should exercise judgment in his use of 5IS4, as permitting too short an interval may injure a tube whereas permitting too long an interval causes excessive loss of program time. A good rule to follow is to allow approximately the same length of re-heat time as the duration of the power-off period. However, regardless of the duration of a power failure, it is not necessary to allow more than 45 seconds of pre-heat time before depressing the EMERG START button.

Two small blowers 4BM1 and 4BM2 provide cooling air for the base of the GL-857B tubes. Best tube operation is provided with condensed mercury temperature from 86° to 104° F, corresponding to ambient temperature (air in the cubicle) of about 77° to 95° F. In locations where low temperatures are experienced, it will be advisable to partially close the damper in the air supply riser to the Rectifier cubicle, in locations where high ambients are experienced, the damper should be open. When first starting up under a condition of low ambient temperature, it may be desirable to turn off the blowers 4BM1 and 4BM2 for a few minutes; this may be done by opening 5S11 on the Control Unit panel.

Testing Rectifier Tubes

Good visibility of the 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 lower part of the tube stem. Temperatures substantially above normal range indicate tubes 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 conduction period. 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:

(1) Remove regular rectifier plate connection and apply filament power. An isolation transformer with 115 volt 60 cycle output and a 50-ohm current-limiting resistor are needed. 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 will show a sharp peak at the start of conduction. The amplitude of this peak is a measure of the initial breakdown voltage.

(2) An isolation transformer and a variable auto transformer which will give an isolation winding output adjustable from 0 to 75 volts is 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 intial breakdown voltage.

Using either method, the peak breakdown voltage for a good tube will average 10 to 20 volts. When the peak breakdown 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.

Note that these tests are suitable for type GL-8008 as well as for type GL-857B tubes.

External Rectifier Equipment

The HV rectifier plate transformers (6T7, 6T8, and 6T9) and the HV filter reactor (6L2) are usually located in the basement or in a fenced enclosure behind the transmitter. Due to the use of non-inflammable Pyranol* in this equipment no fireproof vault is ordinarily required.

The plate transformer bank uses three single phase 50 KVA units delta-connected. This feature makes for good reliability, as the rectifier could, in emergency, be operated open delta with one transformer disconnected at 58 per cent of full load rating. The plate transformers have primary taps to give 60 per cent, 80 per cent, or 100 per cent of normal voltage. (WARNING - the KVA rating of the transformer is reduced accordingly on the 60 per cent and 80 per cent taps. Therefore, full power operation should not be attempted at the reduced voltages). Each plate transformer has a variable ratio adjustor permitting ± 2½ per cent and ± 5 per cent variation in output voltage. Access to the adjustor switch is possible by removing the monogrammed cover from the transformer top. (NOTE - As the transformers are designed to operate sealed, the gasket should be repaired or replaced if damaged, and re-sealed with a suitable cement such as G-E glyptal, #1276.) (See Section XV, MAINTENANCE). If the optional plate regulator 6VR1 is used, the ratio-adjustors should be placed in position V (lowest voltage) for best regulation. If regulator 6VR1 is not used, the ratio adjuster should be set for approximately 10.5 KV d-c rectifier output voltage.

* G-E trade mark

An external Power Cabinet houses the tap change contactors (6K4, 6K5, 6K6), the main start contactor (6K2), the main run contactor (6K3), the primary circuit current transformers (6T5 and 6T6) and the step start resistors (6R1, 6R2, 6R3.) The starting resistors are inserted in the primary circuit during the starting period and are normally adjusted so that the starting plate voltage is approximately 70 per cent of the normal operating voltage. Use of step start resistors reduces the effects of both filter capacitor charging current and transformer inrush current. Copper oxide rectifiers (6CR1 through 6CR14) located in the Power Cabinet provide d-c for quiet operation of the contactors. As 460 volts normally appears on the contactors inside the external Power Cabinet, it is usual practice to keep the exposed door locked in the case where the cabinet is only partly enclosed by the wire fencing.

High speed overcurrent relays 5K41 and 5K42, which protect against rectifier tube arc-back, are located in the Control cubicle. Additional circuit protection is provided by breaker 6S2. The circuit is arranged so that tripping low voltage supply breaker 6S1 also trips breaker 6S2.

WARNING - Note that the step start resistors 6R1, 6R2 and 6R3 are designed for momentary starting service only. When depressing HV RECT ON pushbuttons be sure that the run contactor goes in (observe the second increase of plate voltmeter reading).

-MAIN AIR CIRCULATING SYSTEM-

The Main Air Blower consists of a twin belt-driven fan complete with motor, starter, (6K1) and floating base. The blower is rated at 12,000 cubic feet per minute against a pressure of 2 inches of water. Normal speed is 605 RPM. The sheave is 20 inches in diameter.

The motor is rated 7½ HP and operates at 440/220 volts 3 phase, 50/60 cps. Normal speed at 60 cps is 1735 RPM and at 50 cps, 1450 RPM. The motor sheave is adjustable between 7 and 8.4 inches for 60 or 50 cps operation respectively. The blower starter (6K1) is operated automatically during the transmitter starting sequence. An auxiliary contact of 6K1 is connected in series with the coil circuit of the p-a and modulator tube filament contactors. As further assurance of air flow through the tubes before application of filament power, an air flow interlock, 6S3, is provided. 6S3 should be adjusted to close at approximately 3/4 normal air flow. (See following paragraph). The starter has thermal cut-outs which open its contactor in case of continued overload on the motor. See Section V, INSTALLATION.

The Air Filter consists of fifteen Air-Maze panels. These are corrosion-resistent and washable. The "Standard" panel supplied is equipped with handles on the incoming air side. If necessary, "Reverse Flow" panels can be obtained with handles on the outgoing air side. The frame provided is equipped with locking clamps. See Sections XV and V on MAINTENANCE and INSTALLATION.

An intake air duct is required below the transmitter for conducting air from the blower. An exhaust duct above the transmitter carries the air to the outside. See INSTALLATION, Section V, and Installation Drawing Fig. 39, Sheet 3.

Adjustment of Air Interlock 6S3

6S3 is provided with a disc having a 1-inch diameter hole. The disc is placed in the intake pipe of 6S3 to decrease its sensitivity. If necessary (depending on the particular location of 6S3), the sensitivity may be varied by employing a disc with a different hole diameter. A larger opening gives greater sensitivity, a smaller one less. The position of the diaphragm counterweight may be varied for fine adjustments.

If the diaphragm shows any tendency towards chattering adjust the air gaps around the edge by means of the screw provided.

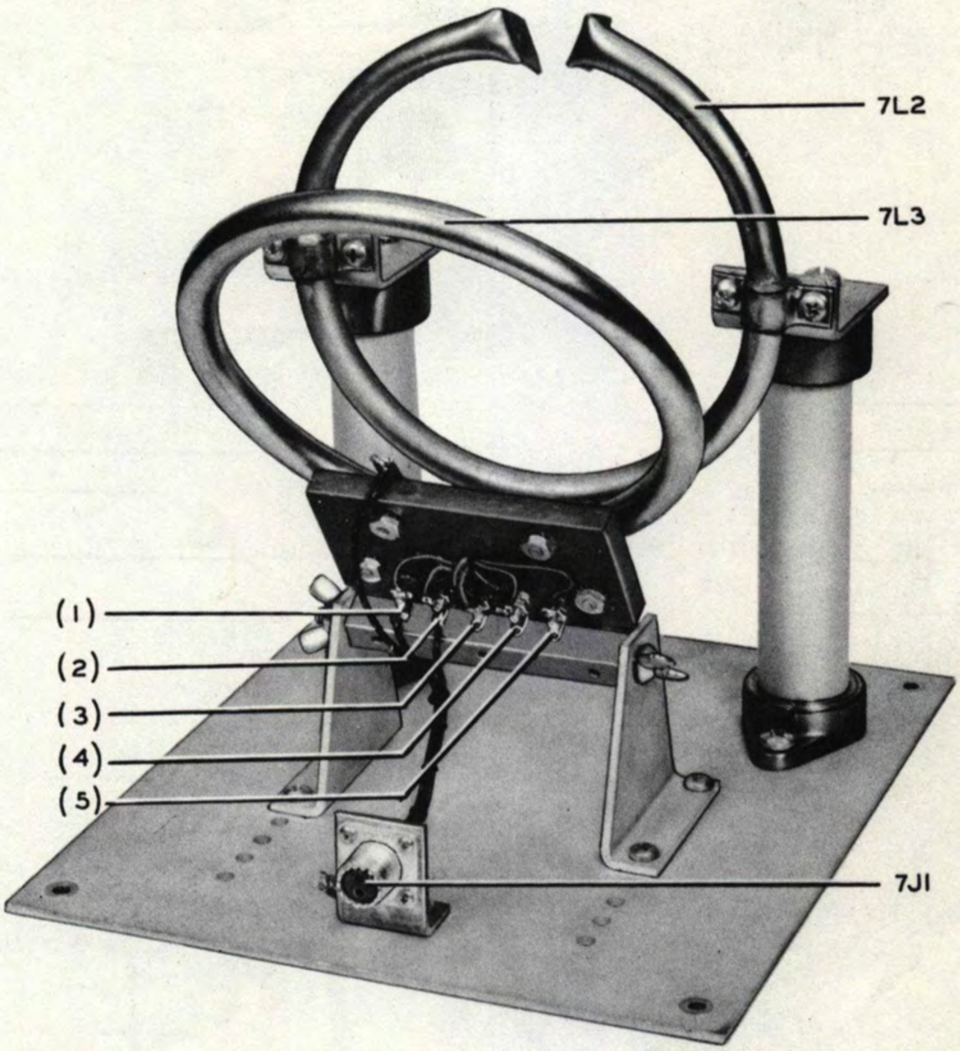


Fig. 32 Monitor Rectifier Coupling Loop, Parts Identified (SY6109A)

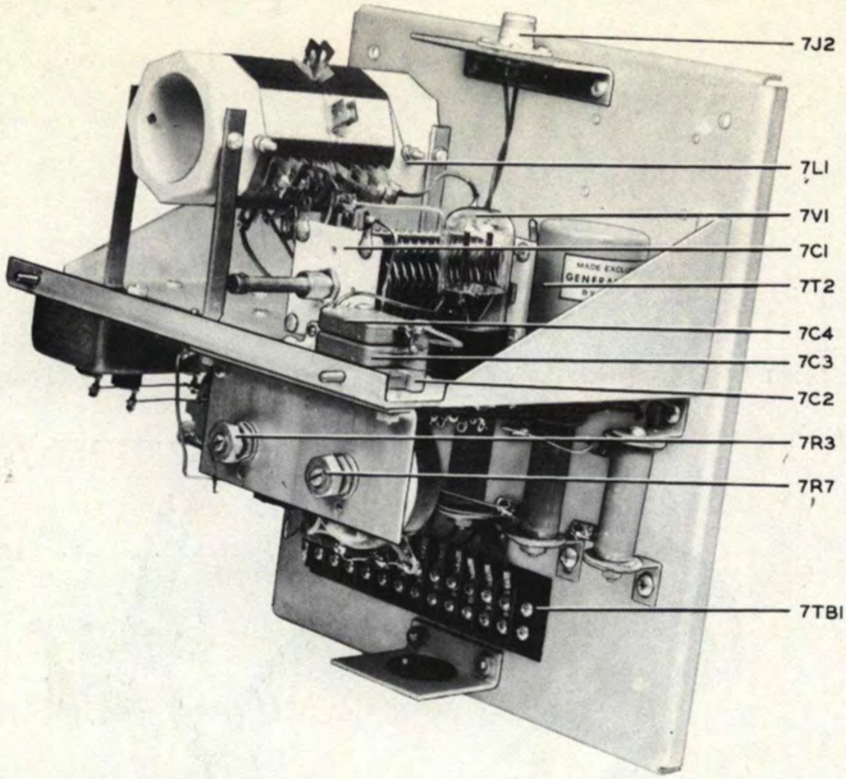


Fig. 33 Monitor Rectifier Unit, Parts Identified (SY6107A)

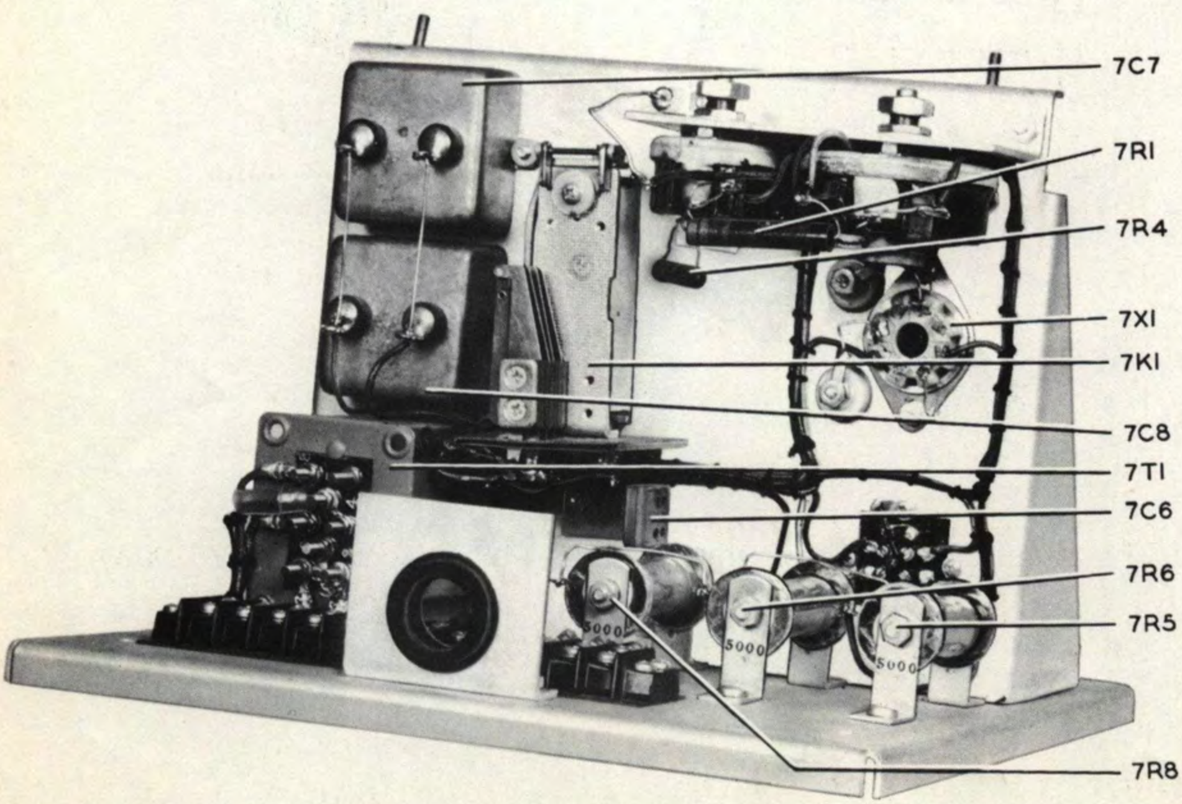


Fig. 34 Monitor Rectifier Unit, Bottom View, Parts Identified (SY6108A)

-MONITOR RECTIFIER-

General

The G-E Type FZ-2-A Monitor Rectifier is designed for remote metering of antenna current. It consists of: (1) an open-mounted pick-up loop and (2) a rectifier enclosed in a shielded box. Both units are normally located in the antenna tuning house (see section on INSTALLATION). The remote meter (2M4) is located on the main transmitter cabinet. Provisions are made for obtaining a signal for aural monitoring, and for relay operation to control a "carrier off" alarm and "time off the air" clock.

Theory

The pick-up loop (7L3) is movable with respect to the fixed loop (7L2) which is connected in series with the Antenna Ammeter. 7L3 is coupled to 7L1 by means of a section of twin coaxial cable.

7L1 is conjunction with 7C1 through 7C4 is adjusted to resonate at the carrier frequency and the resulting voltage is applied to the G-E Type 6X5GT full-wave rectifier. Rectified d-c current proportional to the r-f antenna current flows through linearity resistors 7R6 and 7R8 and develops a voltage across 7R5 and 7R7 for operating relay 7K1. The audio frequency voltage developed across 7R1 is applied through 7C7 and 7C8 (d-c blocking capacitors) to 7T2 and is available for aural monitoring purposes at a level of approximately + 3 dbm, 600 ohms impedance. Relay 7K1 has two sets of SPDT contacts, one of which is used to control the power to the "carrier off" bell 5E1 (through a switch on the transmitter console). The other set may be connected to a carrier "time off the air" clock.

Since it is desirable to use a well-regulated primary filament power supply, 7T1 is fed from the regulated filament bus in the transmitter. 7R3 is used for setting the remote meter to correspond with the antenna ammeter (for this adjustment telephone communication between the antenna tuning house and transmitter room is necessary). The remote meter will then indicate antenna current.

<u>Operation</u>:

The following table furnishes information on rectifier tuning:

Freq.(KC)	Coupling Turns (7L1)	Terminal Used on 7L3	68 MMF Padding Condensers Used (C2-C4)	Tuning Connections on 7L1
540-630	10	5	2	All turns
631-760	10	5	2	1st tap in from each end
761-920	10	5	2	2nd tap in from each end
921-1090	8	5*	1	2nd tap in from each end
1091-1200	8	5*	2	3rd tap in from each end
1201-1480	6	4	1	3rd tap in from each end
1481-1600	6	4	0	3rd tap in from each end

The coupling taps are arranged in pairs around L1; the tuning taps are located in the row near C1. The flexible leads provided should be connected to the proper terminals as indicated in the above table. The blue lead with white tracer as shown on Fig. 35 should be connected to

* For the 921-1200 KC range, connect the brown-and-white lead from 7J1 to terminal 2 in addition to moving the blue-and-white lead to terminal 5.

7L3 (also see Fig. 33) according to the column titled "Terminal Used on 7L3."

Make certain that the monitor rectifier box (terminal 7-1-9) is connected to an external ground. Check the replaceable remote meter scale to ascertain whether or not its range is correct for the antenna current to be measured. (If not, contact the nearest G-E district office). Couple 7L3 very loosely to 7L2. Note that two means of adjusting 7L2-7L3 coupling are provided. Either the coupling loop mounting may be adjusted with respect to the fixed loop, or the loop (7L3) may be tilted. It is desirable to space the base of 7L3 as far as possible from 7L2.

The filament transformer is supplied with a 230/208 volt primary.

Allow normal antenna line current to flow through 7L2. Remove the upper left plug-button. Using an insulated screwdriver, tune 7C1 for maximum reading (use telephone and obtain remote meter readings). Set 7R3 (lower left plug-button) for maximum deflection (reduce 7L2-7L3 coupling to prevent overloading meter if necessary). Next adjust 7R3 to obtain approximately one half of the above meter current. Then couple 7L3 to obtain a meter reading corresponding to the r-f ammeter reading. This procedure adjusts the rectified current to the correct value. Using the two wing nuts, lock 7L3 tightly in position. Future fine adjustments will be made with 7R3.

7R7 (lower right slotted shaft) provides some measure of flexibility in controlling the pull-in or drop-out points of 7K1 and may be adjusted at will. Note that 7R3 must be slightly readjusted after changing the setting of 7R7. Replace plug-buttons after adjustments have been completed. Note: Remote ammeter reading is not affected by modulation, since this meter reads average rectified current.

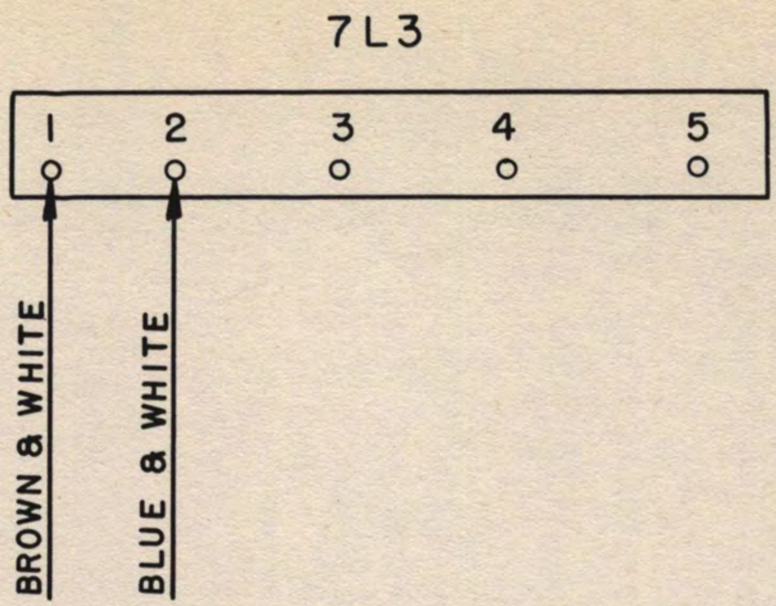
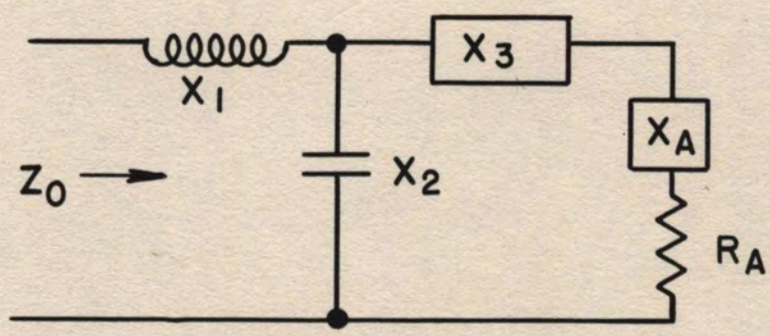


Fig. 35 Connections to 7L3



Z_0 = SURGE IMPEDANCE OF LINE
X_1 = INDUCTIVE REACTANCE
X_2 = CAPACITIVE REACTANCE
X_3 = REACTANCE
X_A = ANTENNA REACTANCE
R_A = ANTENNA RESISTANCE

Fig. 36 Antenna Matching Diagram

-TYPICAL METER READINGS-

CABINET METERS

DESIGNATION	SYMBOL	ZERO MOD. READING	100% MOD. READING
LINE VOLTAGE	3M4	230	
BUS VOLTAGE	3M5	230	230
MODULATOR PLATE CURRENT	3M2	.1/.2 amps	2.9 amps
MODULATOR PLATE CURRENT	3M1	.1/.2 amps	2.9 amps
ANTENNA CURRENT	2M4		
PA GRID CURRENT	2M1	0.9/1.0 amps	
PA PLATE CURRENT	2M2	6.0 amps	
PA PLATE VOLTAGE	2M3	10.5 KV	

EXCITER

DESIGNATION	SYMBOL	READING
AF BIAS RECTIFIER	1M13	540 volts
LV RECTIFIER	1M2	670 volts
OSC. CATHODE CURRENT	1M1	11 ma
1st IPA CATHODE CURRENT	1M9	58 ma
2nd IPA GRID CURRENT	1M3	48 ma
2nd IPA PLATE CURRENT	1M4	165 ma
3rd IPA GRID CURRENT	1M5	240 ma
3rd IPA CATHODE CURRENT	1M6	400 ma
3rd IPA CATHODE CURRENT	1M7	400 ma
3rd IPA CATHODE CURRENT	1M8	400 ma
INTERMEDIATE RECTIFIER	1M11	2700 volts
PA BIAS RECTIFIER	1M12	460 volts (with PA on)

AUDIO MODULATOR

DESIGNATION	SYMBOL	ZERO MOD. READING	100% MOD. READING
3rd AF PLATE CURRENT	3M10	100 ma	225 ma
3rd AF PLATE CURRENT	3M11	100 ma	225 ma
2nd AF PLATE CURRENT	3M6	95 ma	95 ma
2nd AF PLATE CURRENT	3M7	95 ma	95 ma
1st AF CATHODE CURRENT	3M8	22.5 ma	22.5 ma
1st AF CATHODE CURRENT	3M9	22.5 ma	22.5 ma
MODULATOR FILAMENT VOLTAGE	3M3	17.5 volts	17.5 volts

POWER AMPLIFIER

DESIGNATION	SYMBOL	READING
LEFT CATHODE CURRENT	2M6	3.5 amps
RIGHT CATHODE CURRENT	2M7	3.5 amps
FILAMENT VOLTAGE	2M5	18 volts

-ANTENNA TUNING AND LINE TERMINATING-

General

A 50-KW Transmitter is usually operated into a directive array or a vertical radiator. The design and adjustment of networks for directive arrays is a specialized field, and varies with the requirements of the specific installation. Single tower antennas, however, are usually of about .53 of an electrical wavelength in height. Tuning of such an antenna is herein briefly described.

Transmission lines are usually of the 230-ohm six-wire or 70-ohm coaxial type. The six-wire line is very popular because of its reliability and comparative freedom from maintenance requirements. The coaxial line is usually preferred for use with directive arrays where a high degree of protection is required.

See Bulletin EBR-95 for information regarding Lightning Protection.

Antenna and Transmission Line Impedance Measurement

Using one of the methods acceptable to the FCC (such as impedance bridge or substitution method), measure the antenna resistance and reactance at the operating frequency. With all apparatus such as tower lighting chokes, horn gaps, etc. connected, make the measurement at the point of connection of the antenna ammeter. The antenna resistance will normally be 100 to 300 ohms; the antenna reactance, 50 to 150 ohms capacitive. Denote antenna resistance R_a, denote antenna reactance $\angle X_A$.

The characteristic impedance (Z_o) of the transmission line may be calculated by formula with accpetable accuracy. It may also be measured by connecting the bridge (or substitution set-up) to one end of the line and terminating the other end with a non-inductive decade box adjusted so that the input impedance is a pure resistance, equal to the terminating resistance. This value of resistance is Z_o.

Calculation of Matching Network

The matching network located in the antenna tuning house may consist of a T section connected as shown on Fig. 36. Calculate reactance of X_1 and X_2;

$$X_1 = X_2 = \sqrt{Z_o R_A}$$

The algebraic sum of X_2, X_3 and X_A should total 0.

Therefore, if X_2 plus X_A is capacitive, then X_3 must be made inductive and equal to the sum of the other two. If X_2 plus X_A is inductive, then X_3 must be capacitive and equal to their algebraic sum.

For antennas approximately one-half wave length or higher, X_A will usually be capacitive. X_3 will then be an inductance. X_3 should be mounted for minimum coupling to X_1 to avoid transfer of harmonic power.

Tuning Procedure

Adjust X_1, X_2, and X_3 to the values calculated above. Connect the antenna to the matching network.

Note that the combination X_2, X_3 and X_A (with other circuits disconnected) tunes to series resonance. Also X_1 and X_2 resonate with each other.

With transmission line disconnected and with a bridge (or substitution method set-up) connected to the input of the terminating network, adjust X_1 and X_2 for a reading of pure resistance equal to Z_o.

It will be noted that adjusting X_3 has predominant effect on the resistance component, and adjusting X_1 has predominant effect on the reactance.

Connect the transmission line to the terminating network. Measure the impedance looking into the transmission line at the transmitter end. The value of resistance should be very nearly equal to Z_0, and reactance very nearly zero. The transmission line is then properly terminated and power can be applied.

-MAINTENANCE-

General

To assure maximum reliability of operation, it is important that a regular program of preventive maintenance and general inspection, augmented by periodic performance tests, be set up. A system of cards or sheets (itemizing maintenance operations), which are assigned to the maintenance engineer and which he initials and dates on completion, is usually set up by the station engineer. The General Electric publication "How to Maintain Electric Equipment" GEI-1125 included with these instructions (in a separate binder) will be found to be of great value in supplying maintenance information. In addition, descriptive bulletins covering many of the component items of the Transmitter are included in Section XVII of this Instruction Book.

All equipment, particularly high-voltage components and insulators, should be kept free of dust and oil. A small portable electric blower of the hair-drier type is useful in removing dust from hard to get at places such as around terminal boards and between capacitor plates. Keep all obstructions away from the air intake and exhaust openings. Make certain that tubes are properly placed and connected in their sockets. Inspect connections for tightness. Clean air capacitor plates with a lintless cloth. Remove with a flat file any rough points caused by arcs. Crocus cloth will be found useful for obtaining a smooth surface. Never use steel wool for cleaning or polishing near electrical circuits as the particles may cause shorts.

A cloth moistened with alcohol or carbon tetrachloride is effective for removal of grease and dirt (as from insulators).

When cleaning, inspecting, and tightening avoid unnecessary twisting and bending of wires and cables as this might cause eventual breakage.

High-Power Tubes

On receipt of new tubes, immediately inspect them for possible damage resulting from shipment. Before placing a new tube in "spare tube stock" it should be operated for at least one day. The procedure should be repeated every six months. This assures that the spare tubes are in good condition and tends to clean up gas which may have been released from the anode. The spare tubes installed in the PA and Modulator cubicles should be tested monthly (inasmuch as no physical movement of the tube is involved). It is good practice to keep a record of tube life (5M3) for each of the large tubes used so that operating economics can be determined.

The proper procedure to be used for testing the highpowered tubes is as follows: Place the tube in the circuit (gas will clean up more quickly in the PA than in the Modulator) and operate at 60 per cent plate voltage with zero modulation. After 15 minutes operation, increase plate voltage to 80 per cent of normal (HV transformer tap). If a gas kick occurs return to the 60 per cent position and allow additional low-voltage aging until 80 per cent voltage can be applied. Carry out the same procedure between 80 per cent and 100 per cent voltage. Apply modulation gradually until the tube becomes stable at 100 per cent modulation.

As the high-powered tubes have more than adequate emission capabilities (see Section IX on AUDIO-MODULATOR, and Section VIII on POWER AMPLIFIER) they will normally be operated at below rated filament voltage. The minimum filament voltage at which emission limiting (at 95 to 100 per cent modulation), with increasing distortion occurs can be determined by test and the voltage then adjusted to a somewhat higher value. Normally, a new tube can be operated at as low as 17.25 volts in the Modulator and 18 volts in the Power Amplifier.

The grid connector is painted red to correspond with the red grid posts of the tube and the filament connectors are painted black to correspond with the color of their respective posts. To facilitate easy removal or application of a tube connector, the coiled spring should be retracted.

Handling of the Type GL-895-R tube is most easily and safely performed with the use of a tube jack. However, it is possible for two men to remove or replace tubes manually. A small portable wooden platform if placed in front of the tube position will expedite manual changing. Care should be exercised to place tubes gently in their sockets. In transporting them, vibration and shock should be avoided.

Rectifier Tubes

Refer to the HV RECTIFIER, Section X, for the procedure for testing and aging of rectifier tubes. Rectifier tube filaments are to be operated at rated voltage at all times. The glass envelopes should be kept clean. Tubes should be transported and stored in a vertical position, and unnecessary splashing of mercury avoided. A routine (monthly) measurement of tube voltage drop, with a card file record for each tube, will be found effective in determining potential tube failures.

Small Tubes

These should be tested in the Transmitter when received, and approximately each six months thereafter. An unbalance in a push-pull or parallel stage currents is usually indicative of a low emission tube. This can be checked by insertion of a new tube in the circuit.

Socket contacts and tube prongs should be kept in good condition. The filament clamps of the GL-833A sockets should be well tightened. Tube envelopes should be cleaned occasionally with alcohol and tissue paper. The filaments of all tubes (other than GL-895-R) should be operated at rated voltages (within 5 per cent).

Gas-Filled Capacitors

See Section V on INSTALLATION for information on pressurizing the gas-filled capacitors. The ceramic insulators must be kept clean since the voltages involved are high. Lubricate the universal joints with a small amount of light oil and remove all excess lubricant. The connection to the capacitors must be kept tight to avoid heating. The protective gaps should be kept polished.

Normally no further maintenance is required for these capacitors other than periodic checking of gas pressure. It will be necessary to occasionally add additional dry nitrogen gas to maintain the pressure at between 175 and 200 psi.

The capacitors are protected from internal flash-over by the external gap and by action of the carrier-trip protective circuit. If a capacitor should arc internally, pitting of the plates could occur. Although it is possible for transmitter engineers to disassemble the capacitors, dress the plates, and re-assemble, it is a job best performed by the capacitor manufacturer. Due to the importance of the functions of these capacitors, it may be advisable to maintain one spare of each of the two types used.

Motors and Tuning Driver

Inspect small motors of the filament voltage regulator and the tuning system, and keep them clean. Occasionally oil the tuning motor bearings with a few drops of light machine oil. Refer to the publication, "How to Maintain Electric Equipment" for further information on motor maintenance.

Control and Power Equipment

1. Main Breakers:

Refer to "How to Maintain Electric Equipment" for detailed maintenance information. Keep all parts of 6S1 and 6S2 clean. At least once a year, or following repeated tripping, inspect contacts and dress them with a flat file if badly pitted. Check the liquid level in the dashpot timers semiannually and fill to indicated level using G-E oil #21.

2. Switches, Contactors, Relays:

The filament changeover knife switches in the PA and Modulator cubicles should be kept clean and lubricated occasionally with a small amount of vaseline for free operation.

Check operation and timing of time-delay relays. Small relay contacts may be cleaned with carbon tetrachloride and a lint-free cloth. Badly pitted contacts may be smoothed with a fine file or a burnishing tool.

It is essential that metallic filings be kept out of all relays (particularly telephone types). Air may be used to blow out any filings which may have accumulated on the pole faces.

Inspect contacts of overload relays periodically and clean if necessary. Operate the plungers manually to test for freedom of action.

Check door interlocks for proper alignment and tightness of screws. Keep the contacts in good condition by cleaning occasionally and lubricating with a little vaseline.

Check the operation of safety grounding switches. Keep contacts and insulating posts clean and connections secure. Keep high voltage cables free of oil and dust at their taped ends. After cleaning and adjusting relays always allow ample time prior to program for checking transmitter operation.

Air Circulating System

1. Main Blower Equipment:

Periodically inspect drive belts for signs of wear and for uniform tension. Adjust for sufficient tension to prevent slipping. Properly lubricate the motor and fan bearings once a month. Keep the impeller blades free of oil and dirt. If rust spots occur scrape and repaint. Check motor starter contacts occasionally.

Check operation of air interlock 6S3 monthly. When the main blower is stopped, the air interlock switch should open at approximately one-half of normal air flow. The counter-weight on the moving arm may be adjusted for proper calibration. The pivot bearings should be kept dirt-free and oiled occasionally with a drop of light machine oil.

2. Air Filter:

Air-filter panels are removed by opening the locking clamps and withdrawing the units, using the handles provided for the purpose.

Clean the filters at intervals of approximately four months, depending on local conditions, or when an installed manometer reads .4 to .5 inches of water pressure differential between the outer surfaces. Three cleaning methods are listed:

(a) BOILING: Place filter, fine mesh face down, in tank containing solution of Oakite No. 20 (3 pounds to 5 gallons of water), tri-sodium phosphate ($1\frac{1}{2}$ pounds to 5 gallons of water), or other commercial solvent. Boil approximately 5 minutes or until filter is clean. DO NOT USE CAUSTIC SODA.

(b) HOT WATER: Agitate filter, fine mesh face down, in tank containing hot water and Oakite No. 20 (3 pounds to 5 gallons water), or other compound.

(c) HOSE: Use flat nozzle and water pressure. Sweep back and forth across the fine mesh side, holding nozzle firmly against surface, flushing dirt out intake and discharge faces. Hot water is preferred, but cold water may be used if accumulations are of a type cold water will clean.

Inspect the filters by looking through the wire mesh toward the light. When thoroughly clean, no cloudy areas will be visible. While the entire media can be made bright, it is not necessary to wash off the blackened oil coating on the wire element.

Recharge the filter as follows:

(a) Where many filters are to be serviced at regular intervals, a dip tank will be found to be the most feasible. Dip filter in Air-Maze Filterkote (Standard) or regular motor oil, S.A.E. 30 to 50 and allow it to drain. Separate tanks for boiling and dipping are recommended.

(b) Filters may be recharged with a power spray gun. Spray both sides, being sure that the adhesive penetrates the entire media.

(c) When no other equipment is available, panels may be recharged by liberally coating filter with adhesive by means of a brush. To assure complete coverage of the media, adhesive should be applied to both faces.

After the filter element has been thoroughly coated with adhesive, allow the panels to drain completely, face down, or on edge. A receptacle may be used to reclaim the excess oil.

Rectifier Blowers

Keep the motors and impellers clean; occasionally blow accumulated dust out of motor windings. The bearings should be given an annual thorough cleaning and repacked about one-third full of a good grade of grease (such as G-E ballbearing grease).

Pyranol* Filled Components

The HV plate transformers, the modulation transformer, the modulation reactor, the filter reactor and the optional plate regulator, are filled with non-inflammable Pyranol*. Check the gauges occasionally to assure proper liquid level. Approximately once per year, sample the Pyranol* and measure its dielectric strength. See "How to Maintain Electric Equipment" for detailed information. If Pyranol* tests show breakdown below 25 KV, use a filter press to restore the dielectric strength to 30 KV or higher. Due to the Pyranol* tanks being sealed it will normally be found that Pyranol* maintains its dielectric strength for long periods of time and that filtering is seldom required.

If for any reason a Pyranol*-filled tank is opened, it should be resealed using G-E Glyptal on the gaskets. If the gasket is damaged it should be replaced. Avoid leaving Pyranol* exposed to air.

* G-E trade-mark

Keep tanks clean. Clean high-voltage bushings using tissue paper and alcohol. Keep protective gaps clean, polished, and correctly spaced.

Spark Gap Adjustments

Set the antenna and transmission line horn gaps as follows: Adjust spacing until arc-over takes place at 100 per cent modulation, then double this spacing.

Set other gaps as follows:

Symbol	Function	Spacing
2E1	PA grid circuit Gap	.04 inches
2E2	" " " "	.08 "
3E1, 3E2, 3E3	Modulator grid Gaps	.04 "
6T10	Modulation Transformer Horn Gap	.50 "
6L1	Modulation Reactor Horn Gap	.50 "
2C1	PA Tank Capacitor Gap	.75 "
2C2	PA Loading Capacitor Gap	.50 "
6L2	HV Filter Reactor Horn Gap	.10 "

Small Components

1. Capacitors:

Variable capacitors should be kept clean. A small amount of vaseline should be used on the contacts springs (particularly 1C60) to assure ease of operation.

2. Coils:

Make sure all connections (especially on 2L4) are tight to prevent overheating. Clean coils with a cloth moistened with alcohol or carbon-tetrachloride. Never use liquid polish or steel wool. Plate choke 2L10, meter multiplier 2R16, 2R17, 2R18, and their ceramic posts, located in the p-a air box, must be kept clean.

3. Resistors:

Resistors should be kept clean. Vitreous enamelled resistors in the higher resistance values should be replaced if the coating is cracked. Check resistor clips occasionally for proper tension. If the Globar (composition) resistors are overheated, check their resistance values which may have changed. Inspect sliding contacts of variable resistors; clean as necessary.

4. HV Rectifier Tripping Transformers:

Never apply power with the secondary circuits of 6T5 and 6T6 open, as the resulting high voltage might cause insulation failure.

Cabinet Finish

The finish used on the cabinets is a metal-bearing type commercially known as "Mottletone." Large areas of marred paint can best be refinished by sanding and spraying, using the touch-up paint provided. Small scratches and nicks may be touched-up using a camels-hair brush. Best results are obtained by "stippling" the paint into the scratches; ordinary brushing results in a streaked or smeared appearance. The touch-up paint, when first applied, will appear to be several shades too light. In 24 hours the color will attain its darker, permanent shade.

-PARTS LIST-

50 KW AM BROADCAST TRANSMITTER

MODEL 4BT25A1

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

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

EXCITER

SYMBOL	DESCRIPTION	G-E DRAWING
	CAPACITORS	
*1C1 thru 1C3	Mica, 0.01 mfd. ±10%, 300 vdcw.	P-3R28-P9
*1C4 and 1C5	Vernier Frequency Control Capacitors. Variable, air, 4.4-50 mmfd. Hammarlund Cat. #APC-50.	P-3R47-P2
*1C6	Silver mica, 22 mmfd. ±5%, 500 vdcw.	P-3R26-P64
*1C7	Silver mica, 330 mmfd. ±5%, 500 vdcw.	P-3R26-P75
*1C8 thru 1C11	Same as 1C1.	
*1C12	Mica, 0.01 mfd. -10%, 600 vdcw.	P-3R31-P15
*1C13	Oscillator Plate Tuning Capacitor. Variable, air; 7.5-100 mmfd, screw driver control. Hammarlund Cat. #HFA-100-B.	M-2R26-P24
*1C14	Mica, 220 mmfd. ±20%, 500 vdcw.	P-3R26-P14
	INDICATING DEVICES	
*1I1 and 1I2	Crystal Heater Indicator Lamps, 6-8 volts, 0.15 amps. Mazda #47	
	INDUCTORS	
1L1	Cathode Choke Coil. Inductance 2-1/2 mh, distributed capacity 1 mmfd. d-c resistance 50 ohms, current rating 125 ma.	K-7107898
1L2	Plate Inductance	ML-7478058-G1

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

SYMBOL	DESCRIPTION	G-E DRAWING
	RESISTORS	
*1R1 and 1R2	Composition, 15 ohms ±5%, 2 watts.	P-3R67-P115
*1R3	Composition, 0.10 meg. ±10%, 1 watt.	P-3R13-P86
*1R4	Composition, 1800 ohms ±10%, 1 watt.	P-3R13-P65
*1R5 and 1R6	Composition, 10,000 ohms ±5%, 1 watt.	P-3R13-P183
*1R7 and 1R8	Composition, 15,000 ohms ±5%, 2 watts.	P-3R67-P187
	SWITCHES	
1S1	Crystal Transfer Switch. Rotary, 2 positions, 2 circuits. Oak Mfg. Co. Type HC.	M-7478059
	TUBES	
1V1	Crystal Oscillator. Type GL-837.	
	SOCKETS	
*1X1	Crystal Oscillator Tube Socket. 7 contacts American Phenolic Corp. Type #RSS7L.	K-1R13-P45
1X2 thru 1X11	See page 107.	
*1X12 and 1X13	Crystal Sockets Mica-filled phenolic, octal. American Phenolic Corp. Type #MIP8T.	K-1R14-P26
*1X14 and 1X15	Crystal Heater Lamp Sockets. Green jewel, bayonet base. Drake Mfg. Co. Type #80.	K-7108403-P3
	CRYSTALS	
1Y1** and 1Y2**	Crystal Thermocell. Holder G-E Type #32C401G30B thermocell heater 6.3 volts, 50/60 cycles; Crystal selected according to operating frequency. These crystals are interchangeable with G-E Type #32C401G30.	M-7478061
	CAPACITORS	
*1C15 thru 1C18	Mica, 10,000 mmfd. ±10%, 600 vdcw.	P-7769838-P13

* This item or equivalent can often be obtained from a local radio dealer.
** When reordering state operating frequency.

SYMBOL	DESCRIPTION	G-E DRAWING

CAPACITORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
1C19	Mica, 10,000 mmfd. ±10%, 2500 vdcw.	P-3R32-P75
1C20	Plate Tank Capacitor, 1 st. IPA Variable, 32-335 mmfd., 3750 peak voltage. Hammarlund Catalog #TC-330-K.	P-3R25-P13
*1C21	Mica, 100 mmfd. ±10%, 2500 vdcw.	P-3R32-P5
*1C22	Same as 1C15.	
1C23	Neutralizing Capacitor, 2nd IPA. Variable, 15-53 mmfd. 6000 peak voltage. Hammarlund Cat. #TC-50H.	P-3R25-P7
1C24	Mica, 2500 mmfd. ±5%, 5000 vdcw.	M-2R58-P16
*1C25 and 1C26	Same as 1C15.	
1C27	Same as 1C24.	
1C28** thru 1C33	Plate Tank Capacitors 2nd IPA. Vacuum, 100 mmfd. ±5%, 7500 peak voltage. G-E Type #GL-1L33.	K-7897602-P3
1C34	Plate Tank Capacitor, 2nd IPA. Variable, 28.5-115 mmfd. 6000 peak voltage. Hammarlund Cat. #TC-110-H.	P-3R25-P8
1C35** and 1C36	Grid Tank Capacitors, 3rd IPA. Mica, rating depends on customers' requirements. (When ordering replacements specify G-E Drawing number and rating).	
1C37	Grid Tank Capacitor, 3rd IPA. Variable. 32.5-465 mmfd. 2000 peak voltage. Hammarlund Cat. #TC-440-L.	P-3R25-P15
*1C38	Mica, 10,000 mmfd. ±10%, 1200 vdcw.	P-3R32-P17
1C39 and 1C40	Mica, 22,000 mmfd. ±10%, 600 vdcw.	P-3R32-P19
*1C41 and 1C43	Same as 1C38.	
1C44 thru 1C47	Same as 1C39.	
1C48	Neutralizing Capacitor, 3rd IPA. Variable, air; 19-51 mmfd. 11,000 peak breakdown voltage. E. F. Johnson, Cat. #50C110.	K-7118656-P1
1C49	Same as 1C24.	
1C50** thru 1C59	Plate Tank Capacitor, 3rd IPA.	
1C60	Plate Tank Capacitor, 3rd IPA. Variable, air; 350 mmfd. ±5%, 9500 peak voltage. E. F. Johnson Co. Type #350-BA-95.	P-7769241
1C61	Same as 1C24.	

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

** Use depends on operating frequency. See chart in Instruction Book.

CAPACITORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
*1C62 and 1C63	Same as 1C15.	
*1C64 and 1C65	Low Voltage Filter Capacitors. Pyranol, 10 mfd. ±10%, 1000 vdcw. G-E Cat. #23F364.	P-3R88-P9
*1C66 and 1C67	1400 Volt Supply Filter Capacitors. Pyranol, 10 mfd. ±10%, 2000 vdcw. G-E Cat. #23F386.	P-3R87-P4
1C68 thru 1C71	2800 Volt Supply Filter Capacitor. Pyranol, 2 mfd. ±10%, 4000 vdcw. G-E Cat. #23F411.	P-3R87-P14
1C72	Same as 1C24.	
*1C73	Trip CKT Shaping Capacitor. Pyranol, 4 mfd. ±10%, 600 vdcw. G-E Cat. #23F353.	P-3R88-P3
*1C74	Trip CKT Supply Filter Capacitor. Pyranol, 1 mfd. ±10%, 600 vdcw. G-E Cat. #23F320.	P-3R48-P1
1C76	PA Bias Filter Capacitor. Pyranol, 10 mfd. ±10%, 2500 vdcw. G-E Cat. #23F397.	P-3R87-P8
1C77 and 1C78	AF Bias Filter Capacitors. Same as 1C64.	
*1C79	AF Bias Filter Capacitor. Pyranol, 10 mfd. ±10%, 600 vdcw. G-E Cat. #23F354.	P-3R88-P5
1C80 thru 1C83	Power Factor Correction Capacitors. Pyranol, 7.5 kvar, 230 volts. G-E Cat. #16F14.	K-7116521-P1
1C84 and 1C85	AF Bias Filter Capacitors. Same as 1C64.	
*1C86 and 1C87	1400 Volt Supply Filter Capacitors. Same as 1C66.	
1C88 ** thru 1C91	Plate Tank Capacitors 2nd IPA. Vacuum, 100 mmfd. -5%, 7500 peak voltage. G-E Type #GL-1L33.	K-7897602-P3

RECTIFIER

SYMBOL	DESCRIPTION	G-E DRAWING
1CR1	Carrier-Trip Selenium Rectifier, Single phase, half wave; 0.5 amps, 84 volts, d-c. G-E Cat. #6RS114CB1.	M-7479208-P1

INDICATING DEVICES

SYMBOL	DESCRIPTION	G-E DRAWING
1IS1	IPA Plate "ON" Push Button and Lamp. Green translucent button. G-E Cat. #2280664G-3.	K-7107849-P6
1IS2	IPA Plate "OFF" Push Button and Red translucent button. G-E Cat. #2280664G-2.	K-7107849-P5
1IS3	Carrier-Trip Test Push Button and Lamp. Same as 1IS2.	

*This item or equivalent can often be obtained from a local radio dealer.
**Use depends on operating frequency. See chart in Instruction Book.

SYMBOL	DESCRIPTION	G-E DRAWING

JACKS AND RECEPTACLES

*1J1	Convenience Outlet with K-7119169-P1 Plate. Twin outlet. G-E Cat. #2679 Except black.	K-7888177-P1
*1J2	Frequency Monitor Cable Jack. Chassis receptacle. American Phenolic Corp. Cat. #83-1R.	M-2R22-P3
*1J3	Frequency Monitor Cable Jack. Feed thru connector. American Phenolic Corp. Cat. #83-1F.	M-2R22-P6
*1J4 and 1J5	Excitation Cable Jacks. Same as 1J2.	

RELAYS

1K1	Carrier-Trip Relay. 2 form A, 1 form C contacts.	P-7770221-P32

INDUCTORS

1L3	Plate Tank Coil, 1st IPA	ML-7478085-G1
1L4	Frequency Monitor Coupling Coil, 1st IPA	ML-7118755-G1
1L5	Grid Choke, 2nd IPA.	ML-7478165-G1
1L6	Grid Parasitic Choke, 2nd IPA. Coil, 0.3 microhenries, 0.003 ohms. (1R22 included) Ohmite Cat. #P-300.	M-7476387-P1
1L7	Neutralizing Coil, 2nd IPA.	ML-7478082-G2
1L8	Plate Choke Coil, 2nd IPA.	ML-7478157-G1
1L9	Plate Tank Coil, 2nd IPA. (1L10 included)	ML-7769373-G2
1L10	Output Coupling Coil, 2nd IPA. (part of 1L9)	
1L11	Grid Tank Coil, 3rd IPA.	ML-7478397-G1
1L12	Grid Choke, 3rd IPA. Same as 1L8.	
1L13	Grid Parasitic Choke, 3rd IPA. (Includes 1R27)	K-7117635-G2
1L14	Grid Parasitic Choke 3rd IPA. Same as 1L13 (Includes 1R28)	
1L15	Grid Parasitic Choke, 3rd IPA. (Includes 1R32)	
1L16	Neutralizing coil, 3rd IPA.	ML-7768780-G1
1L17	Plate Choke, 3rd IPA.	ML-7478900-G1
1L18	Plate Tank Coil, 3rd IPA.	ML-7768783-G1
1L19	Output Coupling Coil, 3rd IPA.	ML-7478185-G1
*1L20 and 1L21	750 Volt Supply Filter Chokes. 10 henries, 0.175 amps., d-c resistance 100 ohms.	M-7475693
1L22 and 1L23	1400 Volt Supply Filter Chokes; 5 henries, 0.7 amps, d-c resistance 26 ohms.	M-7477716

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

SYMBOL	DESCRIPTION	G-E DRAWING

INDUCTORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
1L24 and 1L25	2800 Volt Supply Filter Chokes. 10 henries, 1.5 amps, d-c resistance 15 ohms.	M-7477708
1L26	PA Fixed Bias Supply Filter Choke, 4 henries, 0.65 amp, d-c resistance, 23 ohms	M-7477715
1L27 and 1L28	AF Bias Supply Filter Chokes. 2 henries, 2 amp. d-c, 8.9 ohms, d-c resistance	M-7469115
1L29	3rd IPA Parasitic Choke. (Includes 1R41)	K-7117635-G1
1L30	2nd IPA Parasitic Choke. Same as 1L29. (Includes 1R51).	

METERS

SYMBOL	DESCRIPTION	G-E DRAWING
1M1	Oscillator Cathode Milliammeter. 20 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P28
1M2	750 Volt Supply Voltmeter. 1000 volts d-c, calibrated for non-magnetic panels only. (External resistance 1R33 supplies).	P-3R34-P20
1M3	Grid Milliammeter, 2nd IPA, 80 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P31
1M4	Plate Milliammeter, 2nd IPA, 200 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P34
1M5	Grid Milliammeter, 3rd IPA. 500 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P36
1M6 thru 1M8	Plate Milliammeters, 3rd IPA. Same as 1M5.	
1M9	Plate Milliammeter, 1st IPA, 100 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P32
1M10	Not used.	
1M11	2800 volt supply voltmeter. 5kv d-c, calibrated for non-magnetic panels only. (External resistance 1R43 supplied).	P-3R34-P26
1M12	PA Fixed Bias Supply voltmeter. 800 v d-c, calibrated for non-magnetic panels only.	P-3R34-P17
1M13	AF Bias Supply Voltmeter. Same as 1M12.	

PLUGS

SYMBOL	DESCRIPTION	G-E DRAWING
*1P1 thru 1P3	Frequency Monitor Plug Connectors. 2 piece straight plug. American Phenolic Corp. Cat. #83-1SP.	M-2R22-P1
*1P4 and 1P5	Excitation Cable Plug Connectors. Same as 1P1.	

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

RESISTORS

SYMBOL	DESCRIPTION	G-E DRAWING
*1R9	Composition, 5600 ohms ±10%, 2 watts	P-3R67-P71
*1R10	Wirewound, 2000 ohms ±5%, 10 watts. Ward Leonard Cat. #K41382-3.	M-2R12-P134
1R11	Suppressor Potentiometer, 1st IPA, power, wirewound; 1000 ohms, ±10%, 50 watts, linear taper, screw driver control. Ohmite Model J, Cat. #0326.	M-2R34-P44
1R12	Screen Potentiometer, 1st Audio. Same as 1R11.	
*1R13	Wirewound, 2000 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P134
1R14	Plate Potentiometer, Oscillator. Same as 1R11.	
1R15	Wirewound, 3150 ohms ±5%, 50 watts.	M-7464828-P36
*1R16	Composition, 100 ohms ±10%, 2 watts.	P-3R67-P50
1R17	Wirewound, 8000 ohms ±5%, 50 watts.	M-7464828-P40
*1R18	Composition, 24,000 ohms ±5%, 2 watts.	P-3R67-P192
*1R19	Wirewound, 5,000 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P138
*1R20	Wirewound, 310 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P126
*1R21	Wirewound, 800 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P130
*1R22	Non-inductive, wirewound, 50 ohms. (Included in 1L6).	
1R23	Wirewound, 100 ohms ±5%, 50 watts.	M-7464828-P21
*1R24	Wirewound, 50 ohms ±5%, 10 watts. Ward Leonard Cat. #K41382-3.	M-2R12-P118
1R25	Wirewound, 1250 ohms ±5%, 160 watts.	M-7464825-P32
*1R26	Same as 1R24.	
1R27	Composition, 100 ohms ±10%, 16 watts. Globar Division Carborundum Co. Type #CX (Included in 1L13).	P-7765370-P32
1R28	Same as 1R27. (Included in 1L14).	
*1R29	Wirewound, 25 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P115
*1R30	Wirewound, 100 ohms ±5%, 10 watts. Ward Loenard Cat. #K41382-3.	M-2R12-P121
*1R31	Same as 1R24.	
*1R32	Same as 1R27. (Included in 1L15).	
1R33	Multiplier, 1 meg. ± 0.2%, 1 kv. G-E Form # 3Y (Supplies with 1M2).	M-7475042-P1
*1R34	Wirewound, 250 ohms ±5%, 35 watts. Ward Leonard Cat. #K41383-3.	M-2R15-P155
*1R35	Wirewound, 40 ohms ±5%, 10 watts. Ward Leonard Cat. #K41382-3.	M-2R12-P117
*1R36	Wirewound, 250 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P125
1R37 and 1R38	Wirewound, 31,500 ohms ±5%, 115 watts.	M-7464826-P46

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

RESISTORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
1R39 and 1R40	Wirewound, 50,000 ohms ±5%, 160 watts.	M-7464825-P48
1R41	Same as 1R27. (Included in 1L29).	
*1R42	Trip-CKT Shaping Resistor. Composition, 39,000 ohms, ±10%, 2 watts.	P-3R67-P81
1R43	Multiplier for 1 M11. 5 meg. ±0.2%, 5 kv. G-E Form 3Y.	M-7475042-P7
1R44 and 1R45	Wirewound, 10,000 ohms ±5%, 50 watts.	M-7464828-P41
1R46	25,000 ohms 20 watts Damping Resistor IRC Type #MPZ.	P-7765390-P29
1R47	Wirewound, 5000 ohms ±5%, 50 watts.	M-7464828-P38
1R48	Bias Adjust. Variable, 1600 ohms ±5%, 50 watts.	M-7483417-P163
1R49	Not used.	
*1R50	Wirewound, 160 ohms ±5%, 35 watts. Ward Leonard Cat. #K41388-3.	M-2R15-P153
1R51	Same as 1R27. (Included in 1L30).	

SWITCHES

SYMBOL	DESCRIPTION	G-E DRAWING
1S2	Safety Grounding Switch. 3pst, 20,000 volts	ML-7769398-G1
1S3	Door Interlock. Spst, 10 amp, 250 volts.	ML-7460330-G4
*1S4	Carrier-Trip Power Switch. Toggle, dpst, 20 amps, 250 volts, G-E Cat. #80421.	K-7116143
*1S5	Cubicle Light Switch, Same as 1S4.	
1S6	Safety Grounding Switch. Same as 1S2. (For remainder of Switches see Indicating Devices)	

TRANSFORMERS

SYMBOL	DESCRIPTION	G-E DRAWING
1T1	Crystal Heater Transformer. Pri: 115 volts, 50/60 cycles; Sec: 11 volts, 0.9 amps.	M-7479609
1T2	Filament transformer, Crystal Oscillator. Pri: 230/208 volts, 50/60 cycles; Sec: 12.6/6.3 volts, 0.75 amps.	M-7478415
1T3	Filament Transformer, 1st and 2nd IPA Pri: 230/208 volts, 50/60 cycles, 0.1225 kva; Sec: #1 and #2: 10 volts, center tap, 4.5 amps.; Sec: #3: 10 volts, center tap, 3.25 amps.	M-7477991
1T4	Filament Transformer, 3rd IPA. Pri: 230/208 volts, 50/60 cycles, 0.30 kva. Sec. #1: 10 volts, center tap; Sec. #2: 10 volts, center tap; Sec. #3: 10 volts, center tap.	M-7477983

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

SYMBOL	DESCRIPTION	G-E DRAWING

TRANSFORMERS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
1T5	Filament Transformer, 750 Volt Supply. Pri: 230/208 volts, 50/60 cycles; Sec: 2.5/1.25 volts, 10 amps.	M-7478441
1T6	Plate Transformer, 750 Volt Supply. Pri: 230/208 volts, 50/60 cycles, 0.164 kva; Sec: 1870/935 volts, 0.232 kva.	M-7477711 UTC CG 302
1T7 and 1T8	Filament Transformers, 2800 Volt Supply. Pri: 230/208 volts, 50/60 cycles, 32.5 va Sec: 5 volts, 37.5 va.	M-7477984
1T9	Plate Transformer, 2800 Volt Supply. Pri: 230 volts, 50/60 cycles, 6.31 kva, Sec: 3300/1650 volts, 6.80 kva.	M-7477710 ✓
1T10	Filament Transformer, 2800 Volt Supply. Same as 1T7.	
1T11	Plate Transformer, PA Bias Rectifier Pri: 230 volts, 50/60 cycles, 0.283 kva, Sec: 760/380 volts, 0.4 kva.	M-7478449 ✓
1T12	Filament Transformer, PA Bias Rectifier. Same as 1T5.	
1T13	Filament Transformer, ~~PA~~ AF Bias Rectifier. Pri: 230/208 volts, 50/60 cycles, 0.075 kva; Sec: 5 volts, center tap, 15 amps.	M-7477985
1T14	Plate Transformer, AF Bias Rectifier Pri: 230 volts, 50/60 cycles, 0.94 kva; Sec: 1250/625 volts, 1.33 kva.	M-7479611 ✓
1T15	Filament Transformer, 2800 Volt Supply. Same as 1T7.	

TUBES

SYMBOL	DESCRIPTION	G-E DRAWING
1V2	Amplifier Tube, 1st IPA. Type GL-828.	
1V3	Amplifier Tube, 2nd IPA. Type GL-810.	
1V4 thru 1V6	Amplifier Tubes, 3rd IPA. Type GL-833 A.	
1V7 and 1V8	Rectifier Tubes, 750 Volt Supply. Type GL-866A.	
1V9 and 1V10	Rectifier Tubes. 2800 Volt Supply. Type GL-8008.	
1V11 thru 1V15	Not used.	
1V16 and 1V17	Rectifier Tubes, 2800 Volt Supply. Same as 1V9.	
1V18 and 1V19	Rectifier Tubes, PA Bias Supply.(3300 Volt) Same as 1V7.	
1V20 and 1V21	Rectifier Tubes, AF Bias Supply. Same as 1V9.	

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

SYMBOL	DESCRIPTION	G-E DRAWING

SOCKETS

SYMBOL	DESCRIPTION	G-E DRAWING
*1X2	GL-828 Socket, 1st IPA. 5 contacts. American Phenolic Corp. Type #RSS5.	K-1R13-P42
*1X3	GL-810 Socket, 2nd IPA. 4 contacts. E. F. Johnson Cat. #211B.	M-7475054-P2
1X4 thru 1X6	GL-833A Sockets, 3rd IPA. E. F. Johnson Cat. #212 except omit plate leads.	M-7479130-P1
1X7 and 1X8	GL-866A Sockets, 750 Volt Supply. 4 contacts. E. F. Johnson Cat. #209B.	M-7475054-P1
1X9 and 1X10	GL-8008 Sockets, 1400 Volt Supply. 4 contacts. E. F. Johnson Cat. #244.	K-7115212-P1
1X11 thru 1X15	See page 99.	
1X16 and 1X17	GL-8008 Sockets. 2800 Volt Supply. Same as 1X9.	
1X18 and 1X19	GL-866A Sockets, PA Bias Supply. Same as 1X7.	M-7475054-P1
1X20 and 1X21	GL-8008 Sockets, AF Bias Supply. Same as 1X9.	
1X22	Not Used.	
*1X23 and 1X24	Lamp Holders. 600 volts, 660 Watts. G-E Cat. #001.	K-7119168-P1

POWER AMPLIFIER

MOTORS

SYMBOL	DESCRIPTION	G-E DRAWING
2B1	PA Tuning Motor. Gear reduction motor, reversible; 230 volts, 50/60 cycles, 1 phase, 45/55 rpm, 240 inch-oz torque, 10 min. 50% duty cycle. Holtzer-Cabot Type #3712 shallow gear case.	M-7476383-P1
2B2	Output Loading Motor. Same as 2B1.	
2B3	Grid Tuning Motor. Same as 2B1.	

CAPACITORS

SYMBOL	DESCRIPTION	G-E DRAWING
2C1	PA Plate Tank Capacitor. Variable, pressure type; 475-1500 mmfd. 15 kv. 100 amps. Lapp Cat. #24457.	K-7120902-P1
2C2	Output Coupling Capacitor. Variable, pressure type, 1450-3250 mmfd., 10 kv, 100 amps.	K-7120902-P2
2C3	Plate Blocking Capacitor. Mica, 0.0015 mfd. ±5%, 40,000 peak v.	K-1R17-P1

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

CAPACITORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
2C4	Plate Bypass Capacitor. Same as 2C3.	
2C5 thru 2C13	Filament Bypass Capacitors. Mica, 0.06 mfd. ±5%, 2000 peak v.	M-2R49-P21
2C14 and 2C15	Grid Tank Bypass Capacitor. Mica, 0.1 mfd. ±5%, 500 peak v.	M-2R23-P21
2C16	Not used.	
2C17	Grid Blocking Capacitor. Mica, 0.004 mfd. ±5%, 8000 peak v.	M-2R59-P13
2C18** thru 2C29	Transmission Line - Load Matching Capacitors. Vacuum, rating depends on customer's requirements. When ordering replacements specify G-E drawing number and rating.	
2C30**	Second-Harmonic Filter Capacitor. Mica, rating depends on customer's requirements. When ordering replacements specify G-E drawing number and rating.	
2C31** thru 2C33	PA Grid Tank Capacitors. Mica, rating depends on customer's requirements. When ordering replacements specify G-E drawing number and rating.	
2C34 thru 2C36	Not used.	
*2C37 thru 2C41	Mica, 10,000 mmfd. ±10%, 1200 vdcw.	P-3R32-P17
2C42	Not used.	
*2C43 and 2C44	Same as 2C37.	
*2C45 thru 2C47	Motor Capacitors. Paper, 1.50 mfd. ±10% 330 vacw. Cornell Dubilier Catalog #PC-1805.	K-7116605-P1
*2C48	Mica, 10,000 mmfd. ±10%, 2500 vdcw.	P-3R32-P75

INDICATING DEVICES

SYMBOL	DESCRIPTION	G-E DRAWING
*2I1 and 2I2	Mazda #47, 6-8 volts, 0.15 amps.	
2IS1	PA "OFF" Push button and Lamp, Red translucent button. G-E Cat. #2280664G-2.	K-7107849-P5
2IS2	PA "ON" Push button and Lamp, Green translucent button. G-E Cat. #2280664G-3.	K-7107849-P6
2IS3	IPA "OFF" Push button and lamp. Same as 2IS1.	
2IS4	IPA "ON" Push button and Lamp. Same as 2IS2.	

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

**Use depends on operating frequency. See chart in Instruction Book.

SYMBOL	DESCRIPTION	G-E DRAWING

JACKS AND RECEPTACLES

SYMBOL	DESCRIPTION	G-E DRAWING
*2J1	Convenience Outlet with K-7119169-P1 Plate. Twin outlet. G-E Cat. #2679 except black.	K-7888177-P1
*2J2	Modulation Monitor Jack. Chassis receptacle. American Phenolic Corp. Cat. #83-1R.	M-2R22-P3
*2J3	Distortion Meter Jack. Same as 2J2.	
*2J4	Distortion Meter Jack. Feed thru connector. American Phenolic Corp. Cat. #83-1F.	M-2R22-P6
*2J5	Modulation Monitor Jack. Same as 2J4.	
*2J6	Same as 2J1.	

INDUCTORS

SYMBOL	DESCRIPTION	G-E DRAWING
2L1	Grid Tank Coil. 18 microhenries. (Includes 2S11 and 2S12).	ML-7352093-G1
2L2**	Tapped Neutralizing Coil. 740 microhenries.	ML-7768797-G1
2L3	Adjustable Neutralizing Coil. 283 microhenries.	ML-7664532-G1
2L4	Plate Tank Coil. 90 microhenries.	ML-7664531-G1
2L5	2nd Harmonic Filter Coil. 18.6 microhenries.	ML-7768789-G1
2L6 and 2L7	Harmonic Filter Coils. 73 microhenries.	ML-7664530-G1
2L8	Stabilizing coil	K-7129769-G1
2L9	Grid Choke.	ML-7478900-G1
2L10**	Plate Choke. When ordering replacements specify G-E drawing number.	
2L11	Grid Parasitic Choke. (2R9 included)	ML-7478192-G1
2L12	Grid Parasitic Choke. Same as 2L11. (2R10 included)	
2L13	Pick-up Coil for Distortion Meter and Modulation Monitor.	ML-7479058-G1

METERS

SYMBOL	DESCRIPTION	G-E DRAWING
2M1	Grid current Ammeter. 2 amps d-c, initial accuracy ±1% of full scale, calibrated for .063" magnetic panels only.	K-7115711-P7
2M2	Total Plate Current Ammeter. 10 amps d-c, initial accuracy ±1% of full scale, calibrated for .063" magnetic panels only.	K-7115711-P8
2M3	PA Plate Voltmeter. 15 kilovolts d-c, initial accuracy ±1% of full scale, calibrated for .063" magnetic panels only. (2R16 thru 2R18 included).	K-7115711-P9
2M4***	Remote Antenna Current Ammeter. 10 ma d-c movement, initial accuracy ±1% of full scale, calibrated for .063" magnetic panels only.	
	With 15 amp. scale	K-7115711-P17
	With 25 amp. scale	K-7115711-P10
	With 50 amp. scale	K-7115711-P18

*This item or equivalent can often be obtained from a local radio dealer.
**Use depends on operating frequency. See chart in Instruction Book.
***Choice of Antenna Ammeter and its scale depends on the antenna resistance and power. See chart in Instruction Book.

SYMBOL	DESCRIPTION	G-E DRAWING

METERS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
2M5	Filament voltmeter. 30 volts a-c, calibrated for magnetic and non-magnetic panels.	P-3R37-P9
2M6 and 2M7	PA Plate Current Ammeters. 8 amps, d-c, calibrated for non-magnetic panels only.	P-3R36-P6

PLUGS

SYMBOL	DESCRIPTION	G-E DRAWING
*2P1	Modulation Monitor Plug. 2 piece straight plug. American Phenolic Corp. Cat. #83-1SP.	M-2R22-P1
*2P2	Distortion Meter. Plug. Same as 2P1.	
*2P3	Modulation Monitor Plug. Same as 2P1.	
*2P4	Distortion Meter Plug. Same as 2P1.	
*2P5	Modulation Monitor Plug. Same as 2P1.	
*2P6	Distortion Meter Plug. Same as 2P1.	

RESISTORS

SYMBOL	DESCRIPTION	G-E DRAWING
2R1	Grid Leak Resistor. Assembly consisting of 3 resistors. G-E Cat. #CR-9033A-240D and 1 resistor G-E Cat. #CR-9033A-240D 5/6 mounted in frame. Connected in series to give 960 ohms total, current capacity 1.62 amp. continuous	K-7118709
2R2	Wirewound, 5 ohms ±5%, 60 watts.	M-7464827-P8
2R3	Not used.	
2R4 and 2R5	Same as 2R2.	
2R6	Not used.	
2R7	Same as 2R2.	
2R8	Wirewound, 2.5 ohms ±5%, 115 watts.	M-7464826-P5
2R9	Grid Parasitic Resistor, Composition, 40 ohms ±10%, 32 watts. Globar Div. Carborundum Type #CX. (Part of 2L11).	P-7765370-P80
2R10	Grid Parasitic Resistor. Same as 2R9. (Part of 2L12).	
2R11 thru 2R14	Not used.	
2R15	PA Holding Bias Adjusting Resistor. Ferrule type, wirewound, 315 ohms ±5%, 9 taps ±10%, 115 watts.	M-2R55-P26
2R16 thru 2R18	Multipliers for 2M3. Precision, 5.0 meg. ± 1/2 of 1%, 1ma, 5kv. Type #MFA505.	M-7470483-P12

SWITCHES

SYMBOL	DESCRIPTION	G-E DRAWING
2S1	Grid Tune Key Switch. Lever type, spdt, 2 form A contacts, neutral locking. 10 amps, 220 volts. D. P. Mossman Cat. #4101.	M-7478768-P1

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

SYMBOL	DESCRIPTION	G-E DRAWING

SWITCHES CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
2S2	Plate Tune Key Switch. Same as 2S1.	
2S3	Plate Load Key Switch. Same as 2S1.	
2S4	Filament Voltmeter Selector Switch. Manually operated, 3 poles, 3 positions. G-E Type #SB-1.	P-7767481-P1
2S5	Filament Voltmeter Selector Switch. Manually operated, 2 poles, 3 positions, G-E Type #SB-1.	P-7767480-P1
2S6	Safety Grounding Switch. 3 pst, 20,000 volts.	ML-7769398-G1
2S7 and 2S8	Filament Transfer Switches. Knife, 3 pdt; 250 volts d-c, 500 volts a-c, 200 amps. G-E Type #LP1 Cat. #6193470G9 without fuses.	K-7126493-P1
*2S9	Tuning Motor Power Switch. Toggle, dpst, 20 amps 125 or 250 volts. Cat. #80421. Arrow-Hart and Hegeman.	K-7116143
2S10	Not used.	
2S11 and 2S12	Limit Switches. Spdt. (Included in 2L1) Micro Switch Corp. Type #STD (blue top) Cat. #B-RL.	K-7103929-P3
2S13	PA Filament Voltage Switch Toggle, dpst, 20 amps, 250 volts. Arrow-Hart and Hegeman Cat. #80421 Special.	K-7871834-P1
2S14	Air Box Interlock. Push button, single circuit, normally open, 3 amps, 250 volts. Arrow-Hart and Hegeman Cat. #3592-D with over travel plunger.	K-7115172-P1
+ 2S15 thru 2S17	Door Interlock. Single circuit, normally open, 10 amp, 250 volts.	ML-7460330-G4
*2S18	Cubicle Light Switch. Same as 2S9.	
2S19	Air Box Interlock. Same as 2S14.	
2S20 and 2S21	Safety Grounding Switches. Same as 2S6.	
2S22	Left PA Plate Link	
2S23	Center PA Plate Link	
2S24	Right PA Plate Link	
2S25 and 2S26	Filament Switch Interlock. Single circuit normally open, 10 amp, 250 volts.	K-7126514-P1

(For remainder of switches see Indicating Devices)

TRANSFORMERS

SYMBOL	DESCRIPTION	G-E DRAWING
2T1 and 2T2	Not used.	
2T3 thru 2T8	Filament voltage Adjusting Transformers Pri: 133 volts, 50/60 cycles; Sec: 33.75 volts, 25 amps.	M-7478419

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

SYMBOL	DESCRIPTION	G-E DRAWING

TRANSFORMERS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
2T9	Indicating Light Transformer. Pri: 230 volts, 50/60 cycles; Sec: 5 volts, 0.5 amps.	M-7477745
2T10	Not used.	
2T11	Same as 2T9.	
2T12 thru 2T14	GL-895R Filament Transformers. Pri: 230volts, 50/60 cycles; Sec: 19 volts, 138 amps.	M-7479634
2T15 thru 2T17	GL-895R Filament Transformers. Pri: 133 volts, 50/60 cycles; Sec: 19 volts, 138 amps.	M-7479633

TUBES

SYMBOL	DESCRIPTION	G-E DRAWING
2V1 thru 2V3	Power Amplifier Tubes. Type GL-895R.	

SOCKETS

SYMBOL	DESCRIPTION	G-E DRAWING
2X1 thru 2X3	GL-895R Sockets	T-7665016
2X4	Tuning Indicator Light Socket. Light green cap. Dial Light Co. Cat. #95410-192L.	K-7117809-P4
2X5	Grid Tuning Limit Indicator Socket. White cap. Dial Light Co. Cat. #95410-198.	K-7117809-P1
2X6	Not used.	
*2X7 and 2X8	Lampholder Sockets. 600 volts, 660 watts. G-E Cat. #001.	K-7119168-P1

AUDIO MODULATOR

SYMBOL	DESCRIPTION	G-E DRAWING
3C1 and 3C2	Not used.	
3C3 and 3C4	Pyranol, 25 mfd. ±10%, 330 vdcw. G-E Cat. #67 X 16.	K-7118712-P1
*3C5 and 3C6	High Frequency Attenuators. Mica, 470 mmfd. ±5%, 500 vdcw.	P-7770296-P34
*3C7 and 3C8	Low Frequency Attenuators. Paper, 0.02 mfd. +30%-10%, 600 vdcw. Sprague Cat. #PPX24B14.	P-7768969-P34
*3C9	Pyranol, 4 mfd. ±10%, 2000 vdcw. G-E Cat. #23F383.	P-3R87-P3
3C10 and 3C11	Pyranol, 1 mfd. ±10%, 3000 vdcw. G-E Cat. #23F402.	P-3R87-P9

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

SYMBOL	DESCRIPTION	G-E DRAWING

AUDIO MODULATOR CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
*3C12	Bypass Capacitor. Mica, 10,000 mmfd. ±10% 600 vdcw.	P-3R31-P15
3C13	Pyranol, 1 mfd. ±10%, 4000 vdcw. G-E Cat. #23F410.	P-3R87-P13
*3C14	Bypass Capacitor. Same as 3C12.	
*3C15 and 3C16	Low Frequency Attenuators. Paper, 0.05 mfd. +30%-10%, 600 vdcw. Sprague Cat. #PPX24B17.	P-7768969-P35
*3C17 and 3C18	High Frequency Attenuators. Mica, 2200 mmfd. ±5%, 500 vdcw.	P-3R28-P44
*3C19 and 3C20	Pyranol, 2 mfd. ±10%, 1000 vdcw. G-E Cat. #23F360.	P-3R88-P7
*3C21	Pyranol, 2 mfd. ±10%, 600 vdcw. G-E Cat. #23F350.	P-3R88-P2
*3C22 and 3C23	High Frequency Bypass. Mica, 220 mmfd. ±5%, 500 vdcw.	P-3R26-P54
3C24 and 3C25	D-C Blocking Capacitor. Pyranol, 1 mfd. +15% - 0%, 15,000 vdcw. G-E Cat. #14F17.	M-7478955-P2

INDICATING DEVICES

SYMBOL	DESCRIPTION	G-E DRAWING
3IS1	IPA, "OFF" Push Button and Lamp. Red button, G-E Cat. #2280644G-2.	K-7107849-P5
3IS2	IPA, "ON" Push button and Lamp. Green button, G-E Cat. #2280664G-3.	K-7107849-P6
3IS3	PA "OFF" Push Button and Lamp. Same as 3IS1.	
3IS4	PA "ON" Push button and Lamp. Same as 3IS2.	

JACKS AND RECEPTACLES

SYMBOL	DESCRIPTION	G-E DRAWING
*3J1 and 3J2	Convenience Outlets with K-7119169-P1 plate. Twin outlets. G-E Cat. #2679. Except Black.	K-7888177-P1

RELAYS

SYMBOL	DESCRIPTION	G-E DRAWING
3K1 thru 3K3	Bias Change Relays. 230 volts, 50/60 cycles, one spdt and one spst NO. contacts. G-E Type #12HMA14E2.	P-7767982-P11
3K4	Audio Attenuating Relay. 220 volts, 60 cycle; 1 form A, 2 form B contacts.	P-7770221-P2

INDUCTORS

SYMBOL	DESCRIPTION	G-E DRAWING
3L1	Driver Coupling Reactor. Dual, inductance 37.5 henries at 0.175 amp, d-c resistance 50 ohms each section.	M-7478421

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

SYMBOL	DESCRIPTION	G-E DRAWING
	METERS	
3M1 and 3M2	Plate Current Ammeter. 5 amps d-c, initial accuracy ±1% of full scale; calibrated for use on 0.063" magnetic panels only.	K-7115711-P6
3M3	Filament Voltmeter. 30 volts a-c, calibrated for magnetic or non-magnetic panels.	P-3R37-P9
3M4	Voltmeter 300 volts a-c, 45-66 cps, initial accuracy ±1% of full scale, calibrated for 0.063" magnetic panels. (Multiplier 3R2 supplied)	K-7115711-P2
3M5	Voltmeter. Same as 3M4. (Multiplier 3R1 supplied)	
3M6 and 3M7	2nd Audio Cathode Milliammeters, 200 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P34
3M8 and 3M9	1st Audio Cathode Milliammeters. 50 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P30
3M10 and 3M11	3rd Audio Plate Milliammeters. 500 ma d-c, calibrated for non-magnetic panels only.	P-3R35-P36
	RESISTORS	
3R1	Multiplier for 3M5.	
3R2	Multiplier for 3M4.	
3R3 thru 3R5	Composition, 40 ohms ±10%, 32 watts. Globar Div. Carborundum Co. Type #CX.	P-7765370-P80
3R6 thru 3R9	Wirewound, 5 ohms ±5%, 60 watts.	M-7464827-P8
3R10 thru 3R13	Composition, 40 ohms ±10%, 16 watts. Globar Div. Carborundum Co. Type #CX.	P-7765370-P30
3R14 thru 3R17	Plate Surge Resistors. Wirewound, 5 ohms ±5%, 160 watts.	M-7464825-P8
*3R18 thru 3R21	Composition, 470 ohms ±5%, 1 watt.	P-3R13-P151
3R22 and 3R23	Grid Loading Resistors. Wirewound, 5000 ohms ±5%, 50 watts.	M-7464828-P38
3R24 and 3R25	Modulator Bias Adjusting Resistors. Wirewound, 63 ohms ±5%, 9 taps ±10%, 160 watts.	M-2R54-P19
3R26	Modulator Balance Control. Rheostat, power, wirewound, dual; 150 ohms ±10%, 300 watts each section. Ohmite Type 6602.	P-7769823-P2
3R27	Modulator Bias Control. Rheostat, power, wirewound; 125 ohms ±10%, 300 watts, linear taper.	M-2R61-P23

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

SYMBOL	DESCRIPTION	G-E DRAWING

RESISTORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
3R28	Wirewound, 200 ohms ±5%, 115 watts.	M-7464826-P24
3R29 and 3R30	3rd Audio Driver Bias Controls. Rheostat, power, wirewound; 150 ohms ±10%, linear taper, 225 watts. Ohmite Model P. Cat. #1262.	M-2R38-P13
3R31 thru 3R34	Composition, 33,000 ohms ±10%, 2 watts.	P-3R67-P80
3R35 thru 3R38	Wirewound, 6300 ohms ±5%, 160 watts.	M-7464825-P39
3R39	2nd Audio Cathode Resistor. Rheostat, power, wirewound; 400 ohms ±10%, 75 watts; linear taper, screw driver control. Ohmite Model G. Cat. #1114.	M-2R35-P39
3R40	Wirewound, 400 ohms ±5%, 50 watts. Ward Leonard Cat. #K-41389-1.	M-2R17-P37
3R41	Discharge Resistor. Composition, 1.0 meg. ±10%, 2 watts.	P-3R67-P98
*3R42 and 3R43	Same as 3R18.	
*3R44 and 3R45	Composition, 0.20 meg. ohms ±5%, 2 watts.	P-3R67-P214
3R46	Same as 3R28.	
3R47	Wirewound, 2000 ohms ±5%, 160 watts.	M-7464825-P34
3R48	Same as 3R41.	
*3R49 and 3R50	Low Frequency Attenuator. Composition, 0.51 meg. ±5%, 2 watts.	P-3R67-P224
*3R51 and 3R52	High Frequency Attenuator. Composition, 2400 ohms ±5%, 2 watts.	P-3R67-P168
3R53 and 3R54	Wirewound, 16,000 ohms ±5%, 35 watts. Ward Leonard Cat. #K41388-1.	M-2R15-P53
3R55 and 3R56	Same as 3R24.	
*3R57 and 3R58	Same as 3R18.	
3R59 and 3R60	1st Audio Cathode Feedback Controls. Rheostat, power, wirewound; 1000 ohms ±10%, 25 watts; linear taper, screw driver control. Ohmite Model H, Cat. #0158.	M-2R33-P42
3R61	1st Audio Bias Control. Rheostat, power, wirewound; 500 ohms ±10%, 25 watts; linear taper, screw-driver control. Ohmite Model #H, Cat. #0156.	M-2R33-P40

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

SYMBOL	DESCRIPTION	G-E DRAWING

RESISTORS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
*3R62 and 3R63	Audio Transformer Loading Resistors. Composition, 27,000 ohms ±5%, 1 watt.	P-3R13-P193
3R64 thru 3R73	Feedback Resistors. Wirewound, 50,000 ohms ±5%, 35 watts. International Resistance Corp. Type #MPC.	P-7764166-P4
3R74 and 3R75	Feedback Controls. Rheostat, power, wire-wound; 1500 ohms ±10%, 25 watts; linear taper, screwdriver control. Ohmite Model H, Cat. #0159.	M-2R33-P43
3R76 thru 3R79	Wirewound, 40 ohms ±5%, 10 watts. Ward Leonard Cat. #K-41382-1.	M-2R12-P17
3R80 and 3R81	Filament Center Tap Potentiometer. Rheostat, power, wirewound; 12 ohms ±10%, 50 watts; linear taper, screwdriver control. Ohmite Model J, Cat. #0314.	M-2R34-P32
3R82 and 3R83	Wirewound, 1.0 ohm ±5%, 10 watts. Ward Leonard Cat. #K-41382-1.	M-2R12-P1
*3R84 and 3R85	Audio Attenuators. Composition, 240 ohms ±5%, 1/2 watt.	P-3R11-P144
*3R86	Audio Attenuator. Composition, 120 ohms ±10%, 1/2 watt.	P-3R11-P51

SWITCHES

SYMBOL	DESCRIPTION	G-E DRAWING
3S1 and 3S2	Plate Transformer Links. Spdt, 22 Kilovolts.	
3S3 and 3S4	Grid Transfer Links. Spdt. 1 kilovolt.	
3S5	Safety Grounding Switch, 3 pdt.	ML-7769398-G1
3S6	Filament Voltmeter Selector Switch. Manually operated, 3 poles, 3 positions. G-E Type #SB-1.	P-7767481
3S7	Filament Voltmeter Selector Switch. Manually operated, 2 poles, 3 positions. G-E Type #SB-1.	P-7767480
3S8 and 3S9	Filament Transfer Switches. Knife 3 pdt, 250 volts d-c, 500 volts, a-c, 200 amps, G-E Type #1P1, Cat. #619347OG9 without fuses.	K-7126493-P1
3S10	Modulator Filament Voltage Swtich. Toggle, dpst, 20 amps, 250 volts. Arrow-Hart and Hegeman Cat. #80421 Special.	K-7871834
3S11	Not used.	
3S12 thru 3S14	Door Interlocks, Single circuit normally open, 10 amps, 250 volts.	ML-7460330-G4

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

SYMBOL	DESCRIPTION	G-E DRAWING

SWITCHES CONTINUED

3S15	Cubicle Light Switch. Toggle, dpst, 250 volts Arrow-Hart and Hegeman Cat. #80421.*	K-7116143
3S16 thru 3S18	Safety Grounding Switches. Same as 3S5.	
3S19 and 3S20	Filament Switch Interlocks. Single circuit normally open, 10 amps, 250 volts.	K-7126514-P1

(For remainder of switches see Indicating Devices)

TRANSFORMERS

3T1 and 3T2	Not used.	
3T3 thru 3T8	Filament Voltage Adjusting Transformers Pri: 133 volts, 50/60 cycles; Sec: 33.75 volts, 25 amps.	M-7478419
3T9	GL-5C24 Filament Transformer. Pri: 230/208 volts, 50/60 cycles; Sec.#1: 10/5 volts, 10.4 amps; Sec.#2: 10/5 volts, 10.4 amps.	M-7478416
3T10	GL-5C24 Filament Transformer. Pri: 230/208 volts, 50/60 cycles; Sec.#1: 10/5 volts, 5.2 amps; Sec. #2: 10/5 volts, 5.2 amps.	M-7477709
3T11	GL-837 Filament Transformer. Pri: 230/208 volts, 50/60 cycles; Sec: 12.6/6.3 +3%, -0%, 1.4 amps.	M-7477712
3T12	Audio Input Transformer. Pri: 600/150 ohms; Sec: 60,000 ohms/30,000 ohms, Thordarson Type #T-49913A.	M-7478088
3T13 thru 3T18	GL-895R Filament Transformers. Pri: 230 volts, 50/60 cycles; Sec: 19 volts, 138 amps.	M-7479634

TUBES

3V1 and 3V2	1st Audio Type GL-837	
3V3 and 3V4	2nd Audio Type GL-5C24	
3V5 thru 3V8	Modulator Driver. Same as 3V3.	
3V9 thru 3V11	Modulator. Type GL-895R	

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

SYMBOL	DESCRIPTION	G-E DRAWING

SOCKETS

3X1 and 3X2	GL-837 Sockets 7 contacts. American Phenolic Corp. Type #RSS7L.	K-1R13-P45
3X3 thru 3X8	GL-5C24 Sockets. 4 pin E. F. Johnson Cat. #244.	K-7115212-P1
3X9 thru 3X11	GL-895R Sockets	T-7665016
3X12 and 3X13	Lampholder Sockets. 600 volts, 660 watts. G-E Cat. #001.	K-7119168-P1

RECTIFIER

MOTORS

4BM1	Blower. CCW rotation, top horizontal. Sirroco Blower Utility set fan size #00; supplied with G-E motor #5KSC52HA68 (ball bearing) 10 watts 50/60 cycles, single phase, 250 volts, 2500/2850 rpm, enclosed, ventilated.	M-7469960-P4
4BM2	Blower, cw rotation, otherwise same as 4BM1.	M-7469960-P5

CAPACITORS

4C1 thru 4C6	Filter Capacitors. Pyranol, 3 mfd. +15%-0%, 12500 vdcw. G-E Cat. #14F15.	M-7478955-P4
4C7 thru 4C12	Coupling Capacitors. Pyranol, 1.25 mfd. ±10%, 20,000 vdcw. G-E Cat. #14F329 except omit brackets.	K-7119420-P2

RECTIFIER

4CR1	Copper Oxide Rectifier. Single phase bridge. 27 volts, 0.5 amps d-c rating. G-E Cat. #6RC3C41VVV.	K-7119657

INDICATING DEVICES

*4I1 thru 4I6	Lamp, 6-8 volts, 0.15 amps. Mazda #47.	
4IS1	Rectifier "ON" Push Button and Lamp. Green Button. G-E Cat. #2280664G-3.	K-7107849-P6
4IS2	Rectifier "OFF" Push Button and Lamp. Red button. G-E Cat. #2280664G-2.	K-7107849-P5

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

SYMBOL	DESCRIPTION	G-E DRAWING
	INDICATING DEVICES CONTINUED	
4IS3	Tube Change Push Button and Lamp. Same as 4IS2.	
	JACKS AND RECEPTACLES	
*4J1	Convenience Outlet with K-7119169-P1 Plate. Twin outlet. G-E Cat. #2679 except black.	K-7888177-P1
	RELAYS	
4K1 thru 4K6	Tube Change Contactor. Dpdt, 230 volt 50/60 cycle coil. E. F. Johnson Cat. #145-2-2, Type #JRDA with 1 auxiliary switch (1 NO. contact each direction).	T-7664564
4K7	Tube Change Relay. 230 volts, 60 cycles, 2 NO. and 2 NC. dpdt contacts. G-E Type #12HMA11B12.	P-7767982-P3
4K8	Tube Change Relay. 230 volts a-c, 1 NC time reclosing contact, 1 second timing. G-E Type #CR 2820-B1A, G-E Cat. #5367373-G6.	M-7478739
	RESISTORS	
4R1 thru 4R8	Bleeder Resistors. Wirewound, 25,000 ohms ±5%, 160 watts.	M-7464825-P45
4R9 and 4R10	Dropping Resistor. Wirewound, 200 ohms ±5%, 115 watts.	M-7464826-P24
4R11	Plate Regulator Control. Rheostat, power, wirewound, 75 ohms ±10%, 150 watts, linear taper. Ohmite Model L Cat. #0535.	M-2R37-P12
	SWITCHES	
4S1	Voltage Selector Switch. Manually operated, 3 stages, G-E Type #SB-1.	P-7770277-P1
4S2	Tube Change Selector Switch. Manually operated, 7 stages. G-E Type #SB-1.	P-7770276-P1
4S3	Door Interlock. Single circuit, normally open, 10 amp, 250 volts.	ML-7460330-G4
4S4	Safety Grounding Switch, 3 pst.	ML-7769398-G1
4S5	Cubicle Light Switch. Toggle, dpst, 20 amps, 250 volts. G-E Cat. #80421.	K-7116143-P1
4S6	Regulator Control Key Switch. Spdt., 2 form B contacts, neutral locking, 10 amps, 220 volts.	M-7478768-P2
4S7	Regulator Raise - Lower Key Switch. Spdt, 2 form A contacts, neutral locking, 10 amps, 220 volts. D. P. Mossman Inc. Cat. #4101.	M-7478768-P1
4S8	Safety Grounding Switch. Same as 4S4. (For remainder of Switches see Indicating Devices)	

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

SYMBOL	DESCRIPTION	G-E DRAWING
	TRANSFORMERS	
4T1 thru 4T7	857 B Filament Transformers. Pri: 230 volts, 50/60 cycles; Sec: 5 volts, 33 amps.	M-7467896
4T8 thru 4T13	Indicator Light Transformers. Pri: 230 volts, 50/60 cycles; Sec: 5 volts, +3% -1%, 0.5 amps.	M-7477745
	TUBES	
4V1 thru 4V6	Rectifier Tubes. Type GL-857B.	
4V7	Spare Rectifier Tube. Same as 4V1.	
	SOCKETS	
4X1 thru 4X3	857-B Tube Mounting	ML-7770472-G2
4X4	857-B Tube Mounting	ML-7770472-G3
4X5 and 4X6	857-B Tube Mounting	
4X7	857B Tube Mounting.	ML-7770472-G1
4X8 thru 4X13	Indicator Light Sockets. White translucent jewel. Dial Light Co. Cat. #95410-198.	K-7117809-P1
4X14 and 4X15	Lampholders, 600 volts, 660 watts. G-E Cat. #001	K-7119168-P1
	CONTROL UNIT	
	STRUCTURAL PARTS	
5A1	Filament Regulator Control Panel. Supply voltage (for motor) 115 volts, 50/60 cycles, control voltages 115 volts, 50/60 cycles, for use with external 75 ohms variable resistor in series with voltmeter coil permitting +10% control of regulated voltage.	M-7478781-P1
5A2	Plate Regulator Control Panel. Same as 5A1.	
	RECTIFIERS	
5CR1 and 5CR2	Selenium Rectifier. Half wave. G-E Cat. #6RS126ASB1.	K-7119368
5CR3 and 5CR4	Not used.	

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

SYMBOL	DESCRIPTION	G-E DRAWING
	RECTIFIERS CONTINUED	
5CR5 and 5CR6	Selenium Rectifier. Same as 5CR1.	
	MISCELLANEOUS ELECTRICAL PARTS	
5E1	Carrier "OFF" Bell. 4" vibrating, 115 volts, 50/60 cycles. Edwards and Co. Adaptabel Cat. #560.	M-7479234
5E2 and 5E3	Fuse Block, 3 pole, 30 amps, at 250 volts. G-E Cat. #34372.	P-7763583-P5
5E4	Crystal Heater Fuse Block. 2 pole, 30 amps, at 250 volts. G-E Cat. 34367.	P-7763583-P4
	FUSES	
*5F1 thru 5F3	3 amps, 250 volts, G-E Cat. #3167	K-1R11-P1
5F4 thru 5F6	10 amps, 250 volts, G-E Cat. #3169	K-1R11-P3
5F7 thru 5F8	Same as 5F1.	
	INDICATING DEVICES	
*5I1 thru 5I29	Lamp #47, 6-8 volts, 0.15 amps.	
5IS1	Transmitter "ON" Push Button and Lamp. Green translucent button. G-E Cat. #2280664G-3.	K-7107849-P6
5IS2	Transmitter "OFF" Push Button and Lamp. Red translucent button. G-E Cat. #2280664G-2.	K-7107849-P5
5IS3	Overload Reset Push Button and Lamp. White translucent button. G-E Cat.#2280664G-	K-7107849-P9
5IS4	Emergency Start Push Button and Lamp. Same as 5IS3.	
	JACKS AND RECEPTACLES	
*5J1	Convenience Outlet with K-7119169-P1 cover. Twin. G-E Cat. #2679 except black.	K-7888177-P1
	RELAYS	
5K1	Transmitter "Start" Latching Relay. 230 volts, 60 cycle coils, 2 NO. poles, rated 25 amps. 230 volts. Struthers Dunn latch-in electrical reset relay type #5BXX.	M-7474993-P1

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

RELAYS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
5K2	L. P. Filament Contactor. 220 volt, 60 cycle coil; 4 NO. poles, 2 NC interlocks. G-E Cat. #9320873G3.	P-7770259-P1
5K3	L. P. Filament Auxiliary. 230 volts, 50/60 cycle coil; one spdt and 1 spst NO. contact. G-E Type #12HMA14D2.	P-7767982-P12
5K4	Blower Start Auxiliary. Same as 5K2.	
5K5	Shut Down Timing. 220 volt, 60 cycle coil, 1 NO. instantaneous close, 1 NO. close on time and 1 NC open on time contacts; 1 to 17 min. time delay. G-E Type #CR2820-1099E3.	P-7768998-P12
5K6	Filament Time Delay: 220 volt, 60 cycle coil; 1 NO. instantaneous close, 1 NO. close on time and 1 NC open on time contacts; 15 sec. to 5 min. time delay. G-E Cat. #CR2820-1099S3.	P-7768998-P13
5K7	Time Delay Bypass Relay. 220 volt, 60 cycle coil, 3 sec. ±0.5 sec. time interval. G-E Cat. #CR2820-1731A3.	M-7477464-P2
5K8	Auxiliary Relay. 230 volt, 60 cycle coil; 2 NO., 2 NC dpst contacts. G-E Type #12HMA11A32.	P-7767982-P4
5K9	Air Interlock relay. Same as 5K8.	
5K10	Modulator Door Interlock Relay. Same as 5K8.	
5K11	Exciter Door Interlock Relay. Same as5K8.	
5K12	PA Door Interlock Relay. Same as 5K8.	
5K13	Rectifier Door Interlock Relay. Same as 5K8.	
5K14	External Door Interlock Relay. Same as 5K8.	
5K15	Door Interlock Relay. Same as 5K2.	
5K16	L-V and Bias Auxiliary. Same as 5K2.	
5K17	AF Bias Interlock. Coil resistance 1 ohm or less, pull in current 1.2 amp. adjustable from .9 to 1.5 amps; 2 form A, 1 form B contacts.	P-7770222-P23
5K18	PA Bias Interlock. Coil resistance 4000 ohms or less; pull in current 12 ma adjustable from 9 to 15 ma; 2 form A, 1 form B contacts.	P-7770222-P7
5K19	PA Filament Contactor. 220 volt 60 cycle a-c coil, 3 NO. main poles 1 NO. and 2 NC interlock G-E Type #CR2811-C24AW, Cat. #8667275.	P-7769202-P2
5K20	Modulator Filament Contactor. Same as 5K19.	
5K21	Int. Rectifier Start Latching Relay. Same as 5K1.	
5K22	Int. Rectifier Start. Contactor, 220 volt, 60 cycle a-c coil, 3 main poles, 1 NC interlock. G-E Type #CR2811-C22DA Cat. #8238857G3.	M-7478977-P2
5K23	Int. Rectifier Step Start Timing 220 volt, 60 cycle coil, 1 NO. time closing contact, time setting 1 sec. approx. G-E Type #CR2820F1A, Cat. #5367392-G2.	M-7478826-P1

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

SYMBOL	DESCRIPTION	G-E DRAWING

RELAYS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
5K24	Int. Rectifier Run. Same as 5K22.	
5K25	Int. Rectifier Overload. 35 amp. coil, 2 NO. 2 NC contacts; 40-120 calibration. G-E Type #12PAC13B15.	M-7478191-P3
5K26	2nd IPA Overload. Relay. Coil resistance 10 ohms or less; pull in current 250 ma adjustable from 190 ma to 310 ma; 2 form A, 2 form B contacts.	P-7770222-P11
5K27	3rd IPA Overload Relay. Coil resistance 0.75 ohms or less; pull in current 1.75 amp. adjustable from 1.2 amp to 2.2 amp; 2 form A, 2 form B contacts.	P-7770222-P15
5K28	3rd Audio Overload Relay. Coil resistance 2 ohms or less; pull in current 600 ma adjustable from 450 to 750 ma; 2 form A, 2 form B contacts.	P-7770222-P19
5K29	Int. Rectifier Reclosure Relay. 230 volt, 60 cycle coils; momentary duty; 1 contact with sequence OOOC, 1 contact with sequence OCCO and 1 auxiliary NO. contact. Struthers Dunn reclosure relay Cat. #99BXX102.	M-7474991-P1
5K30	Int. Rectifier Lockout Relay. 230 volt, 60 cycle coil, 2 NO. and 2 NC dpdt contacts, G-E Type #12HMA11A32.	P-7767982-P4
5K31	Int. Rectifier Lockout and Reclosure Reset Relay. Same as 5K30.	
5K32	Int. Rectifier Auto-Reset Timing. 230 volt, 60 cycle coil; 1 NO. instantaneous close, 1 NO. close on time, and 1 NC open on time contacts; 4 to 40 sec. time delay. G-E Type #CR2820-1099G3.	P-7768998-P14
5K33	HV Rectifier Start Latching Relay. Same as 5K1.	
5K34	Not Used.	
5K35	HV Rectifier Reclosure Time Relay. 220 volts, 60 cycle, 1 sec. ±0.25 sec. time interval. G-E Cat. #CR2820 1731B3.	M-7477464-P3
5K36	PA and Modulator Filament Interlock. Same as 5K3.	
5K37 and 5K38	PA Overload. 5 amp. coil, 2 NO. and 2 NC contacts, 5-15 calibration, automatic reset. G-E Type #12PAC13B5.	M-7478191-P2
5K39 and 5K40	Modulator Overload. 4 amp. coil, 2 NO. 2 NC contacts, 4-12 calibration, automatic reset. G-E Type #12PAC13B4.	M-7478191-P4
5K41 and 5K42	HV Rectifier Overload. Same as 5K37.	
5K43	HV Rectifier Reclosure. Same as 5K29.	

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

SYMBOL	DESCRIPTION	G-E DRAWING
	RELAYS CONTINUED	
5K44	HV Rectifier Lockout. Same as 5K8.	
5K45	HV Rectifier Auto-Reset. Same as 5K32.	
5K46	HV Rectifier Lockout Reset. Same as 5K8.	
5K47	Int. Rectifier Supervisory Relay. 220 volt, 60 cycle, coil, 2 form A contacts.	P-7770221-P6
5K48	2nd IPA Supervisory Relay. Same as 5K47.	
5K49	3rd IPA Supervisory Relay. Same as 5K47.	
5K50	3rd A-F Supervisory Relay. Same as 5K47.	
5K51	Carrier Trip Supervisory Relay. Same as 5K47.	
5K52 and 5K53	PA Supervisory Relays. Same as 5K47.	
5K54 and 5K55	Modulator Supervisory Relays. Same as 5K47.	
5K56 and 5K57	HV Rectifier Supervisory Relays. Same as 5K47.	
5K58	3rd A-F Overload. Same as 5K28.	
5K59	3rd A-F Supervisory Relay. Same as 5K47.	
5K60	Timing Relay. Same as 5K23.	
	METERS	
5M1 and 5M2	Not used.	
5M3	Filament Time Meter. 230 volts. 60 cycles. G-E Model 8KT8D6 or 230 volts, 50 cycles G-E Model 8KT8D12.	P-3R66-P3 P-3R66-P8
	RESISTORS	
5R1 and 5R2	Run resistors. Wirewound, 400 ohms ±5%, 115 watts.	M-7464826-P27
5R3	Int. Rectifier Start Resistor. Wirewound, 4.8 ohms, 9.4 amps, 7 equal steps. G-E Type #CR9033-B-4.8C 7/8.	M-7476995-P3
5R4	Filament Regulator Control. Rheostat, Power, wirewound; 75 ohms ±10%, 150 watts, linear taper. Ohmite Model Cat. #0535.	M-2R37-P12
	SWITCHES	
5S1 and 5S2	Breaker Control Switches. Manually operated G-E Cat. #16SB1B1.	M-7479209

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

SYMBOL	DESCRIPTION	G-E DRAWING

SWITCHES CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
5S3	Int. Rectifier Lockout Switch. Toggle, dpdt, 10 amps, 125 volts, 5 amps. 250 volts. Arrow-Hart and Hegeman Cat. #80638.	K-7116628
5S4 and 5S5	Voltmeter Switches. G-E Cat. #16SB1CF1 except for pistol grip handle.	M-7478964
5S6	HV Rectifier Lockout Switch. Same as 5S3.	
5S7	Not used.	
5S8	Control Breaker. 230 volts a-c, 60 cycles, 35 amps, 2 pole time overload curve 2. Heineman Cat. #2263S-35.	P-7768829-P13
5S9	Not used.	
5S10	Main Blower Breaker. 230 volts, a-c, 60 cycles, 50 amps; 3 pole, time overload curve 1. Heinemann Cat. #3363S-50.	P-7768830-P7
5S11	HV Rectifier Blower Breaker, 230 volts a-c, 60 cycles, 10 amps, 2 pole, time overload curve 2. Heinemann Cat. #2263S-10.	P-7768829-P9
5S12	L-V and Bias Breaker. Same as 5S11.	
5S13	Int. Rectifier Breaker. 230 volts a-c, 60 cycles, 50 amps; 2 pole, time overload curve 1. Heinemann Cat. #2263S-50.	P-7768829-P7
5S14	Filament Breaker. 230 volts a-c, 60 cycles, 15 amps; 3 pole, time overload curve 2. Heinemann Cat. #3363S-15.	P-7768830-P10
5S15	PA Filament Breaker. 250 volts a-c, 100 amps, 3 pole. Trumbull Cat. #ATB32100.	P-7770473-P8
5S16	Modulator Filament Breaker. Same as 5S15.	
5S17	Cubicle Light and Outlet Breaker. Same as 5S8.	
5S18	Cubicle Light Switch. Toggle, dpst, 20 amps, 250 volts. G-E Cat. #80421.	K-7116143
5S19	Not used.	
5S20	Filament Regulator Raise - Lower Key Switch, spdt, 2 form A contacts, neutral locking, 10 amps, 220 volts. D. P. Mossman Cat. #4101.	M-7478768-P1
5S21	Spare Breaker. Same as 5S10.	
5S22	Filament Regulator Key Switch Spdt., 2 form B contacts, neutral locking. 10 amps, 220 volts.	M-7478768-P2

(For remainder of switches see Indicating Devices)

TRANSFORMERS

SYMBOL	DESCRIPTION	G-E DRAWING
5T1 thru 5T4	Breaker Indicator Light Transformers. Pri: 230 volts, 50/60 cycles; Sec: 5 volts, +3% -1%, 0.5 amps.	M-7477745
5T5	Not used.	
5T6	Transmitter "ON" Light Transformer. Same as 5T1.	

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

SYMBOL	DESCRIPTION	G-E DRAWING

TRANSFORMERS CONTINUED

SYMBOL	DESCRIPTION	G-E DRAWING
5T7	Transmitter "OFF" Light Transformer. Same as 5T1.	
5T8	Air Interlock Light Transformer. Same as 5T1.	
5T9	Modulator Door Light Transformer. Same as 5T1.	
5T10	Exciter Door Light Transformer. Same as 5T1.	
5T11	PA Door Light Transformer. Same as 5T1.	
5T12	Rectifier Door Light Transformer. Same as 5T1.	
5T13	External Door Light Transformer. Same as 5T1.	
5T14	Bias "OFF" Light Transformer. Same as 5T1.	
5T15	PA Filament "OFF" Light Transformer. Same as 5T1.	
5T16	Modulator Filament "OFF" Light Transformer. Same as 5T1.	
5T17	Int. Plate "ON" Light Transformer. Pri: 230 volts, 50/60 cycles. Sec: 5 volts, 1 amp.	M-7477744
5T18	Int. Plate "OFF" Light Transformer. Same as 5T17.	
5T19	Int. Rectifier Lockout Light Transformer. Same as 5T1.	
5T20	Int. Rectifier Lockout Switch Light Transformer. Same as 5T1.	
5T21	HV Plate "ON" Light Transformer. Same as 5T17.	
5T22	HV Plate "OFF" Light Transformer. Same as 5T17.	
5T23	HV Rectifier Lock-out Light Transformer. Same as 5T1.	
5T24	HV Rectifier Lock-Out Switch Light Transformer. Same as 5T1.	
5T25	Control Voltage Transformer. Pri: 230 volts 50/60 cycles; Sec: 220/183/70 volts, 11.7 amps.	M-7477746
5T26 and 5T27	Second IPA Overload Light Transformer. Same as 5T1.	
5T28	3rd IPA Overload Light Transformer. Same as 5T1.	
5T29	3rd A-F Overload Light Transformer. Same as 5T1.	
5T30	Carrier Trip Light Transformer. Same as 5T1.	
5T31 and 5T32	PA Overload Light Transformer. Same as 5T1.	
5T33 and 5T34	Modulator Overload Light Transformers. Same as 5T1.	
5T35 and 5T36	HV Rectifier Overload Light Transformers. Same as 5T1.	

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

TRANSFORMERS CONTINUED

5T37	Overload Reset Light Transformer. Same as 5T1.	
5T38	3rd AF Overload Light Transformer. Same as 5T1.	
5T39	Supply Transformer for 5A1. Pri: 230 volts, 50 cycles; Sec: 115 volts, 0.5 kva. G-E Cat. #61G106.	M-7478471
5T40	Potential Transformer for 5A1. Pri: 240 volts, 60 cycles; Sec: 120 volts, 0.20 kva. G-E Cat. #86X772.	M-7478470
5T41	Emergency Start Push Button Light Transformer. Same as 5T1.	

VOLTAGE REGULATORS

5VR1	Filament Regulator. 230 volts, 50/60 cycles, 136 amp. load; provides voltage regulation of 10% rise or 10% lower; consists of 3 single phase units mounted on common base. Includes, vertically mounted ball bearing capacitor type motor, single phase, 120 volts 50/60 cycles, double worm gear reduction unit and limit switch G-E Type #AIRT.	M-7478876

SOCKETS

5X1	Dial light, translucent dark red cap. Dial Light Co. Cat. #95410-192D.	K-7117809-P5
5X2	Dial Light, light green cap. Dial Light Co. Cat. #95410-192L.	K-7117809-P4
5X3	Same as 5X1.	
5X4	Same as 5X2.	
5X5 thru 5X29	Dial Light, white translucent cap. Dial Light Co. Cat. #95410-198	K-7117809-P1
5X30 and 5X31	Lampholder Socket. 600 volts, 660 watts. G-E Cat. #001.	K-7119168-P1

EXTERNAL EQUIPMENT

BLOWER MOTOR

6B1	Main Blower and Motor. Blower: rating 12,000 CFM at 2" water static pressure. 605 rpm 70°F. at sea level. American Sirocco HS fan, Series 81, size 397, single inlet, single width, arrangement 3, class 1 cw rotation, up blast discharge. Motor: 7 1/2 hp 440/220 volts, 3 phase, 50/60 cycles, 1450/1735 rpm; G-E Type K, frame 284, triclad, open type normal starting torque.	P-7770293

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

SYMBOL	DESCRIPTION	G-E DRAWING

FUSES

6F1 and 6F2	Fuse, 25 amp, 600 volts, G-E Type #3208.	K-7119745-P6

RELAYS

6K1	Main Blower Starter. 230 volts, 60 cycles, 3 poles, 1 NO. interlock. (External coil supplied for 50 cycles)	M-7478861

INDUCTORS

6L1	Modulation Reactor. Inductance 25 henries at 6.5 amps. d-c; resistance 25 ohms max.	M-7477981
6L2	Filter Reactor. Inductance 1 henry min. at 12.5 amps. d-c; resistance 5 ohms. max.	M-7477980

SWITCHES

6S1	Main Circuit Breaker. 3 pole, 220 volts, 50/60 cycles, 125 amps, inverse time adjustment 125 to 250 amps. G-E Type AE-1-15.	M-7478786-P2
6S2	HV Rectifier Circuit Breaker. 3 pole, 220 volts, 50/60 cycles, 225 amps, inverse time adjustment 225 to 450 amps. G-E Type AE-1-15.	M-7478786-P1
6S3	Air Interlock. Drying System Inc. Standard Pressure Type.	P-7770288-P1
6S4	Safety Switch, enclosed, 30 amps, 2 pole, 575 volts a-c, 7 1/2 hp. Trumbell Elec. Co. Cat. #66261.	P-7770225-P1
6S5	Door Interlock. Single Circuit normally open, 10 amps, 25 volts.	ML-7460330-G4
6S6	Door Interlock. Single circuit, normally closed momentary contact, 3 amps, 250 volts. Arrow-Hart and Hegeman Cat. #3592-E with over travel plunger.	K-7116627-P1

TRANSFORMERS

6T1 thru 6T3	Auto Transformer. Pri: 266 volts, 50/60 cycles; Sec: 133 volts, 0.25 kva.	M-7478468
6T4	Breaker Control Transformer. Pri: 230/460 volts, 50 cycles; Sec: 230/115 volts, 3.0 kva. G-E Cat. #61G132.	M-7478473
6T7 thru 6T9	HV Plate Transformer Pri: 460 volts, 50/60 cycles; Sec: 8100 volts ±2 1/2% and ±5%, 50 kva.	M-7478467
6T10	Modulation Transformer. 30/10,000 cycles, 31.5 kw. Pri: 5470/5470 volts RMS; Sec: 7425 volts RMS.	M-7477982

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

SYMBOL	DESCRIPTION	G-E DRAWING

VOLTAGE REGULATOR

SYMBOL	DESCRIPTION	G-E DRAWING
6VR1	Plate Regulator. 460 volts, ±10%, 50/60 cycles, 15 kva, 3 phase, 188 amps, ambient temperature low 0°C high 55°C; pyranol immersed, self cooled, manually controlled, motor operated. For indoor and outdoor service. G-E Type #IRT.	M-7478780

EXTERNAL POWER CUBICLE

RECTIFIERS

SYMBOL	DESCRIPTION	G-E DRAWING
6CR1 thru 6CR14	Copper Oxide Rectifiers. G-E Cat. #6RC3B259 VVV.	M-7479227-P1

JACK AND RECEPTACLE

SYMBOL	DESCRIPTION	G-E DRAWING
*6J1	Convenience Outlet with K-7101594 Outlet Box. Twin. G-E Cat. #2679 except black.	K-7888177-P1

RELAYS

SYMBOL	DESCRIPTION	G-E DRAWING
6K2	HV Rectifier Start Contactor. Rating 300 amps; 3 NO. contacts, 1 NC interlock and 1 NO. time delay interlock. G-E Cat. #CR2810-1527A3 with blowout coils.	P-7770230-P3
6K3	HV Rectifier Run Contactor. Same as 6K2 less NO. time delay interlock.	P-7770230-P4
6K4 thru 6K6	HV Transformer Tap Change Contactors. Rating 188 amps at 460 volts a-c, 3 poles with auxiliary interlock, 1 NO. and 1 NC contact. G-E Type CR-2810-1505M6 (quick drop out) Cat. #8236381-M.	P-7770231-P3
6K7	Auxiliary Relay for 6K2. 230 volt, 50/60 cycle coil; 2 NO. and 1 NC contacts. G-E Type #12HGA14V2.	P-7770250-P5
6K8	Auxiliary Relay for 6K3. Same as 6K7.	

RESISTORS

SYMBOL	DESCRIPTION	G-E DRAWING
6R1 thru 6R3	Step Start Resistors. Resistor assembly consisting of 2 type CR-9033-C-0.8D and 1 type CR-9033-C-0.8 3/4 resistors mounted in frame. (3 resistors, 0.8 ohms each, 1 tapped)	K-7117981-P1
6R4 and 6R5	Protective Shunts. Wirewound, 5 ohms ±5%, 115 watts.	M-7464826-P8
6R6 thru 6R8	Holding Resistors. Wirewound, 300 ohms, 122 watts. G-E Cat. #CR9006, QFK2673251.	

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

SYMBOL	DESCRIPTION	G-E DRAWING

TRANSFORMERS

SYMBOL	DESCRIPTION	G-E DRAWING
6T5 and 6T6	Tripping Transformers Pri: 200 amps; Sec: 5 amps. G-E model #9JY285FAW2.	M-7477748-P1

MONITOR RECTIFIER

CAPACITORS

SYMBOL	DESCRIPTION	G-E DRAWING
*7C1	Tuning Capacitor. Variable, 13-98 mmfd. Hammarlund Cat. #HFB-100-E.	P-3R23-P15
*7C2 thru 7C4	Tuning Capacitors. Mica, 68 mmfd. ±10%, 2500 vdcw.	P-3R31-P2
7C5	Not used.	
*7C6	RF Bypass Capacitor. Mica, 680 mmfd. ±10%, 500 vdcw.	P-3R28-P1
*7C7 and 7C8	DC Blocking Capacitors. Pyranol, 4 mfd. ±10%, 100 vdcw. G-E Cat. #23F582.	P-7768999-P33

JACKS AND RECEPTACLES

SYMBOL	DESCRIPTION	G-E DRAWING
*7J1 and 7J2	Type UG-103/U. Twin Connector Receptacle.	K-7113240-P1

RELAYS

SYMBOL	DESCRIPTION	G-E DRAWING
7K1	Relay, resistance 6500 ohms ±10%, pull in less than 5.5 ma, 2 form C contacts.	P-7770602-P8

INDUCTORS

SYMBOL	DESCRIPTION	G-E DRAWING
7L1	Tuning Inductor	ML-7469415-G1
7L2	Series Antenna Coil	K-7120934-L2
7L3	Secondary Pick-up Coil	T-7665580-L3

PLUGS

SYMBOL	DESCRIPTION	G-E DRAWING
*7P1 and 7P2	RG-22U Cable Plug. Twin connector plug. Type UG-102/U.	K-7113239-P1

RESISTORS

SYMBOL	DESCRIPTION	G-E DRAWING
*7R1	Audio Load Resistor. Wirewound, 620 ohms ±5%, 2 watt.	P-3R21-P115
7R2	Not used.	

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

SYMBOL	DESCRIPTION	G-E DRAWING
	RESISTORS CONTINUED	
*7R3	Meter Shunt Resistor. Rheostat, power, wire-wound; 100 ohms ±10%, 25 watts; linear taper, screw driven control. Ohmite Model #H, Cat. #0151.	M-2R33-P35
*7R4	Meter Series Resistor. Wirewound, 22 ohms ±10%, 1 watt.	P-3R19-P20
*7R5	Relay Shunt Resistor. Wirewound, 5000 ohms ±5%, 25 watts. Ward Leonard Cat. #K41383-3.	M-2R14-P138
*7R6	Diode Load Resistor. Same as 7R5.	
*7R7	Relay Shunt Resistor. Rheostat, power, wire-wound; 10,000 ohms ±10%, 50 watts, linear taper, screw driver control. Ohmite Model #J, Cat. #0332.	M-2R34-P50
*7R8	Diode Load Resistor. Same as 7R5.	M-2R14-P138
	TRANSFORMERS	
7T1	Filament Transformer. Primary: 115/208/230 volts, 50/60 cycles; Secondary: 6.3/3.15 volts, 0.7 amps.	M-7479903-P1
7T2	Audio Output Transformer. Primary: 600/150 ohms. Secondary: 600/150 ohms.	M-7478411-P1 or M-7488409-P1
	TUBE	
*7V1	Diode Rectifier. Type GE-6X5GT.	
	TUBE SOCKET	
*7X1	G-E 6X5GT Socket. Octal. American Phenolic Corp. Type #4SS8.	K-1R13-P47

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

Wire No.	Terminal	From	To	Terminal	Wire Size	Remarks	Wire Lgth Inches

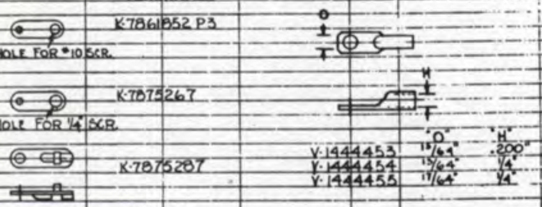
Wire and terminals for the following interconnections (Wires 1-188 incl.) are supplied in bulk with the equipment by the General Electric Co.

For location of connection points referenced on this running list, see Installation Requirements Drawing No. W-7352440.

- WIRE TABLE -

Wire Code	G.E. Ordering Reference	Wire Size	Thickness V.C. Insul.	Thickness Lead	Max. O.D.	Working Voltage A.C.
BB	S-392382-1-A1	#14 Solid	3/64"	.025"	.241"	600
BC	S-392382-1-A3	#10 "	3/64"	1/32"	.292"	600
BD	S-392382-1-A5	#6 St'd	1/16"	1/32"	.405"	600
BE	S-392382-1-C1	#14 Solid	3/32"	1/32"	.348"	2000
A	SI-12348	#6 St'd	15/64"	3/32"	.811"	12000
B	S-392382-1-D2	#12 Solid	4/32"	1/32"	.427"	3000
C	S-392382-1-A4	#8 Solid	3/64"	1/32"	.318	600
FB	B11B15C	1/4" O.D. Copper Tubing, F70C1B				

- TERMINALS -



Sheet 1, Rev. 1

Wire No.	Terminal	From	To	Terminal	Wire Size	Remarks	Wire Lgth Inches
	Run #1 - (Wires #1-35 Incl.) goes from Control Unit to Audio-Modulator Unit						
1		5TB1-3	3TB1-7	K-7861852 P3	BB		
2		5TB1-4	3TB1-8	"	BB		
3		5TB1-5	3TB1-9	"	BB		
4		5.B1-6	3TB1-10	"	BB		
5	K-7861852 P3	5TB8-1	3TB3-5	"	BB		
6	"	5TB8-4	3TB1-2	"	BB		
7	"	5TB8-5	3TB1-3	"	BB		
8	"	5TB8-6	3TB1-4	"	BB		
9	"	5TB8-7	3TB1-5	"	BB		
10	"	5TB8-8	3T31-1	"	BB		
11	"	5TB8-12	3TB3-8	"	BB		
12	"	5TB9-3	3TB3-6	"	BB		
13							
14	K-7861852P3	5TB9-10	3TB3-4	K-7861852P3	BB		
15	"	5TB9-11	3TB2-7	"	BB		
16	"	5TB9-12	3TB2-8	"	BB		
17	"	5TB10-4	3TB5-6	"	BB		
18	"	5TB10-5	3TB5-7	"	B3		
19	"	5TB10-6	3TB5-8	"	BB		
20	"	5TB10-7	3TB5-9	"	BB		
21	"	5TB10-11	3TB5-5	"	BB		
22	"	5TB10-12	3TB5-4	"	BB		
23	K-7875287	5TB11-1	3TB2-5	K-7875287	BC		
24	"	5TB11-2	3TB2-6	"	BC		
25	K-7861852 P3	5TB12-7	3TB5-10	K-7861852P3	BB		
26	"	5TB12-8	3TB2-9	"	BB		
27	"	5TB12-9	3TB2-10	"	BB		
28	K-7875287	5TB12-11	3TB2-11	K-7875287	BC		
29	K-7861852P3	5TB12-12	3TB2-12	K-7861852P3	BB		
30	V-1444455	5TB13-7	3TB4-4	V-1444455	BD		
31	"	5TB13-8	3TB4-5	"	BD		
32	"	5TB13-9	3TB4-6	"	BD		
33	"	5TB13-10	3TB4-10	"	BD		
34	"	5TB13-11	3TB4-11	"	BD		
35	"	5TB13-12	3TB4-12	"	BD		

Sheet 2, Rev. 0

Wire No.	Terminal	From	To	Terminal	Wire Size	Remarks	Wire Lgth Inches
	Run #2 - (Wires #40-56 Incl.) goes from Control Unit to Exciter Unit.						
40	K-7861852P3	5TB8-9	1TB5-4	K-7861852P3	BB		
41	"	5TB8-10	1TB5-5	"	BB		
42	"	5TB9-4	1TB3-6	"	BB		
43	"	5TB10-1	1TB5-10	"	BB		
44	"	5TB10-2	1TB5-11	"	BB		
45	"	5TB10-3	1TB5-12	"	BB		
46	"	5TB11-3	1TB6-7	"	BB		
47	"	5TB11-4	1TB6-8	"	BB		
48	V-1444453	5TB11-5	1TB6-1	V-1444453	BD		
49	"	5TB11-6	1TB6-2	"	BD		
50	K-7861852P3	5TB11-7	1TB6-9	K-7861852P3	BB		
51	"	5TB11-8	1TB6-10	"	BB		
52	"	5TB12-1	1TB6-4	"	BB		
53	"	5TB12-4	1TB5-9	"	BB		
54	"	5TB12-5	1TB1-10	"	BB		
55	"	5TB12-6	1TB5-8	"	BB		
56	"	5TB12-10	1TB6-12	"	BB		
	Run #3 - (Wires 60-73 Inc.) goes from Control Unit to Power Amplifier Unit.						
60	K-7861852P3	5TB9-1	2TB2-1	K-7861852P3	BB		
61	"	5TB9-5	2TB2-6	"	BB		
62	"	5TB9-9	2TB2-4	"	BB		
63	"	5TB10-8	2TB4-9	"	BB		
64	"	5TB10-9	2TB4-8	"	BB		
65	"	5TB10-10	2TB4-10	"	BB		
66	"	5TB11-11	2TB2-7	"	BB		
67	"	5TB11-12	2TB2-8	"	BB		
68	V-1444453	5TB13-1	2TB3-4	V-1444453	BD		
69	"	5TB13-2	2TB3-5	"	BD		
70	"	5TB13-3	2TB3-6	"	BD		
71	"	5TB13-4	2TB3-10	"	BD		
72	"	5TB13-5	2TB3-11	"	BD		
73	"	5TB13-6	2TB3-12	"	BD		

Sheet 3, Rev. 0

Wire No.	Terminal	From	To	Terminal	Wire Size	Remarks	Wire Lgth Inches
	Run #4 - (Wires 80-93 Incl.) goes from Control Unit to Main Rectifier Unit						
80	K-7861852P3	5TB4-12	4TB3-7	K-7861852P3	BB		
81	"	5TB6-1	4TB4-7	"	BB		
82	"	5TB6-2	4TB4-8	"	BB		
83	"	5TB6-3	4TB4-9	"	BB		
84	"	5TB6-4	4TB4-10	"	BB		
85	"	5TB6-5	4TB4-11	"	BB		
86	"	5TB6-6	4TB4-12	"	BB		
87	"	5TB8-3	4TB3-8	"	BB		
88	"	5TB8-11	4TB3-3	"	BB	Note: If plate regulator 6VR1 is not used, these wires (88-93) may be omitted.	
89	"	5TB8-12	4TB3-4	"	BB		
90	"	5TB9-6	4TB4-6	"	BB		
91	"	5TB11-9	4TB4-3	"	BB		
92	"	5TB11-10	4TB4-4	"	BB		
93	"	5TB12-2	4TB3-12	"	BB		
	Run #5 - (Wires 100-121 Incl.) goes from Audio-Modulator Unit to Exciter Unit.						
100	K-78x1852P3	3TB1-1	1TB1-1	K-7861852P3	BB		
101	"	3TB1-2	1TB1-2	"	BB		
102	"	3TB1-3	1TB1-3	"	BB		
103	"	3TB1-7	1TB1-7	"	BB		
104	"	3TB1-8	1TB1-8	"	BB		
105	K-7875287	3TB2-5	1TB6-5	K-7875287	BC		
106	"	3TB2-6	1TB6-6	"	BC		
107	K-7861852P3	3TB2-11	1TB6-11	K-7861852P3	BB		
108	"	3TB3-6	1TB3-5	"	BB		
109	"	3TB3-7	1TB5-7	"	BB		
110	V-1444453	3TB4-1	1TB4-1	V-1444453	C		
111	"	3TB4-2	1TB4-2	"	C		
112	"	3TB4-3	1TB4-3	"	C		
113	"	3TB4-7	1TB4-4	"	C		
114	"	3TB4-8	1TB4-5	"	C		
115	"	3TB4-9	1TB4-6	"	C		
116	K-7861852 P3	3TB5-11	1TB1-9	K-7861852 P3	BE		
117	"	3TB5-12	1TB1-12	"	BB		
118	K-7875267	3TB6-1	1TB2-1	K-7875267	BE		
119	"	3TB6-2	1TB2-2	"	BE		

Sheet 4, Rev. 0

Fig. 37 Wire Running List for External Connections (K-7121596)

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
120	K-7875267	3TB6-3	1TB2-3	K-7875267	B		
121	K-7861852P3	3TB3-5	1TB5-6	K-7861852 P3	BB		

RUN #6-(WIRES #130-135 INCL.) GOES FROM AUDIO-MODULATOR UNIT TO POWER AMPLIFIER UNIT.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
130	V-1444455	PO 11	PO 5	V-1444455	A		
131	K-7861852P3	3TB1-4	2TB1-4	K-7861852P3	BB		
132	"	3TB1-5	2TB1-5	"	BB		
133	"	3TB1-9	2TB1-9	"	BB		
134	"	3TB1-10	2TB1-10	"	BB		
135	"	3TB3-3	2TB2-3	"	BB		

RUN #7-(WIRES #140-144 INCL.) GOES FROM AUDIO-MODULATOR UNIT TO MAIN RECTIFIER UNIT.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
140	K-7861852P3	3TB2-12	4TB2-12	K-7861852P3	BB		
141	"	3TB3-9	4TB3-9	"	BB		
142	"	3TB3-10	4TB3-10	"	BB		
143	"	3TB3-11	4TB3-11	"	BB		
144	"	3TB3-5	4TB3-5	"	BB		

RUN #8-(WIRES #150-167 INCL.) GOES FROM EXCITER UNIT TO POWER AMPLIFIER UNIT.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
150	V-1444454	PO9	PO8	V-1444454	FB		
151	"	PO10	PO7	"	FB		
152	K-7861852P3	1TB1-1	2TB1-1	K-7861852P3	BB		
153	"	1TB1-2	2TB1-2	"	BB		
154	"	1TB1-3	2TB1-3	"	BB		
155	"	1TB1-8	2TB1-8	"	BB		
156	"	1TB1-10	2TB4-12	"	BB		
157	K-7875287	1TB1-11	2TB4-11	K-7875287	B		

Sheet 5, Rev. 0

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
158	K-7875267	1TB2-3	PO6	K-7875267	B		
159	K-7861852P3	1TB3-6	2TB2-5	K-7861852P3	BB		
160	V-1444455	1TB4-7	2TB3-1	V-1444455	C		
161	"	1TB4-8	2TB3-2	"	C		
162	"	1TB4-9	2TB3-3	"	C		
163	"	1TB4-10	2TB3-7	"	C		
164	"	1TB4-11	2TB3-8	"	C		
165	"	1TB4-12	2TB3-9	"	C		
166	K-7875287	1TB6-5	2TB2-9	K-7875287	BC		
167	"	1TB6-6	2TB2-10	"	BC		
168	K-7861852P3	1TB1-7	2TB1-7	K-7861852P3	BB		

RUN #9-(WIRES #170-171 INCL.) GOES FROM EXCITER UNIT TO MAIN RECTIFIER UNIT.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
170	K-7861852P3	1TB6-11	4TB2-11	K-7861852P3	BB		
171	"	1TB6-12	4TB2-10	"	BB		

RUN #10-(WIRES #180-188 INCL.) GOES FROM POWER AMPLIFIER UNIT TO MAIN RECTIFIER UNIT.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
180	V-1444455	PO5	BUS #1	V-1444455	A		
181	K-7861852P3	2TB1-1	4TB1-1	K-7861852P3	BB		
182	"	2TB1-4	4TB1-4	"	BB		
183	"	2TB1-5	4TB1-5	"	BB		
184	"	2TB1-9	4TB1-9	"	BB		
185	"	2TB1-10	4TB1-10	"	BB		
186	"	2TB2-6	4TB4-5	"	BB		
187	K-7875287	2TB2-9	4TB2-5	K-7875287	BC		
188	"	2TB2-10	4TB2-6	"	BC		

Sheet 6, Rev. 1

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES

WIRE FOR THE FOLLOWING INTERCONNECTIONS, WIRES #200-426 INCL., IS TO BE SUPPLIED, WITH TERMINALS, BY THE CUSTOMER.

FOR AUDIO CIRCUIT WIRING OF SUPERVISORY CONSOLE TYPE BC-3A, SEE INSTALLATION DRAWING T-7665061.

TABLE - OF RECOMMENDED WIRE SIZES

WIRE CODE	WIRE SIZE	WORKING VOLTAGE A.C.
BX	#14	600
BY	#10	600
BZ	#8	600
A	#6	12000
D	#4	600
E	#2	600
F	#00	600
G	250,000CM	600
H	400,000CM	600
I	#8 BARE	
J	#6 "	
K	#00 "	
L	3/4" O.D. X .031" WALL COPPER TUBING.	
M	[illegible] COAXIAL [illegible]	
N	TWIN #14	—
P	" #20	AUDIO WIRE
R	900,000CM	600

NOTE #1-T&B TERMINAL REFERENCES ARE THOMAS & BETTS, ELIZABETH, N.J. OR EQUIVALENT, THESE ARE RECOMMENDED.

NOTE #2- IT IS RECOMMENDED THAT WHERE WIRES ARE RUN IN A TRENCH, THEY BE LEAD JACKETED.

Sheet 7, Rev. 1

GROUND WIRES

RUN #00 BARE CABLE FROM MAIN STATION GROUND FOR FULL LENGTH OF TRANSMITTER WIRING TRENCH. CONNECT TO BARE CABLE (GND. BUS) WITH SUITABLE CLAMPS AS FOLLOWS.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
200	V-1444463	G1	GND. BUS	T&B 40811	K		
201	"	G2	GND. BUS	"	K		
202	"	G3	GND. BUS	"	K		
203	"	G4	GND. BUS	"	K		
204	"	G5	GND. BUS	"	K		

GROUND EXTERNAL APPARATUS TO STATION GROUND AS FOLLOWS.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
205	V-1444463	G8	STN. GND.		K		
206		6L1-FRAME	STN. GND.		K		
207		6L2-FRAME	STN. GND.		K		
208		6T10-FRAME	STN. GND.		K		
209	V-1444465	6T7-FRAME	STN. GND.		K		
210	"	6T8-FRAME	STN. GND.		K		
211	"	6T9-FRAME	STN. GND.		K		
212	"	6VR1-FRAME	STN. GND.		K		
213		6T1-FRAME	STN. GND.		I		
214		6T2-FRAME	STN. GND.		I		
215		6T3-FRAME	STN. GND.		I		
216		6T4-FRAME	STN. GND.		I		
217		6S1-CASE	STN. GND.		I		
218		6S2-CASE	STN. GND.		I		
219		6K1-CASE	STN. GND.		I		
220		6B1-FRAME	STN. GND.		I		
221		INC. AIR DUCT	STN. GND.		I		
222		OUT. AIR DUCT	STN. GND.		I		
223		6S4-CASE	STN. GND.		I		

THE FOLLOWING WIRES RUN BETWEEN EXTERNAL ITEMS

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
224		INCOMING	CUSTOMER'S SWITCH #1		H		
225		460 VOLTS	CUSTOMER'S SWITCH #2		H		
226		3 PHASE	CUSTOMER'S SWITCH #3		H		
227		6S4-1	CUSTOMER'S SWITCH #5		BX		
228		6S4-2	CUSTOMER'S SWITCH #6		BX		
229		6S4-3	6T4-H1		BX		

Sheet 8, Rev. 0

Fig. 37 con't.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
230		6S4-4	6T4-H4		BX		
231		6T4-H2	6T4-H3			BOLT TOGETHER	
232		6T4-X1	6S1-2		BY		
233		6S1-2	6S2-2		BY		
234		6T4-X4	6S1-1		BY		
235		6S1-1	6S2-1		BY		
236		6T4-X2	6T4-X3			BOLT TOGETHER	
237		6T4-X2	STN. GND.		BY		
238		6S1-6	6S2-4		BX		
239		6S1-7	6S2-1		BX		
240	CUST. SWITCH #4		6S1-A		F		
241	CUST. SWITCH #5		6S1-B		F		
242	CUST. SWITCH #6		6S1-C		F		
243	CUST. SWITCH #4		6S2-A		G		
244	CUST. SWITCH #5		6S2-B		G		
245	CUST. SWITCH #6		6S2-C		G		
246		6S1-D	6T1-3		F		
247		6S1-E	6T2-3		F		
248		6S1-F	6T3-3		F		
249		6T1-1	6T2-1		G		
250		6T2-1	6T3-1		G		
251		6T3-1	STN. GND.		F		
252		6K1-T1	6BM1-1		BZ	CHECK FOR CORRECT	
253		6K1-T2	6BM1-2		BZ	ROTATION OF	
254		6K1-T3	6BM1-3		BZ	BLOWER MOTOR.	
255							
256		6S2-D	6T5-H1	TGB-51013	G		
257		6S2-E	6K2-2	"	G		
258		6S2-F	6T6-H1	"	G		
259	V-1444463	6K6-6	6T7-X2		F		
260	"	6K6-5	6T8-X2		F		
261	"	6K6-4	6T9-X2		F		
262	V-1444461	6K5-6	6T7-X3		E		
263	"	6K5-5	6T8-X3		E		
264	"	6K5-4	6T9-X3		E		
265	"	6K4-6	6T7-X4		D		
266	"	6K4-5	6T8-X4		D		
267	"	6K4-4	6T9-X4		D		
268	V-1444463	6K4-2	6T7-X1		F		
269	"	6K4-1	6T8-X1		F		
270	"	6K4-3	6T9-X1		F		
271		6T7-H2	6T8-H1		A		
272		6T8-H2	6T9-H1		A		
273		6T9-H2	6T7-H1		A		
274		7TB1-9	GND.		BX		
275		6S6-1	6S2-4		BX	SEE NOTE, TOP	
276		6S6-2	6S2-1		BX	OF NEXT SHEET.	

Sheet 9, Rev. 0

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
	NOTE- IF IT IS DESIRED TO HAVE MAIN BREAKER 6S1 ALSO GO OUT WHEN TRANSFORMER ENCLOSURE DOOR IS OPENED, CONNECT WIRES #275 & 276 TO 6S1-4 AND 6S1-1 INSTEAD AS INDICATED.						
277		6T10-X2	6L1-2		L	INSULATE	
278		6T10-H2	6T10-H2		L	FOR	
279		6T10-H2	6L1-1		L	25 KV.	
280	TGB-51013	6K3-4	6VR1-31		G		
281	"	6K3-5	6VR1-21		G	SEE	
282	"	6K3-6	6VR1-11		G	NOTE	
283	"	6K6-1	6VR1-38		G	BELOW	
284	"	6K6-2	6VR1-28		G		
285	"	6K6-3	6VR1-18		G		
	NOTE- IF PLATE REGULATOR 6VR1 IS NOT USED OMIT WIRES #280-285 INCL. AND SUBSTITUTE THE FOLLOWING WIRES #286, 287 & 288.						
286	TGB-51013	6K3-4	6K6-1	TGB-51013	G	USE ONLY IF	
287	"	6K3-5	6K6-2	"	G	6VR1 IS NOT	
288	"	6K3-6	6K6-3	"	G	USED.	
	RUN #11- (WIRES #290-318 INCL.) GOES FROM EXTERNAL APPARATUS TO TRANSMITTER CONTROL UNIT.						
290		6S1-1	5TB4-1	K-7861852P3	BX		
291		6S1-3	5TB4-2	"	BX		
292		6S1-4	5TB4-3	"	BX		
293		6S1-5	5TB4-4	"	BX		
294		6S2-4	5TB4-8	"	BX		
295		6S2-3	5TB4-7	"	BX		
296		6S2-5	5TB4-9	"	BX		
297		6S2-6	5TB8-8	"	BX		
298		6S2-7	5TB8-7	"	BX		
299		6T1-2	5TB3-1	TGB-51013	R		
300		6T2-2	5TB3-2	"	R		
301		6T3-2	5TB3-3	"	R		
302		6K1-L2	5TB5-5	V-1444453	BZ		
303		6K1-L3	5TB5-6	"	BZ		
304		6K1-L1	5TB5-7	"	BZ		
305		6K1-3	5TB5-1	K-7861852P3	BX		
306		6S3-2	5TB9-2	"	BX		
307		6VR1-G	5TB6-6	"	BX		
308		6VR1-5	5TB6-7	"	BX		

Sheet 10, Rev. 3

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
309		6VR1-6	5TB6-8	K-7861852P3	BX		
310		6VR1-L	5TB6-9	"	BX		
311		6VR1-H	5TB6-10	"	BX		
312		6VR1-F	5TB6-11	"	BX		
313		6VR1-J	5TB6-12	"	BX		
314		6VR1-5	5TB7-1	"	BX		
	NOTE- IF PLATE REGULATOR 6VR1 IS NOT USED, WIRES #307-314 INCL. MAY BE OMITTED.						
315	STATION		5TB2-3	K-7875287	BY	FOR CRYSTAL HEATERS	
316	115V. SUPPLY		5TB2-4	"	BY	& CUBICLE OUTLETS.	
317		6S1-A	5TB9-8	K-7861852P3	BX		
318		6S5-2	5TB9-7	"	BX		
	RUN #12- (WIRES #325-327 INCL.) GOES FROM EXTERNAL APPARATUS TO AUDIO-MODULATOR UNIT.						
325		6T10-H1	PO1		L	SUPPORT ON	
326		6T10-H3	PO2		L	25 KV. INSULATORS.	
327		6K1-B	5TB5-3	K-7861852P3	BX		
	RUN #13- (WIRES #330-335 INCL.) GOES FROM EXTERNAL APPARATUS TO POWER-AMPLIFIER UNIT.						
330		6S3-1	2TB2-2	K-7861852P3	BX		
331		6T10-X2	PO3		L	SUPPORT ON 25KV. INSULATORS	
332	R.F. TRANSM. LINE		PO4		J	HIGH R.F. SIDE	
333	R.F. TRANSM. LINE		G6 & G7		J	GROUND SIDE	
334	MODULATION MONITOR		215		M		
335	DISTORTION METER		214		M		
	RUN #14- (WIRES #340-347 INCL.) GOES FROM EXTERNAL APPARATUS TO MAIN RECTIFIER UNIT.						
340		6T7-H1	4TB5-2	V-1444455	A		
341		6T8-H1	4TB5-3	"	A		
342		6T9-H1	4TB5-4	"	A		

Sheet 11, Rev. 1

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
343		6L2-2	4TB5-1	V-1444455	A		
344		6L2-1	G5	V-1444461	BZ		
345		6L1-1	BUS #1	V-1444461	A		
346		6T10-X1	BUS #2	V-1444461	A		
347		6S5-1	4TB4-6	K-7861852P3	BX		
	RUN #15- (WIRES #350-359 INCL.) GOES FROM EXTERNAL POWER CABINET TO TRANSMITTER CONTROL UNIT.						
350	K-7861852P3	6TB1-1	5TB8-12	K-7861852P3	BX		
351	"	6TB1-2	5TB8-11	"	BX		
352	"	6TB1-3	5TB5-11	"	BX		
353	"	6TB1-6	5TB4-11	"	BX		
354	"	6TB1-7	5TB4-12	"	BX		
355	K-7875287	6TB2-1	5TB11-1	K-7875287	BY		
356	"	6TB2-2	5TB11-2	"	BY		
357	K-7861852P3	6TB2-3	5TB7-7	K-7861852P3	BX		
358	"	6TB2-4	5TE7-8	"	BX		
359	"	6TB2-5	5TB7-9	"	BX		
	RUN #16- (WIRES #365-366 INCL.) GOES FROM EXTERNAL POWER CABINET TO EXCITER UNIT.						
365	K-7861852P3	6TB1-4	1TB5-6	K-7861852P3	BX		
366	"	6TB1-5	1TB5-7	"	BX		
	RUN #17- (WIRES #370-372 INCL.) GOES FROM EXTERNAL POWER CABINET TO MAIN RECTIFIER UNIT.						
370	K-7861852P3	6TB1-8	4TB3-11	K-7861852P3	BX		
371	"	6TB1-9	4TB3-10	"	BX		
372	"	6TB1-10	4TB3-9	"	BX		
	RUN #18- (WIRE #375) GOES FROM EXTERNAL APPARATUS TO EXCITER UNIT.						
375	FREQ. MONITOR		135		M		

Sheet 12, Rev. 1

Fig. 37 con't.

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
	RUN #19-(WIRES #380-391 INCL.) GOES FROM SUPERVISORY CONSOLE TO TRANSMITTER CONTROL UNIT.						
380	K-7861852P3	8TB2-2	5TB2-2	K-7861852P3	BX		
381	"	8TB3-2	5TB8-5	"	BX		
382	"	8TB3-4	5TB1-4	"	BX		
383	"	8TB3-6	5TB8-7	"	BX		
384	"	8TB3-8	5TB1-6	"	BX		
385	"	8TB3-9	5TB8-8	"	BX		
386	"	8TB3-10	5TB8-4	"	BX		
387	"	8TB3-12	5TB1-3	"	BX		
388	"	8TB3-14	5TB8-6	"	BX		
389	"	8TB3-16	5TB1-5	"	BX		
390	JUMPER 8TB3-1, 8TB3-5, 8TB3-9, 8TB3-13 TOGETHER.						
391	JUMPER 8TB3-3, 8TB3-7, 8TB3-11, 8TB3-15 TOGETHER AND GROUND.						
	RUN #20-(WIRES #400-402 INCL.) GOES FROM SUPERVISORY CONSOLE TO AUDIO MODULATOR UNIT.						
400		8TB4-35	5TB7-1		P	CONDUIT RUN DIRECT TO 5TB7	
401		8TB4-36	5TB7-2		P		
402	CONNECT SHIELD OF ABOVE CABLE TO 5TB7-3						
	RUN #21-(WIRES #405-407 INCL.) GOES FROM ANTENNA RECTIFIER UNIT TO TRANSMITTER CONTROL UNIT.						
405	K-7861852P3	7TB1-1	5TB12-10	K-7861852P3	BX		
406	"	7TB1-2	5TB12-12	"	BX		
407	"	7TB1-3	5TB2-1	"	BX		

Sheet 13, Rev. 0

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
	RUN #22-(WIRES #410-411 INCL.) GOES FROM ANTENNA RECTIFIER UNIT TO POWER AMPLIFIER UNIT.						
410	K-7861852P3	7TB1-9	2TB5-11	K-7861852P3	BX		
411	"	7TB1-10	2TB5-12	"	BX		
	RUN #23-(WIRES #415-417 INCL.) GOES FROM ANTENNA RECTIFIER UNIT TO SUPERVISORY CONSOLE.						
415	K-7861852P3	7TB1-4	8TB2-1	K-7861852P3	BX		
416	"	7TB1-11	8TB4-49	"	N		
417	"	7TB1-12	8TB4-50	"	N		
	RUN #24-(WIRES #420-421 INCL.) GOES FROM EXTERNAL SOURCE TO SUPERVISORY CLOCK PANEL, IF USED.						
420	STATION 115V. SUPPLY		9TB1-1	K-7861852P3	BX		
421			9TB1-2	"	BX		
	RUN #25-(WIRES #425-426 INCL.) GOES FROM ANTENNA RECTIFIER UNIT TO SUPERVISORY CLOCK PANEL, IF USED.						
425	K-7861852P3	7TB1-7	9TB1-3	K-7861852P3	BX		
426	"	7TB1-8	9TB1-4	"	BX		

Sheet 14, Rev. 0

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
	THE FOLLOWING TERMINALS IN TRANSMITTER CONTROL UNIT ARE PROVIDED FOR EXTENSION OF SUPERVISORY LIGHT CIRCUITS IF DESIRED. THESE CIRCUITS (5 VOLTS) OPERATE AGAINST GROUND RETURN.						
	5TB1-1	TRANSM. START GREEN				INDICATING LIGHT	
	5TB1-2	TRANSM. STOP RED				" "	
	5TB1-9	3RD AUDIO OL RELAY (RH)				" "	
	5TB1-10	INTER. RECT. OL RELAY				" "	
	5TB1-11	2ND IPA OL RELAY				" "	
	5TB1-12	3RD IPA OL RELAY				" "	
	5TB1-13	3RD AUDIO OL RELAY (LH)				" "	
	5TB1-14	LIGHTNING TRIP RELAY				" "	
	5TB1-15	RESET BUTTON				" "	
	5TB1-16	P.A. OL RELAY (LH)				" "	
	5TB1-17	P.A. OL RELAY (RH)				" "	
	5TB1-18	MODULATOR OL RELAY (LH)				" "	
	5TB1-19	MODULATOR OL RELAY (RH)				" "	
	5TB1-20	MAIN RECT. AC OL RELAY				" "	
	5TB1-21	MAIN RECT. AC OL RELAY				" "	
	5TB1-24	EMERGENCY START BUTTON				" "	
	5TB1-25	AIR FLOW				" "	
	5TB1-26	MODULATOR UNIT DOORS				" "	
	5TB1-27	EXCITER UNIT DOORS				" "	
	5TB1-28	P.A. UNIT DOORS				" "	
	5TB1-29	RECTIFIER UNIT DOORS				" "	
	5TB1-30	EXTERNAL DOORS				" "	
	5TB1-31	BIAS				" "	
	5TB1-32	P.A. FILAMENTS				" "	
	5TB1-33	MODULATOR FILAMENTS				" "	
	5TB1-34	INTER. RECT. LOCKOUT				" "	
	5TB1-35	INTER. RECT. LOCKOUT SWITCH				" "	
	5TB1-36	MAIN RECT. LOCKOUT				" "	
	5TB1-37	MAIN RECT. LOCKOUT SWITCH				INDICATING LIGHT	

Sheet 15, Rev. 0

WIRE NO.	TERMINAL	FROM	TO	TERMINAL	WIRE SIZE	REMARKS	WIRE LGTH INCHES
	THE FOLLOWING TERMINALS IN TRANSMITTER CONTROL UNIT ARE PROVIDED FOR EXTENSION OF CIRCUITS OTHER THAN SUPERVISORY LIGHTS.						
	5TB5-3, 5TB5-4	STARTER CIRCUIT FOR SPARE MAIN BLOWER.					
	5TB5-8, 5TB5-9, 5TB5-10	230 VOLTS FOR SPARE MAIN BLOWER. (CHECK FOR CORRECT ROTATION)				SEE NOTE BELOW	
	5TB7-3, 5TB7-4	EMERGENCY START BUTTON EXTENSION.					
	5TB7-5, 5TB7-6	REMOTE SUPERVISORY LIGHT RESET. (REMOVE EXISTING JUMPER BETWEEN 5TB7-5 & 5TB7-6).					
	5TB7-10	COMMON FOR EXTENSION TRANSM. START AND TRANSM. STOP BUTTONS.					
	5TB7-11	EXTENSION TRANSM. START BUTTON.					
	5TB7-12	EXTENSION TRANSM. STOP BUTTON.					
	NOTE:- ABOVE CIRCUITS MAY BE WIRED WITH #14 WIRE (BX) EXCEPT FOR 230 VOLTS FOR SPARE MAIN BLOWER, WHICH SHOULD BE WIRED WITH #8 WIRE (BZ).						

Sheet 16, Rev. 0 (Final)

Fig. 37 con't.

TABLE 1
FIXED TANK CAPACITORS

SYMBOL	540-680	681-840	841-1000	1001-1150	1151-1300	1301-1450	1451-1600
	FREQUENCY (F) IN KC						
	2ND IPA PLATE TANK						
1C28	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)
1C29	↕	↕	↕	↕	↕	K-7897602P3 (.0001)	K-7897602P3 (.0001)
1C30	↕	↕	↕	K-7897602P3 (.0001)	K-7897602P3 (.0001)	OMIT	OMIT
1C31	↕	↕	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT
1C32	↕	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT
1C33	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
	3RD IPA GRID TANK						
1C35	M-2R23P9 (.001)	M-2R23P9 (.001)	M-2R23P9 (.001)	M-2R23P8 (.00068)	M-2R23P8 (.00068)	M-2R23P7 (.00047)	M-2R23P7 (.00047)
1C36	M-2R23P9 (.001)	M-2R23P9 (.001)	M-2R38P8 (.00068)	M-2R23P8 (.00068)	M-2R23P7 (.00047)	M-2R23P7 (.00047)	M-2R23P7 (.00047)

SYMBOL	540-590	591-680	681-840	841-1000	1001-1150	1151-1300	1301-1450	1451-1600
	3RD IPA PLATE TANK							
1C50	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)	K-7897602P3 (.0001)
1C51	↕	↕	↕	↕	↕	↕	↕	↕
1C52	↕	↕	↕	↕	↕	↕	↕	↕
1C53	↕	↕	↕	↕	↕	↕	↕	↕
1C54	↕	↕	↕	↕	↕	↕	↕	↕
1C55	↕	↕	↕	↕	↕	↕	↕	K-7897602P3 (.0001)
1C56	↕	↕	↕	↕	↕	K-7897602P3 (.0001)	K-7897602P3 (.0001)	OMIT
1C57	↕	↕	↕	K-7897602P3 (.0001)	K-7897602P3 (.0001)	OMIT	OMIT	OMIT
1C58	↕	↕	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT
1C59	↕	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
1C88	↕	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
1C89	↕	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
1C90	↕	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
1C91	K-7897602P3 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
	PA GRID TANK							
2C31	M-2R48P14 (.002)	M-7479203P1 (.0016)	M-7479203P1 (.0016)	M-7479203P1 (.0016)	M-7479203P1 (.0016)	M-2R48P12 (.0012)	M-2R48P11 (.001)	M-2R48P10 (.00081)
2C32	M-2R48P14 (.002)	M-7479203P1 (.0016)	M-7479203P1 (.0016)	M-7479203P1 (.0016)	M-2R48P12 (.0012)	M-2R48P12 (.0012)	M-2R48P11 (.001)	M-2R48P10 (.0008)
2C33	M-2R48P14 (.002)	M-2R48P14 (.002)	M-7479203P1 (.0016)	M-2R48P12 (.0012)	M-2R48P12 (.0012)	M-2R48P12 (.0012)	M-2R48P1 (.001)	M-2R48P10 (.0008)

NOTE: ALL CAPACITOR VALUES IN MFD.

TABLE 2
LOAD MATCHING CAPACITORS

SYMBOL	540-630	631-730	731-810	811-920	921-1070	1071-1280	1281-1600
	FREQUENCY (F) IN KC						
	FOR 70 OHM TRANSMISSION LINE IMPEDANCE						
2C18	P-7767477P25 (.00015)	P-7767477P25 (.00015)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)
2C19	↕	↕	↕	↕	↕	↕	↕
2C20	↕	↕	↕	↕	↕	↕	↕
2C21	↕	↕	P-7767477P21 (.0001)	↕	↕	↕	↕
2C22	↕	↕	P-7767477P25 (.00015)	↕	↕	↕	↕
2C23	↕	↕	↕	↕	↕	↕	↕
2C24	↕	↕	↕	↕	↕	↕	↕
2C25	↕	↕	↕	P-7767477P21 (.0001)	↕	↕	↕
2C26	↕	↕	↕	P-7767477P25 (.00015)	↕	↕	P-7767477P21 (.0001)
2C27	↕	↕	↕	↕	↕	↕	OMIT
2C28	↕	↕	↕	↕	↕	P-7767477P21 (.0001)	OMIT
2C29	P-7767477P25 (.00015)	P-7767477P25 (.00015)	P-7767477P25 (.00015)	P-7767477P25 (.00015)	P-7767477P21 (.0001)	OMIT	OMIT
	FOR 230 OHM TRANSMISSION LINE IMPEDANCE						
2C18	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)	P-7767477P21 (.0001)
2C19	↕	↕	↕	↕	↕	↕	↕
2C20	↕	↕	↕	↕	↕	↕	↕
2C21	↕	↕	↕	↕	↕	↕	↕
2C22	↕	↕	↕	↕	↕	↕	P-7767477P21 (.0001)
2C23	↕	↕	↕	↕	↕	P-7767477P21 (.0001)	OMIT
2C24	↕	↕	↕	↕	P-7767477P21 (.0001)	OMIT	OMIT
2C25	↕	↕	↕	P-7767477P21 (.0001)	OMIT	OMIT	OMIT
2C26	↕	↕	P-7767477P21 (.0001)	OMIT	OMIT	OMIT	OMIT
2C27	↕	P-7767477P21 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT
2C28	P-7767477P21 (.0001)	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT
2C29	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT	OMIT

FOR OTHER TRANSMISSION LINE IMPEDANCES CONSULT ENG'G. DEP'T

TABLE 3
2ND HARMONIC FILTER CAPACITOR *

SYMBOL	540-700	701-950	951-1100	1101-1300	1301-1600
	FREQUENCY (F) IN KC				
	FOR 70 OHM TRANSMISSION LINE IMPEDANCE				
2C30	M-2R48P14 (.002)	M-2R48P13 (.0015)	M-2R48P12 (.0012)	M-2R48P11 (.001)	M-2R48P10 (.0008)
	FOR 230 OHM TRANSMISSION LINE IMPEDANCE				
2C30	M-2R48P12 (.0012)	M-2R48P11 (.001)	M-2R48P10 (.0008)	M-2R48P9 (.0006)	M-2R48P8 (.0005)

*FOR OTHER TRANSMISSION LINE IMPEDANCES CONSULT ENG'S DEPT.

TABLE 4
COILS

SYMBOL	540-1080	1081-1600	FUNCTION
	FREQUENCY (F) IN KC		
2L2	ML-7768797G1	OMIT	PA NEUTRALIZING COIL

SYMBOL	540-675	676-1000	1001-1600	FUNCTION
	FREQUENCY (F) IN KC			
2L10	ML-7768791G1	ML-7768793G1	ML-7768795G1	PA PLATE CHOKE

TABLE 5
REMOTE ANTENNA AMMETER (2M4)

SCALE	FULL-SCALE CURRENT	DRAWING NUMBER
0-5 AMPS. RF	10 MA DC	K-7115711-14
0-8	↕	↕ 15
0-10	↕	↕ 16
0-15	↕	↕ 17
0-50 AMPS. RF.	10 MA DC	K-7115711-18

PROCEDURE

1. CUSTOMER INFORMATION REQUIRED.
   A. OPERATING FREQUENCY (F) IN KC.
   B. TRANSMISSION LINE IMPEDANCE IN OHMS.
2. SELECTION OF FIXED TANK CAPACITORS.
   A. USE TABLE 1
3. SELECTION OF LOAD MATCHING CAPACITORS.
   A. USE TABLE 2 FOR 70 OR 230 OHM TRANSMISSION LINE IMPEDANCES.
   B. FOR ALL OTHER TRANSMISSION LINE IMPEDANCES CONSULT ENG'G. DEP'T.
4. SELECTION OF 2ND HARMONIC FILTER CAPACITOR.
   A. USE TABLE 3 FOR 70 OR 230 OHM TRANSMISSION LINE IMPEDANCES.
   B. FOR ALL OTHER TRANSMISSION LINE IMPEDANCES CONSULT ENG'G. DEP'T.
5. SELECTION OF COILS
   A. USE TABLE 4
6. REFERENCE TO ENG'G. DEP'T. REQUIRED.
   A. FOR SELECTION OF LOAD MATCHING CAPACITORS OF TABLE 2 AND FILTER CAPACITORS OF TABLE 3 WHEN CUSTOMER TRANSMISSION LINE IMPEDANCE IS OTHER THAN THE TABULATED 70 OR 230 OHMS.
7. IN TABLE 5
   THE SELECTION OF THE AMMETER WITH ITS PROPER SCALE DEPENDS ON THE ANTENNA RESISTANCE AND POWER.

Fig. 38 Load and Frequency Application Drawing (T-7665084, Rev. 4)

-COMMERCIAL BULLETINS-

TUBE BULLETINS:

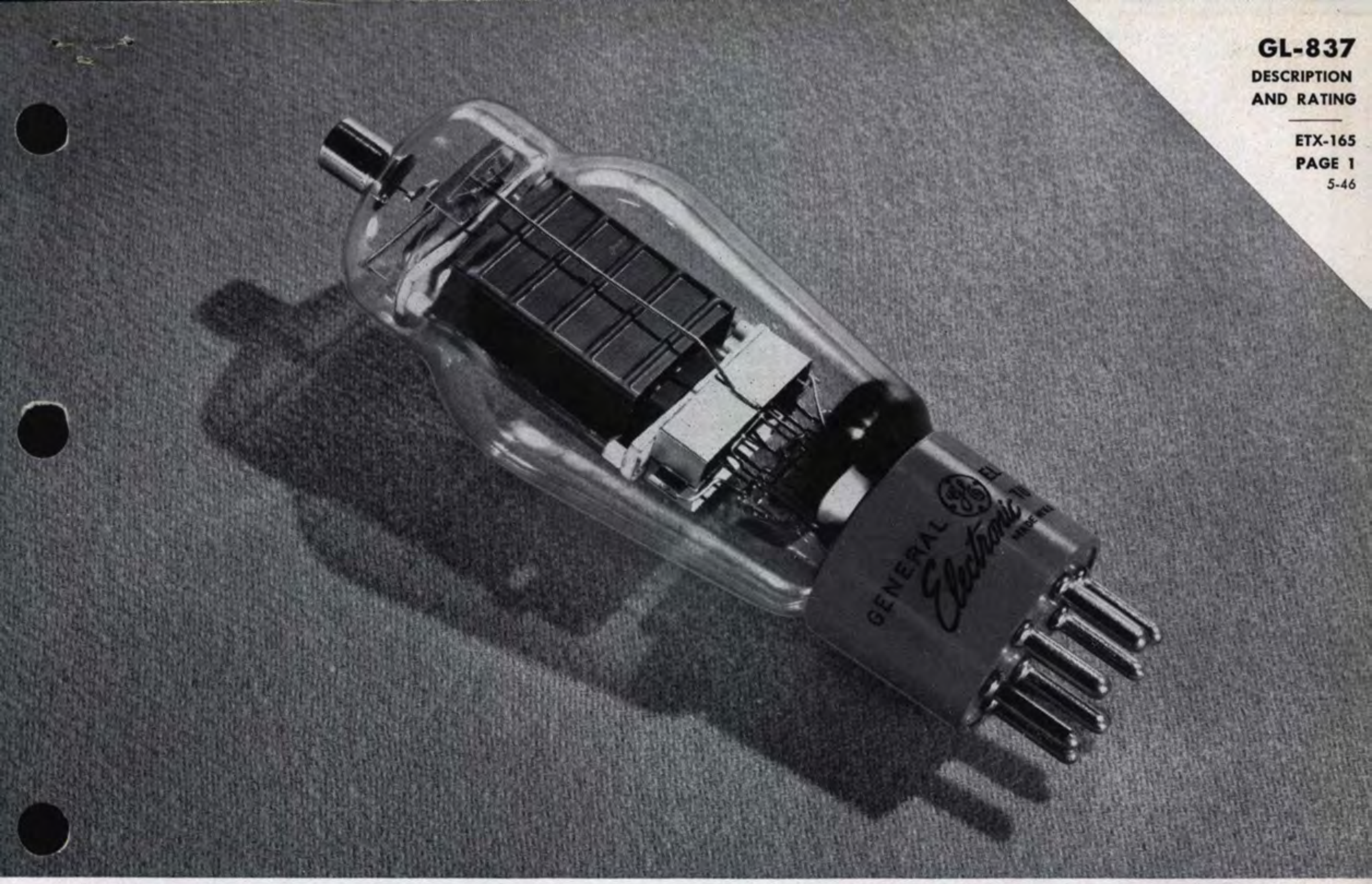
Reference	Type and Title	
ETX-150	GL-810	Description and Rating
ETX-158	GL-828	Description and Rating
ETX-162A	GL-833-A	Description and Rating
ETX-165	GL-837	Description and Rating
ETX-172	GL-857-B	Description and Rating
ETX-175	GL-866-A/866	Description and Rating
ETX-189A	GL-895-R	Description and Rating
ETX-202	GL-8008	Description and Rating
ETX-217	GL-5C24	Description and Rating

COMMERCIAL BULLETINS:

Reference	Title
GEH-1039B	CR2810 A-C Low-Voltage Contactors with D-C Magnet
GEH-1020B	CR2953-7 Definite Time Interlock
GEH-85E	CR2820-1054 Time Relay
GEH-954B	Plunger Relays-Types PAA, PAC, PAV, PBA, PBC and PCV
GEH-985G	A-C Motor-Operated Definite-Time Relay (CR2820-1099)
GEH-1016C	Time Delay Relay - CR2820-1731A and 1731B
GEH-1141A	CR2820-1729 Definite-Time Relay
GEI-15593A	Instantaneous Auxiliary Relays - Types HMA11A, HMA11B, HMA12A, HMA12B, HMA13A, HMA13B and HMA15A
GEI-10904E	A-C and D-C Auxiliary Relays and A-C Current Relays
GEH-75C	General Instructions for Magnetic Controller
GEJ-1660	A-C Magnetic Switch - CR2811-C24B
GEI-10982B	Air Circuit Breaker - Type AE-1-15
GEH-1085B	Type Airs Induction-Voltage Regulator
GEI-21709	Instructions for Installing and Operating Small KVA Size Liquid-Filled Triplex Induction Voltage Regulators
GEJ-831	50 KVA Pyranol Transformer
GEH-1093A	Pyranol Transformers and Reactors
GEI-18370C	Pressure Relief Device for Power Transformers
GEH-230M	Instrument Transformers - Dry Type
GEH-790M	Horizontal, Polyphase Induction Motors

ADDITIONAL ITEMS:

Reference	Title
EBR-95	Protecting Against Carrier Failure
GET-1125	How to Maintain Electric Equipment (one per customer)



PENTODE

DESCRIPTION

The GL-837 is a pentode transmitting tube for use as a radio-frequency amplifier, frequency-multiplier, oscillator, and suppressor-, grid-, or plate-modulated amplifier. The plate connection is brought out through a separate seal at the top of the bulb to maintain low grid-plate capacitance. Neutralization is generally unnecessary in adequately shielded circuits. The suppressor and the special internal shield are connected to individual base pins. The 837 may be operated at maximum ratings at frequencies as high as 20 megacycles. The maximum plate dissipation is 12 watts.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Number of electrodes	5	
Electrical		
Cathode-Heater type		
Heater voltage, a-c or d-c	12.6	volts
Heater current	0.7	ampere
Transconductance, for plate current of 24 ma	3400	micromhos
Direct interelectrode capacitances		
Grid-plate, with external shielding	0.20	micromicrofarad
Input	16	micromicrofarads
Output	10	micromicrofarads
Frequency for maximum ratings	20	megacycles

Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

Mechanical

Cap	small metal
Base	medium 7-pin bayonet
Net weight, approximate	5 ounces
Shipping weight	3 pounds
Mounting position	vertical or horizontal

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AS RADIO-FREQUENCY POWER AMPLIFIER PENTODE—CLASS B TELEPHONY

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

	Typical Operation			Maximum Ratings	
D-c plate voltage	400	500	500	500	volts
D-c suppressor voltage, Grid No. 3	0	0	40	200	volts
D-c screen voltage, Grid No. 2	200	200	200	200	volts
D-c grid voltage, Grid No. 1	−25	−25	−25		volts
D-c plate current	35	30	30	40	milliamperes
D-c screen current	10	15	12		milliamperes
D-c grid current, approximate	1	0	0		milliamperes
Peak r-f grid voltage	28	25	24		volts
Internal shield	connected to cathode at socket				
Plate input				16	watts
Suppressor input				5	watts
Screen input				5	watts
Plate dissipation				12	watts
Driving power, approximate*	0.4	0.2	0.1		watt
Power output, approximate	4	5	5.5		watts

AS SUPPRESSOR-MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

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

	Typical Operation		Maximum Ratings	
D-c plate voltage	400	500	500	volts
D-c suppressor voltage, Grid No. 3	−55	−65		volts
D-c grid voltage**	−20	−20	−200	volts
D-c screen voltage, Grid No. 2			200	volts
Peak r-f grid voltage	45	32		volts
Peak a-f suppressor voltage	55	65		volts
Internal shield	connected to cathode at socket			
D-c plate current	35	30	40	milliamperes
D-c screen current	37	23		milliamperes
D-c grid current, approximate	8	3.5	8	milliamperes
Plate input			16	watts
Screen input			8	watts
Plate dissipation			12	watts
Screen resistor	6500	14000		ohms
Grid resistor	2500	5700		ohms
Driving power, approximate	0.4	0.1		watt
Power output, approximate	4	5		watts

AS GRID-MODULATED RADIO-FREQUENCY POWER AMPLIFIER PENTODE—CLASS C TELEPHONY

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

	Typical Operation			Maximum Ratings	
D-c plate voltage	400	500	500	500	volts
D-c suppressor voltage	0	0	40	200	volts
D-c screen voltage	200	200	200	200	volts
D-c grid voltage**	−50	−45	−43	−200	volts
Peak r-f grid voltage	58	48	44		volts
Peak a-f grid voltage	25	20	18		volts
Internal shield	connected to cathode at socket				
D-c plate current	35	30	30	40	milliamperes
D-c screen current	9	7	6		milliamperes
D-c grid current, approximate	1	0	0		milliampere
Plate input				16	watts
Suppressor input				5	watts
Screen input				5	watts
Plate dissipation				12	watts
Driving power, approximate*	0.5	0.2	0.15		watt
Power output, approximate	4	5	5.5		watts

TECHNICAL INFORMATION (CONT'D)

AS PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER PENTODE—CLASS C TELEPHONY

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

D-c plate voltage	400	400	volts
D-c suppressor voltage	40	200	volts
D-c screen voltage	140	200	volts
D-c grid voltage**	−40	−200	volts
Peak r-f grid voltage	60		volts
Internal shield	connected to cathode at socket		
D-c plate current	45	50	milliamperes
D-c screen current	20		milliamperes
D-c grid current, approximate	5	8	milliamperes
Plate input		20	watts
Suppressor input		5	watts
Screen input		5	watts
Plate dissipation		8	watts
Screen resistor #	13000		ohms
Grid resistor	8000		ohms
Driving power, approximate	0.3		watt
Power output, approximate	11		watts

AS PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER TETRODE—CLASS C TELEPHONY (Grids No. 2 and 3 connected together)

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

D-c plate voltage	400	400	volts
D-c screen voltage	100	200	volts
D-c grid voltage**	−70	−200	volts
Peak r-f grid voltage	100		volts
Internal shield	connected to cathode at socket		
D-c plate current	45	50	milliamperes
D-c screen current	30		milliamperes
D-c grid current, approximate	7	8	milliamperes
Plate input		20	watts
Screen input, Grids No. 2 and 3		7.5	watts
Plate dissipation		8	watts
Screen resistor ##	10000		ohms
Grid resistor	10000		ohms
Driving power, approximate	0.7		watt
Power output, approximate	11		watts

AS RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR PENTODE—CLASS C TELEGRAPHY

Key-down conditions per tube without modulation‡

D-c plate voltage	400	500	500	500	volts
D-c suppressor voltage	0	0	40	200	volts
D-c screen voltage	200	200	200	200	volts
D-c grid voltage**	−40	−85	−75	−200	volts
Peak r-f grid voltage	70	120	100		volts
Internal shield	connected to cathode at socket				
D-c plate current	70	60	60	80	milliamperes
D-c screen current	32	30	15		milliamperes
D-c grid current, approximate	8	8	4	8	milliamperes
Plate input				32	watts
Suppressor input				5	watts
Screen input				8	watts
Plate dissipation				12	watts
Screen resistor	6300	10000	20000		ohms
Grid resistor	5000	10600	18700		ohms
Driving power, approximate	0.5	0.8	0.4		watt
Power output, approximate	16	20	22		watts

TECHNICAL INFORMATION (CONT'D)

AS RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR TETRODE—CLASS C TELEGRAPHY

(Grids No. 2 and 3 connected together)

D-c plate voltage	400	500	500	volts
D-c screen voltage	110	80	200	volts
D-c grid voltage**	−70	−70	−200	volts
Peak r-f grid voltage	115	110		volts
Internal shield	connected to cathode at socket			
D-c plate current	70	60	80	milliamperes
D-c screen current	25	15		milliamperes
D-c grid current, approximate	8	8	8	milliamperes
Plate input			32	watts
Screen input, Grids No. 2 and 3			8	watts
Plate dissipation			12	watts
Screen resistor	11600	28000		ohms
Grid resistor	8700	8700		ohms
Driving power, approximate	0.75	0.7		watt
Power output, approximate	18	20		watts

* At crest of audio-frequency cycle with modulation factor of 1.0.
** The total effective grid-circuit resistance should not exceed 25000 ohms.
‡ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.
#Connected to modulated plate-voltage supply.
##Connected to unmodulated plate-voltage supply.

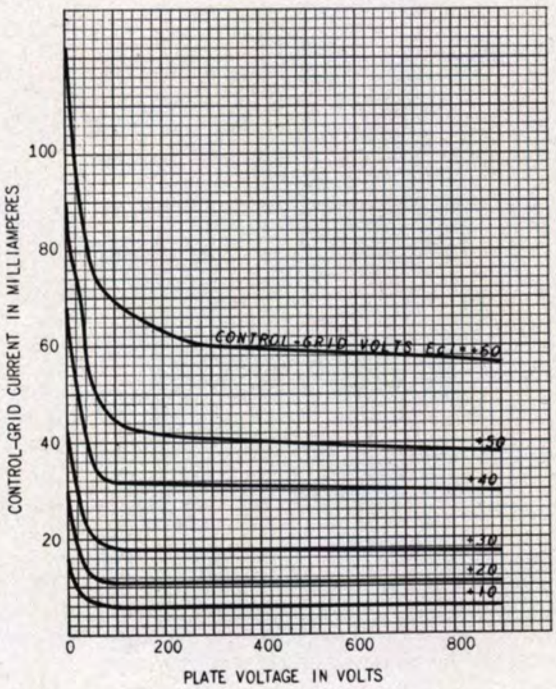
APPLICATION NOTES

The maximum ratings apply only at frequencies below 20 megacycles. For operation at higher frequencies, adequate ventilation and normal ambient temperatures must be maintained, and the plate voltage must be reduced as indicated.

Frequency	20	40	60	megacycles
Percentage of maximum rated plate voltage and plate input				
Class B, Class C grid- or suppressor-modulated	100	90	84	per cent
Class C, plate-modulated	100	76	62	per cent
Class C, telegraphy	100	76	62	per cent

GL-837 AVERAGE CHARACTERISTICS

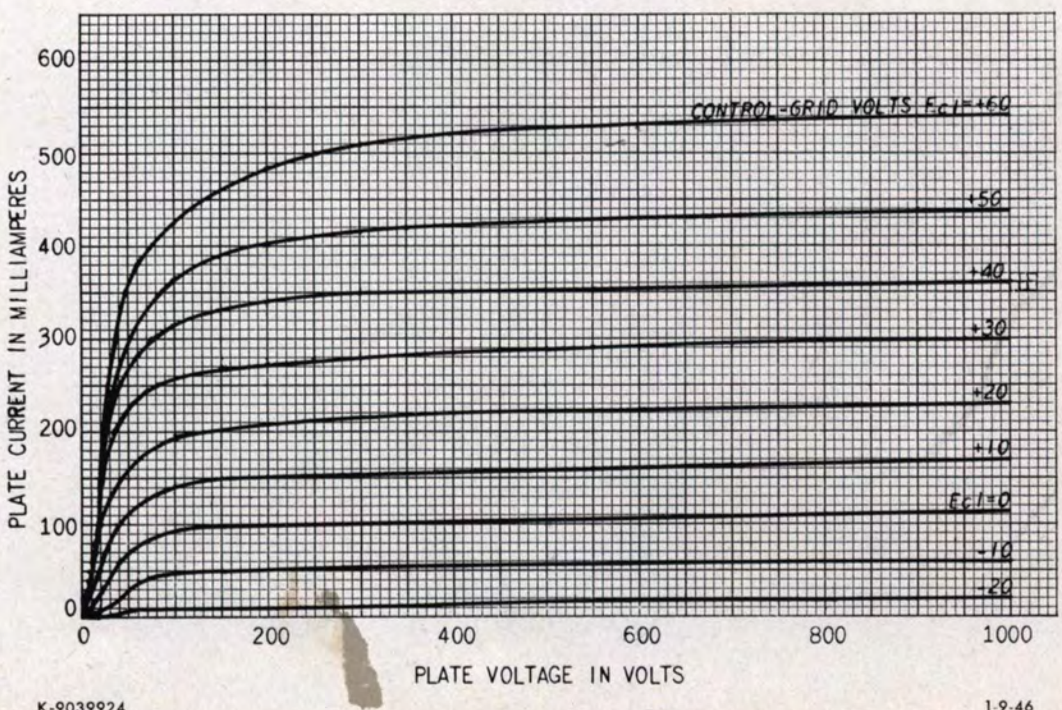
(E_f=12.6 VOLTS, SCREEN VOLTS=200, SUPPRESSOR VOLTS=+40)



K-9186063 1-9-46

GL-837 AVERAGE PLATE CHARACTERISTICS

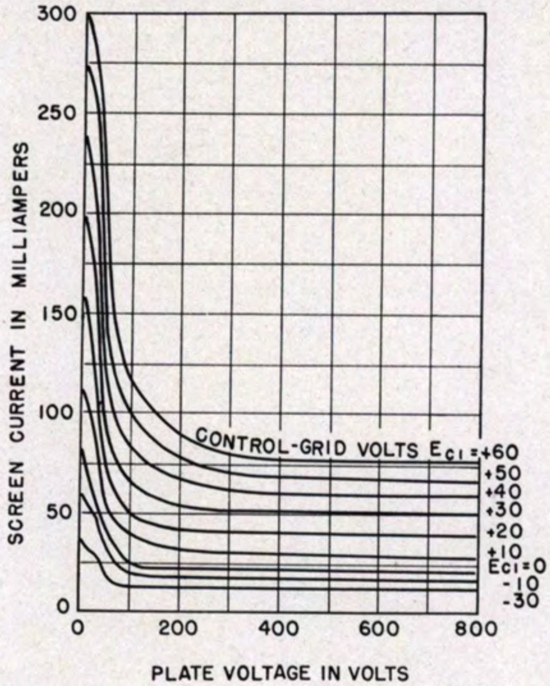
(E_f=12.6 VOLTS, D-C SUPPRESSOR VOLTS=+40, D-C SCREEN VOLTS=200)



K-9039924 1-9-46

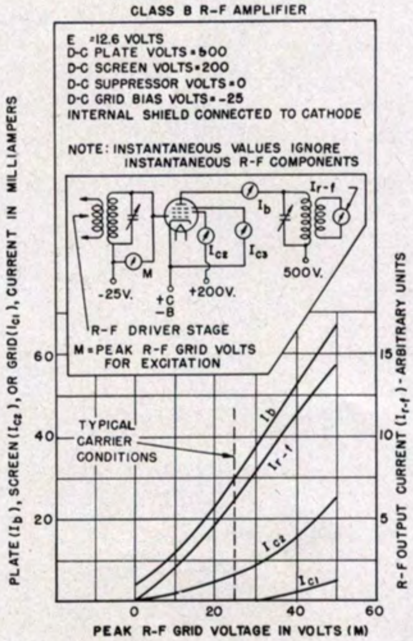
GL-837 AVERAGE CHARACTERISTICS

(E_f = 12.6 VOLTS, SCREEN VOLTS = 200, SUPPRESSOR VOLTS = +40)



K-9033961 10-8-45

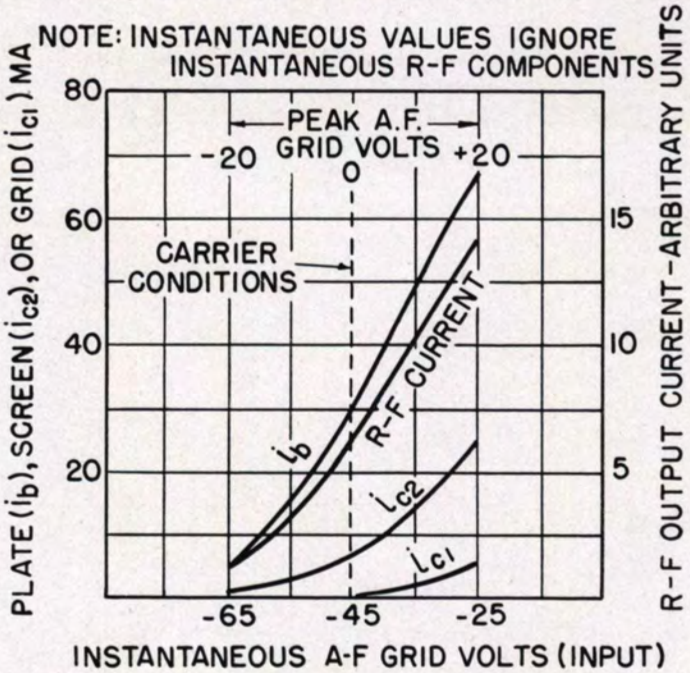
GL-837
OPERATION CHARACTERISTICS
CLASS B R-F AMPLIFIER



K-9033957 10-8-45

GL-837 GRID MODULATION CHARACTERISTICS

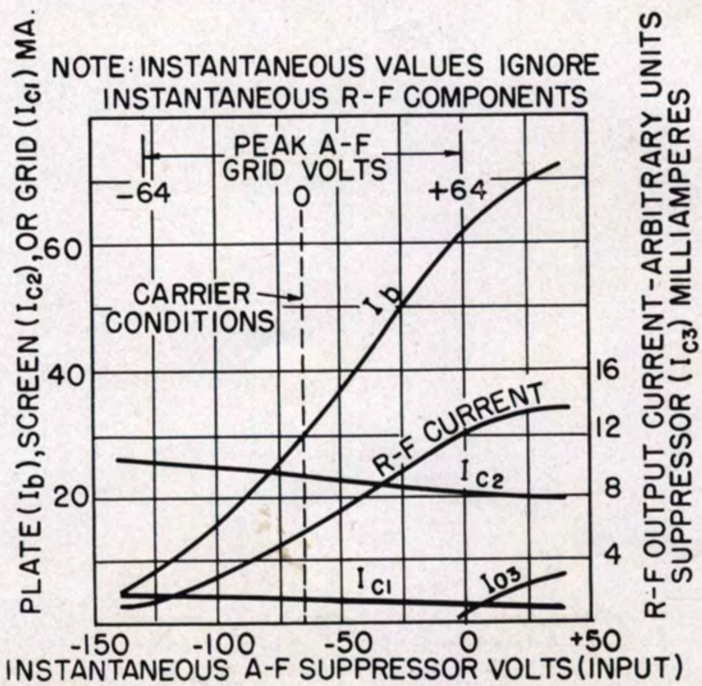
(E_f=12.6 VOLTS, D-C PLATE VOLTS=500, D-C SCREEN VOLTS=200, D-C SUPPRESSOR VOLTS=0)
(D-C GRID BIAS VOLTS=−45, PEAK R-F GRID VOLTS=50, INTERNAL SHIELD CONNECTOR TO CATHODE)



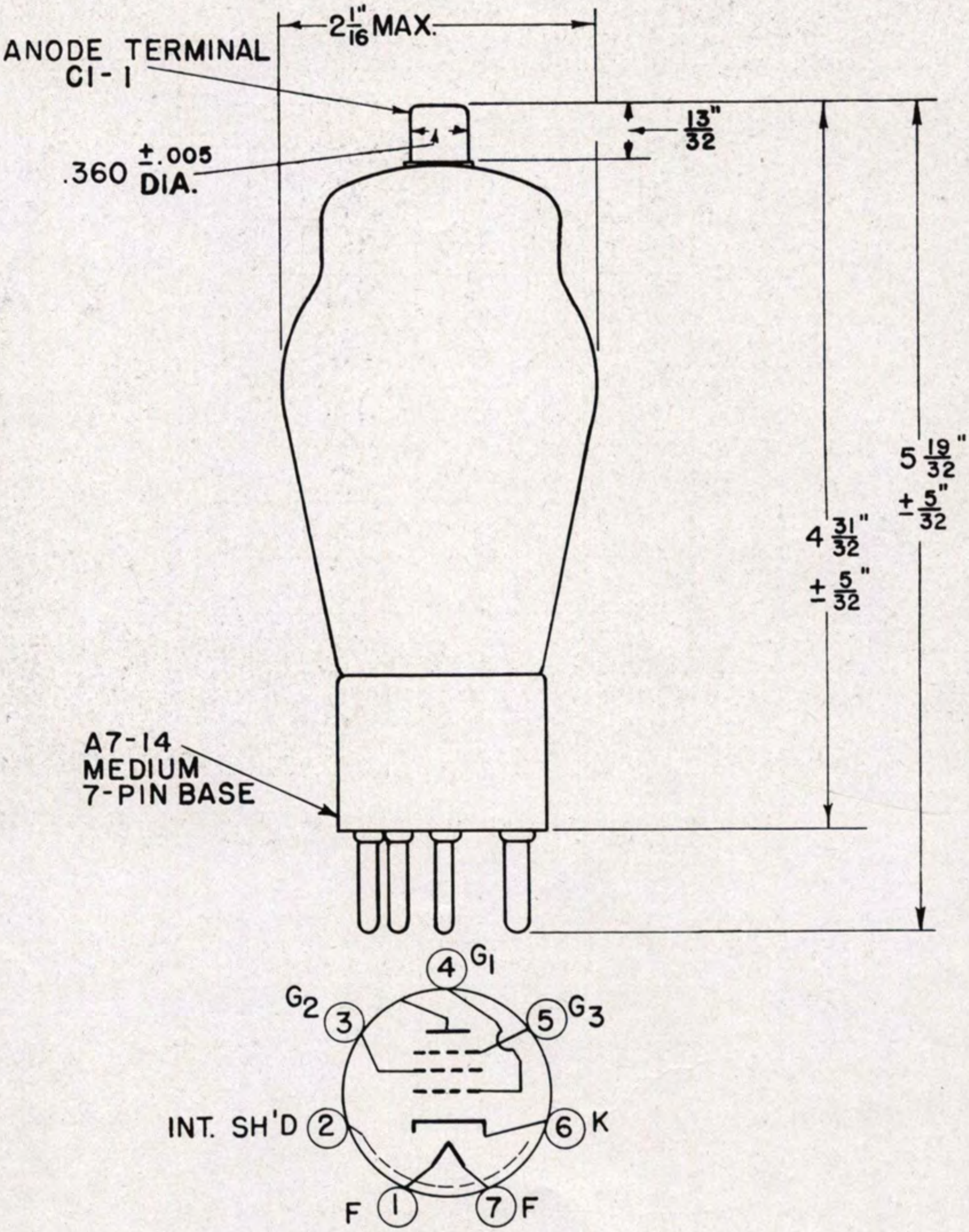
K-9033992 1-9-46

GL-837 SUPPRESSOR MODULATION CHARACTERISTICS

(E_f=12.6 VOLTS, D-C PLATE VOLTS=500, D-C SCREEN VOLTS=500 MINUS DROP IN SERIES SCREEN RESISTOR OF 1400 OHMS)
(D-C SUPPRESSOR VOLTS=−64, D-C GRID BIAS VOLTS=−20, PEAK R-F GRID VOLTS=140)
INTERNAL SHIELD CONNECTED TO CATHODE



K-9033991 1-9-46



BOTTOM VIEW
BASING DIAGRAM

GL-837 OUTLINE

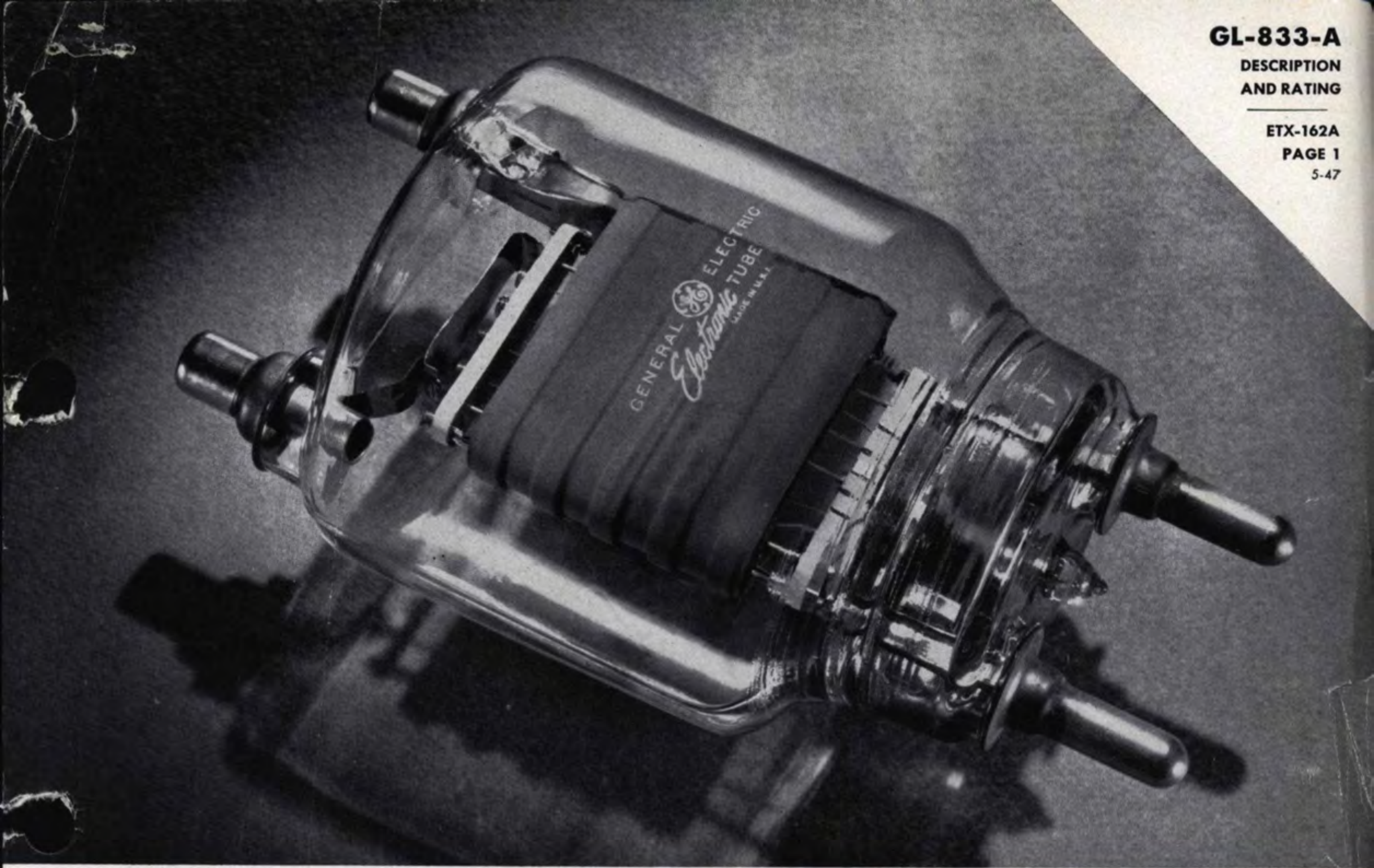
K-9033896 7-26-45

Electronics Department

GENERAL ELECTRIC

Schenectady, N. Y.

5-46 (7M)
Filing No. 8850



TRIODE

DESCRIPTION

GL-833-A is a three-electrode transmitting tube of the high-mu type for use as a radio-frequency amplifier, oscillator, and Class B modulator. Because of its high perveance, the 833-A can be operated at high plate efficiency with low driving power.

Designed in a new way with post terminals which provide a sturdy structure and make bases unnecessary, the 833-A has a minimum amount of insulation within the tube. The anode is supported directly from its post terminal at the top of the tube. Short, heavy-current leads are used to connect the anode and the grid to their respective terminals in order to carry the high circulating r-f current at the high frequencies and to minimize internal lead inductance.

As a result of its construction, the 833-A provides exceptional efficiency at high frequencies. It can be operated in Class C telegraph service with maximum input of 2000 watts at frequencies as high as 30 megacycles, and with reduced input at frequencies as high as 75 megacycles.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Number of electrodes 3

Electrical

Cathode—Filamentary

Filament voltage . . . . 10 volts

Filament current . . . . 10 amperes

Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

Average characteristics
- Amplication factor 35
- Direct interelectrode capacitances
  - Grid-plate .... 6.3 micromicrofarads
  - Grid-filament .... 12.3 micromicrofarads
  - Plate-filament .... 8.5 micromicrofarads
- Frequency for maximum ratings .... 30 megacycles

Mechanical
- Type of cooling .... convection or forced air
- Maximum ambient temperature, convection-cooled .... 60 centigrade
- Net weight, approximate .... 1 pound
- Shipping weight, approximate .... 3 pounds
- Operating position ...... vertical with filament terminals up or down or horizontal with plate in a plane vertical

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES)

	Typical Operation			Maximum Ratings			
	CCS	*	ICAS *	CCS	*	ICAS *	
D-c plate voltage	3000	4000	4000	3000	4000	4000	volts
Maximum signal plate current, per tube†				500	500	500	milliamperes
D-c maximum signal plate input, per tube†				1125	1600	1800	watts
Plate dissipation†				300	400	450	watts
D-c grid voltage‡	−70	−100	−100				volts
Peak a-f grid input voltage	400	480	510				volts
Zero signal plate current	100	100	100				milliamperes
Maximum signal plate current	750	800	900				milliamperes
Maximum signal driving power, approximate	20	29	38				watts
Effective load, plate to plate	9500	12000	11000				ohms
Maximum signal plate power output, approximate	1650	2400	2700				watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

Carrier conditions per tube for use with a max modulation factor of 1.0		*	*		*	*	
D-c plate voltage	3000	4000	4000	3000	4000	4000	volts
D-c grid voltage‡	−70	−120	−120				volts
D-c plate current	150	150	150	300	300	300	milliamperes
Plate input				450	600	675	watts
Plate dissipation				300	400	450	watts
Peak r-f grid input voltage	90	120	130				volts
Driving power§△, approximate	10	14	21				watts
Plate power output, approximate	150	225	250				watts
D-c grid current, approximate△	2	2	3				milliamperes

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

Carrier conditions per tube for use with a max modulation factor of 1.0		*	*		*	*	
D-c plate voltage	2500	3000	4000	2500	3000	4000	volts
D-c grid voltage π	−300	−300	−325	−500	−500	−500	volts
	4000	3600	3600				ohms
D-c plate current	335	415	450	400	450	450	milliamperes
D-c grid current, approximate	75△	85△	90△	100	100	100	milliamperes
Plate input				835	1250	1800	watts
Plate dissipation				200	270	350	watts
Driving power△, approximate	30	37	42				watts
Plate power output, approximate	635	1000	1500				watts
Peak r-f grid voltage	460	490	520				volts

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS (CONT'D)

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation □

	Typical Operation			Maximum Ratings			
	CCS	*	ICAS *	CCS	*	ICAS *	
D-c plate voltage	3000	4000	4000	3000	4000	4000	volts
D-c grid voltage#	−200	−200	−225	−500	−500	−500	volts
	3500	2650	2400				ohms
	425	380	380				ohms
D-c plate current	415	450	500	500	500	500	milliamperes
D-c grid current, approximate	55△	75△	95△	100	100	100	milliamperes
Plate input				1250	1800	2000	watts
Plate dissipation				300	400	450	watts
Peak r-f grid input voltage, approximate	360	375	415				volts
Driving power△, approximate	20	26	35				watts
Plate power output, approximate	1000	1440	1600				watts

* Forced-air cooling required at these conditions of operation. When forced-air cooling is required an air flow of 40 cfm from a two-inch diameter nozzle directed vertically downward on bulb between grid and plate seals is required. Bulb temperature between grid and plate seals must not exceed 145 C. For conditions of operation where forced-air cooling is not required, adequate free circulation of air around the tube is necessary for satisfactory operation.

† Averaged over any audio-frequency cycle of sine-wave form.

‡ For a-c filament supply.

§ At crest of audio-frequency cycle.

△Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

π Obtained by grid resistor of value shown or by partial self-bias methods.

□ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

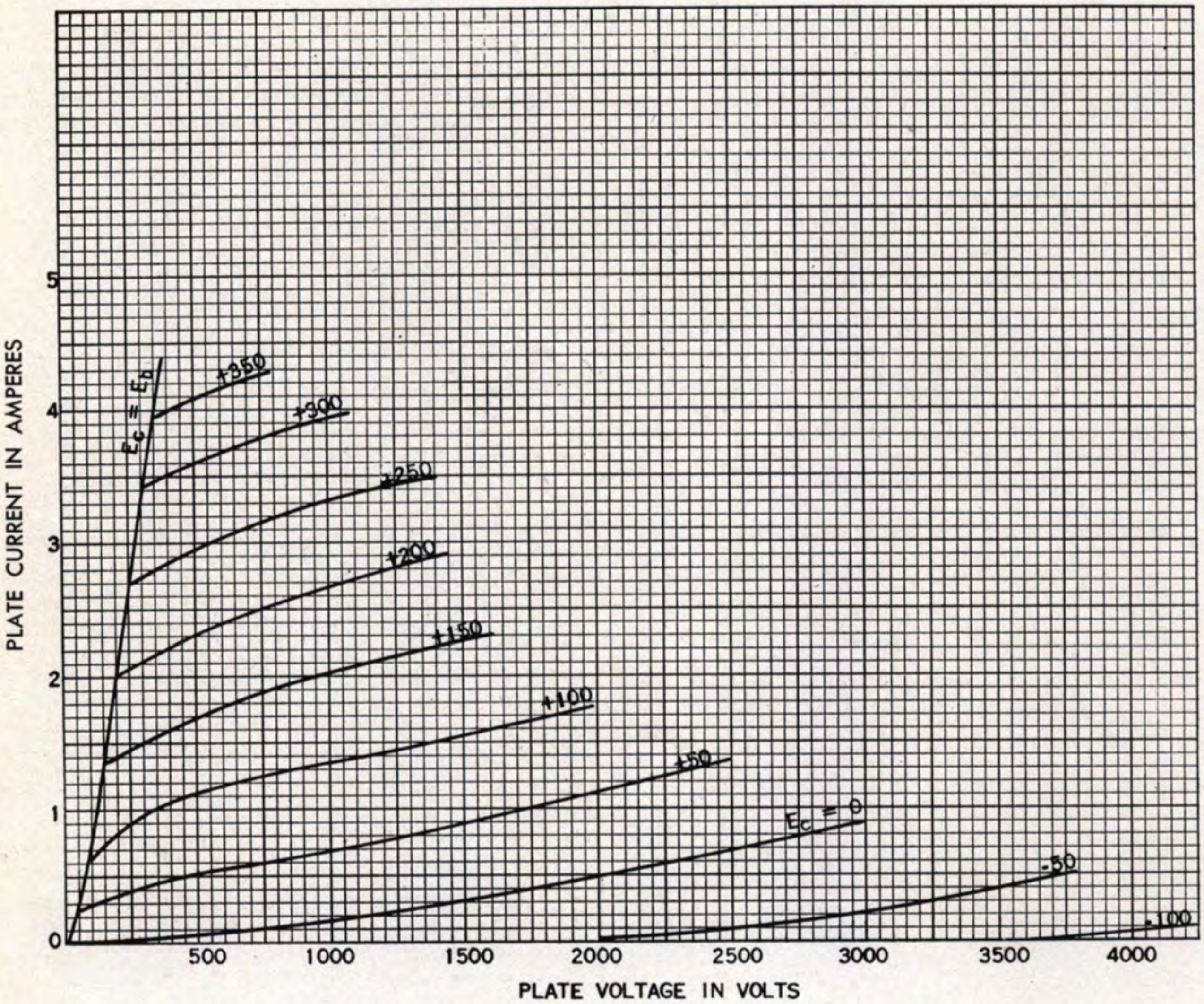
#Obtained from fixed supply, by grid resistor (3500, 2650, 2400), or by cathode resistor (425, 380, 380).

APPLICATION NOTES

The GL-833-A can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 75 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

	Natural Cooling			Forced-air Cooling			
Frequency	30	50	75	20	50	75	megacycles
Maximum permissible percentage of maximum rated plate voltage and plate input							
Class B, r-f	100	98	94	100	97	93	per cent
Class C, plate-modulated	100	90	72	100	83	65	per cent
Class C, unmodulated	100	90	72	100	83	65	per cent

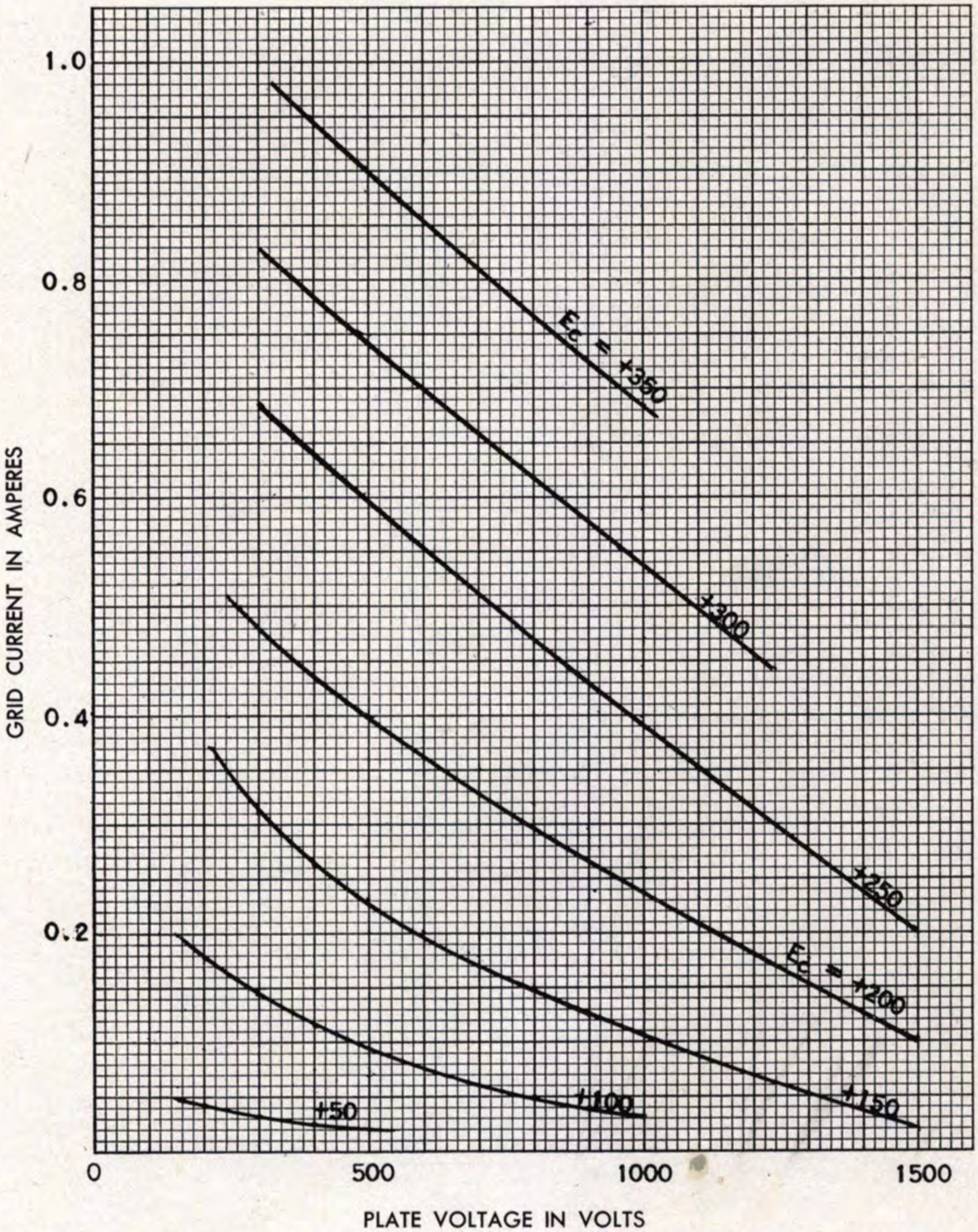
GL-833-A TYPICAL CHARACTERISTICS ($E_f = 10$ VOLTS A-C)



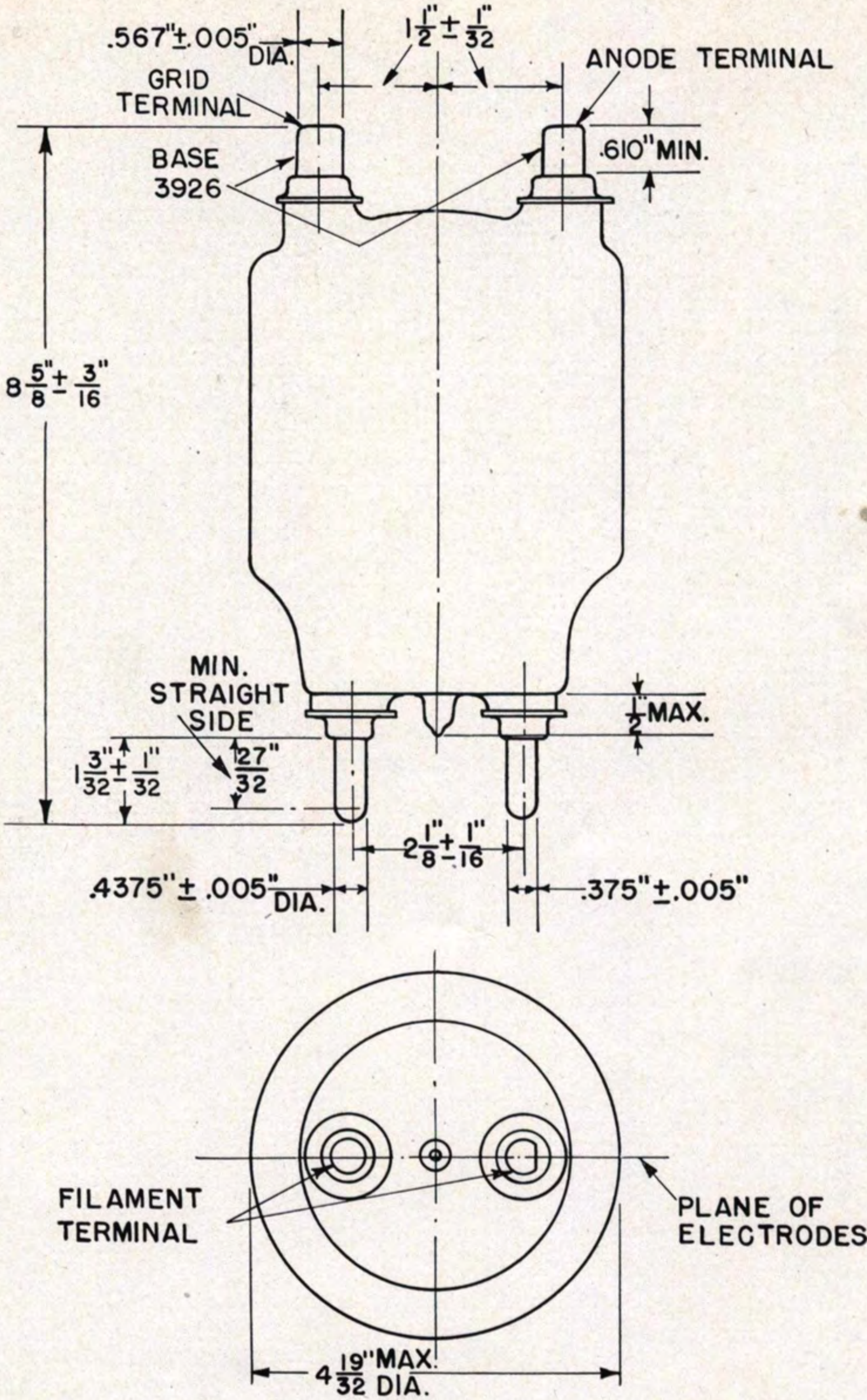
K-69087-72A109

2-6-47

GL-833-A
TYPICAL CHARACTERISTICS
$E_f = 10$ VOLTS A-C



K-69087-72A107 2-6-47



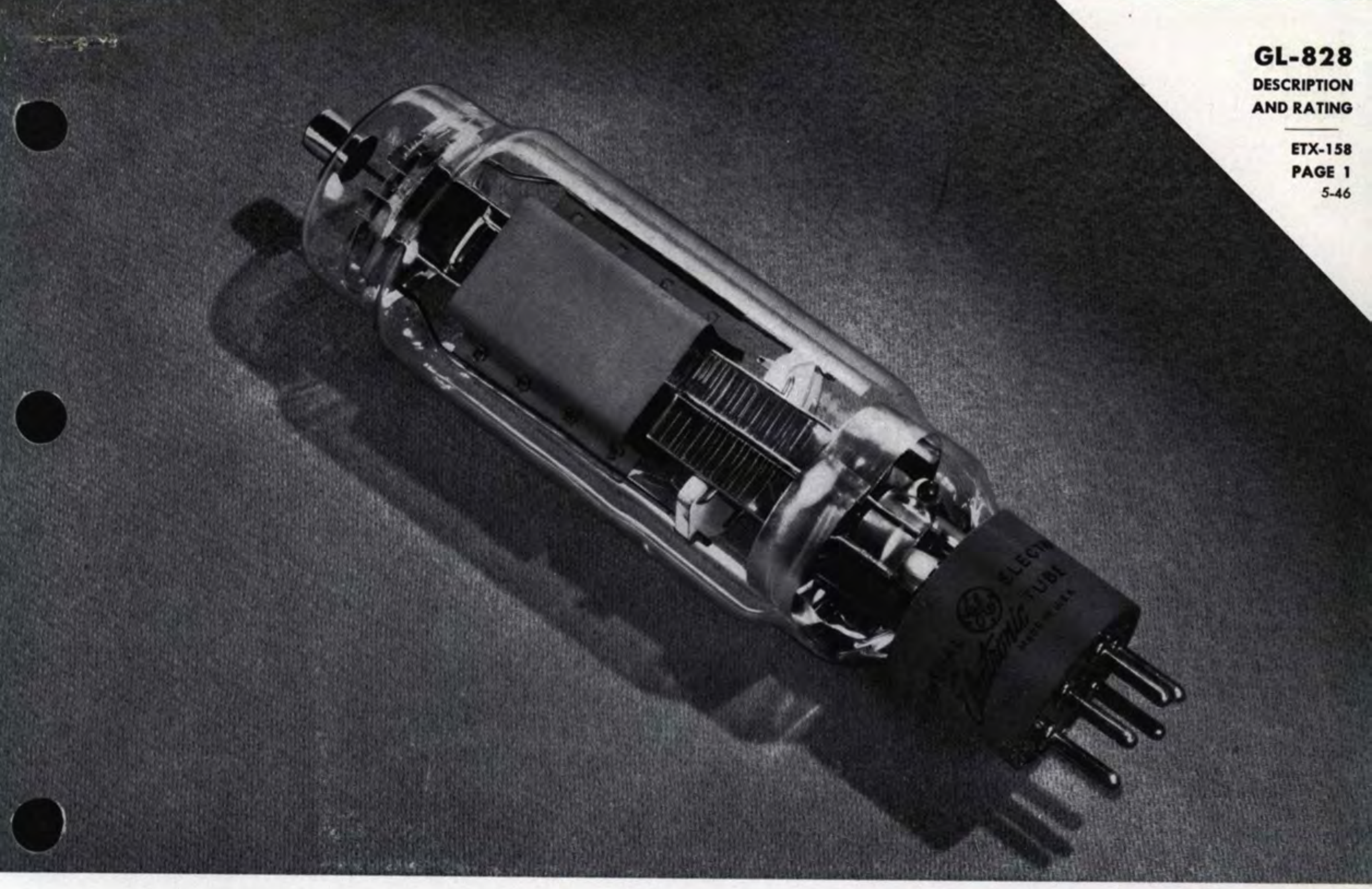
GL-833-A OUTLINE

NOTE: THE HORIZONTAL ANGLE BETWEEN THE PLANE DETERMINED BY THE AXIS OF THE FILAMENT TERMINALS AND THE PLANE DETERMINED BY THE AXIS OF THE GRID AND ANODE CAPS IS NOT MORE THAN 5 DEGREES.

K-6966950 9-23-44

Electronics Department
GENERAL ELECTRIC
Schenectady, N. Y.

5-47 (8M)
Filing No. 8850



BEAM POWER TUBE

DESCRIPTION

The GL-828 is a beam power amplifier tube designed particularly for use as a Class AB_1 audio-frequency amplifier. The high power sensitivity of the 828 allows it to be used in radio-frequency services with very little driving power. Neutralization is generally unnecessary in properly shielded circuits. This tube can be operated at maximum ratings at frequencies as high as 30 megacycles.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Number of electrodes 5

Electrical

Cathode-Filamentary
- Filament voltage . . . . 10 volts
- Filament current . . . . 3.25 amperes

Grid-plate transconductance, for anode current of 43 ma . . . . 4500 micromhos

Direct interelectrode capacitances
- Grid-plate, with external shielding . . . . 0.05 micromicrofarad
- Input . . . . 13.5 micromicrofarads
- Output . . . . 14.5 micromicrofarads

Mechanical

Base or terminal description . . . . medium 5-pin

Net weight, approximate . . . . 3 ounces

Shipping weight, approximate . . . . 3 pounds

Mounting position . . . . vertical, base down—horizontal, plane of electrodes vertical

GE Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS AB_1 AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings △ CCS	Maximum Ratings △ ICAS	
D-c plate voltage	1700	2000	1750	2000	volts
D-c suppressor voltage	60	60	100	100	volts
Maximum signal plate current*			150	150	milliamperes
D-c maximum signal plate input*			225	270	watts
Screen input*			16	23	watts
Plate dissipation*			70	80	watts
D-c grid voltage†	−120	−120			volts
D-c screen voltage‡	750	750	750	750	volts
Peak a-f grid-to-grid voltage	240	240			volts
Zero signal plate current	50	50			milliamperes
Maximum signal plate current	248	270			milliamperes
D-c suppressor current	9	9			milliamperes
Zero signal screen current	4	2			milliamperes
Maximum signal screen current	43	60			milliamperes
Load resistance, per plate	4050	4625			ohms
Effective load, plate-to-plate	16200	18500			ohms
Maximum signal plate power output	300**	385			watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

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

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings △ CCS	Maximum Ratings △ ICAS	
D-c plate voltage	1250	1500	1250	1500	volts
D-c grid voltage†	75	75	100	100	volts
D-c grid voltage†	−50	−50			volts
D-c screen voltage	400	400	400	400	volts
D-c plate current	84	80	100	100	milliamperes
D-c suppressor current	4	4			milliamperes
D-c screen current	5	5			milliamperes
Plate input			105	120	watts
Suppressor input			5	5	watts
Screen input			11	11	watts
Plate dissipation			70	80	watts
Peak r-f grid-to-grid voltage	52	50			volts
Driving power, approximate§	0.5	0.4			watt
Plate power output	36	41			watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—GRID-MODULATED

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

	Typical Operation CCS	Typical Operation ICAS	Maximum Ratings △ CCS	Maximum Ratings △ ICAS	
D-c plate voltage	1250	1500	1250	1500	volts
D-c suppressor voltage	75	75	100	100	volts
D-c grid voltage	−150	−150	−300	−300	volts
D-c screen voltage	400	400	400	400	volts
D-c plate current	84	80	100	100	milliamperes
D-c suppressor current	4	3.5			milliamperes
D-c grid current, approximate	1.6	1.3			milliamperes
D-c screen current	5	4			milliamperes
Plate input			105	120	watts
Suppressor input			5	5	watts
Screen input			11	11	watts
Plate dissipation			70	80	watts
Peak r-f grid-to-grid voltage, approximate	165	165			volts
Peak a-f grid voltage	94	94			volts
Driving power, approximate§	2.5	2.5			watts
Plate power output	36	41			watts

TECHNICAL INFORMATION (CONT'D)

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

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

	Typical Operation		Maximum Ratings		
	CCS	ICAS	CCS	ICAS	
D-c plate voltage	1000	1250	1000	1250	volts
D-c suppressor voltage	75	75	100	100	volts
D-c grid voltage of	−140	−140	−300	−300	volts
From a grid resistor of	14000	11700			ohms
D-c screen voltage	400	400	400	400	volts
From a series resistor of ◆	26000	30000			ohms
D-c plate current	135	160	135	160	milliamperes
D-c suppressor current	13	15			milliamperes
D-c grid current, approximate	10	12	15	15	milliamperes
D-c screen current	23	28			milliamperes
Plate input			135	200	watts
Suppressor input			5	5	watts
Screen input			11	11	watts
Plate dissipation			47	70	watts
Peak r-f grid-to-grid voltage, approximate	230	250			volts
Driving power, approximate	2.1	2.7			watts
Plate power output	100	150			watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Key-down conditions per tube without modulation π

	Typical CCS	Typical ICAS	Maximum CCS	Maximum ICAS	
D-c plate voltage	1250	1500	1250	1500	volts
D-c suppressor voltage	75	75	100	100	volts
D-c grid voltage			−300	−300	volts
From a fixed supply of	−95	−100			volts
From a cathode resistor of	415	430			ohms
From a grid resistor of	7900	8300			ohms
D-c screen voltage	400	400	400	400	volts
D-c plate current	160	180	160	180	milliamperes
D-c suppressor current	22	14			milliamperes
D-c grid current, approximate	12	12	15	15	milliamperes
D-c screen current	35	28			milliamperes
Plate input			200	270	watts
Suppressor input			5	5	watts
Plate dissipation			70	80	watts
Screen input			16	16	watts
Peak r-f grid-to-grid voltage, approximate	195	205			volts
Driving power, approximate	2.1	2.2			watts
Plate power output	150	200			watts

*Averaged over any a-f cycle of sine-wave form.

**Distortion only 1 per cent with 20 db of feedback to grid of driver.

†Grid voltages are given with respect to the midpoint of filament operated on a-c. If d-c is used, each stated value of grid voltage should be decreased by one-half the filament voltage and the circuit returns made to the negative end of the filament.

‡Zero-signal screen voltage must not exceed 775 volts.

§At crest of audio-frequency cycle with modulation factor of 1.0.

◆Connected to modulated plate voltage supply.

π Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

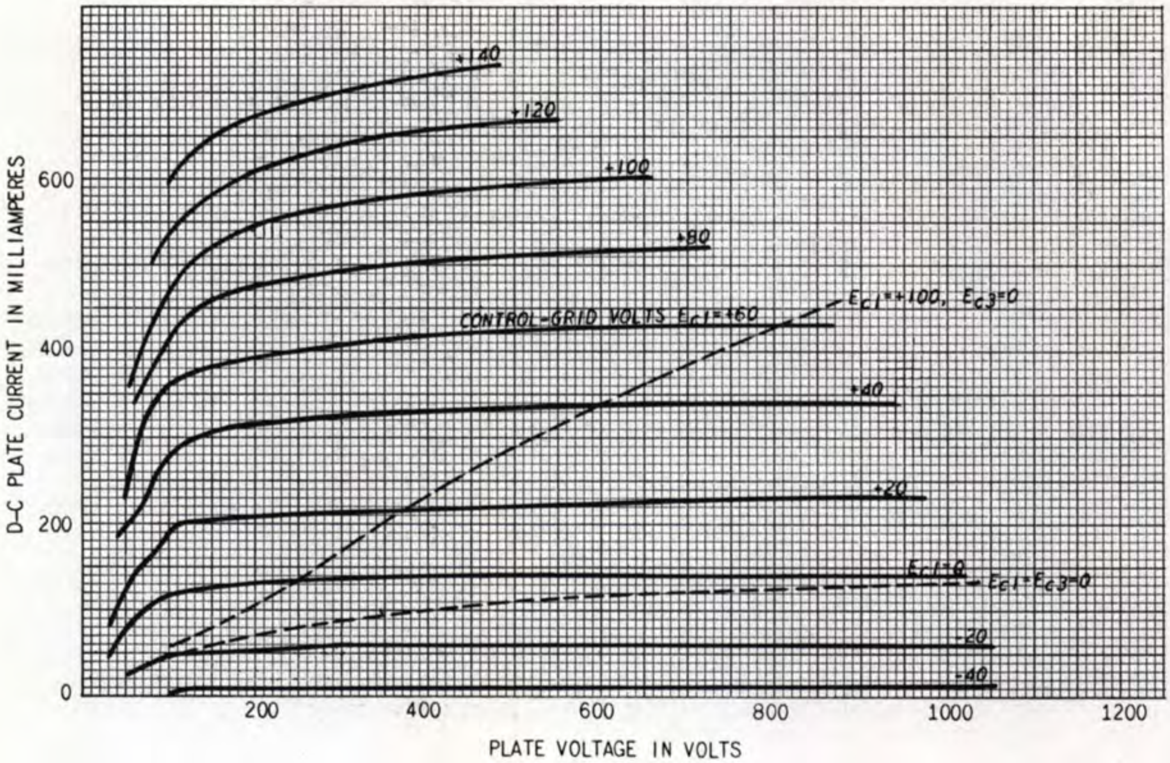
APPLICATION NOTES

△The GL-828 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 75 megacycles for the various classes of service. Special attention should be given to shielding, radio-frequency by-passing, and adequate ventilation of the bulb at these frequencies.

Frequency	30	50	75	megacycles
Maximum permissible percentage of maximum rated plate voltage and plate input				
Class B, r-f	100	90	80	per cent
Class C, grid-modulated	100	90	80	per cent
Class C, plate-modulated	100	80	65	per cent
Class C, telegraphy	100	80	65	per cent

GL-828 AVERAGE PLATE CHARACTERISTICS

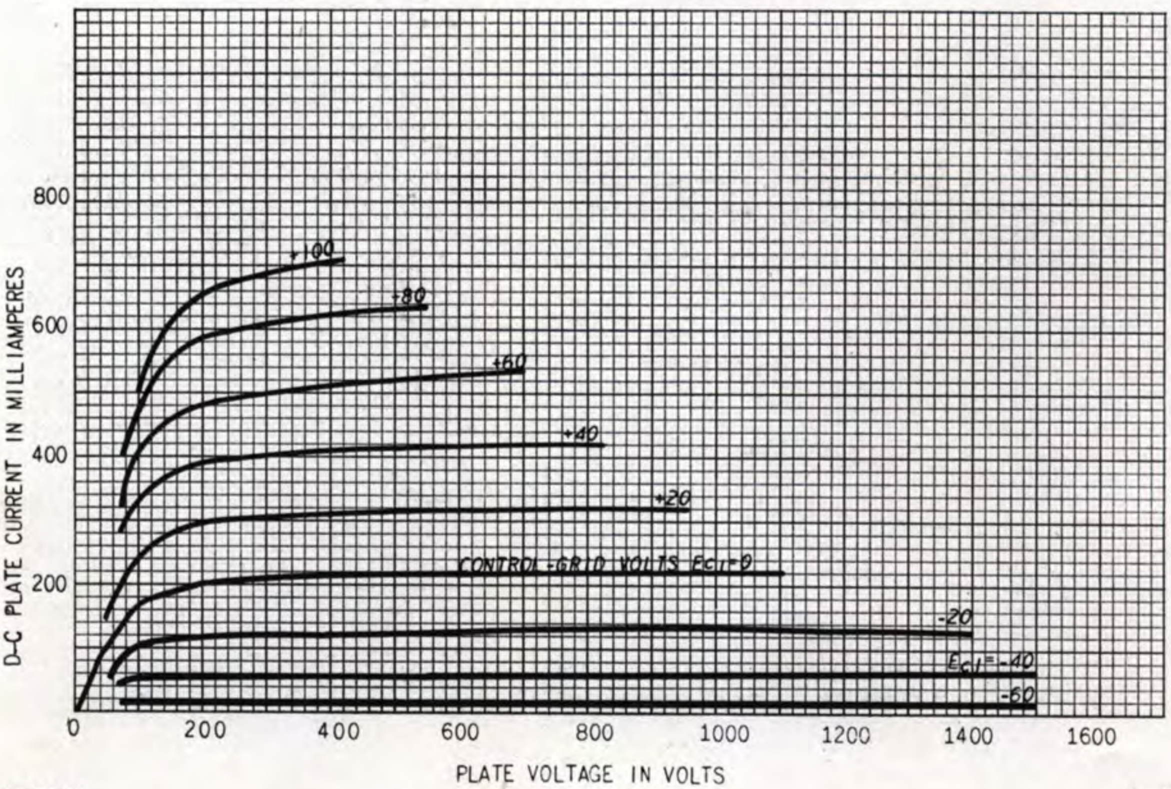
(E_f=10 VOLTS D-C, SCREEN VOLTS=300, SUPPRESSOR VOLTS (Ec_3)=75)



K-9186059 1-9-46

GL-828 AVERAGE PLATE CHARACTERISTICS

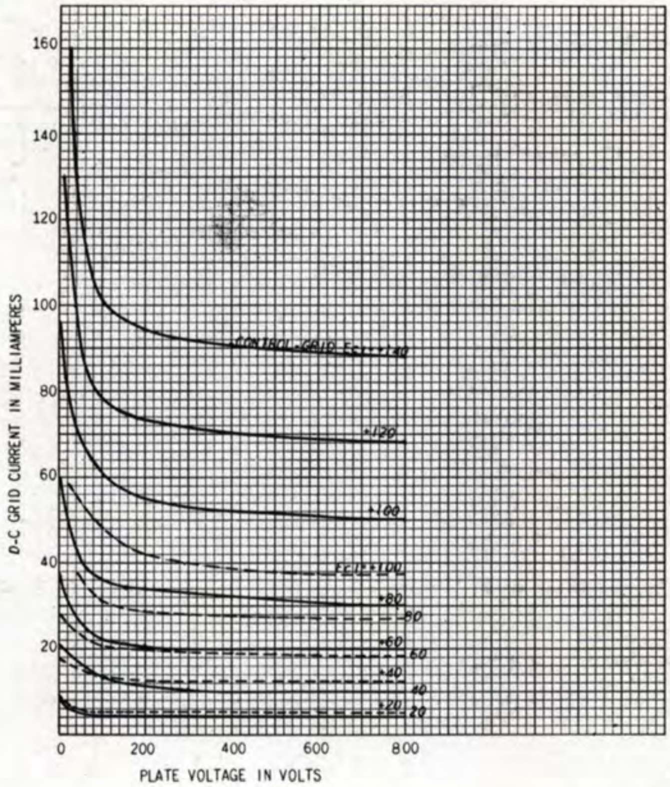
(E_f=10 VOLTS D-C, SCREEN VOLTS=400, SUPPRESSOR VOLTS (Ec_3)=75)



K-9186061 1-9-46

GL-828 TYPICAL CHARACTERISTICS

(E_f=10 VOLTS D-C, SCREEN VOLTS=300——, SCREEN VOLTS=400- - - -, SUPPRESSOR VOLTS=75)

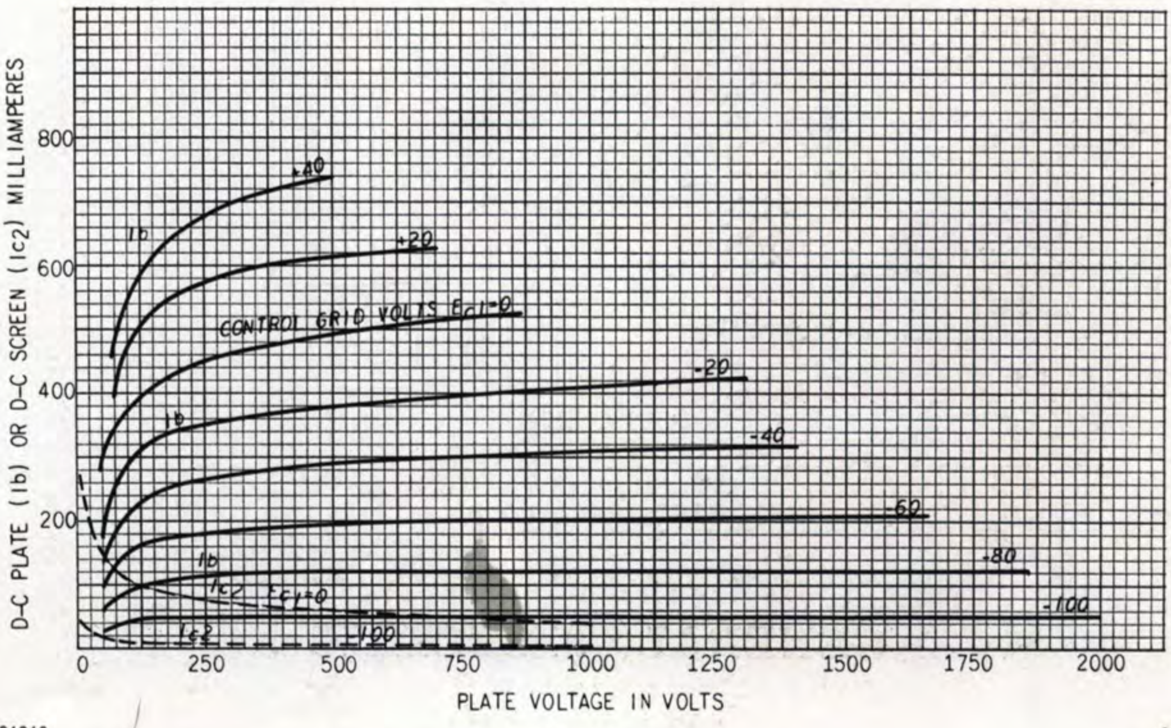


K-9033930

1-9-46

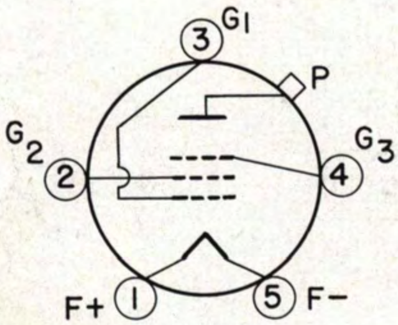
GL-828 AVERAGE PLATE CHARACTERISTICS

(E_f=10 VOLTS D-C, SCREEN VOLTS=750, SUPPRESSOR VOLTS (Ec_3)=60)

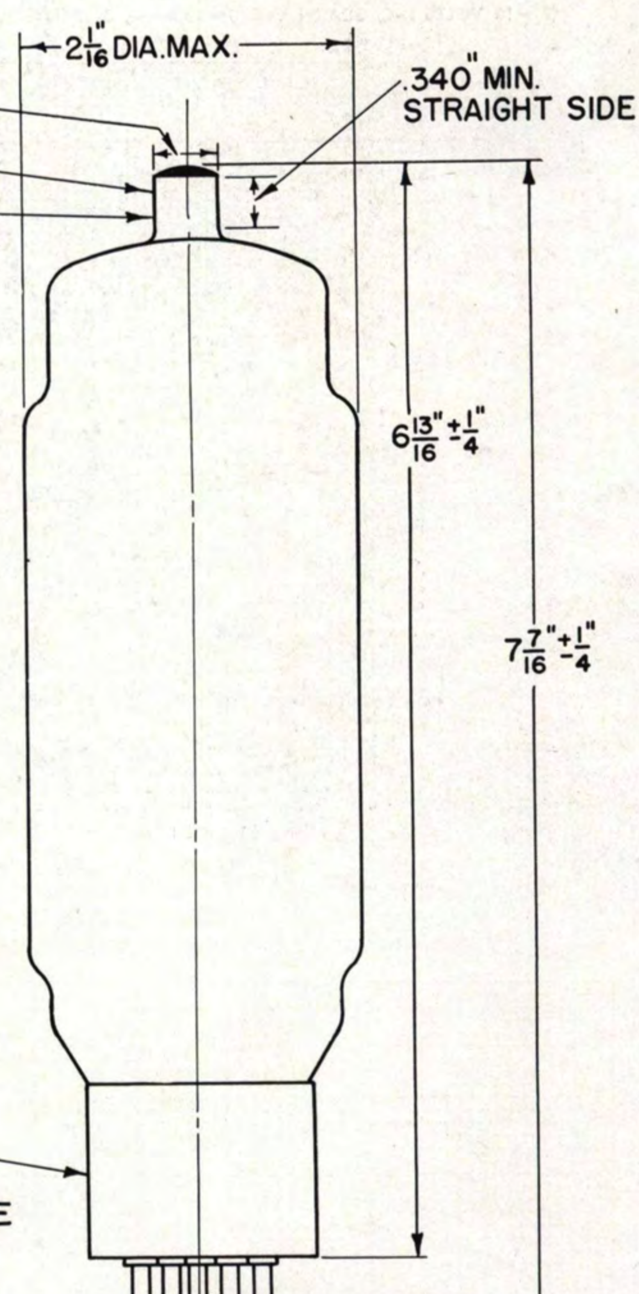


K-9186060

1-9-46



BOTTOM VIEW
BASING DIAGRAM



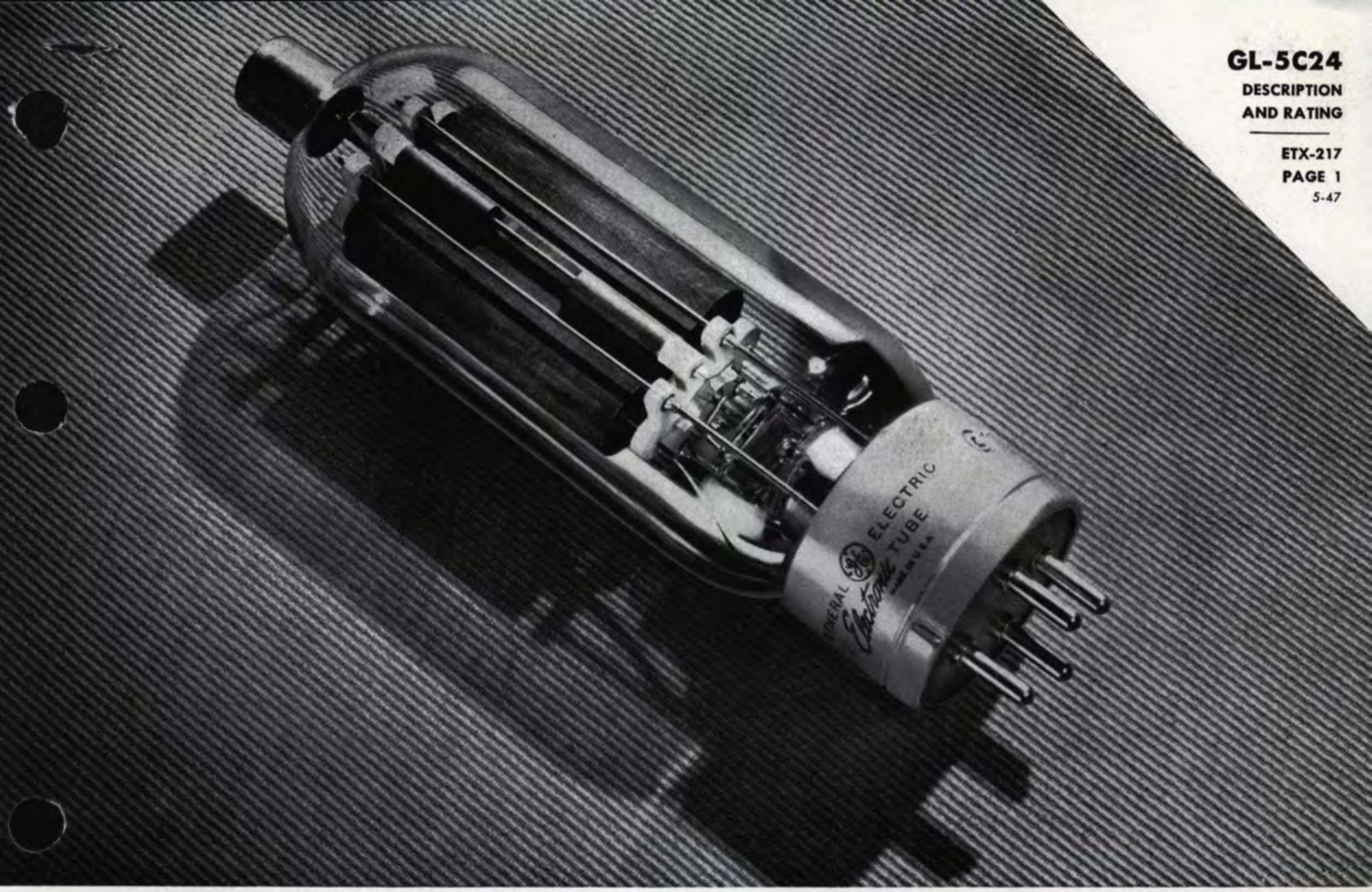
GL-828 OUTLINE

K-9033897

7-12-45

Electronics Department
GENERAL ELECTRIC
Schenectady, N. Y.

5-46 (7M)
Filing No. 8850



TRIODE

DESCRIPTION

The GL-5C24 is a three-electrode tube designed for use as a Class A and Class AB_1 amplifier. The anode is capable of dissipating 160 watts and cooling is accomplished by radiation. The cathode is a thoriated-tungsten filament.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Electrical	Min.	Bogey	Max.	
Filament voltage	9.5	10	10.5	volts
Filament current at bogey filament voltage	4.9	5.2	5.6	amperes
Amplification factor	7.2	8	8.8	
Transconductance (I_b = 160 ma)	—	5500	—	micromhos
Interelectrode capacitance				
Grid-plate	7.6	8.8	10.0	micromicrofarads
Grid-cathode	4.6	5.6	6.6	micromicrofarads
Plate-cathode	2.5	3.3	4.1	micromicrofarads

Mechanical

Mounting position	Vertical, or horizontal with plane of electrodes vertical
Maximum glass temperature	275 centigrade
Net weight, approximate	14 ounces

Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum Ratings, Absolute Values	CCS	
D-c plate voltage	1750	volts
Plate input	250	watts
Plate dissipation	160	watts

Typical Operation

D-c plate voltage	1500	volts
D-c grid voltage	−155	volts
Peak a-f grid voltage	150	volts
D-c plate current	107	milliamperes
Load resistance	8200	ohms
Power output (5% second harmonic)	55	watts

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB_1

Maximum Ratings, Absolute Ratings (per Tube)	CCS	
D-c plate voltage	1750	volts
D-c grid voltage	−300	volts
Maximum signal d-c plate current*	250	milliamperes
Maximum signal plate input*	300	watts
Plate dissipation*	160	watts

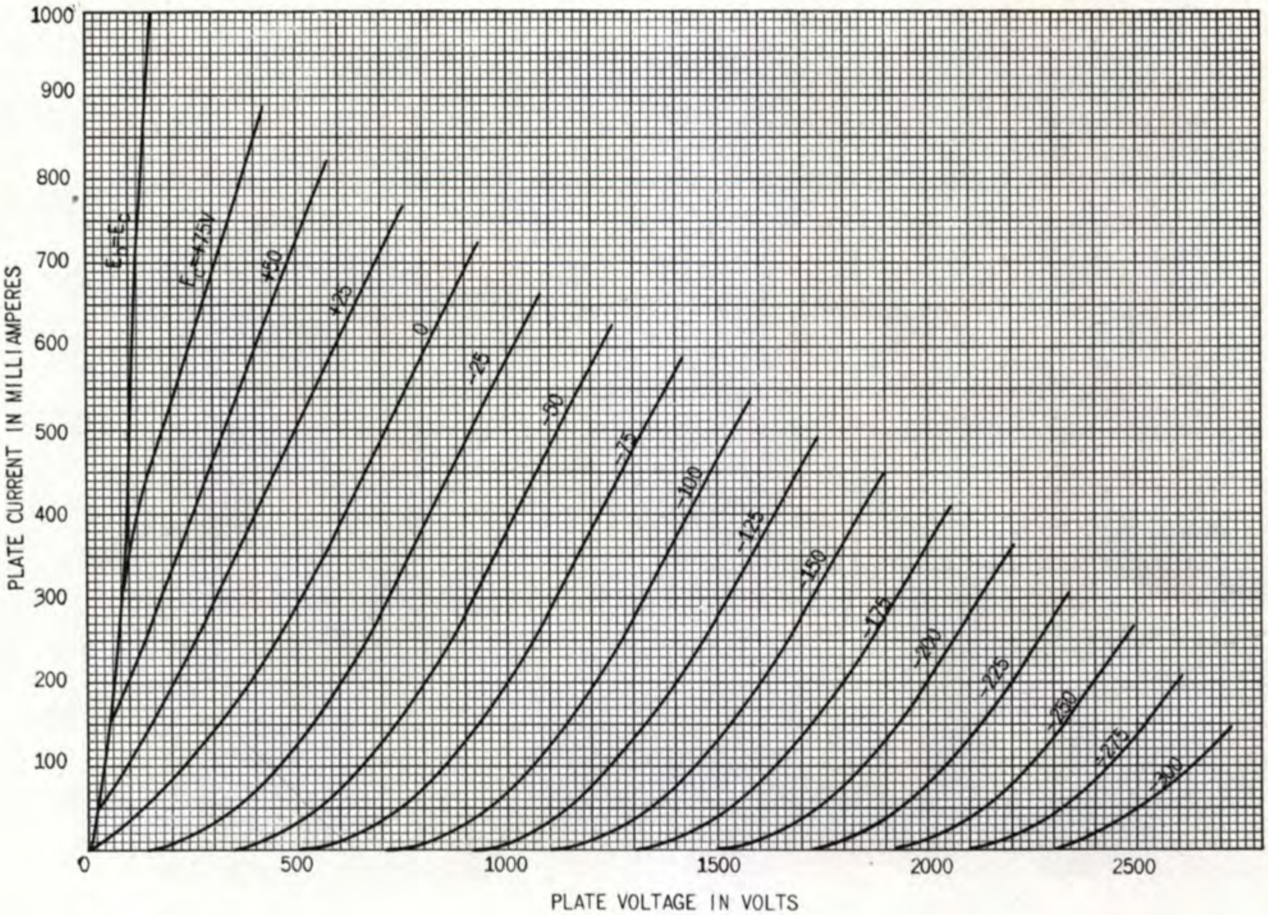
Typical Operation

Unless Otherwise Specified, Values Are for Two Tubes

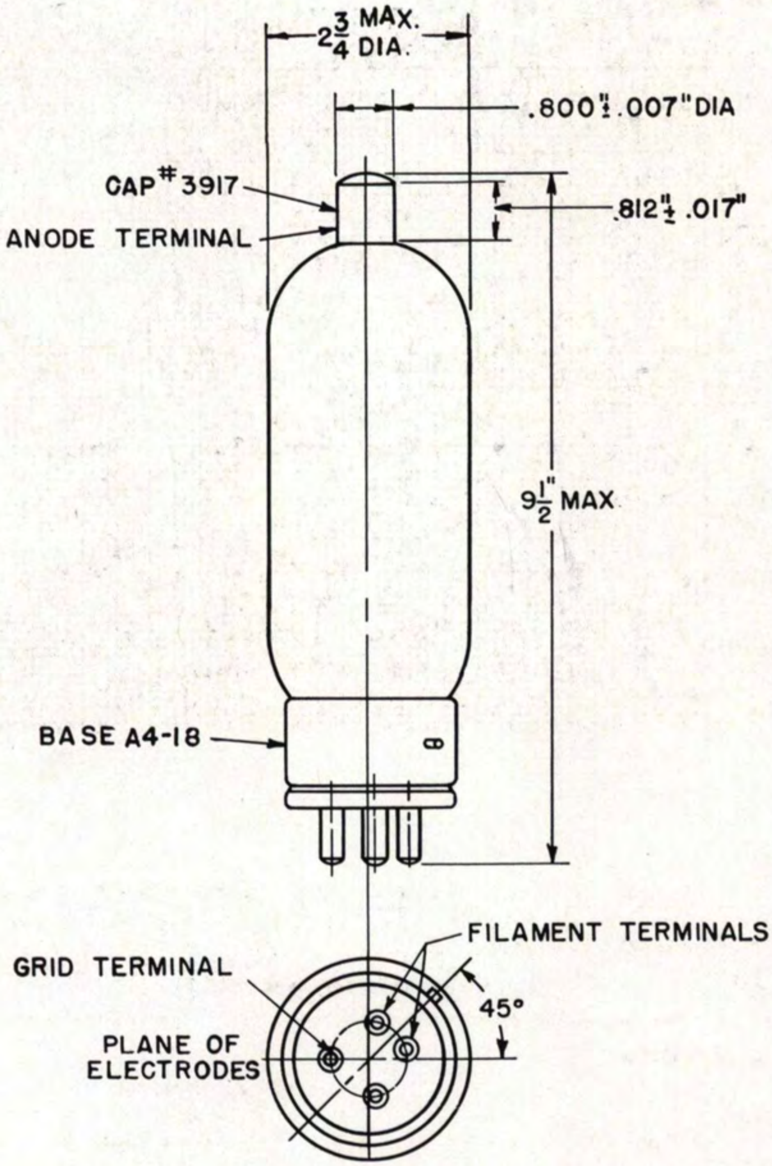
D-c plate voltage	1750	volts
D-c grid voltage	−200	volts
Peak a-f grid-to-grid voltage	390	volts
Zero signal d-c plate current	110	milliamperes
Maximum signal d-c plate current	320	milliamperes
Effective load resistance, plate-to-plate	8000	ohms
Maximum signal power output	240	watts

*Averaged over any audio-frequency cycle of sine-wave form.

GL-5C24
PLATE CHARACTERISTICS
$E_f = 10$ V

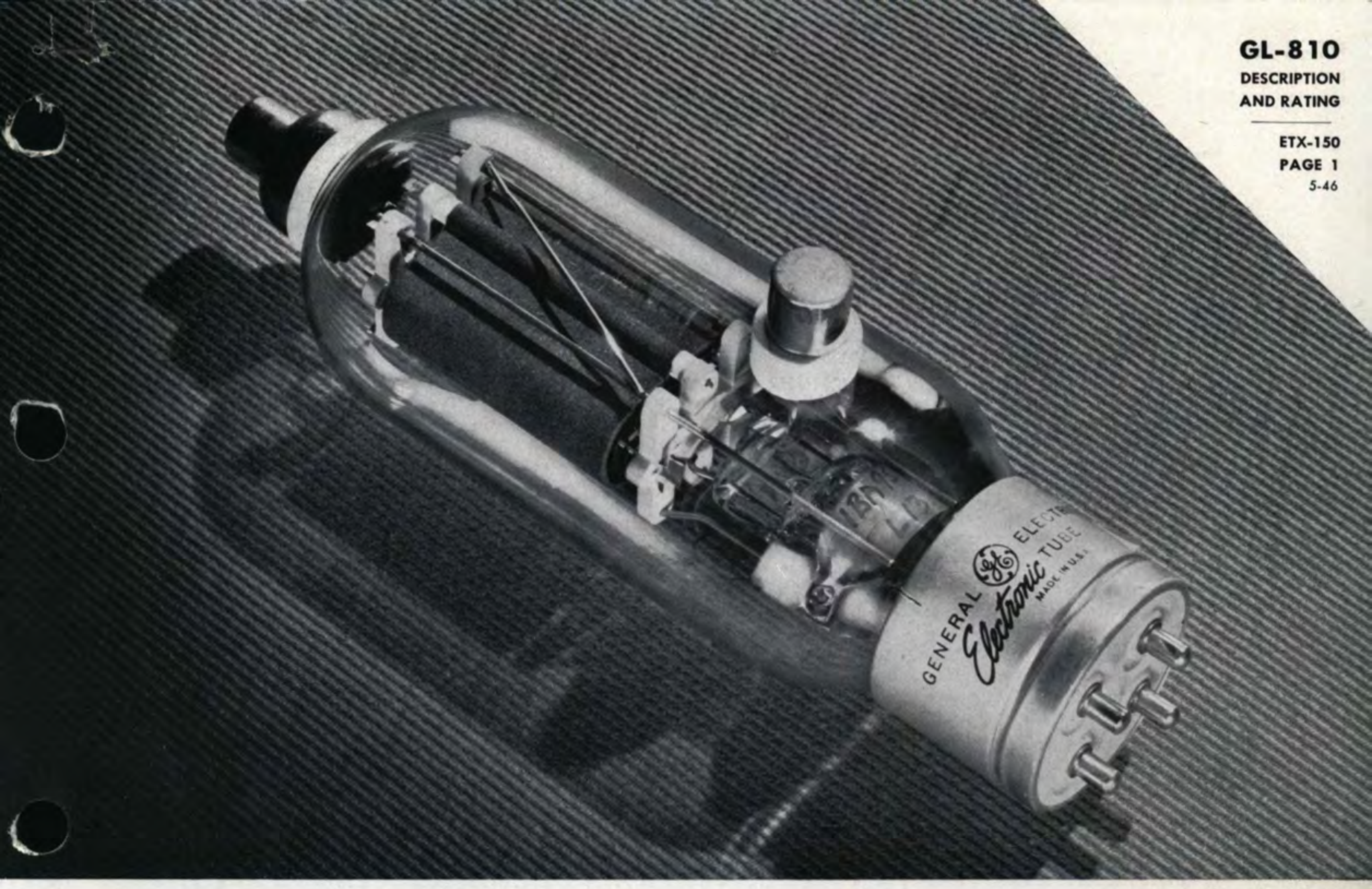


K-69087-77A1 11-7-46



GL-5C24 OUTLINE

K-5182000 6-28-46



TRIODE

DESCRIPTION

The GL-810 is a high-mu tube with a typical power output of 475 watts (ICAS) for Class C telegraph service. Because of its high perveance the tube can be operated at high plate efficiency with low driving power and relatively low plate voltage. The heavy duty filament, shielded at each end, conserves input power by eliminating bulb bombardment and stray electrons. The plate and grid leads are brought out to terminals at the top and side of the bulb, respectively—a design which provides very short internal leads, low internal lead inductance, and permits compact high-frequency circuits.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Number of electrodes	3	
Electrical		
Cathode—Filamentary		
Filament voltage	10	volts
Filament current	4.5	amperes
Average characteristics		
Amplification factor	36	
Direct interelectrode capacitance		
Grid-plate	4.8	micromicrofarads
Grid-cathode	8.7	micromicrofarads
Plate-cathode	12	micromicrofarads
Frequency for maximum ratings	30	megacycles

GE Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

Mechanical

Type of cooling	convection	
Maximum ambient temperature	60	centigrade
Net weight, approximate	8	ounces
Shipping weight, approximate	1	pound
Mounting position		vertical, base down: horizontal—plane of electrodes vertical

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CLASS B AUDIO-FREQUENCY POWER AMPLIFIER (TWO TUBES)

	Typical Operation		Maximum Ratings		
	CCS	ICAS	CCS	ICAS	
D-c plate voltage	2000	2250	2000	2250	volts
Maximum signal plate current (per tube)†			250	250	milliamperes
D-c maximum signal plate input (per tube)†			425	510	watts
Plate dissipation (per tube)†			125	150	watts
D-c grid voltage	−50	−60			volts
Peak a-f grid input voltage	345	380			volts
Zero signal plate current	60	70			milliamperes
Maximum signal plate current	420	450			milliamperes
Maximum signal driving power, approximate	10	13			watts
Effective load (plate-to-plate)	11000	11600			ohms
Maximum signal plate power output	590	725			watts

CLASS B RADIO-FREQUENCY POWER AMPLIFIER

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

D-c plate voltage	1500	2000	2250	2000	2250	volts
D-c grid voltage	−50	−65	−70			volts
D-c plate current	115	93	100	185	185	milliamperes
Plate input				185	225	watts
D-c grid current	2	2	2			milliamperes
Plate dissipation				125	150	watts
Peak r-f grid input voltage	110	100	100			volts
Driving power, approximate	6	4	4			watts
Plate power output	60	60	75			watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR—PLATE-MODULATED

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

D-c plate voltage	1250	1600	1800	1600	1800	volts
D-c grid voltage§	−200	−200	−200	−500	−500	volts
	4000	4000	4000			ohms
D-c plate current	210	210	250	210	250	milliamperes
D-c grid current, approximate	50	50	50	70	70	milliamperes
Plate input				335	450	watts
Plate dissipation				85	125	watts
Peak r-f grind input voltage, approximate	370	370	370			volts
Driving power, approximate	17	17	17			watts
Plate power output	180	250	335			watts

CLASS C RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

(Key-down conditions per tube without modulation)‖

	Typical Operation			Maximum Ratings		
	CCS		ICAS	CCS	ICAS	
D-c plate voltage	1500	2000	2250	2000	2250	volts
D-c grid voltage¶	−120	−160	−160	−500	−500	volts
	3000	4000	4000			ohms
	415	550	510			ohms
D-c plate current	250	250	275	250	275	milliamperes
D-c grid current	40	40	40	70	70	milliamperes
Plate input				500	620	watts
Plate dissipation				125	150	watts
Peak r-f grid input voltage, approximate	280	330	330			volts
Driving power, approximate	10	12	12			watts
Plate power output	275	375	475			watts

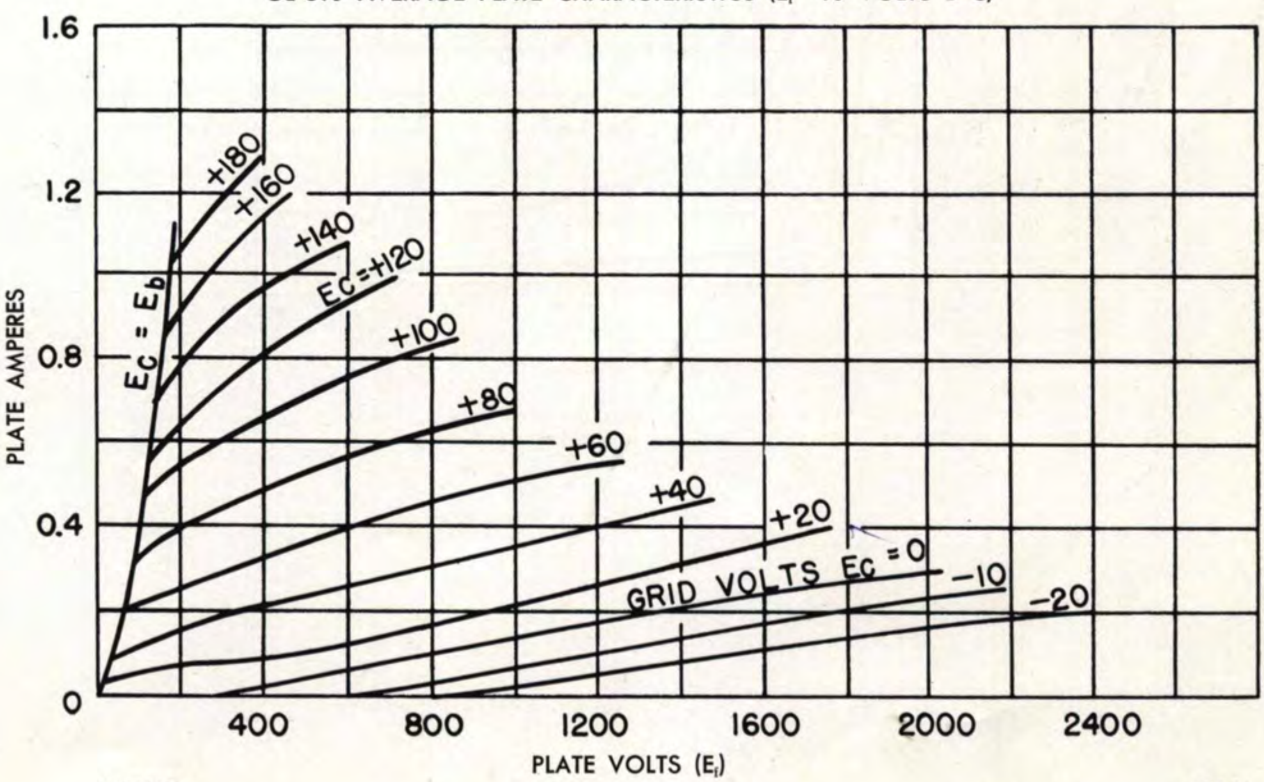
† Averaged over any audio-frequency cycle.
‡ At crest of audio-frequency cycle.
§ Obtained by grid-resistor of value shown or by partial self-bias methods.
‖ Modulation, essentially negative, may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.
¶ Obtained from fixed supply, by grid resistor (3000, 4000), or by cathode resistor (415, 550, 510).

APPLICATION NOTES

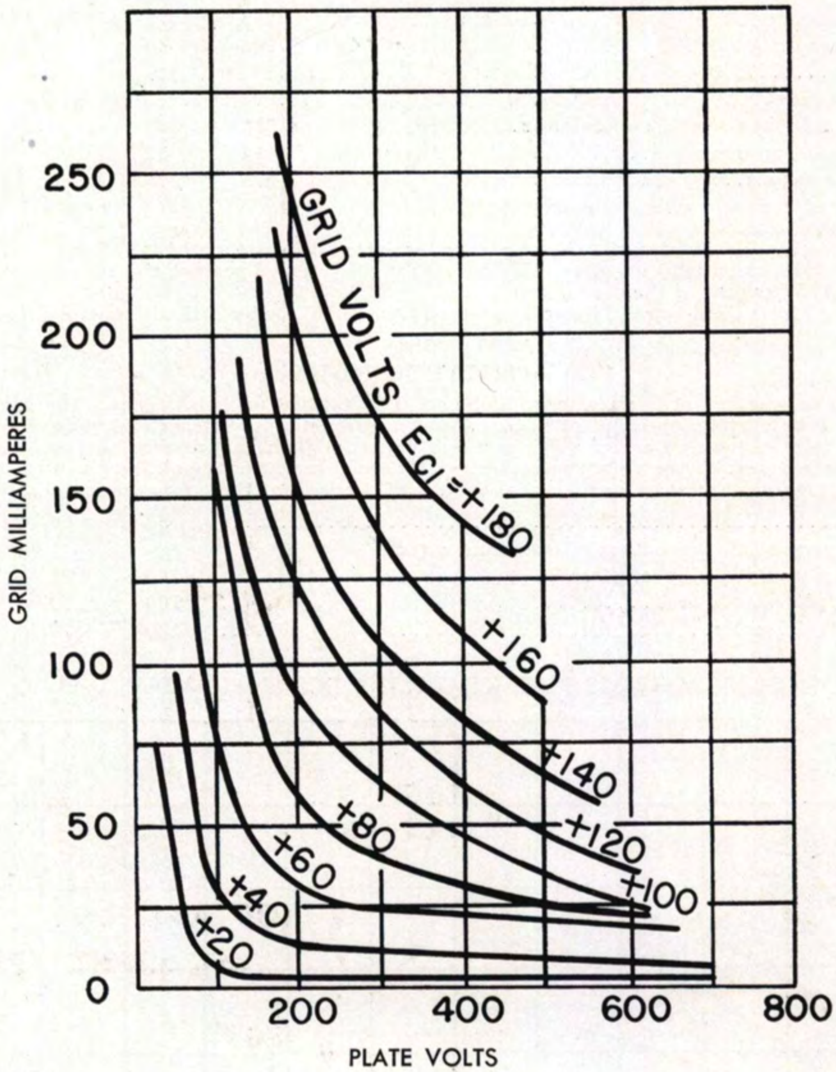
* The GL-810 can be operated at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown above). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 megacycles for the various classes of service. Special attention should be given to adequate ventilation of the bulb at these frequencies.

Frequency	30	60	100	megacycles
Maximum permissible percentage of maximum rated				
Plate voltage and plate input, Class B	100	88	80	per cent
Class C, plate-modulated	100	70	50	per cent
Class C, telegraphy	100	70	50	per cent

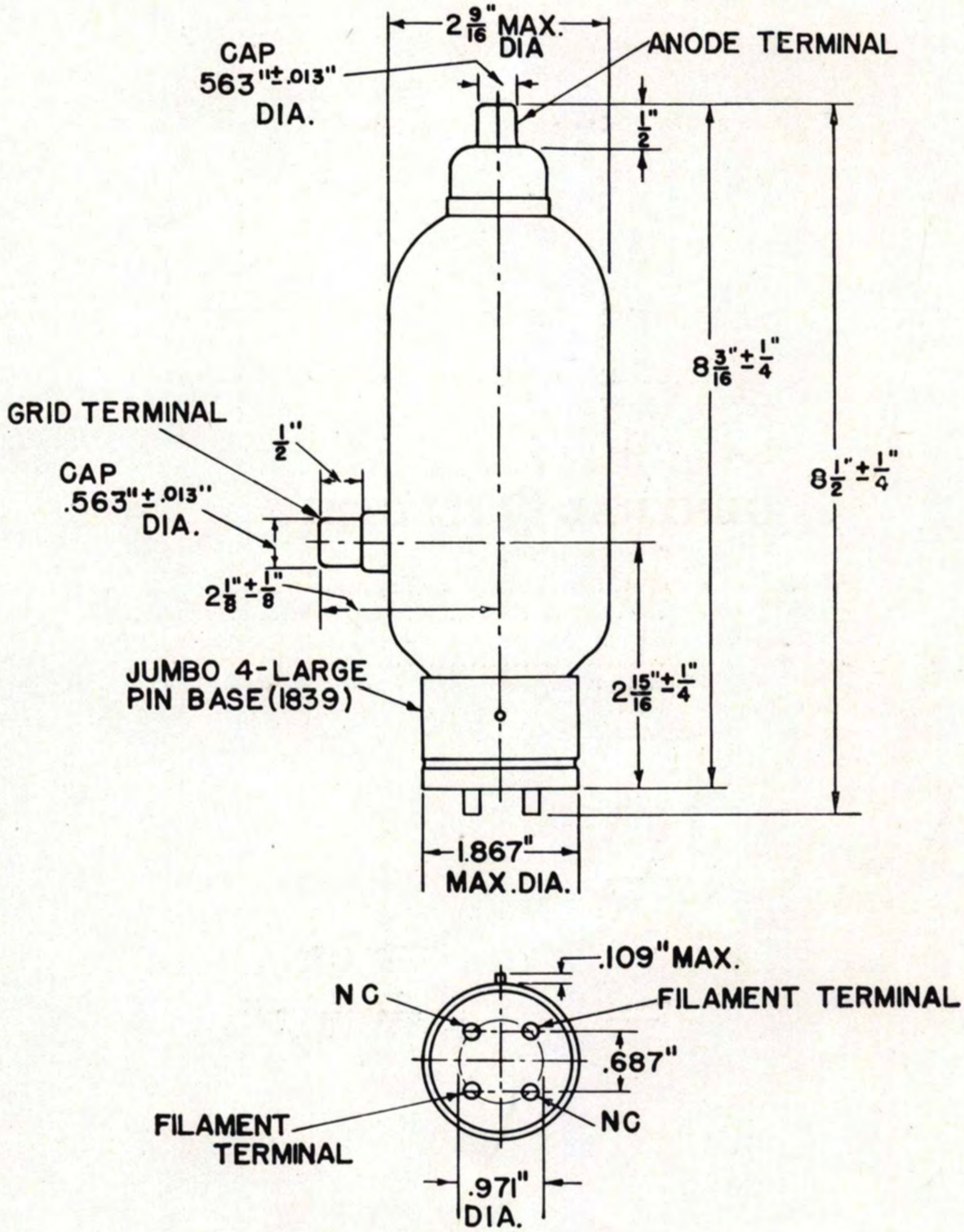
GL-810 AVERAGE PLATE CHARACTERISTICS ($E_f = 10$ VOLTS D-C)



GL-810 TYPICAL CHARACTERISTICS ($E_f = 10$ VOLTS D-C)



K-8639692 9-28-44



GL-810 OUTLINE

K-9033819 2-22-45

Electronics Department

GENERAL ELECTRIC

Schenectady, N. Y.

5-46 (7M)
Filing No. 8850

MERCURY-VAPOR RECTIFIER

DESCRIPTION

This half-wave, mercury-vapor rectifier is designed to withstand high peak inverse voltages and to conduct at low applied voltages. The construction minimizes the danger of bulb cracks caused by corona discharge. An edgewise-wound ribbon filament provides a large emission reserve and improved life.

Two 866-A's operating in a full-wave rectifier are capable of delivering to the input of a choke-input filter a rectified voltage of 3180 volts at 0.5 ampere with good regulation.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

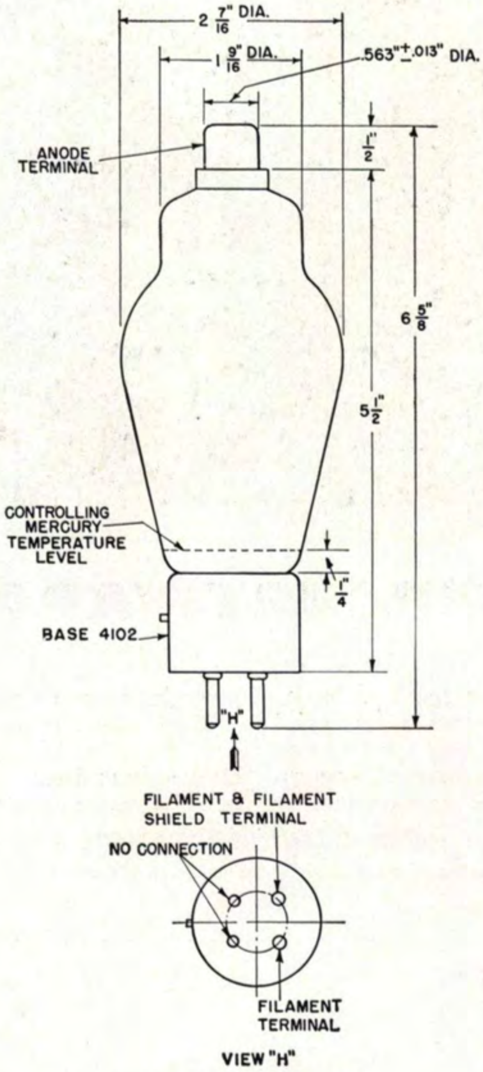
	Minimum	Bogey	Maximum	
Number of electrodes		2		
Electrical				
Cathode—Filamentary				
Filament voltage	2.37	2.5	2.62	volts
Filament current, approximate		5.0	5.4	amperes
Heating time, typical	15			seconds
Peak voltage drop, typical		15		volts
Mechanical				
Type of cooling		convection		
Equilibrium condensed-mercury temperature rise over ambient				
No load, approximate		26C		
Full load, approximate		33C		
Net weight, approximate		3		ounces
Shipping weight, approximate		3		pounds
Mounting position		vertical, base down		

Electronic TUBE

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Maximum peak inverse anode voltage			
150 cycles per second or less	2000	10,000	volts
Condensed mercury temperature	25–70	25–60	centigrade
1000 cycles per second or less		5000	volts
Condensed mercury temperature		25–70	centigrade
Maximum cathode current			
Instantaneous	2.0	1.0	amperes
Average	0.5	0.25	amperes
Surge (maximum duration 0.1 second)	20	20	amperes
Maximum averaging time	30	30	seconds

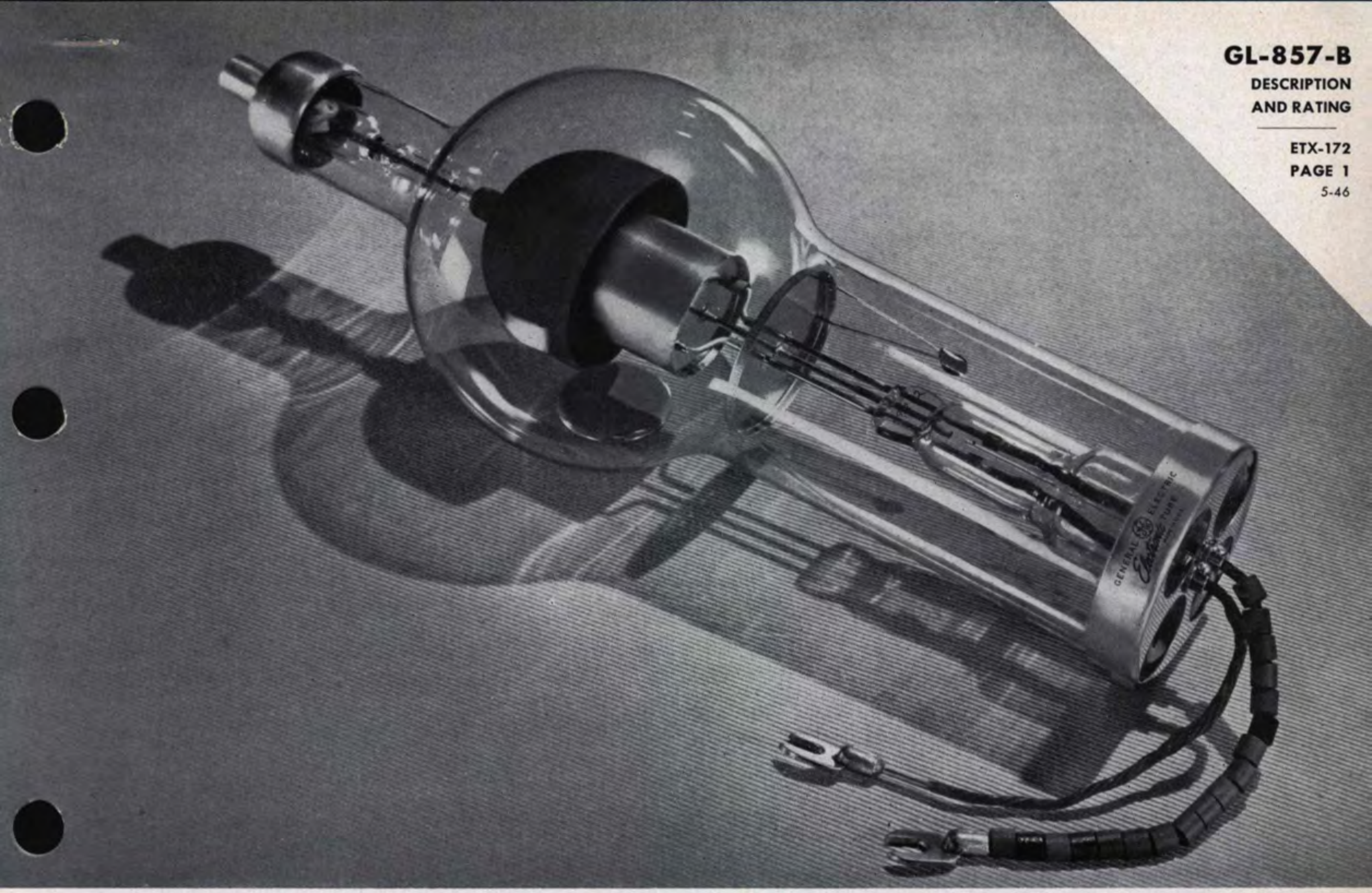


GL-866-A OUTLINE

K-6966978 9-23-44

Electronics Department
GENERAL ELECTRIC
Schenectady, N. Y.

3-48 (8M)
Filing No. 8850



MERCURY-VAPOR RECTIFIER

DESCRIPTION

The GL-857-B is a half-wave, mercury-vapor rectifier tube for use in the high voltage field. The low voltage drop characteristic inherent in mercury-vapor tubes, together with other features of design and construction assure maximum efficeincy of operation in many different rectifier applications.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL CHARACTERISTICS

Number of electrodes 2

Electrical

Cathode—Filamentary
Filament voltage . . . . 5.0 volts
Filament current, approximate . . . . 30.0 amperes
Heating time, typical . . . . 1 minute
Peak voltage drop, typical . . . . 15 volts

Mechanical

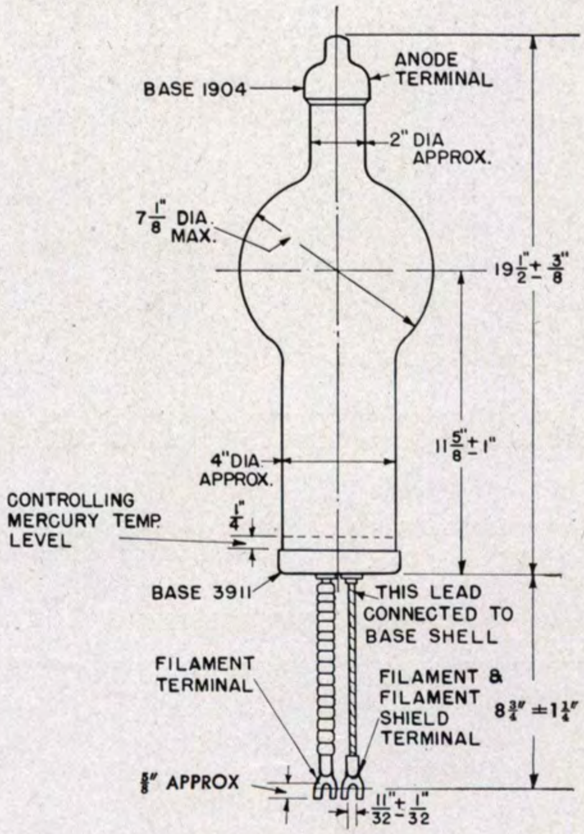
Type of cooling . . . . convection or forced-air
Net weight, approximate . . . . 3½ pounds
Shipping weight, approximate . . . . 10 pounds
Mounting position . . . . vertical, base down

Electronic TUBE

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Maximum peak inverse anode voltage, 150 cycles or less	10,000 volts	22,000	volts
Type of cooling	Convection	Forced-air	
Corresponding mercury temperature	25–65 centigrade	30–40	centigrade
Maximum anode current			
Instantaneous, 25 cycles and above			
In-phase operation		20	amperes
Quadrature operation		40	amperes
Average			
In-phase operation		5	amperes
Quadrature operation		10	amperes
Surge, for design only		400	amperes
Duration of surge current		0.2	second
Maximum time of averaging current		30	seconds
Recommended temperature, condensed mercury		35 ±5	centigrade



GL-857-B OUTLINE

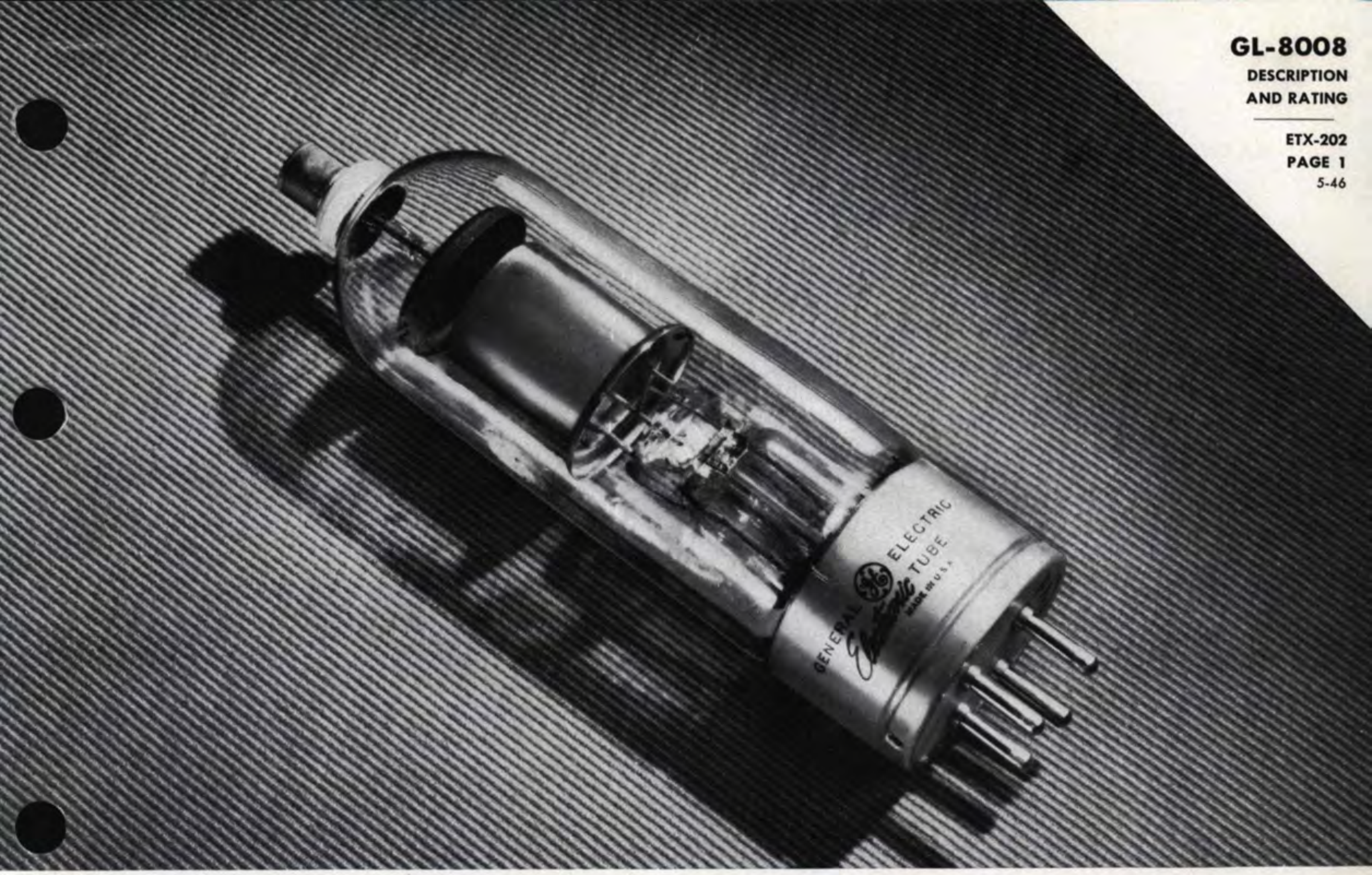
K-4903593 8-22-45

Electronics Department

GENERAL ELECTRIC

Schenectady, N. Y.

5-46 (7M)



MERCURY-VAPOR RECTIFIER

DESCRIPTION

The GL-8008 is a half-wave, mercury-vapor rectifier tube designed to withstand high peak inverse voltages, and to conduct at relatively low applied voltages. The ratings of this tube are the same as those for the 872-A/872. The 8008, however, has a Super-Jumbo push-type base.

TECHNICAL INFORMATION

These data are for reference only. For design information refer to specifications.

GENERAL DESIGN

Number of electrodes	2	
Electrical		
Cathode—Filamentary type		
Filament voltage	5.0	volts
Filament current, approximate	7.5	amperes
Transformer watts, for design purposes	50	
Heating time, typical	30	seconds
Peak voltage drop, typical	10	volts
Mechanical		
Type of cooling	convection	
Base	super-jumbo 4-pin bayonet, RMA A4-18	
Cap	medium metal, RMA C1-5	
Net weight, approximate	½	pound
Shipping weight, approximate	3	pounds
Mounting position	vertical, base down	

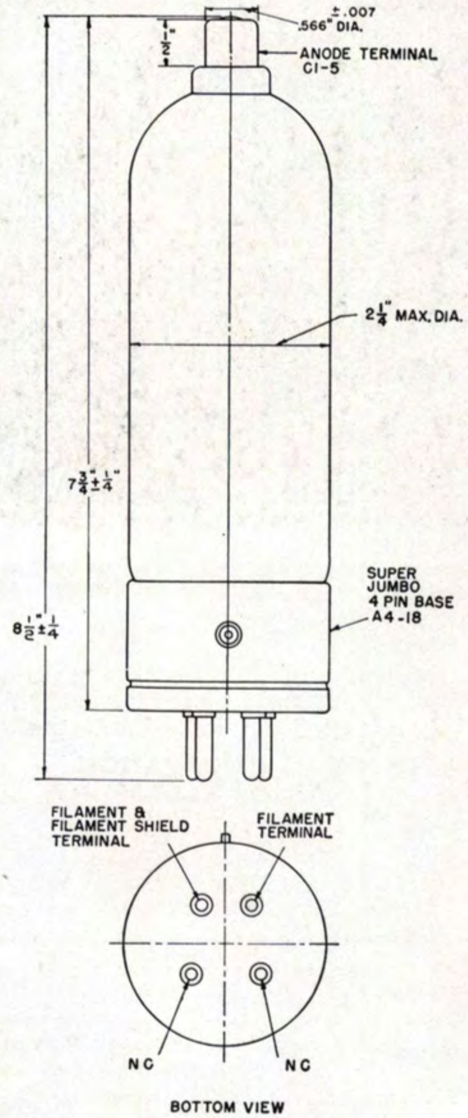
Electronic TUBE

GENERAL ELECTRIC

TECHNICAL INFORMATION (CONT'D)

MAXIMUM RATINGS

Maximum peak inverse anode voltage		
150 cycles or less	5000–10,000	volts
Condensed-mercury temperature limits	20–70, 20–60	centigrade
Maximum anode current		
Instantaneous		
25 cycles and above	5.0	amperes
Average	1.25	amperes
Surge, for design only	50	amperes
Duration of surge current	0.2	seconds
Maximum time of averaging current	15	seconds
Recommended temperature, condensed mercury	40 ±5	centigrade



GL-8008 OUTLINE

N-21502AZ 9-7-45

Electronics Department
GENERAL ELECTRIC
Schenectady, N. Y.

5-46 (7M)
Filing No. 8850

INSTRUCTIONS

A-C AND D-C AUXILIARY RELAYS

TYPES

HGA14A TO 14K INCLUSIVE, HGA14N, HGA14V

A-C CURRENT RELAYS

TYPES

HGC11A, HGC11B AND HGC11C

Switchgear

GENERAL ELECTRIC

SCHENECTADY, N.Y.

A-C AND D-C AUXILIARY RELAYS
AND
A-C CURRENT RELAYS

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.

GENERAL INFORMATION

Application

The HGA and HGC relays described below are double-pole, hinge-type relays suitable for application wherever a high-speed, low-energy device is required. Details of construction of the individual relays, which may adapt them to specific duties, are brought out in the following paragraphs on construction and operation.

Construction and Operation

The relay units covered by this instruction book are all of the same basic construction. The contact circuits are closed or opened by moving contact arms, controlled by a hinge-type armature, which in turn is actuated by the operating coil and restrained by an adjustable control spring. The length of contact gap is adjustable by means of screw contacts and locknuts in the front fixed-contact positions. The armature gap and back-contact wipe can be controlled by the screws and locknuts located on the moving contact arms. These latter features make it possible to reduce the pickup energy and pickup time to relatively low values.

The armature, magnet assembly and contact assemblies are all mounted on a compact molded textolite base provided with a mounting strap. The relays have either a molded textolite cover or are mounted in a standard six-inch case. In either case, studs are provided for back-of-panel connections. Individual models are described in greater detail in the following sections.

HGA14A

This model is described fully by the general discussion above.

HGA14B

The HGA14B is identical in construction with the HGA14A except that its operating coil is intermittently rated to obtain high-speed pickup, and stronger contact springs have been used to eliminate contact chatter under this condition.

HGA14D

The HGA14D relay unit is similar in construction to the HGA14A except that it is available for D-c applications only. It is supplied with external capacitor and adjustable resistor to provide an adjustable time delay in pickup.

HGA14E

The HGA14E model consists of two HGA14B units mounted in a six-inch case.

HGA14H

The HGA14H consists of two HGA14A units in a six-inch universal case, or a single-unit, double-end drawout case.

HGA14J

The HGA14J is similar to the HGA14A except for stronger contact springs and special test adjustments to secure pickup time settings as specified by the customer.

HGA14K

The HGA14K is similar in construction to the HGA14A except for contact springs and method of adjustment in test. It is recommended for use in locations, such as on circuit breaker mechanisms, where the relay is subjected to mechanical shock during operation.

HGA14N

The HGA14N is similar to the HGA14A except that the operating coils have been designed to offer very low burdens at rated voltage. It is designed for use as an auxiliary relay in conjunction with protective devices whose contacts are incapable of handling the current required by standard HGA auxiliary relays.

HGA14V

The HGA14V is similar to the HGA14A except that it is designed for dual frequency rating and pickup is adjusted for less than 90 per cent of the higher frequency rating and lower voltage rating.

HGC11A, 11B & 11C

The HGC relays included in this instruction book are similar in construction to the HGA14A except that they are designed for use as overcurrent and undercurrent devices with special adjustments of the ratio of pickup current to dropout current.

All special adjustments of HGA or HGC units are covered more completely under Inspection and Adjustment.

Ratings

The HGA14A, 14H, 14J, and 14N relays are available for both a-c and d-c in all standard voltage ratings and frequencies. The HGA14B, 14D, 14E, and 14K are available in all standard voltage ratings, but for d-c service only. The HGA14V is available for a-c only and is assigned a dual frequency rating. The HGC type relays are designed for a-c overcurrent and undercurrent relays in ratings up to 10 amps.

The contacts will make and carry 5 amps continuously or 30 amps for 1 minute, and will interrupt the following:

Volts	Interrupt (Single Break)
115 a-c	2 amps.
230 a-c	1 amp.
125 d-c	0.6 amp.
250 d-c	0.25 amp.

Rated D-C Volts	Coil Ohms	Resistor Ohms	Raged Max. Time Delay, Secs.	Capacitor Mu f
48	640	0-700	.067	100
125	12,800	0-4000	.100	25
125	3,070	0-4000	.050	25
250	12,800	0-12000	.100	25
250	12,800	0-12000	.150	50
125	12,800	0-4000	.200	50

The HGA14N has a burden of approximately 1.7 watts when cold and 1.5 watts when hot.

The burdens of the HGC relays at 5 amps. 60 cycles are as follows:

HGC11A:

Rating	Impedance	Volt Amps.	Watts
1.6 amps.	7.1 ohms	177 v-a	82
4	1.05	26.2	11.8
7	0.386	9.7	4.4
10	0.25	6.3	2.9

HGC11B:

Rating	Impedance	Volt-Amps.	Watts
2 amps	3.76 ohm	100 v-a	47

HGC11C:

3.3 amps	0.46 ohm	11.5 v-a	5.5

SHIPPING - UNPACKING - STORAGE

Immediately upon receipt of HGA or HGC relays, an examination should be made for any damage sustained during shipment. If injury or rough handling is evident, a damage claim should be filed at once with the transportation company and the nearest General Electric Sales Office notified promptly.

If it is necessary to store the relay for any length of time before installation, it should be placed in a dry location, free from excessive vibration, preferably resealed in its original packing carton.

The values given in the above table are for non-inductive loads with contacts set as recommended under Adjustments and Inspection.

Burdens

The burdens of HGA14A, 14J, 14K, 14V and for each unit of the HGA14H are as follows:

for a-c coils: 13 voltamperes, 5 watts (approx.)
d-c coils: 5 watts, cold; 4 watts hot (approx.)

Burdens of HGA14B and each unit of HGA14E are as follows:

for potential coils: 20 watts (approx.) *
current coils: 10 watts (approx.) *

* Intermittent rating

The characteristics of the HGA14D relay is given in the table below:

INSTALLATION

Location and Mounting

The relay should be installed in a location that is clean and dry, and free from excessive vibration. It should be mounted on a vertical surface by means of the steel mounting strap, or by means of the large steel mounting studs in the case of relays in universal cases. Care should be taken to allow sufficient clearance in front of the relay to remove the textolite cover. Outline and panel drilling dimensions are listed in the table in the section on connections.

Connections

Internal connections, as well as outline and panel drilling, of the relays covered by this instruction book are given at the back of the book and are listed in the following table:

Relay Type	Outline, Panel Drilling Internal Connections
HGA14A	Fig. 1
HGA14B	Fig. 2
HGA14D Relay	Fig. 2
HGA14D Auxiliaries	Fig. 3
HGA14D Ext. Conn.	Fig. 4
HGA14E & H (Univ. case)	Fig. 5
HGA14H (Drawout case)	Figs. 7 & 8
HGA14J	Fig. 1
HGA14K	Fig. 1
HGA14N	Fig. 1
HGA14V	Fig. 9
HGC11A	Fig. 1
HGC11B	Fig. 2
HGC11C	Fig. 2

In the case of the HGA14D reference should also be made to the auxiliary outline and the external connections.

ADJUSTMENTS AND INSPECTION

Pick-Up

All HGA relays covered by these instructions, except HGA14D, 14K, and 14N have been adjusted at the factory to pickup at 30 per cent of rating (D-C), or 40 per cent of rating (A-C). The pickup of the HGA14D is dependent upon the desired time delay setting but is usually below 50 per cent of rating. The HGA14K, since it has a strong control spring setting to reduce closing tendency under shock, is set to pick up at approximately 80 per cent of rating. The HGA14N, because of its low-burden design, will pick up at approximately 80 per cent of rating.

The pickup value is adjusted by means of the control spring at the lower tail-end of the armature. It should be in the upper hole of the spring post for relays adjusted for 30-40 per cent pickup and in the lower hole for relays adjusted for 60-80 per cent pickup. An exception to this is the HGA14N which must have a weak spring setting because of its low-burden coil. A finer adjustment of pickup is obtained by means of the notches in the armature tail. The pickup - dropout ratio adjustments of the HGC relays are controlled by the setting of "a" contact wipe and control spring tension.

The HGA14D requires special adjustments in that the control spring is set in the weakest position possible; that is, its bottom loop is hooked in the top hole of the spring post and its top loop is in the top usuable notch of the armature tail. Adjustment of time delay pickup is made by means of the series resistor; increasing resistance increases the time while decreasing it has the opposite effect.

The HGC relays as previously mentioned, have special adjustments of pickup and dropout. The HGC11A is set for 35 per cent pickup and drops out at 60 per cent of pickup. The HGC11B is set for 70 per cent pickup only. The HGC11C is set for 90 per cent pickup and drops out at 85 per cent of pickup.

The pickup adjustments in general are similar for all the relays. As shipped from the factory all relays having low pickup are provided with but one "b", or normally closed, contact circuit. The left-hand (front view) screw contact is backed out of engagement with its moving contact. This is necessary since the low control spring tension used on relays adjusted for 30 per cent pickup is not great enough to give sufficient pressure on two "b" contacts. Both "b" contacts can be utilized if the control spring tension is increased sufficiently to raise the pickup to 60 per cent of rating (D-c) or 80 per cent of rating (A-c). In the case of the HGA14B and 14D, and HGC11B and 11C, the left "b" contact has been replaced by a backstop, and in the HGA14K and 14N the pickup is set at the factory for 80 per cent of rating, so no further adjustment is possible.

Contact Wipe

The minimum recommended contact wipe is one turn of the screw in the moving contact arm. To set the wipe close the armature by hand and adjust the screws so that they are just touching the contact carrier. Then back them each off one full turn and lock them in place with the lock nut. The minimum recommended contact gap is 3-3/4 turns of the fixed-contact screw. To adjust, turn both screws in until there is zero gap on the "a", or normally open contacts. Then back each screw out 3-3/4 turns and lock in position with the locknut. Lower contact gaps are permissible in special applications provided contact interrupting capacities are pro-rated according to the table under contact ratings. These ratings are for minimum recommended gap setting.

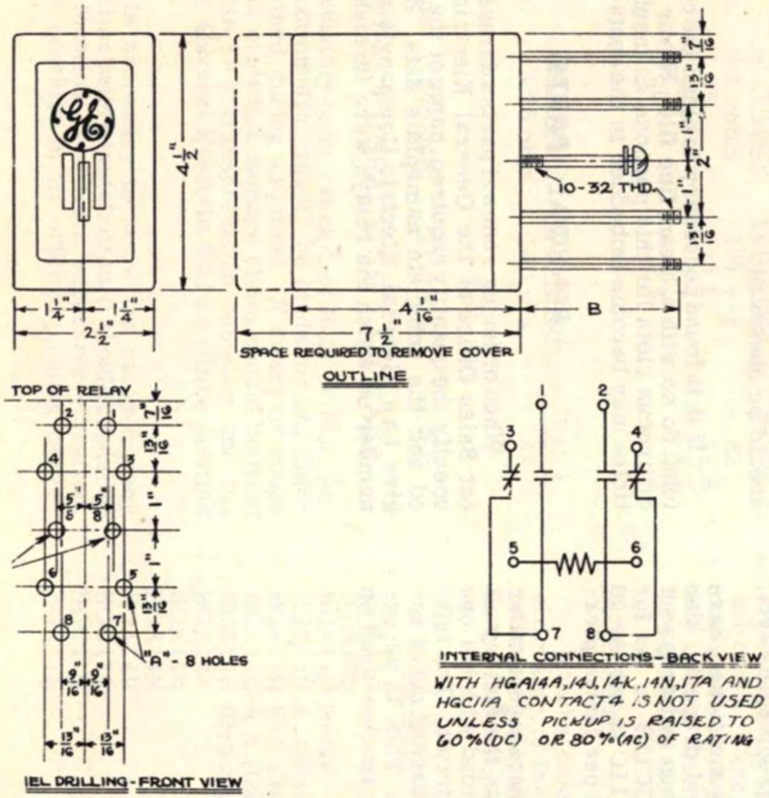
MAINTENANCE

Auxiliary relay equipment should be checked for operation at regular intervals, preferably at the same time that the associated protective devices are inspected. Relays should be checked for pickup values, and dropout values and time settings when specified. These settings should not require readjustment, but if changes are necessary the points discussed under adjustment and inspection should be observed.

If it is found necessary to clean the contact buttons, do so with a clean, fine file. Never use emery or crocus cloth for this purpose as insulating particles may become embedded in the contact surface.

RENEWAL PARTS

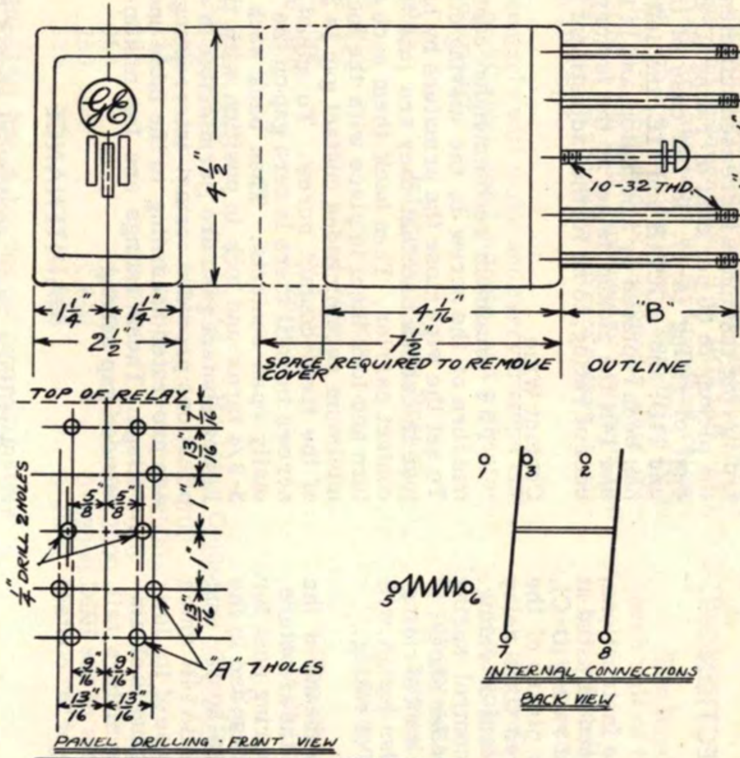
When ordering renewal parts address the nearest Sales Office of the General Electric Company specify the quantity required, name of the part wanted and the complete nameplate data. If possible, give the General Electric Company's requisition number on which the relays were furnished.



TYPE OF PANEL	"A" DIA. OF HOLE	"B" DIM.
INSULATING	1/4"	2 3/4"
STEEL	9/16"	1 3/8"

FIG. 1

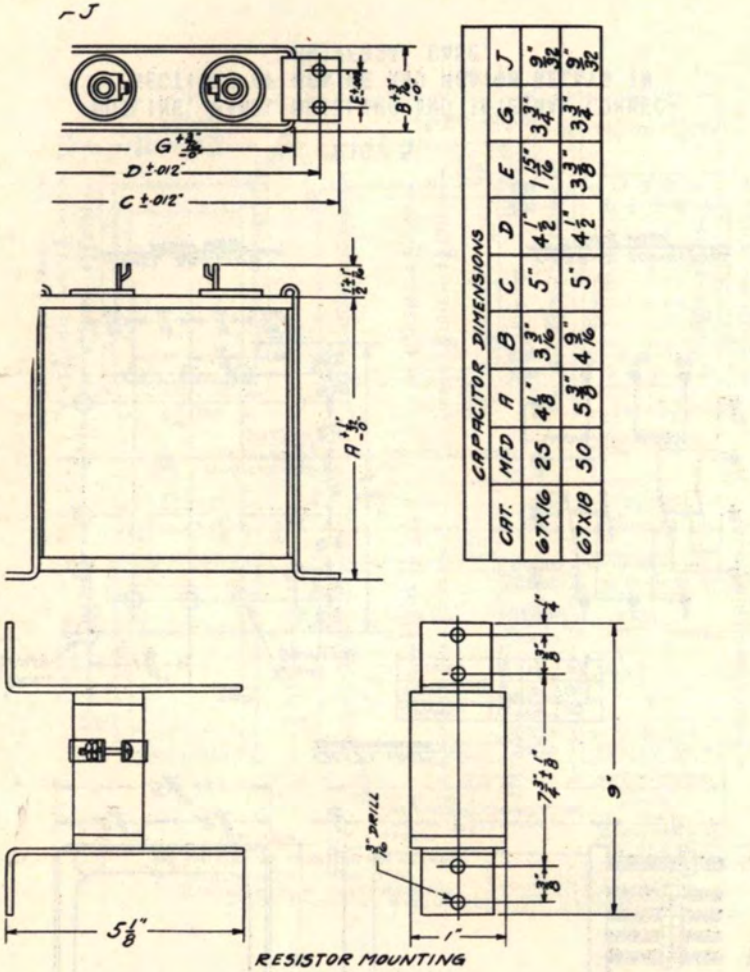
OUTLINE, PANEL DRILLING AND INTERNAL CONNECTIONS OF HGA14A, HGA14J, HGA14K, HGA14N AND HGC11A.



TYPE OF PANEL	"A" DIA. OF HOLE	"B" DIM.
INSULATING	1/4"	2 3/4"
STEEL	9/16"	1 3/8"

FIG. 2

OUTLINE, PANEL DRILLING AND INTERNAL CONNECTIONS OF HGA14B, HGA14D, HGC11B, AND HGC11C.



CAPACITOR DIMENSIONS								
CAT.	MFD	A	B	C	D	E	G	J
67X16	25	4 1/8"	3 3/16"	5"	4 1/2"	1 15/16"	3 3/4"	9/32"
67X18	50	5 3/8"	4 9/16"	5"	4 1/2"	3 3/8"	3 3/4"	9/32"

FIG. 3

MOUNTING DIMENSIONS OF CAPACITOR AND RESISTOR USED WITH HGA14D RELAYS.

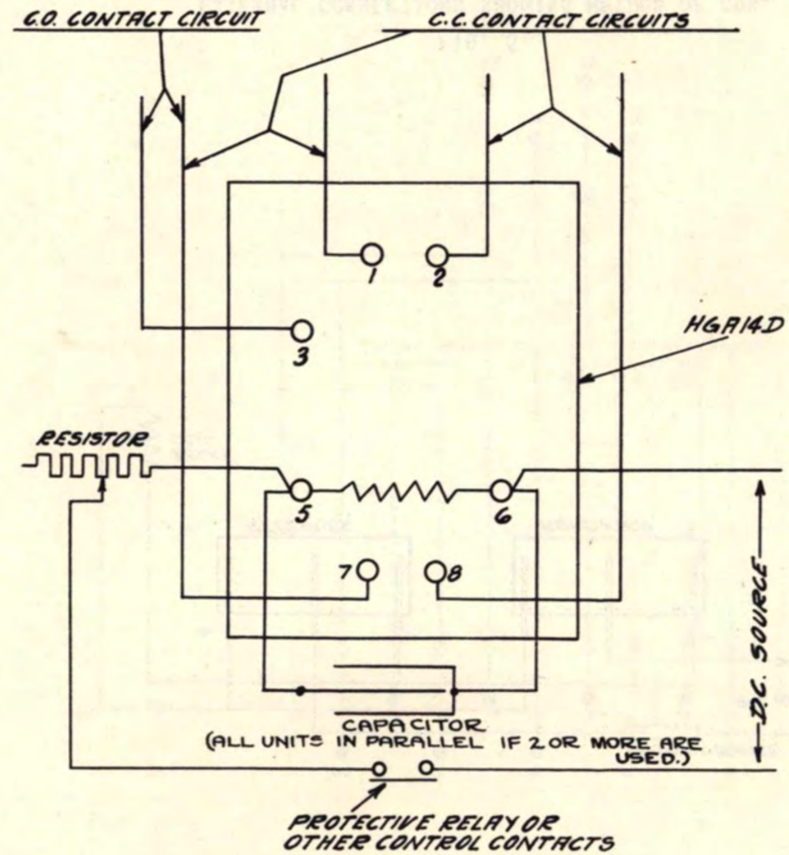
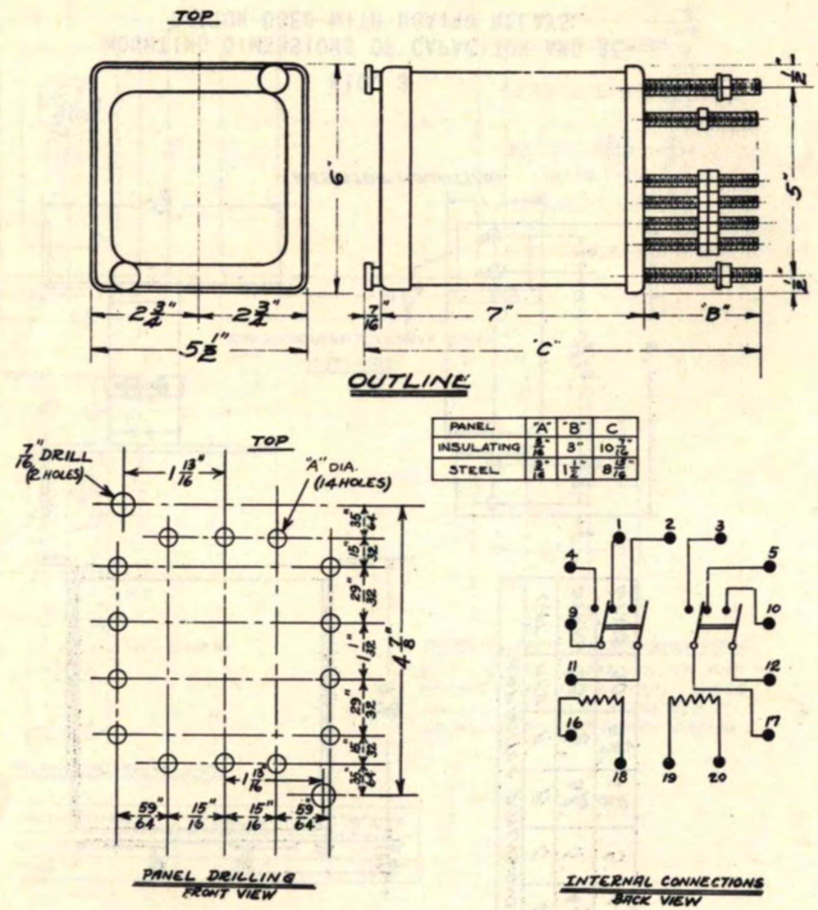


FIG. 4

EXTERNAL CONNECTIONS (BACK VIEW) OF HGA14D (TIME-DELAY PICKUP).



PANEL	"A"	"B"	C
INSULATING	5/16"	3"	10 7/16"
STEEL	3/16"	1 1/2"	8 13/16"

FIG. 5

OUTLINE, PANEL DRILLING AND INTERNAL CONNECTIONS OF HGA14E AND HGA14H RELAYS IN UNIVERSAL CASE.

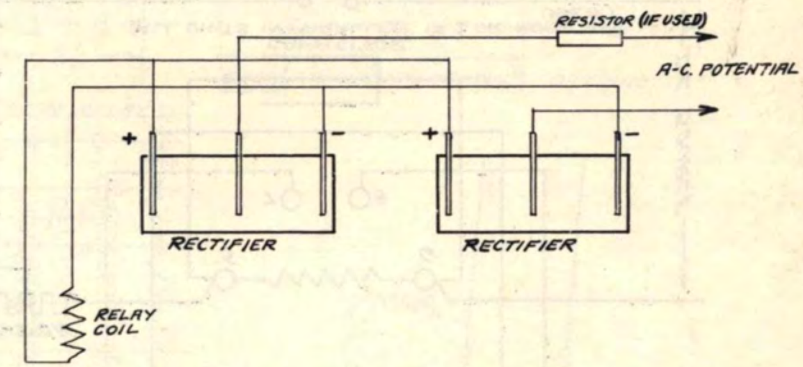


FIG. 6.

EXTERNAL CONNECTIONS SHOWING METHOD OF CONNECTING FULL-WAVE RECTIFIER AND RELAY OPERATING COIL.

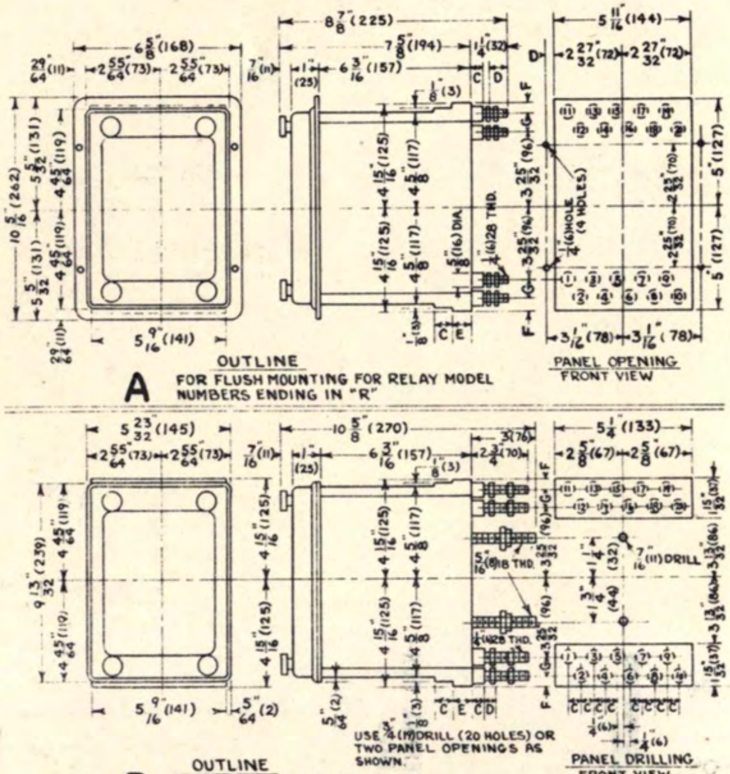


FIG. 7

OUTLINE AND PANEL DRILLING FOR HGA14H IN DRAWOUT CASE.

	C	D	E	F	G
ENGLISH	1/2	7/32	13/16	7/16	23/32
METRIC	(13)	(5)	(21)	(11)	(18)

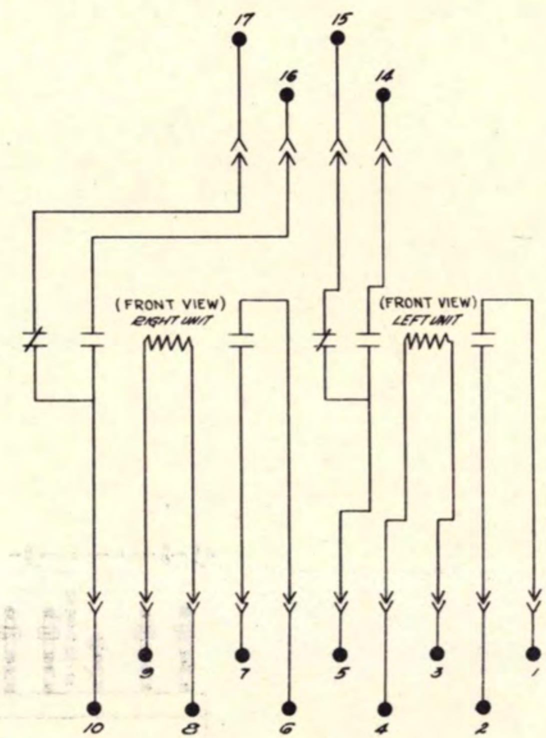


FIG. 8

INTERNAL CONNECTIONS FOR HGA14H IN DRAWOUT CASE.

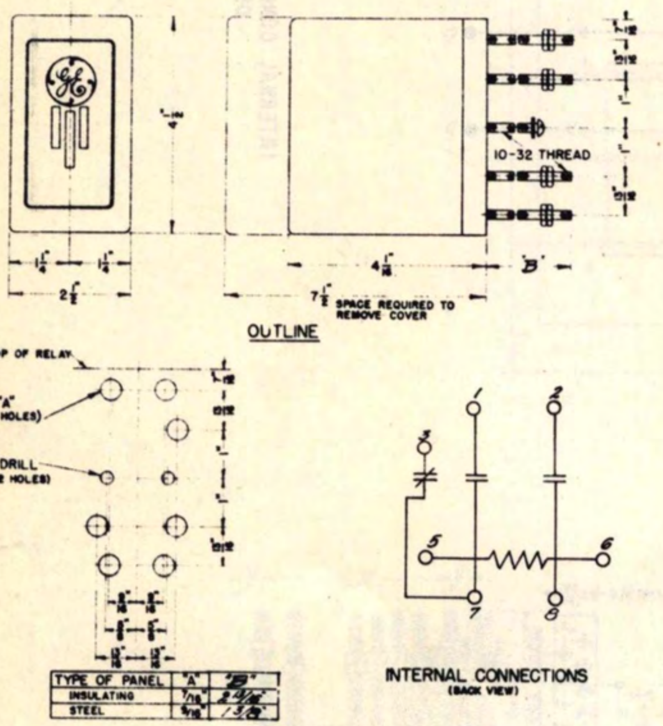


FIG. 9

OUTLINE, PANEL DRILLING, AND INTERNAL CONNECTIONS FOR RELAY TYPE HGA14V.

IF YOU REQUIRE SERVICE

IF AT ANY TIME you find it necessary to repair, recondition, or rebuild your G-E apparatus, there are 26 G-E service shops whose facilities are available day and night for work in the shops or on your premises. Factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E apparatus. If you need parts only, immediate shipment of many items can be made from warehouse stock.

The services of our factories, engineering divisions, and sales offices are also available to assist you with engineering problems. For full information about these services, contact the nearest service shop or sales office listed below:

APPARATUS SERVICE SHOPS

Atlanta, Ga.............496 Glenn St., S.W.
*Baltimore 30, Md...........920 E. Fort Ave.
Buffalo 11, N. Y...............318 Urban St.
Charleston 28, W. Va..306 MacCorkle Ave., S.E.
Chicago 80, Ill..............849 S. Clinton St.
Cincinnati 2, Ohio...........215 W. Third St.
Cleveland 4, Ohio......4966 Woodland Ave.
Dallas 2, Texas...........1801 N. Lamar St.
Denver 5, Colo.............3353 Larimer St.
Detroit 2, Mich..............5950 Third Ave.
Houston 1, Texas..........1312 Live Oak St.
Johnstown, Pa..................841 Oak St.
Kansas City 8, Mo..............819 E. 19th St.
Los Angeles 1, Calif.......6900 Stanford Ave.
Milwaukee 3, Wisc.......940 W. St. Paul Ave.
Minneapolis 1, Minn........410 Third Ave., N.
New York 14, N. Y...........416 W. 13th St.
Philadelphia 23, Pa........429 N. Seventh St.
Pittsburgh 6, Pa..............6519 Penn Ave.
St. Louis 1, Mo............1110 Delmar Blvd.
Salt Lake City 9, Utah...141 S. Third West St.
San Diego 1, Calif.........2045 Kettner Blvd.
San Francisco 3, Calif.......1098 Harrison St.
Seattle 4, Wash............1508 4th Ave., S.
West Lynn 3, Mass.........920 Western Ave.
Youngstown 3, Ohio......121 E. Boardman St.

*Convenient G-E Renewal Parts Center for over-the-counter purchases of industrial parts, located at same address.

APPARATUS SALES OFFICES

Akron 8, Ohio...............335 S. Main St.
Albany 1, N. Y...................90 State St.
Allentown, Pa..............1014 Hamilton St.
Amarillo, Texas..............701 E. Fifth St.
Atlanta 3, Ga...........187 Spring St., N.W.
Bakersfield, Calif.............211 E. 18th St.
Baltimore 1, Md..........39 W. Lexington St.
Bangor, Maine................77 Central St.
Beaumont, Texas..............398 Pearl St.
Binghamton, N. Y............19 Chenango St.
Birmingham 2, Ala.......600 N. Eighteenth St.
Bluefield, W. Va. P.O. Box 447, Appalachian Bldg.
Boston 1, Mass................140 Federal St.
Buffalo 3, N. Y...........535 Washington St.
Butte, Mont..............20 West Granite St.
Canton 1, Ohio.......700 Tuscarawas St., W.
Cedar Rapids, Iowa......203 Second St., S.E.
Charleston 28, W. Va..306 MacCorkle Ave., S.E.
Charlotte 1, N. C............200 S. Tryon St.
Charlottesville, Va............123 E. Main St.
Chattanooga 2, Tenn.......832 Georgia Ave.
Chicago 80, Ill..............840 S. Canal St., P.O. Box 5970A
Cincinnati 2, Ohio...........215 W. Third St.
Cleveland 4, Ohio......4966 Woodland Ave.
Columbia 23, S. C.......1225 Washington St.
Columbus 15, Ohio............40 S. Third St.
Dallas 2, Texas...........1801 N. Lamar St.
Davenport, Iowa..........511 Pershing Ave.
Dayton 2, Ohio..............25 N. Main St.
Denver 2, Colo..........650 Seventeenth St.
Des Moines, Iowa.........418 W. Sixth Ave.
Detroit 2, Mich.............700 Antoinette St.
Duluth 2, Minn.........14 W. Superior St.
El Paso, Texas............109 N. Oregon St.
Erie 2, Pa..................10 E. Twelfth St.
Evansville 19, Ind.........123 N.W. Fourth St.
Fairmont, W. Va............511 Jacobs Bldg.
Fergus Falls, Minn........102 W. Lincoln Ave., P.O. Box 197
Fort Wayne 2, Ind..........127 W. Berry St.
Fort Worth 2, Texas......408 W. Seventh St.
Fresno 1, Calif...........Tulare and Fulton St.
Grand Rapids 2, Mich..148 Monroe Ave., N.W.
Greenville, S. C.......106 W. Washington St.
Hagerstown, Md........Professional Arts Bldg.
Hartford 3, Conn.............410 Asylum St.
Houston 1, Texas..........1312 Live Oak St.
Indianapolis 4, Ind..........110 N. Illinois St.
Jackson, Mich..........120 W. Michigan Ave.
Jackson 1, Miss...........203 W. Capitol St.
Jacksonville 2, Fla.........237 W. Forsyth St.
Jamestown, N. Y...............2 Second St.
Johnson City, Tenn............334 E. Main St.
Johnstown, Pa..................841 Oak St.
Kansas City 6, Mo......106 W. Fourteenth St.
Knoxville 08, Tenn............602 S. Gay St.
Lincoln 8, Neb..................1001 "O" St.
Los Angeles 54, Calif........212 N. Vignes St.
Louisville 2, Ky..............455 S. Fourth St.
Madison 3, Wisc.............111 S. Hamilton
Manchester, N. H................839 Elm St.
Medford, Ore...2015 E. Main St., P.O. Box 1349
Memphis 3, Tenn................8 N. Third St.
Miami 32, Fla............25 S.E. Second Ave.
Milwaukee 3, Wisc.......940 W. St. Paul Ave.
Minneapolis 2, Minn............12 S. Sixth St.
Mobile 13, Ala...............54 St. Joseph St.
Nashville 3, Tenn...........234 Third Ave., N.
Newark 2, N. J................744 Broad St.
New Haven 6, Conn............129 Church St.
New Orleans 12, La..........837 Gravier St.
New York 22, N. Y........570 Lexington Ave.
Niagara Falls, N. Y...........253 Second St.
Norfolk 10, Va.................229 Bute St.
Oakland 12, Calif..........409 Thirteenth St.
Oklahoma City 2, Okla....119 N. Robinson St.
Omaha 2, Nebr........409 S. Seventeenth St.
Pasco, Wash..............421 W. Clark St.
Philadelphia 2, Pa............1405 Locust St.
Peoria 2, Ill...................410 Main St.
Phoenix, Ariz............435 W. Madison St.
Pittsburgh 22, Pa..........535 Smithfield St.
Portland 3, Maine..........477 Congress St.
Portland 7, Ore..........920 S.W. Sixth Ave.
Providence 3, R. I.........Industrial Trust Bldg.
Raleigh, N. C............304 So. Salisbury St.
Reading, Pa...................31 N. Sixth St.
Richmond 17, Va...........700 E. Franklin St.
Riverside, Calif...............3972 Main St.
Roanoke 11, Va..........202 S. Jefferson St.
Rochester 4, N. Y.................89 E Ave.
Rockford, Ill...................110 S. First St.
Rutland, Vt...................38½ Center St.
Sacramento 14, Calif..........1107 Ninth St.
St. Louis 2, Mo.............112 N. Fourth St.
Salt Lake City 9, Utah........200 S. Main St.
San Antonio 5, Texas.....310 S. St. Mary's St.
San Diego 1, Calif..............861 Sixth Ave.
San Francisco 6, Calif.....235 Montgomery St.
San Jose, Calif......177 W. Santa Clara Ave.
Savannah, Ga................16 Drayton St.
Seattle 11, Wash...........710 Second Ave.
Shreveport 39, La.............803 Jordan St.
Sioux City 13, Iowa............507 Sixth St.
South Bend 11, Ind.....112 W. Jefferson Blvd.
Spokane, Wash...............S. 162 Post St.
Springfield, Ill..............607 E. Adams St.
Springfield 3, Mass............1387 Main St.
Syracuse 2, N. Y............113 S. Salina St.
Tacoma 1, Wash...........1019 Pacific Ave.
Tampa 6, Fla..............1206 North A St.
Toledo 4, Ohio............420 Madison Ave.
Trenton, N. J...............214 Hanover St.
Tulsa 3, Okla.............320 S. Boston Ave.
Utica 2, N. Y...............258 Genesee St.
Washington 5, D. C.....806 Fifteenth St., N.W.
Waterbury 89, Conn.........111 W. Main St.
Waterloo, Iowa..............716 Water St.
Wheeling, W. Va.........40 Fourteenth St.
Wichita 2, Kan.............200 E. First St.
Wilmington, Del.........1326 Market St.
Williamston, N. C...............Town Hall
Worcester 8, Mass.............507 Main St.
York, Pa..................56 W. Market St.
Youngstown 3, Ohio.......25 E. Boardman St.

Hawaii: W. A. Ramsay, Ltd., Honolulu **Canada: Canadian General Electric Company, Ltd., Toronto**

APPARATUS DEPARTMENT, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y. ②

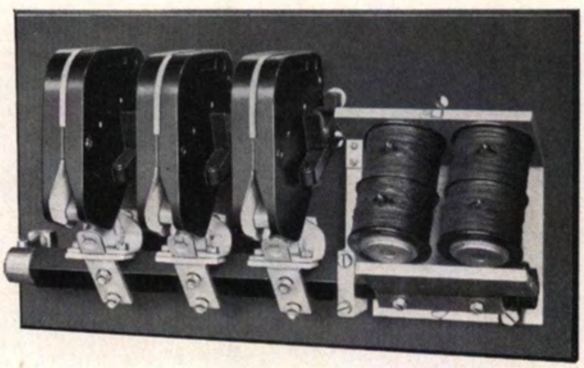
4-48

Supersedes GEI-10904E

PRINTED IN U.S.A.

INSTRUCTIONS

CR2810 A-C LOW-VOLTAGE CONTACTORS WITH D-C MAGNET



GENERAL ELECTRIC

CR2810 A-C LOW-VOLTAGE CONTACTORS WITH D-C MAGNET

600 VOLTS MAXIMUM

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.

The coils of these contactors operate from an a-c circuit by means of rectifiers but they can be operated from a separate d-c supply if desired. Coils for use with rectifiers are designed to allow for the drop of voltage due to rectification and are therefore different from the coils used on a d-c supply.

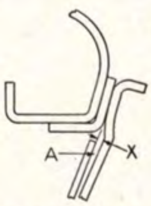


***Fig. 1.* CR2810-1503 to 1507**
CR2810-1541 to 1544

Contactors, 150 to 600 Amp Inclusive

Care of Contacts

In general, the contacts do not require attention during their normal life, but if prominent copper beads form on the surfaces, or if the contacts turn a dark color, their faces should be dressed with a fine file or replaced with new contacts.

When renewing contacts see that the contact surfaces between the contact and the shunt are clean, but the plating must not be removed from bolted joints.

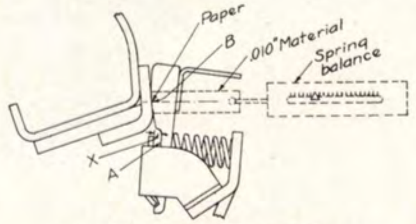


***Fig. 2.* CR2810-1514 to 1518**
CR2810-1525 to 1528
CR2810-1831 to 1834

The movable contacts of the contactors having spring caps can be removed by slightly compressing the spring with the cap and turning the latter 90 degrees.

To remove the front arcing contact from the 300- and 600-ampere sizes, take out the screws in the shunt above the spring; then, holding the spring in place, pull out the contact, using the arcing horn for a handle. The horn should then be transferred to the new contact unless badly burned.

Contact Force

It is important that the compression of the springs for the contacts be kept at values as given in the table on page 4. If the force is too low, the contacts may overheat; if too high, the magnet may be prevented from completely closing.

Spring balances should always be checked for readings in a horizontal position before checking contact force.

Initial contact force: With the contactor open and the coil de-energized, insert a strip of thin

POLES		75 Amp	150 Amp	300 AMP		600 Amp	1000 Amp
Normally Open	Normally Closed			Single Coil *	Double Coil		
3	2	...	...	...	...	CR2810–1570*(2)	...
1	—	CR2810–1541	CR2810–1503	CR2810–1514	CR2810–1525	CR2810–1571*	...
2	—	CR2810–1542	CR2810–1504	CR2810–1515	CR2810–1526	CR2810–1572*	CR2810–1250*
3	—	CR2810–1543	CR2810–1505	CR2810–1516	CR2810–1527	CR2810–1573*	CR2810–1251*
4	—	CR2810–1544	CR2810–1506	CR2810–1517	CR2810–1528	CR2810–1574*	CR2810–1259*
5	—	...	CR2810–1507	CR2810–1518	...	...	...
3	2	...	CR2810–1513*(1)	...	CR2810–1569*(2)	CR2810–1575*	CR2810–1549*(3)
1	—	...	...	...	...	CR2810–1831	...
2	—	...	...	...	...	CR2810–1832	CR2810–1842
3	—	...	...	...	...	CR2810–1833	CR2810–1843
4	—	...	...	...	...	CR2810–1834	...

* Coils require resistor inserted in coil circuit by means of an interlock when the contactor closes.
(1) Normally closed pole rated 75 amp is not designed to break current.
(2) Normally closed pole rated 300 amp is not designed to break current.
(3) Normally closed pole rated 600 amp is not designed to break current.

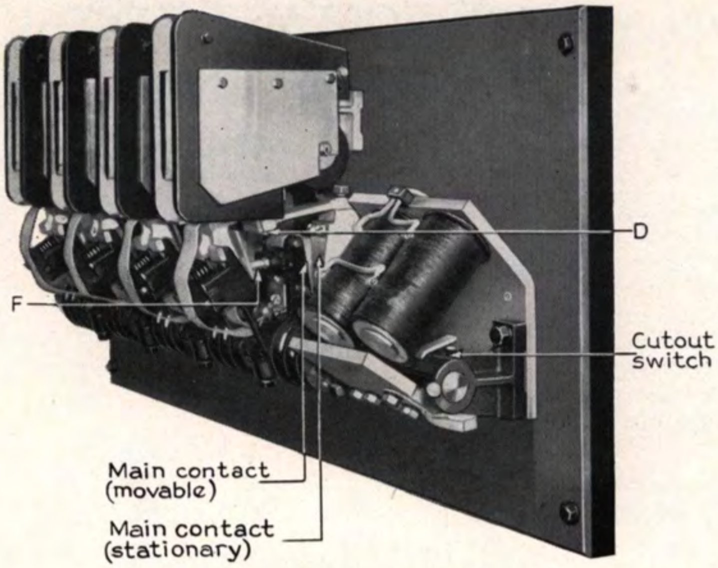


Fig. 3. Four-pole, alternating-current contactor with D-c magnet (1000-amp size)

paper between the contact support and contact, just back of spring at A in Figs. 1 and 3. Attach the hook of a spring balance to a string or a strip of thin material fastened around the contact at the line of final contact. The pounds pull at the instant the paper can be moved is the initial contact force.

Final Contact Force

The final contact force given in the table will be found only with new contacts. To measure this force insert a piece of paper and a strip of material not more than 0.01 in. thick as shown in Fig. 2 at B. With the contactor armature closed the pounds pull when the paper can be moved is the final contact force.

Failure to Open

If the contactor does not open when the coil circuit is opened, see if the contacts are frozen together.

1000-amp Contactors

Care of Contacts

In general, the contacts do not require attention during their normal life, but if prominent copper

Contactor	Contacts	CONTACT FORCE IN POUNDS				DIMENSION "X," FIG. 1 AND 2 IN INCHES WITH CONTACTOR CLOSED	
		Initial		Final			
		Min.	Max.	Min.	Max.	New Contacts	*Worn Contacts
CR2810-1541 to -1545 Incl.	Norm. Open	1½	2	2	2½	3/16	1/16
CR2810-1503 to -1507 Incl. CR2810-1513	Norm. Open	3½	4½	7	9	9/64	1/16
CR2810-1514 to -1518 Incl., 1525 to-1528 Incl., -1569	Norm. Open	7	9	14	18	17/64	1/8
CR2810-1831 to -1834 Incl. CR2810-1570 to-1575 Incl.	Norm. Open	15	17	30	34	7/32	7/64
CR2810-1513	Norm. Closed	1½	2	2	2½	1/8	1/16
CR2810-1569, -1570	Norm. Closed	7	9	11	13	1/8	1/16
CR2810-1549	Norm. Closed	7	9	16	20	13/64	7/64
CR2810-1250 CR2810-1251 CR2810-1259 CR2810-1842 CR2810-1843 CR2810-1549	Norm. Open Main	23	29	45 φ	55 φ	See Tables 1 and 2, page 6.	
	Norm. Open Arcing	11	15	12	15		
	Norm. Open Auxiliary	6	8	10	12		

* Renew contacts when worn to "worn contact" dimension.
φ This force only to be measured directly over center line of spring.

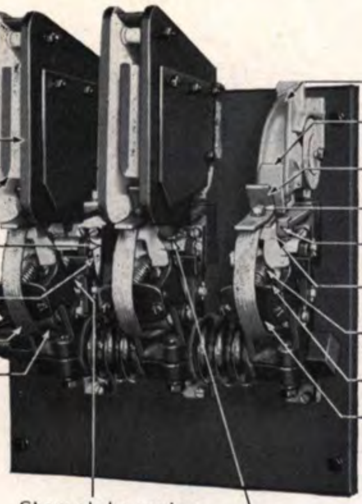


Fig. 4. Contact parts (1000-amp size)

beads form on the surfaces of the arcing or auxiliary contacts their faces should be dressed with a fine file or replaced with new contacts.

When renewing contacts the surfaces between the contacts and the shunt should be clean but the plating must not be removed from bolted joints.

If the main contacts have become roughened, they should be smoothed with a fine file and can continue in use as long as the silver facing remains. To remove them take out the screws at the lower end and remove the pins and the spring plate.

Contact Renewals

The contact gaps should be in accordance with Table 2, page. 6. *It is important that the arcing contacts touch before the auxiliary contacts, and that the auxiliary contacts touch before the main contacts.* The auxiliary contacts may be adjusted by means of the screw F, Fig. 3. The correct armature gaps are given in Table 2 (see Figs. 5, 6, and 7). When the minimum armature gap is reached, the arcing and auxiliary contacts should be replaced.

Also the arcing contacts should be replaced if so worn that they fail to make contact in advance of the auxiliary contacts. Replace the main contacts before the silver face has worn through.

To renew the arcing contacts remove the arc chute A, Fig. 8, by lifting until it releases at notch B, then remove screws C, Fig. 4.

The arcing contacts are provided with arcing horns which help in preventing the concentration of arcs on small areas, and greatly increase the life of the contacts and arc chutes.

To renew the stationary auxiliary contact after the arc chute has been removed, remove screws D, Fig. 3. To remove the front auxiliary contact remove the two screws in the spring plate E, Fig. 4, which will allow the springs to drop out. Then remove the screw which acts as a spring seat. When renewing the contacts, see that the contact surfaces between the contacts and shunts are clean to insure a good contact and to reduce heating at this point. However, the plating must not be removed from bolted joints.

Do not wait until trouble occurs, but inspect all parts at regular intervals. Keep all parts free from dirt, oil and grease. Replace contacts when worn. If the current-carrying parts, bearings, springs, and interlocks are carefully inspected periodically, trouble will be reduced to a minimum. Keep on hand extra coils, springs and contacts.

Renewal Parts

For renewal part information not given in the table on page 7, refer to the nearest Sales Office of the General Electric Company, giving the complete nameplate rating, and describing the part in detail.

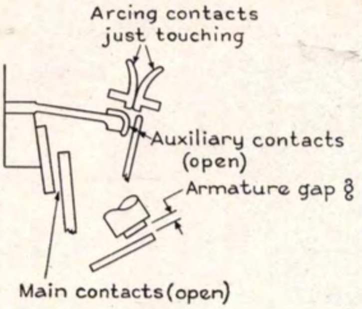


Fig. 5.
Arcing contacts just touching

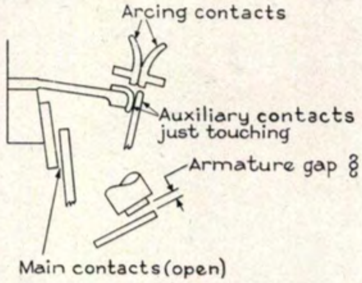


Fig. 6.
Auxiliary contacts just touching

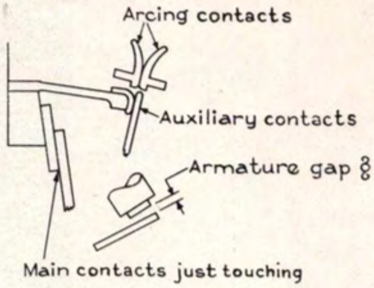


Fig. 7.
Main contacts just touching

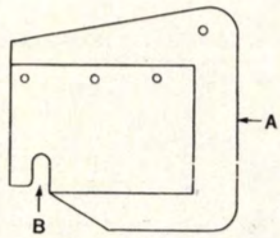


Fig. 8. Arc chute

TABLE 1

Contact	Contact Gaps in Inches with New Contacts—Contactor Open
Main	11/16 ± 1/16
Arcing	1 3/16 ± 1/16
Auxiliary	1 7/32 ± 1/16

TABLE 2

MAXIMUM AND MINIMUM ARMATURE GAP § IN INCHES

WITH ARCING CONTACTS JUST TOUCHING FIG. 5		WITH AUXILIARY CONTACTS JUST TOUCHING FIG. 6		WITH MAIN CONTACTS JUST TOUCHING FIG. 7	
New Contacts	Min. With Worn Contacts	New Contacts	Min. With Worn Contacts	New Contacts	Min. With Worn Contacts
31/64	5/16	21/64	3/16	1/4	*

* The main contacts should be replaced before the silver face has worn through.

§ The armature gap should be measured at the front edge of the armature.

RENEWAL PARTS

Contactor	Main Contacts (Normally Open)		Main Contact Shunt	Arc Chute Side (If Used)		Main Contact Spring	Cutout Switch (if Used)
	Stationary Cat. No.	Movable Cat. No.	Cat. No.	Left Cat. No.	Right Cat. No.	Cat. No.	Cat. No.
CR2810–1503A	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1504A, B, E	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1505A, B, F	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1506A	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1507A	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1513A	2457337	2457351	3667564G1	3671035P1	3671036P1	2415140	5304720G1
CR2810–1514A, B	2447762	5350495	4311012G3	4338332	4338333	2414881	5304720G2
CR2810–1515A, B	2447762	5350495	4311012G3	4338332	4338333	2414881	5304720G2
CR2810–1516A, B	2447762	5350495	4311012G3	4338332	4338333	2414881	5304720G2
CR2810–1517A	2447762	5350495	4311012G3	4338332	4338333	2414881	5304720G2
CR2810–1518A	2447762	5350495	4311012G3	4338332	4338333	2414881	5304720G2
CR2810–1525A	2447762	5350495	4311012G3	4338332	4338333	2414881	....
CR2810–1526A	2447762	5350495	4311012G3	4338332	4338333	2414881	....
CR2810–1527A, B	2447762	5350495	4311012G3	4338332	4338333	2414881	....
CR2810–1528A	2447762	5350495	4311012G3	4338332	4338333	2414881	....
CR2810–1541A, B, C, G, H, L	1468908	1445307	2840225G3	1435844	1435843	189703	5304720G1
CR2810–1542A, B, C, G, H, J	1468908	1445307	2840225G3	1435844	1435843	189703	5304720G1
CR2810–1543A, B, C, D, K, L, M, N	1468908	1445307	2840225G3	1435844	1435843	189703	5304720G1
CR2810–1544A, B	1468908	1445307	2840225G3	1435844	1435843	189703	5304720G1
CR2810–1549A	2644936G1	2644936G4	....	1432511	1432510	244804	2839201G1(1) 2839201G2(2)
CR2810–1569A	2447762	5350495	4311012G3	4338332	4338333	2414881	3845750G4
CR2810–1570A	2458490	5151779	4959811G1	4927032	4927033	2413921	6920501G1
CR2810–1571C	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1572C	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1573C	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1574C	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1575C	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1831A	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1832A, B	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1833A, B	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1834A, B	2458490	5151779	4959811G1	4927032	4927033	2413921	....
CR2810–1842A, B	2644936G1	2644936G4	....	1432511	1432510	244804	....
CR2810–1843A, B	2644936G1	2644936G4	....	1432511	1432510	244804	....

Contactor	Normally Open Auxiliary Contact			Normally Open Arcing Contact			Arcing Horn for Movable Contact
	Stationary	Movable	Shunt	Stationary	Movable	Shunt	
CR2810–1549A	1977637P14	1977637P1	1447756G1	1476440	1476440	1447754G1	1444088
CR2810–1842A, B	1977637P14	1977637P1	1447756G1	1476440	1476440	1447754G1	1444088
CR2810–1843A, B	1977637P14	1977637P1	1447756G1	1476440	1476440	1447754G1	1444088

Contactor	Normally Closed Contact				
	Stationary	Movable	Shunt	Operating Spring	Contact Spring
CR2810–1513A	2457337	2457351	3667564G1	216683	2413399
CR2810–1549A	4959854G1	4959854G2	4959811G1	2415330	2415359
CR2810–1569A	2447762	5350495	4311012G3	2415330	2414881
CR2810–1570A	2447762	5350495	4311012G3	2415330	2414881

WHEN SERVICE IS REQUIRED

GENERAL ELECTRIC operates 23 apparatus service shops strategically located and competently manned by trained personnel. Each shop is a complete service unit with modern equipment for repairing, reconditioning, and rebuilding G-E apparatus to factory specifications. The services of these shops are available at any time of day or night for work in the shops or on purchaser's premises.

GENERAL ELECTRIC APPARATUS SERVICE SHOPS

SERVICE SHOP	ADDRESS	DAY PHONE	NIGHT PHONE
Atlanta, Ga.	496 Glenn Street, S.W.	WAlnut-9667	WAlnut-7859
Buffalo 11, N. Y.	318 Urban Street	HU-5849	RI-7579
Charleston 28, W. Va.	306 MacCorkle Avenue, S.E.	2-6177	3-1244
Chicago 7, Ill.	849 South Clinton St.	Wabash-5611	Wabash-5654
Cincinnati 2, Ohio	215 West Third Street	Parkway-3433	Parkway-3433
Cleveland 4, Ohio	4966 Woodland Avenue	EN-4464	EN-4464
Dallas 2, Texas	1801 North Lamar St.	R-9121	L-4111
Detroit 2, Mich.	5950 Third Avenue	TRinity-2-2600	TRinity-2-2606
Houston 1, Texas	1312 Live Oak Street	C-9711	C-9714
Kansas City 8, Mo.	819 East 19th Street	Victor-9745	WAbash-3850
Los Angeles 54, Calif.	733 Banning Street	Madison-7381	Madison-1813
Milwaukee 3, Wis.	940 W. St. Paul Ave.	Marquette-5000	Marquette-5002
Minneapolis 1, Minn.	410 Third Ave., N.	Main-2541	Main-2546
New York 14, N. Y.	416 West 13th Street	Wickersham-2-1311	Chelsea-2-8390
Philadelphia 23, Pa.	429 N. Seventh St.	Pennypacker-9000	Pennypacker-8448
Pittsburgh 6, Pa.	6519 Penn Avenue	Atlantic-6400	Atlantic-6408
St. Louis 1, Mo.	1110 Delmar Avenue	Chestnut-8505	Chestnut-3899
Salt Lake City 9, Utah	141 South Third West St.	4-1892	6-4448
San Diego 1, Calif.	2045 Kettner Blvd.	Franklin-7684	Glencove-5-3675
San Francisco 7, Calif.	361 Bryant Street	DO-3740	DO-3748
Seattle 4, Wash.	1508 4th Ave., South	Elliott-1778	CA-3679
West Lynn 3, Mass.	920 Western Avenue	Ly-3-6000	Ly-3-6008
Youngstown 3, Ohio	121 East Boardman St.	Youngstown-44331	Youngstown-44331

APPARATUS DEPARTMENT

GENERAL ELECTRIC

SCHENECTADY, N. Y.

4-46 (2M)

Superseding GEH-1039A

PRINTED IN U.S.A.

INSTRUCTIONS

A-C MAGNETIC SWITCH

CR2811-C24B ALSO FORM . . . SWITCH

The various forms of this switch consist of a two-pole (or more), 150-ampere contactor with accessories suitable for push-button control. The maximum ampere ratings for these switches are 150 amperes for open switch and 135 amperes for enclosed switch. Fig. 4 is a typical example.

INSTALLATION

1. Remove the bindings from the arc chutes and armature.
2. Thoroughly remove the rust-inhibiting material which covers the magnet sealing surfaces.
3. Before applying power to the contactor, operate the moving parts by hand to make sure they operate freely.

MAINTENANCE

The sealing surfaces on the magnet frame and armature should be kept clean.

Do not lubricate tips. In general, tips will not require attention during their normal life, but if prominent beads form on the surface, the contact faces should be dressed with a fine file. To determine the condition of the contacts, block the contactor closed, applying force to the magnet laminations and not the supporting bracket and measure the gap between the movable tip and tip support at point (A), Fig. 4. When this gap is $\frac{1}{16}$ inch or less, the tips should be renewed.

To Renew Stationary Tips

Remove the arc chutes by sliding them upward off the projection of the stationary tip arcing horn. Remove screws (B) and the movable tip arc horns. Next loosen screw (C) sufficiently to allow armature to open beyond the armature stop. The slotted stationary tips may now be removed by loosening screws (D) and drawing them forward. It is not necessary to remove screws (D) completely.

To Renew Movable Tips

Insert a screw driver in the top of the spring at point (G) and slide the spring upward out of its holder. The screw holding the tip to the shunt is then exposed for removal. To replace the spring, slide the movable tip forward and place the end of the spring over the screw. Then slide both spring and tip backward into place. After reassembling the arcing horns, the gap between the end of the horn and the stationary tip should be ½ inch plus or minus $\frac{1}{32}$.

To Renew Interlock Tips

The entire interlock should be removed from the contactor base by removing screw (E) for replacement of the interlock tips. Removing screws (F) permits complete disassembly of the interlock unit.

To Reassemble Normally Open Interlock

Assemble the parts on the operating rod as shown in Fig. 1. Place the entire assembly on the molded base with the longer portion of the operating rod toward the contactor and replace screws (F). Check to see that the operating rod moves without binding.

To Reassemble Normally Closed Interlock

Assemble the parts on the operating rod as shown in Fig. 2. Complete reassembly in the manner described for the normally open interlock.

To Renew Coil

Remove the arc chutes as described previously. Loosen screws (B) sufficiently to allow arc horns to be turned down over load connections. Next remove screw (C) and armature stop (R). This permits the armature to be opened to its maximum amount. The coil can now be removed by drawing it outward and turning it clockwise through the opening between the magnet and the coil support strap.

RENEWAL PARTS

When ordering renewal parts, refer to the nearest Sales Office of the General Electric Company, giving the complete nameplate rating, the Cat. No., a description of the part wanted, and the quantity desired.

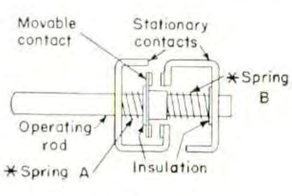


Fig. 1

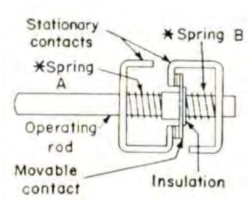
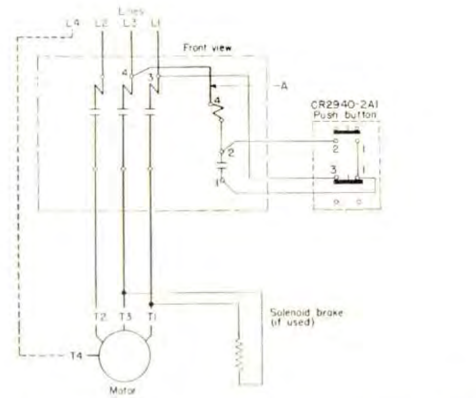


Fig. 2

* Spring A has a free length of approx 0.64 in.
* Spring B has a free length of approx 1.69 in.
(The length of the spring when in neither tension nor compression is its free length)



For Separate Control: Remove wire A and connect control source to No. 4 on coil and No. 3 on push button.
For 2-phase 4-wire Operation: Where not prohibited by local codes, L4 may be connected to T4 as shown by dotted line on diagram. L1-L3 is phase No. 1, L2-L4 is phase No. 2.
For 2-phase 3-wire Operation: L3 and T3 are common line circuit.

Fig. 3. Typical wiring diagram

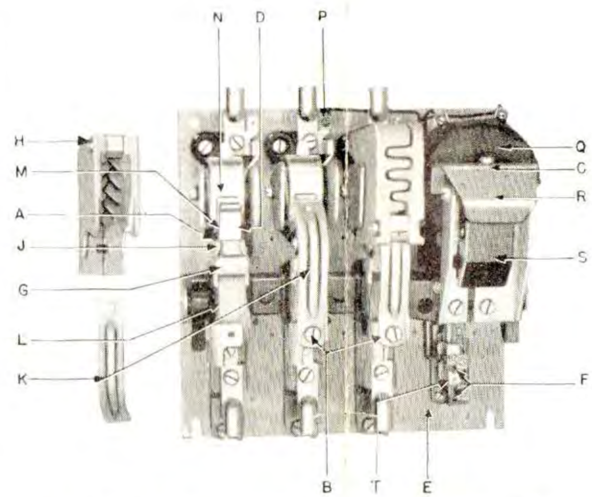


Fig. 4. Typical magnetic switch with arc chute and arcing horn removed from third pole

PRINCIPAL AND RENEWAL PARTS

Ref Letter	Description	Cat. No.
H	Arc chute	6960039G1
J	Contact spring	2416432
K	Arc horn	8280986P1
L	Shunt assembly	6963440G3
M	Movable contact	6908543
N	Stationary contact	5352149
P	Control terminal	....
Q	Coil	Order by No. marked on coil
R	Armature stop	....
S	Armature	....
T	Electrical interlock assembly	....

8-45 (2M)

GENERAL ELECTRIC
SCHENECTADY, N.Y.

PRINTED IN U.S.A.

INSTRUCTIONS

CR2820-1054 TIME RELAY

GENERAL ELECTRIC

SCHENECTADY, N.Y.

CR2820-1054 TIME RELAY

The CR2820-1054 relay is designed primarily as a d-c instantaneous pick-up, time delay drop-out relay. It may also be utilized as a d-c voltage or current relay with an adjustable pick-up and relatively low drop-out voltage or current. If a source of d-c voltage is not available, the relay may be energized from an a-c source through a copper-oxide rectifier.

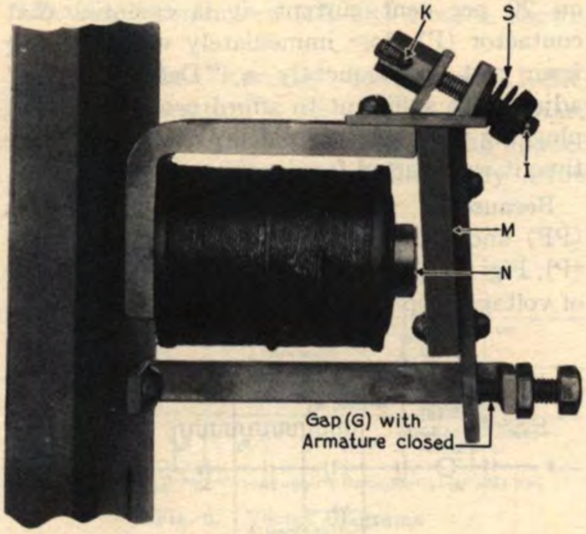


Fig. 1. CR2820-1054B Relay

If the relay coil is short-circuited when energized, the current in the coil and the flux in the magnetic circuit will die out slowly. As indicated in Fig. 3, for armature spring force (P1), the armature will release at time (T1), while if the spring force is decreased to (P2), a further decrease in flux is necessary before the armature releases, and the time delay is increased to (T2). Since the flux density in the magnetic circuit is above the point of saturation when the armature is closed, the time adjustment is substantially independent of the usual variation in line voltage.

For certain applications it is more convenient to initiate the time-delay drop-out of the relay by opening the coil circuit instead of short-circuiting the coil as described above. For such applications coils are supplied which have a cylindrical copper jacket around the core of the relay. When the coil is de-energized, the decay of flux induces in the copper jacket a current which dies down relatively slowly, and the resulting slow decay of flux gives a time-delay drop-out in the same manner as described in the previous paragraph.

When applied to the usual type of d-c steel mill or crane control equipment, this relay serves three separate and distinct functions as described below.

(1) DEFINITE-TIME CONTROL OF ACCELERATION (CR2820-1054B)

Fig. 4 shows this application of this relay. It will be noted that the coils of the accelerating relays (1A) and (2A) are connected across divisions (R1-R2) and (R1-R3) respectively of the resistor.

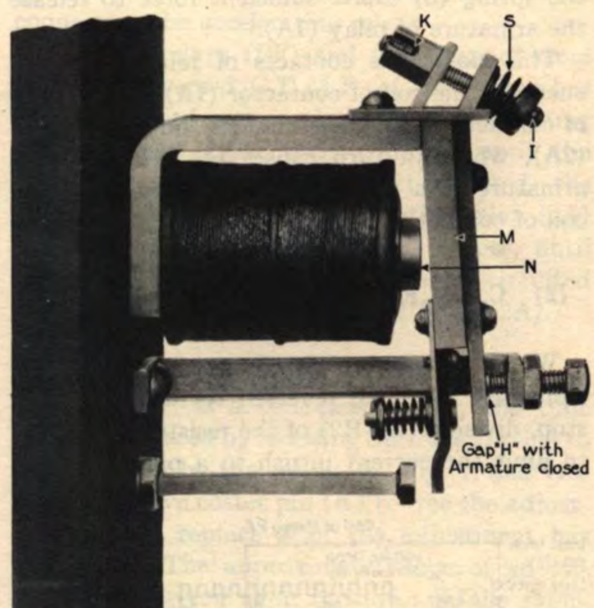


Fig. 2. CR2820-1054A Relay

When the forward contactors (1F-2F) close and establish the armature circuit through the resistor, the voltage drop across division (R1-R2)

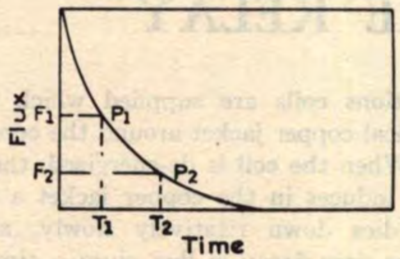


Fig. 3. Flux-time Curve

is applied to the coil of relay (1A), and the voltage drop across divisions (R1-R2), plus (R2-R3) is applied to the coil of relay (2A). The respective relay armatures close, opening the contacts of these relays.

Assuming contactor (P) to close, as explained later in Section 2, its tips will short-circuit resistor division (R1-R2), also the coil of relay (1A), and the magnetic energy stored in the relay (1A), due to the flux produced in the heavy iron frame, tends to dissipate itself as previously explained, until a density is reached such that the spring (S) exerts sufficient force to release the armature of relay (1A).

This closes the contacts of relay (1A) and energizes the coil of contactor (1A). The closing of contactor (1A) short-circuits the coil of relay (2A), which in turn causes the release of its armature in a definite time and energizes the coil of contactor (2A).

(2) C.E.M.F. CONTROL OF PLUGGING (CR2820-1054A)

When an equipment is subject to being "plugged," that is, reversed to insure a quick stop, division (R1-R2) of the resistor is adapted to limit the current inrush to a predetermined

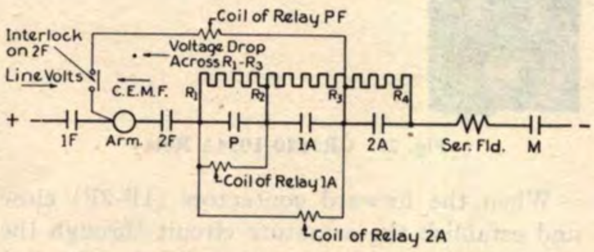


Fig. 4. Elementary Connection Diagram

safe value (approximately 140 per cent). The resistance of division (R1-R2) is such that in conjunction with divisions (R2-R3) and (R3-R4), the current inrush when starting from rest will not exceed approximately 70 per cent of the motor rating. Since the motor may not start on 70 per cent current, it is essential that contactor (P) close immediately when starting from rest, consequently a "Definite Time" adjustment sufficient to afford protection when plugging would seriously delay the motor every time it was started from rest.

Because of this the normally open relays (PF) and (PR) controlling plugging contactor (P), Fig. 4 and 5, are actuated by a combination of voltage drop across (R1-R2) and C.E.M.F. to

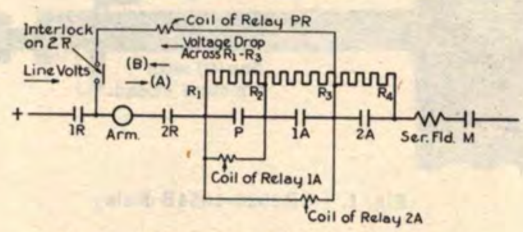


Fig. 5. Elementary Connection Diagram

afford protection when plugging and to give instantaneous closing when starting.

Referring to Fig. 4, the coil of relay (PF) is connected across the armature, the plugging division (R1-R2), and the first accelerating division (R2-R3) of the resistor, this circuit being established through the interlock only when the "Forward" contactors (1F-2F), are closed. The coil of relay (PR) is connected in a similar manner except that its circuit is established through an interlock only when the "Reverse" contactors (1R-2R) are closed.

Assuming contactors (1F-2F) and interlock to be closed, Fig. 4, the voltage drop across the resistor and the motor C.E.M.F. may be imagined as opposing the applied voltage as indicated by the arrows. The voltage drop across the resistor will produce instantaneous pickup of the relay, which will be held closed by the C.E.M.F. and voltage drop across resistor division (R2-R3) after division (R1-R2) is short-circuited by contactor (P). This is also shown by the vector diagrams (A) and (B) in Fig. 6.

If the motor is now accelerated to full speed in the "Forward" direction and then plugged, the condition existing immediately after the "Reverse" contactors (1R-2R) close is shown, Fig. 5.

Closing the "Reverse" contactors (1R-2R) while the armature is rotating in the forward direction results in the C.E.M.F. being applied in the opposite direction, as shown by arrow

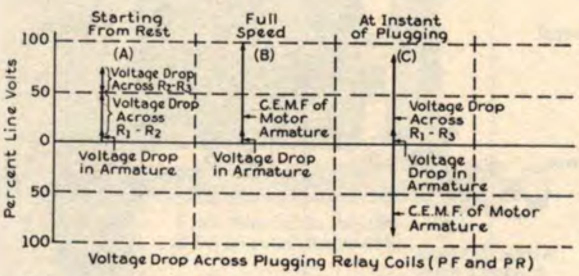


Fig. 6. Vector Diagrams

(A) in Fig. 5. This is also shown in the vector diagram (C) in Fig. 6.

At the instant of plugging, therefore, the voltage across the coil of relay (PR) is practically zero, and it remains open.

During the time of deceleration, the motor acts as a generator, and the C.E.M.F. is opposite in effect to the voltage drop across (R1-R2). The C.E.M.F. falls off to zero as the motor comes to rest, while the voltage across (R1-R2) decreases from the maximum shown at instant of plugging to a similar value to that at starting from rest (vector diagram (A), Fig. 6). The relay (PR) will therefore pick up as the motor comes to rest (approximately) and will then energize the plugging contactor (P), and the acceleration is the same as previously described.

The CR2820-1054A relay, when used for plugging, should be adjusted to pick up on the voltage drop across the plugging resistor (R1-R2) when the motor is started from rest. It must not be set too low since, on plugging, the relay will close too quickly (producing an excessive current peak) while the motor is running at a considerable speed. This adjustment should be made entirely with spring (S), Fig. 2.

(3) SEQUENCE INTERLOCKING

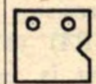
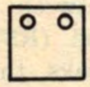
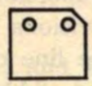
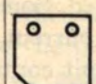
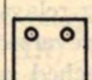
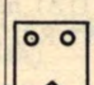
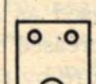
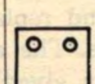
Because of the relation that must exist between resistor divisions (R1-R2), (R2-R3), and (R3-R4) to insure uniform accelerating peaks, that is, each succeeding division being proportionately smaller, it is necessary that the divisions be short-circuited in this order. After the line contactors close, contactors (P), (1A) and (2A) must close in sequence. This definite sequence of operation is ordinarily secured by means of interlocks on the contactors, each contactor having an interlock which must close before the coil of the succeeding contactor may be energized. Sometimes this interlock is part of a series "current limit" attachment providing current limit control and sequence.

Referring to Fig. 4 and 5, it will be noted that contactors (P), (1A) and (2A) are without any form of interlock and that the sequence of operation is assured through the method of connecting the accelerating relays.

Plugging relays (PF) and (PR) cannot close until the reversed C.E.M.F. of the motor has almost reached zero, and the time accelerating relays cannot close their contacts until the preceding contactor has short-circuited the relay coil. For instance, accelerating relay (2A) will not permit contactor (2A) to close, until contactor (1A) has closed and short-circuited division (R2-R3) and the coil of relay (2A).

ADJUSTMENTS

When used as a time-delay relay, the time may be increased by reducing the force applied to the armature by the spring (S), Fig. 1, and vice versa. Remove cotter pin (K) to free the adjusting nut and replace after the adjustment has been made. The approximate range of adjustment for a given shim is shown in the table, Fig. 7. The armature spring force must be strong enough to hold the armature positively against the back stop screw, but must not be increased to a value where the armature will fail to close if the coil is energized when at its maximum operating temperature.

Qty	Shim Cat. No.	Effective Thickness in Inches	Identification			Approximate Time Range—Seconds †		
						For Coils with Copper Jacket		For Coils Without Copper Jacket
			New	Old	Material	CR2820-1054B	Other Forms	
1	5354688	.0005			bimetal			
1	5155942	.001			bimetal			1.5–2.5
1	5354689	.0015			bimetal	1.3–2	1.5–2	1.3–1.9
1	2451597	.005		same	bronze	0.9–1.6	1.3–1.6	0.8–1.3
1	8616834	.007		same	bronze	0.75–1.4	1–1.4	0.65–1.15
1	2450533	.010*		same	bronze	0.6–1.25	0.75–1.25	0.5–1
1	8047765	.015			bronze	0.4–0.8	0.5–0.8	0.4–0.7
1	2439592	.020		same	bronze	0.35–0.7	0.4–0.6	0.25–0.45
2	8047765	.030ϕ			bronze	0.2–0.35	0.25–0.35	0.15–0.25
1	1453458	.060		same	bronze			

*Standard shim for steel-mill service.
†Maximum time is reduced about 30 per cent for relays having four double-break contacts, or two finger-type contacts and one or more double-break contacts.
ϕTwo shims each .015 inch thick

Fig. 7. Shim Data

If the desired time cannot be secured by adjustment of the armature spring pressure, it may be necessary to utilize a shim of different thickness. For the frequent operation encountered in steel-mill service, the use of shims thinner than 0.010 inch is not recommended. The 0.010-inch thick shim is ordinarily supplied with the relay unless a shim of different thickness is required to secure a longer or shorter time for certain applications.

If bimetallic shims are used, see that the bronze side of the shim is next to the armature, and make sure that brass screws (not steel screws) are used to fasten the shim in place on the armature. The effective air gap in the magnetic circuit when bimetallic shims are used is so small that such factors as accumulation of dirt particles, or mechanical wear will tend to affect the timing to a greater extent than when thicker shims are used.

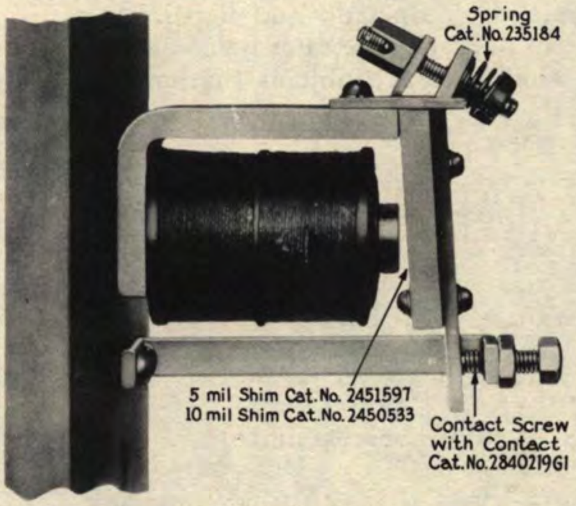


Fig. 8. Renewal Parts for CR2820-1054B Relay

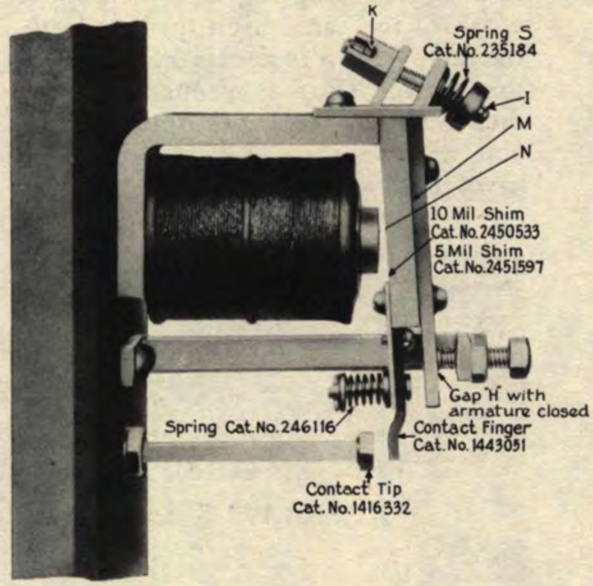


Fig. 9. Renewal Parts for CR2820-1054A Relay

In addition to affecting the amount of time delay, the shim prevents residual magnetism in the magnetic circuit from holding the armature closed indefinitely. A shim must always be used. While it may appear possible in some cases to secure a relatively long time delay by omitting the shim, the time is likely to be erratic, and it is probable that after a few operations the residual magnetism will prevent the armature from opening at all.

For the CR2820-1054B relay, the armature back stop screw is normally adjusted at the factory to give a gap of $\frac{1}{16}$ inch at (G), Fig. 1, with the armature closed, and it should not ordinarily be necessary to change this adjustment. For the CR2820-1054A relay, and for other forms without magnetic blowouts, gap (H), Fig. 2, should be $\frac{1}{4}$ inch. For CR2820-1054 relays with magnetic blowouts and arc chutes, this gap is usually $\frac{5}{16}$ inch.

Armature (M) may be easily removed without disturbing the calibration by removing cotter pin (I), while to change the calibration it is necessary to remove cotter pin (K).

RENEWAL PARTS

When ordering parts other than those shown in Fig. 8 or 9, give the complete nameplate rating of the relay and describe the part in detail.

WHEN SERVICE IS REQUIRED

THE facilities of our engineering divisions and factories are available to purchasers of G-E apparatus through G-E service shops and sales offices, a list of which is given below.

When it is necessary to renovate, repair, or change apparatus to meet a new operating condition or a new application, the facilities of the nearest G-E service shop are at your disposal. Each of them is equipped to turn out work of the same high quality, both as to workmanship and materials, as at the factory. If it is necessary that the work be done on the customer's premises, the service shop is prepared to send trained, competent, and dependable men who will do it promptly and efficiently. Similarly, the sales office nearest you will be glad to help you with any engineering problems that may be involved.

SERVICE SHOPS

Atlanta, Ga.....496 Glenn Street, Southwest
Buffalo 11, N. Y.....318 Urban Street
Charleston 28, W. Va.....306 MacCorkle Avenue, Southeast
Chicago 7, Ill.....849 South Clinton Street
Cincinnati 2, Ohio.....215 West Third Street
Cleveland 4, Ohio.....4966 Woodland Avenue
Dallas 2, Texas.....1801 North Lamar Street
Detroit 2, Mich.....5950 Third Avenue
Houston 1, Texas.....1312 Live Oak Street
Kansas City 8, Mo.....819 East Nineteenth Street
Los Angeles 54, Calif.....733 Banning Street
Milwaukee 3, Wis.....940 West St. Paul Avenue
Minneapolis 1, Minn.....410 Third Avenue, North
New York 14, N. Y.....416 West Thirteenth Street
Philadelphia 23, Pa.....429 North Seventh Street
Pittsburgh 6, Pa.....6519 Penn Avenue
St. Louis 1, Mo.....1110 Delmar Boulevard
Salt Lake City 9, Utah.....141 South Third West Street
San Diego, Calif.....2045 Tettner Boulevard
San Francisco 7, Calif.....361 Bryant Street
Seattle 4, Wash.....1508 Fourth Avenue, South
West Lynn 3, Mass.....920 Western Avenue
Youngstown 3, Ohio.....121 East Boardman Street

Special service divisions are also maintained at the following Works of the Company: Erie, Pa.; Ft. Wayne, Ind.; Pittsfield, Mass.; Schenectady, N. Y.; and West Lynn, Mass. (West Lynn Works)

APPARATUS SALES OFFICES (Address nearest office)

Akron 8, Ohio.....335 South Main Street
Atlanta 3, Ga.....187 Spring Street, Northwest
Baltimore 1, Md.....39 West Lexington Street
Beaumont, Texas.....398 Pearl Street
Binghamton, N. Y.....19 Chenango Street
Birmingham 2, Ala.....600 North Eighteenth Street
Bluefield, W. Va.....Appalachian Building
Boston 1, Mass.....140 Federal Street
Buffalo 2, N. Y.....1 West Genesee Street
Butte, Mont.....20 West Granite Street
Canton 1, Ohio.....700 Tuscarawas Street, West
Charleston 3, S. C.....18 Broad Street
Charleston 28, W. Va.....306 MacCorkle Avenue, Southeast
Charlotte 1, N. C.....200 South Tryon Street
Chattanooga 2, Tenn.....832 Georgia Avenue
Chicago 7, Ill.....840 South Canal Street
Cincinnati 2, Ohio.....215 West Third Street
Cleveland 4, Ohio.....4966 Woodland Avenue
Columbia 23, S. C.....1225 Washington Street
Columbus 15, Ohio.....40 South Third Street
Dallas 2, Texas.....1801 North Lamar Street
Davenport, Iowa.....511 Pershing Avenue
Dayton 2, Ohio.....25 North Main Street
Denver 2, Colo.....650 Seventeenth Street
Detroit 2, Mich.....700 Antoinette Street
Duluth 2, Minn.....14 West Superior Street
El Paso, Texas.....109 North Oregon Street
Erie 2, Pa.....10 East Twelfth Street
Evansville 19, Ind.....123 Northwest Fourth Street
Fairmont, W. Va.....511 Jacobs Building
Fort Wayne 2, Ind.....127 West Berry Street
Fort Worth 2, Texas.....408 West Seventh Street
Grand Rapids 2, Mich.....148 Monroe Avenue, Northwest
Hartford 3, Conn.....410 Asylum Street
Houston 1, Texas.....1312 Live Oak Street
Indianapolis 4, Ind.....110 North Illinois Street
Jackson, Mich.....212 Michigan Avenue, West
Jacksonville 2, Fla.....237 West Forsyth Street
Kansas City 6, Mo.....106 West Fourteenth Street
Knoxville 08, Tenn.....602 South Gay Street
Los Angeles 54, Calif.....212 North Vignes Street
Louisville 2, Ky.....455 South Fourth Street
Memphis 3, Tenn.....8 North Third Street
Miami 32, Fla.....25 Southeast Second Street
Milwaukee 3, Wis.....940 West St. Paul Avenue
Minneapolis 2, Minn.....12 South Sixth Street
Nashville 3, Tenn.....234 Third Avenue, North
Newark 2, N. J.....744 Broad Street
New Haven 6, Conn.....129 Church Street
New Orleans 12, La.....837 Gravier Street
New York 22, N. Y.....570 Lexington Avenue
Niagara Falls, N. Y.....253 Second Street
Norfolk 1, Va.....267 Bank Street
Oakland 12, Calif.....409 Thirteenth Street
Oklahoma City 2, Okla.....119 North Robinson Street
Omaha 2, Nebr.....409 South Seventeenth Street
Philadelphia 2, Pa.....1405 Locust Street
Phoenix, Ariz.....435 West Madison Street
Pittsburgh 22, Pa.....535 Smithfield Street
Portland 7, Ore.....920 Southwest Sixth Avenue
Providence 3, R. I.....111 Westminster Street
Reading, Pa.....31 North Sixth Street
Richmond 17, Va.....700 East Franklin Street
Roanoke 11, Va.....202 South Jefferson Street
Rochester 4, N. Y.....89 East Avenue
St. Louis 2, Mo.....112 North Fourth Street
Salt Lake City 9, Utah.....200 South Main Street
San Antonio 5, Texas.....310 South St. Mary's Street
San Diego 1, Calif.....861 Sixth Avenue
San Francisco 4, Calif.....235 Montgomery Street
Schenectady 5, N. Y.....202 State Street
Seattle 11, Wash.....710 Second Avenue
Shreveport B, La.....206 Market Street
Spokane 8, Wash.....421 Riverside Avenue
Springfield, Ill.....607 East Adams Street
Springfield 3, Mass.....1387 Main Street
Syracuse 1, N. Y.....113 South Salina Street
Tacoma 1, Wash.....1019 Pacific Avenue
Tampa 6, Fla.....1206 North A Street
Toledo 4, Ohio.....420 Madison Avenue
Tulsa 3, Okla.....409 South Boston Street
Utica 2, N. Y.....258 Genesee Street
Washington 5, D. C.....806 Fifteenth Street, Northwest
Waterbury 32, Conn.....111 West Main Street
Wichita 2, Kan.....102 South Broadway
Worcester 8, Mass.....165 Commercial Street
Youngstown 3, Ohio.....25 East Boardman Street

Canada: Canadian General Electric Company, Ltd., Toronto   Hawaii: W. A. Ramsay, Ltd., Honolulu

G-E products can also be obtained through Agents and Distributors located in principal cities and towns (3)

GENERAL ELECTRIC

9-44 (17M)
Filing No. B8490-CR2820

Superseding GEH-85D
PRINTED IN U.S.A.

INSTRUCTIONS

CR2820-1099

A-C MOTOR-OPERATED DEFINITE-TIME RELAY

GENERAL ELECTRIC

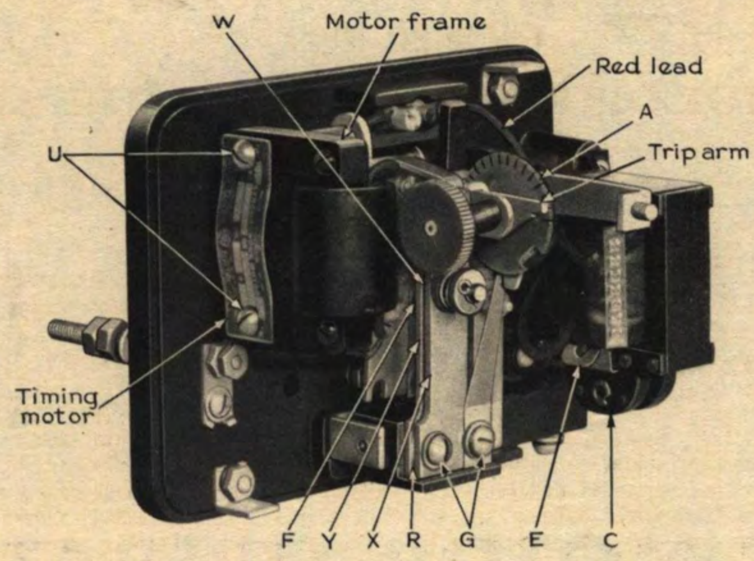


Fig. 1. CR2820-1099 Relay with Cover Removed

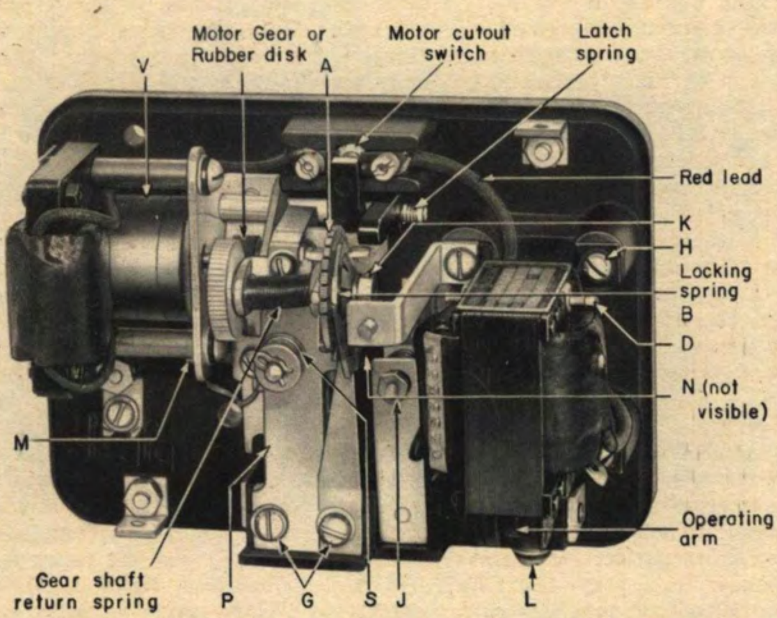


Fig. 2. Another View of Relay Shown in Fig. 1

CR2820-1099

A-C MOTOR-OPERATED DEFINITE-TIME RELAY

Operation

The CR2820-1099 time-delay relay is driven by a synchronous motor suitable for use on alternating current only. When the relay is energized, the solenoid engages the motor with the contact-operating mechanism; a tap on the solenoid provides the correct voltage for the motor. After the predetermined time interval has elapsed, the normally open contact (TC) closes, the normally closed contact (TO) opens (See Fig. 3 and 4), and the motor cutout switch (TO) disconnects the motor. The contacts remain in the timed-out position until the relay is de-energized, at which time the solenoid drops out and the contacts are reset instantly to their original position.

An interlock contact (J), Fig. 2, is provided to establish a holding circuit when the relay is energized from a momentary-contact push button as shown in Fig. 3. This contact is normally open, and closes when the solenoid is energized.

The time setting may be adjusted by releasing the locking spring (B) and turning the calibrating dial (A) until the locking spring is dropped into the slot marked with the desired time. The dial is calibrated either in seconds or in minutes, depending on the maximum time obtainable.

Certain relays (such as the CR2820-1099-P, -Q, -R, and -S) have a metal driving gear on the motor shaft, while others (including the CR2820-1099-AB, -AC, -AD, -AE, -AH, -AJ, and -AP) have a rubber disk on the motor shaft which drives by friction the metal gear on the calibrating unit assembly.

Replacing Solenoid or Coil

The solenoid consists of a frame, a plunger, a coil and two springs.

First, it is necessary to remove the four screws (H) and remove the solenoid and plunger from the base. This frees the plunger from the operating arm and the plunger (C) may then be removed. Then take out cotter pin (D) and springs (E). The coil may then be removed.

Before reassembling the solenoid the sealing surfaces should be cleaned (that is, the upper end of the plunger and the surface of the frame against which the plunger seats). The color-coded coil leads should be connected as shown in Fig. 4.

Maintenance of Relay

The silver contacts should not require any attention until the silver has worn almost completely away. To replace the interlock contacts remove screw (J). The movable contact and spring may then be removed and the stationary contact may be removed by unscrewing from the front of the base.

To replace the main contacts, first remove screws (G) and the calibrating unit assembly. The movable contacts may then be taken off by removing screw (F). To remove the stationary contacts first take off nut (M) and remove the complete movable contact assembly. The stationary contacts may then be unscrewed from their studs. On relays having a metal gear on the motor shaft, before tightening screw (M), the contact arm resetting spring must be wound up by inserting a screwdriver in the slotted end of shaft (N) and giving it three turns counter-clockwise. With the spring held in this position, tighten nut (M). In replacing the calibrating unit assembly on the relays having a rubber driving disk on the motor shaft, see that the pivoting bushings are replaced with screws (G) and that washers (R) are inserted between the two brackets of the calibrating unit assembly.

To replace the gear shaft return spring, remove the calibrating unit assembly as described in the preceding paragraph. Then remove nut (K), take off the calibrating disk, and pull out the gear shaft. Insert one end of the new spring through the hole provided in the calibrating-unit bracket on the gear side. Insert the gear shaft through the spring and slip the loose end of the spring through the hole in the trip arm. Push the gear shaft through the bearing and trip arm and assemble the calibrating disk and nut (K). Bend over at right angles the end of the spring projecting through the calibrating unit bracket. Pull out the other end of spring 1½ inches, bend at right angle, and cut off excess wire. Care must be taken in assembling the calibrating disk back on the shaft to have the forked portion over the projection on the bracket.

In replacing the latch spring, insert one end of the spring through the hole in the latch arm, tighten the spring by giving it ½-turn clockwise, and reset the other end in the slot provided in the end of the shaft. Pinch the slotted end of the shaft together to clamp the end of the spring in place.

For relays having the rubber disk on the motor shaft, the rubber disk should be replaced if it has worn so the gap between brackets (X) and (Y) at point (W) is reduced to $\frac{1}{32}$ in.

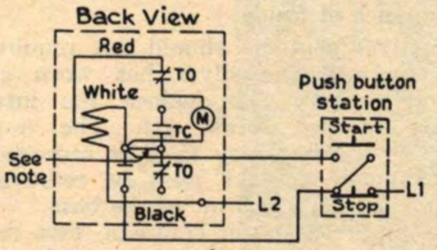


Fig. 3. Connections with Momentary-contact Push-button Station

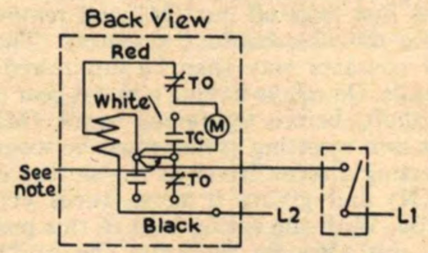


Fig. 4. Connections with Maintaining-contact Master Switch

NOTE: If the relay studs in Fig. 3 and 4 are connected by a punching, as indicated, the punching should be removed unless the wiring diagram shows these studs connected together.

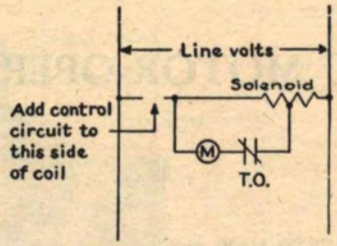


Fig. 5. Elementary Connections

Renewal Parts

Renewal parts should be ordered from the nearest Sales Office of the General Electric Company, Cat. No. as listed below:

	Cat. No.
Movable contact for interlock	3805658G8
Stationary contacts for interlock, for normally open and for normally closed contacts	3805657G1
Movable contact, normally open or normally closed	4901681G1
Torsion spring for latch arm	2413952
Compression spring for motor cut out switch contact	2412941
Spring for interlock contact	2411917
Gear shaft return spring	2413999
Torsion resetting spring for contact arm (omit for relays having rubber disk drive)	2414157
Spring (S, Fig. 2). Used only for relays having rubber disk drive	235182
Rubber disk, $\frac{25}{32}$ in. diam for 2–20 and 4–40 second relays (if used)	5181591
Rubber disk, $\frac{33}{64}$ in. diam for other relays (if used)	5352523

PRINTED IN U.S.A.

INSTRUCTIONS

CR2820-1729 DEFINITE-TIME RELAY

The CR2820-1729 definite-time relay provides 2, 4, 6, or 8 contacts with independent time adjustment.

The contacts will carry continuously 15 amperes and make momentarily 30 amperes, but should not be used to interrupt current in excess of the values tabulated below:

Alternating Current		Direct Current	
Amp	Volts	Amp*	Volts
30	110		
20	220	1	125
4	440	0.3	250
3	550	0.1	500

*For time-opening contacts adjusted to open in less than the total time setting, use one half of values tabulated for d-c.

Relays can not be supplied for use on 25-cycle supply voltage.

Mounting

The CR2820-1729 relay must be mounted in a vertical position with the escapement mechanism at the bottom as shown in Fig. 1.

Operation

The relay shown in Fig. 1 has two contacts, (A) normally closed, and (B) normally open. A solenoid (C) has its plunger connected to an escapement mechanism (D). When the solenoid is energized, the mechanism and all contacts connected to it, whether normally open or normally closed, are actuated instantaneously by the solenoid plunger on the up stroke. When the solenoid is de-energized, the escapement mechanism provides time delay action for the contacts. In Fig. 1 the contact (A) has a time delay on closing, and contact (B) has time delay on opening. Other forms are available having various combinations of normally open and normally closed contacts, some forms having time delay after the solenoid is de-energized, and others having the time delay after the solenoid is energized.

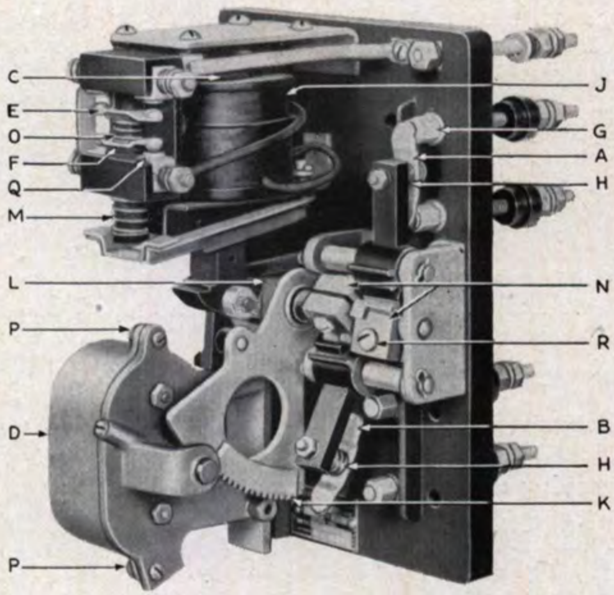


Fig. 1. CR2820-1729A Definite-time Relay

Renewal Parts

Ref Letter Fig. 1	CR2820-1729-	Cat. No.	Description
A. B	All Forms	3667572G1	Movable Contact
G	All Forms	3840413G2	Stationary Contact
H	All Forms	2411917	Contact Spring
L	A, B, C, D	2415130	Clutch Spring
L	E to AK, incl	2415131	Clutch Spring
E, F	A, C, E, G, J, L, P, Q, R, S, T, V, AA, AB, AC, AD, AF, AG, AH	3805658G8	Interlock Movable Contact
Q	A, C, E, G, J, L, P, Q, R, S, T, V, AA, AB, AC, AD, AF, AG, AH	3845725G3	Interlock Stationary Contact
O	Q, S, T, V, AA, AB, AG	2411917	Interlock Contact Spring
O	A, C, E, G, J, L, P, R, AC, AD, AF, AH	2414612	Interlock Contact Spring
M	A, C, E, G, J, L, P, Q, R, S, AB, AC, AD, AF, AH	2413639	Interlock Operating Spring
M	T, V, AA, AG	2238080	Interlock Operating Spring
J	All Forms	Order by Cat. No. on Spool	Coil

The instantaneous interlocks shown at (E) and (F) in Fig. 1 are used on forms of the relay for direct current. The normally open interlock (E) may be used to form a holding circuit around the push-button contacts in using push-button control, and normally closed interlock (F) is used to either cut out part of the solenoid-coil turns or to cut out a resistance in series with the solenoid coil to give more pull on closing.

Standard a-c relays do not have the instantaneous interlocks E and F, although special a-c relays may have a normally open instantaneous interlock similar to that shown at E, Fig. 1, for use as a holding interlock with a momentary-contact push button.

Connections

Figs. 2, 3, and 4 show the method of connecting the CR2820-1729A relay for use on control circuits in which a number of contacts are set to operate in definite-time sequence. The interlocks (2) and (3), Fig. 2, should always be connected to the same side of the line.

Adjustment

The total time delay may be regulated by moving the adjusting screw on the escapement arm up or down. In order to change the adjustment, it will first be necessary to remove nuts (P) and cover (D). Setting the screw at the top end of the long slot in the arm gives the shortest time, and setting it at the bottom end of the slot gives the longest time. The time interval between opening or closing of the various contacts is adjusted by changing the position of the operating gears (N), Fig. 1, first loosening screw (R). Relay forms A, B, C, D, L, M, and Q have a time range of 1 to 7 seconds, and Forms E, F, G, H, J, K, N, P, R, and S have a time range of 1 to 10 seconds.

Disassembling Solenoid

To take out the solenoid coil it is necessary to remove the frame from the supporting bracket and then take out the plunger. This may be done without disconnecting the plunger from the escapement mechanism. Remove the plunger guides and the two spacing springs between the coil and frame, and then the coil will drop out.

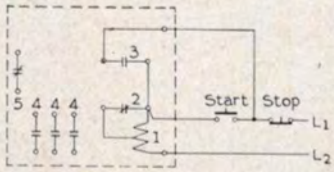
Maintenance

The CR2820-1729 relay should not be oiled as it has had lubricant applied at the factory which is sufficient for its normal life.

The contacts are faced with solid silver and will give long life under normal service within their rating. They should not be dressed with a file but should be renewed in case of excessive wear.

Renewal Parts

When ordering renewal parts, refer to the table beneath Fig. 1; order by Cat. No. For any parts not listed, refer to the nearest sales office of the General Electric Co.; give the complete nameplate rating of the relay, and describe the part in detail.



1. Solenoid
2. Interlock, Normally Closed
3. Interlock, Normally Open
4. Contacts, Normally Open, Time Closing
5. Contact, Normally Closed, Time Opening

Fig. 2. Typical Connection Diagram for D-c Circuits of 250 Volts or Less (Back View)

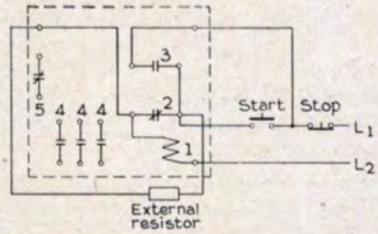


Fig. 3. Typical Connection Diagram for D-c Circuits with Voltages Higher Than 250 Volts

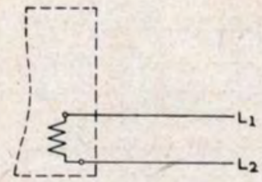


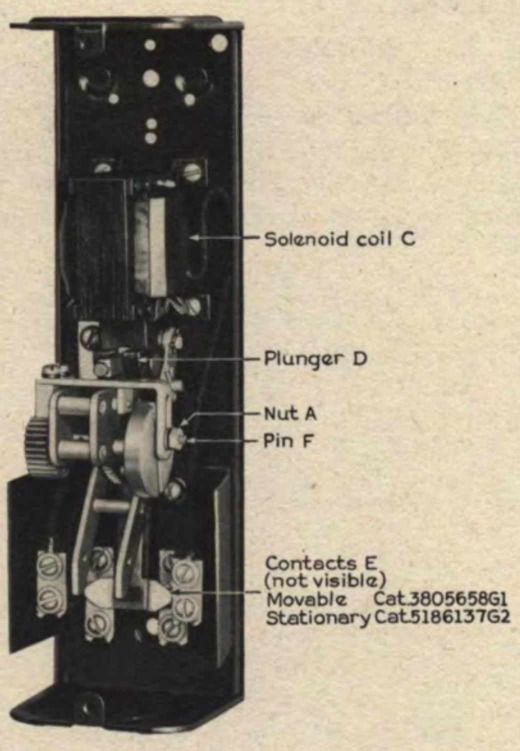
Fig. 4. Coil Connection Diagram for A-c Circuits

10-43 (2M)
Filing No. 8490-CR2820

Superseding GEH-1141
PRINTED IN U.S.A.

INSTRUCTIONS

TIME DELAY RELAY
CR2820-1731A AND 1731B
Also for Form..................Switch



Movable Contact	Stationary Contact
Cat. 4929723G6 for CR2820-1713A	Cat. 5186137G2 for CR2820-1731A
Cat. 5346421G1 for CR2820-1731B	Cat. 5346423G1 for CR2820-1731B

Fig. 1. CR2820-1731A Time-delay Relay (Cover Removed)

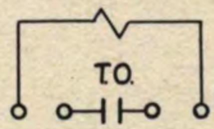


Fig. 2.
Internal Connections
(CR2820-1731A)

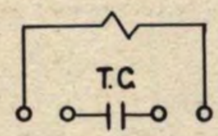


Fig. 3.
Internal Connections
(CR2820-1731B)

The CR2820-1731 time-delay relay provides either an instantaneous-closing time-delay opening (1731A), or an instantaneous-opening time-delay closing (1731B) device, for use in control circuits. The relay is designed for applications that require only infrequent operation; for example, as an under-voltage relay.

INSTALLATION

The switch should be mounted on a vertical surface as free from vibration as possible, with the solenoid coil (C) mounted at the top.

Check the voltage and frequency stamped on the nameplate of the relay with that of the panel to which it is connected. The relay is designed for alternating-current circuits only.

ADJUSTMENTS

These relays are adjusted in the factory, and under ordinary conditions the time adjustment need not be disturbed. However, if this time interval is not correct, it can be changed by loosening nut (A), Fig. 1, and moving pin (F) down for increased time or up for decreased time. The time may be adjusted from 1 to 4 seconds.

OPERATION

When the CR2820-1731A solenoid coil (C) is energized, plunger (D) is lifted and contacts (E) are closed instantly.

Upon removal of voltage to the coil, plunger (D) starts to drop but is retarded by the escapement mechanism. As the rack nears the end of its travel, it drops off the pinion and releases the arm, opening contacts (E). Contacts (E) will not reclose until the solenoid coil (C) is reenergized.

If voltage is reapplied before the arm is released, contacts (E) remain closed.

GENERAL ELECTRIC
SCHENECTADY, N.Y.

When the CR2820-1731B solenoid coil (C) is energized, plunger (D) is lifted and contacts (E) are opened instantly.

Upon removal of voltage to the coil, plunger (D) starts to drop but is retarded by the escapement mechanism. As the rack nears the end of its travel it drops off the pinion and releases the arm, closing contacts (E). Contacts (E) will not reopen until solenoid coil (C) is re-energized.

If voltage is reapplied before the arm releases, contacts (E) remain open.

CARE OF RELAY AND CONTACTS

The switch is lubricated in the factory and should require no further lubrication during its life.

In general, the contact tips do not require attention during their normal life. The silver contacts must be replaced before they are completely worn down to their supports. The renewal contacts consist of the silver tips assembled on their supports.

RENEWAL PARTS

Renewal parts should be ordered by the Cat. No. given in Fig. 1. For other parts not identified by Cat. No. refer to the nearest Sales Office of the General Electric Company giving the complete nameplate rating of the relay and describing the part in detail.

2-44 (3M)
Filing No. B8490-CR2820

Superseding GEH-1016B
PRINTED IN U.S.A.

CR2953-7 DEFINITE TIME INTERLOCK

These geared type time interlocks are adjustable between ½ and 4 seconds and are for use on a-c contactors to provide a time interval between the closing of the contactor and the opening or closing of the contacts on the interlock.

CR2953-7C forms have contacts which are OPEN when the contactor is de-energized but have a delayed CLOSING after the contactor is energized. Contacts open quickly when contactor is de-energized.

CR2953-7D forms have contacts which are CLOSED when the contactor is de-energized but have a delayed OPENING after the contactor is energized. Contacts close quickly when contactor is de-energized.

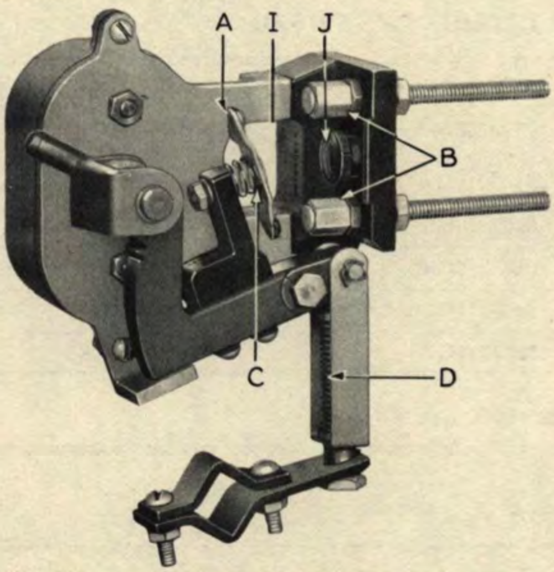


Fig. 1. CR2953-7C Interlock, Normally Open Contact, Time Closing

The contacts will carry continuously 15 amperes, make momentarily 40 amperes, and break the values of current listed below:

A-c Volts	Amp
110	40
220	20
440	8
550	6

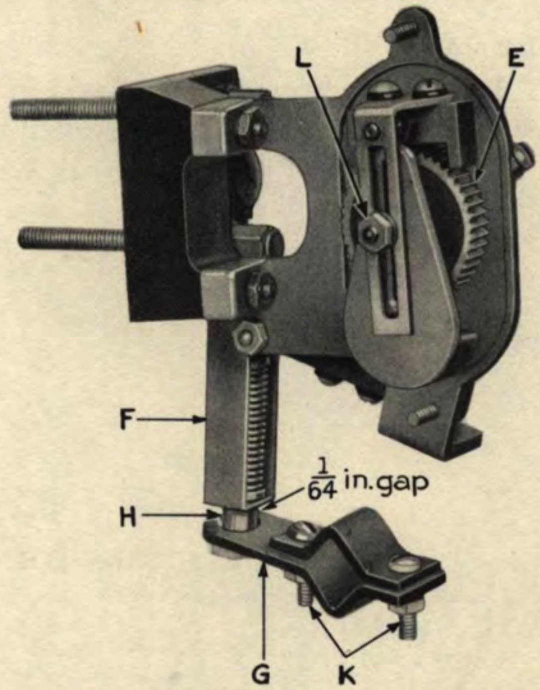


Fig. 2. CR2953-7 Interlock with Cover Removed to Show Escapement and Means of Adjusting the Time Interval

ASSEMBLY AND TIME ADJUSTMENT CR2953-7C, FIG. 1 AND 2

Assemble interlock to panel and connect links (F) to operating lever (G). When contactor armature is sealed in CLOSED position the head of Screw (I) should close against insulated unit (J) with a gap of $\frac{1}{64}$ in. between links (F) and pull rod (H). This combination is obtained by adjusting Screw (K).

CR2953-7D, FIG. 2 AND 3

This form is similar to form 7C except that the head of screw (I) must close against part (Q) with a gap of $\frac{1}{64}$ in. between links (F) and pull rod (H).

TIME ADJUSTMENT FOR BOTH FORMS, FIG. 2

The interlock is adjusted at the tactory to give approximately 2½ seconds time interval.

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.

GENERAL ELECTRIC

To obtain more or less than this, loosen nut (L) and move same up to obtain a shorter time interval and down for a longer time interval. Tighten nut after time adjustment is obtained.

Lubrication

The interlock bearings are lubricated with a graphite lubricant and should not require further lubrication during their life.

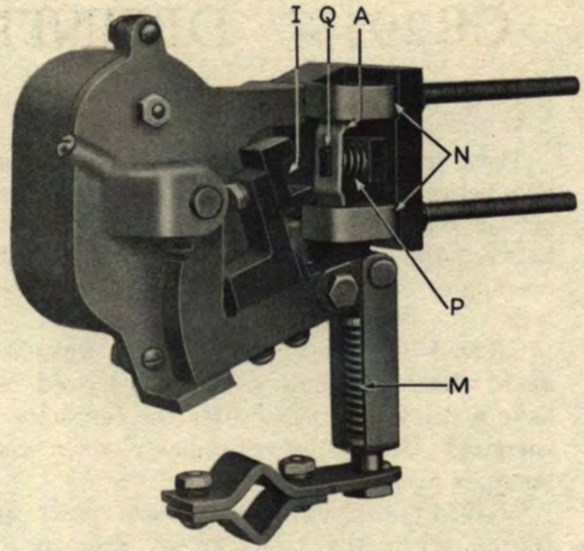


Fig. 3. CR2953-7D Interlock, Normally Closed Contact, Time Opening

CONTACTOR WITH WHICH INTERLOCK IS USED

8-hour Amp Rating	Contactor	CAT. NO. OF INTERLOCK	
		CR2953-7C	CR2953-7D
75	CR2810-1343, -1353	5167219G1	5167219G2
150	CR2810-1553	5167219G9	5167219G10
300	CR2810-1563	5167219G3	5167219G4
600	CR2810-1573	5167219G11	5167219G12
1000	CR2810-1251	5167219G7	5167219G8

RENEWAL PARTS—SEE FIG. 1, 2, AND 3

Ref Letter	CR2953-7C Cat. No.	CR2953-7D Cat. No.	Name of Part
A	3667572G1	3667572G1	Movable contact
B	3840413G2	....	Stationary contact
C	2411917	....	Spring for movable contact
D	....	....	Spring for operating arm
E	5371332G4	5371332G4	Shaft and ratchet assembly
F	4963667P7	4963667P7	Pinion (not shown in illustration)
M		....	Spring for operating arm
N		4962365G2	Stationary contact
P		2414109	Spring for movable contact

READ These INSTRUCTIONS Before INSTALLING

INSTRUCTIONS

HORIZONTAL, POLYPHASE INDUCTION MOTORS

SQUIRREL CAGE AND WOUND ROTOR—OPEN AND SPLASHPROOF

FRAMES 203 TO 579 INCLUSIVE AND FRAMES 6323 TO 6339 INCLUSIVE

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.

INSTALLATION

Location

1. OPEN MOTORS. Install in a clean, well-ventilated place. If motors are stored, store in a clean, dry place.
2. SPLASHPROOF MOTORS. Where a choice of locations is possible, locate the motor so that it will be subjected to the least amount of splashing.

Lifting

When lifting a motor, it is advisable to lift by means of slings placed under the bearing housings.

Floor Mounting

1. FOUNDATION should be rigid and solid. Level the motor base (or motor). A motor base on a concrete foundation should be grouted in place.

Wall or Ceiling Mounting

1. OIL-LUBRICATED, SLEEVE-BEARING MOTORS (may be identified by spring-cover sight hole on top of bearing housing): End shields should be located with oil-filler gage in horizontal position below the center of the shaft.
2. GREASE-LUBRICATED, BALL-BEARING MOTORS (may be identified by pressure-grease fitting on top of bearing housing): End shields should be located with pressure-gun fitting on top as close to vertical as the bolt holes permit.

NOTE: Screenless open type textile motors are not designed to permit end shield rotation for wall or ceiling mounting.

Tilted and Vertical Mounting

1. SLEEVE-BEARING, OIL-LUBRICATED MOTORS should always be mounted with the shaft horizontal.
2. GREASE-LUBRICATED, BALL-BEARING MOTORS in Frames 203–326 (incl) may be operated in any position, provided excessive thrust loads are not imposed.

Motors in Frames 365 and larger should have the bearings modified for vertical operation.

Mounting a Motor Having Wool-yarn-packed Sleeve Bearings

A motor having wool-yarn-packed sleeve bearings should always be mounted so that the load will never be applied on the side of the bearing lining in which the opening for oil feeding appears.

Face or Flange Mounting

Carefully align the motor with the driven unit and securely bolt into place.

Alignment

Always align accurately with the driven unit. When aligning an adjustable base, allow for movement, and locate the adjusting screwhead away from the driven unit.

Coupled Drive

When the motor and driven unit together have four or more bearings, flexible couplings may be used to facilitate alignment. Three-bearing construction requires rigid coupling.

Flat Belt Drive

Arrange the location of the driving and driven shaft so that they are parallel. Adjust belt tension just enough to prevent slippage; excess tension unnecessarily loads the bearings. Avoid a vertical drive; an angle of 45 deg or less between the line of shaft centers and the horizontal is desirable. Distance between centers should be at least 2½ times the diameter of the larger pulley unless a belt-tightener attachment is used. Pulley ratio should not exceed 5 to 1. Belt speed should not exceed 5000 feet per minute. If possible, make the lower side of belt the driving side. Run the grain or smooth side of the belt on the pulleys. Check the recommendations of the belt manufacturer for the diameter of the smallest pulley to use for a particular belt thickness.

"V" Belt Drive

Align the sheaves carefully to avoid thrust on the bearings. Adjust belt tension just enough to prevent excessive sag of the slack side. If possible, make the lower side the driving side. Pulley ratio should not exceed 8 to 1. Belt speeds should not exceed 5000 ft per minute, unless otherwise recommended by belt manufacturer. Check recommendations of belt manufacturer for the diameter of the smallest sheave which should be used.

Chain Drive

Align sprockets and adjust chain just enough to permit a slight sag on the slack side. Avoid vertical drive; an angle of 45 deg or less between the line of shaft centers and the horizontal is desirable. The distance between shaft centers should not be less than the diameter of the larger sprocket plus the radius of the smaller. If possible, make the lower side the driving side. Consult the chain manufacturer for maximum ratio and speed of chain, minimum sprocket diameter, and lubrication of the chain.

Gear Drive

Motor should be ball-bearing type for helical gears since they impose axial thrust on the bearings. The pinion diameter should not be less than that recommended by the General Electric Company. When quiet gear drive is desired, Textolite pinions with helical teeth should be used. Consult the nearest sales office of the General Electric Company for recommendation.

GENERAL ELECTRIC

Position of Oil Filler Gage

Oil filler gages on sleeve-bearing motors may be located on the most convenient side of the bearing housing. However, it is desirable to locate the gage on the side of the housing on which the oil ring enters the oil. Use oil sealing compound (such as G-E No. 1201 Glyptal compound) on threads on pipe plug and oil filler gage when interchanging.

Position of Conduit Box

It is standard practice to locate the conduit box on the left-hand side of the motor viewed from the driving end. The conduit box may be located on the opposite side by removing the end shields and rotor, turning the stator frame around, and reassembling.

Relocating the position of the secondary leads of wound-rotor motors requires redrilling and rethreading the end shield at the desired point.

Connection of Stator Winding

Single-speed motors with three leads (three phase) or four leads (two phase) for single voltage should have leads connected one to each line.

Single-speed motors with nine leads (three phase) or eight leads (two phase) for dual voltage should be connected in accordance with the connection diagram plate on the motor.

Multispeed motors should be connected in accordance with the diagram, the number of which is stamped on the nameplate.

Wiring and Grounding

Motor and control wiring, overload protection, and grounding should be done in accordance with the National Electrical Code and local requirements.

OPERATION

Before Initial Starting

1. If a motor has become damp in shipment or in storage, it is advisable to measure insulation resistance of the stator winding with an insulation-resistance meter; this value should be not less than:

$$\frac{\text{Rated voltage}}{(0.75 \times \text{hp rating}) + 1000} \text{ megohms}$$

2. If insulation resistance is lower than this value, it is advisable to dry out the moisture in one of the following ways:
   a. Bake motor in oven at temperature not exceeding 90 C until insulation resistance becomes practically constant.
   b. Enclose motor with canvas or similar covering, leaving a hole at the top for moisture to escape, and insert heating units or lamps.
   c. Pass a current at low voltage (rotor locked) through the stator windings. Increase the current gradually until winding temperature, measured with a thermometer, reaches 90 C. Do not exceed this temperature.
3. See that the voltage and frequency stamped on motor and control nameplates correspond with that of the line.
4. Check all connections to the motor and control with the wiring diagrams.
5. For sleeve-bearing motors fill each sleeve-bearing reservoir, through the oil filler gage to within 1/8 inch of the gage overflow level, with a good grade of mineral oil.

NOTE: Oil-lubricated, sleeve-bearing motors in frames covered by these instructions are shipped without oil.
Grease-lubricated, ball-bearing motors are shipped with bearing housings packed with grease.

6. Be sure rotor turns freely, and does not rub when disconnected from load. Any foreign material in the air gap should be removed.
7. Leave the motor disconnected from the load for the initial start; it is desirable to operate the motor without load for about one hour to test for any unusual localized heating in bearings and windings. Be sure that the oil ring on sleeve-bearing motor turns freely. Check for proper rotation.

Reversal of Rotation

Three-phase: Interchange any two line leads.
Two-phase: Interchange lines of either phase.

Heating

Open and splashproof motors are rated 40 C rise and 50 C rise respectively. The actual operating temperature of the motor, however, is this rise plus the temperature of the surrounding air. An open motor operating in a 30 C (86 F) temperature, for example, may reach a total temperature of 40+30=70 C (158 F). These motors will withstand a maximum observable temperature of 90 C (194 F) without harm to the insulation if encountered infrequently.

Allowable Voltage and Frequency Range

If voltage and frequency are within the following range, motors will operate, but with somewhat different characteristics than obtained with correct nameplate values:

1. Voltage: Within 10 per cent above or below the value stamped on the nameplate.
2. Frequency: Within 5 per cent above or below the value stamped on the nameplate.
3. Voltage and Frequency together: Within 10 per cent (providing frequency alone is less than 5 per cent) above or below values stamped on the nameplate.

MAINTENANCE

Oil Sleeve Bearings

For average indoor temperatures, use a good grade of mineral oil having a viscosity of 150 to 200 seconds Saybolt at 100 F. For higher temperatures and for slow-speed belted motors, slightly heavier oil with a viscosity of 250 to 350 seconds Saybolt at 100 F may be required. (In automotive terms, the above viscosities correspond to SAE No. 10 and SAE No. 20 respectively. but turbine oil rather than automotive oil is recommended.) Reputable oil companies should be consulted regarding special lubricants for unusual operating conditions.

Cleaning Sleeve Bearings

Sleeve-bearing housings are provided with liberal settling chambers into which dust, dirt, and oil sludge collect. The only cleaning necessary is to remove the drain plug and drain the oil, which will flush out most of the settled material with it.

NOTE: Frames 203, 204, 224, and 225 do not have drain plugs, and may be flushed through the oil filler gage. After draining, seal the threads of the drain plug with an oil sealing compound (such as G-E No. 1201 Glyptal compound) and refill the oil reservoir.

Whenever the motor is disassembled for general cleaning, the bearing housing may be washed out with a solvent such as carbon tetrachloride. Dry the bearing lining and cover the shaft with a film of oil before assembling.

Wool-yarn-packed, Oil-lubricated Sleeve Bearings

Oiling:

Wool-yarn-packed, oil-lubricated, sleeve-bearing motors are shipped less oil but with a packing of good grade coarse wool yarn in place in the bearing housings.

Before starting the motor initially remove the drain plug and pour a liberal quantity of oil over the yarn and bearing lining, allowing the excess oil to drain off. Replace the drain plug, coating it with an oil-sealing compound (such as G-E No. 1201 Glyptal compound). Add oil through the oil filler gage before starting the motor and at regular intervals* thereafter, maintaining a level approximately 1/8-inch below the top of the gage. For average indoor temperature a good grade of mineral oil as described on page 2 under Oil Sleeve Bearings should be used. Pick up and repack the yarn occasionally* to prevent its becoming matted.

* NOTE: The length of time intervals must be determined by the motor user since it depends upon the severity of operating conditions. Wipe housings dry after any spillage or overflow.

Cleaning:

Used oil should be drained off and new oil added occasionally as outlined above.

Whenever the motor is disassembled for general cleaning and reconditioning, the yarn packing should be removed, the bearing housing washed clean with a solvent such as carbon tetrachloride, and the housing repacked with clean wool yarn. The new yarn should be saturated with oil as outlined above.

Removal of Sleeve-bearing Lining (Tri-Clad Motors)

(a) Remove baffle inside end shield. (For Frames 203 to 326. On larger frames, this is unnecessary.)

(b) Remove oil well cover plate.

(c) Remove oil ring retaining clip.

(d) With oil ring disengaged, bearing lining can now be tapped out.

Greasing Ball Bearings

Ball-bearing motors covered by these Instructions are usually shipped with the bearing housings packed with G-E grease. However, to be sure there is sufficient grease present before placing the motors in operation, more grease should be added to each bearing, using the procedure outlined below. After the initial start, the length of time before adding grease again depends upon operating conditions.

These ball-bearing motors are equipped with pressure-gun grease fittings and pressure-relief plugs which, if used according to instructions, provide convenience in greasing. The grease should be added as often as operating conditions demand with a hand-operated (not pedal- or air-operated) pressure gun as follows:

1. Wipe clean the pressure gun fitting and the regions around the fitting and relief plug.
2. Remove relief plug.
3. Free the relief hole of any hardened grease.
4. Add grease with the motor running until it is expelled through the relief hole. (If fittings are not safely accessible with motor running, grease may be added sparingly with motor at rest.) Adding until new grease is expelled purges the housing of old grease.
5. Run the motor for about 20 minutes with the relief plug removed to expel excess grease.
6. Clean and replace the relief plug.

Exclusion of dirt from the housings and the lubricant is very important.

A good grade of grease should be used, having the following characteristics:

a. ASTM worked consistency 300–330 with minimum change over the range of operating temperatures.
b. Melting point preferably above 150 C.
c. Freedom from separation of oil and soap.
d. Freedom from abrasive matter and acidity.

For the convenience of motor users, the General Electric Company can supply special G-E greases in cans and drums.

Cleaning Ball Bearings

Since the method of greasing ball bearings tends to purge the housing of used grease, removal of all grease should be required infrequently. Whenever the motor is disassembled for general cleaning, however, the bearings and housings should be cleaned of old grease by washing with carbon tetrachloride.

If desired, ball bearings of horizontal motors only can be cleaned without disassembly of the motor as follows:

1. Remove pressure fitting and relief plug.
2. Free both holes of any hardened grease.
3. Replace bottom relief plug and fill housing with flushing liquid, with the motor running. After about 10 minutes, drain off. Repeat this process adding enough liquid to partly fill the housing each time, until the liquid being drained comes out clear, showing that most of the grease has been removed.
4. Rinse housing free of carbon tetrachloride with small amounts of light mineral oil **only** if carbon tetrachloride was used for flushing. Replace relief plug.

Removal of Ball Bearings

Ball bearings can be removed from the rotor shaft by using a puller, or by tapping against the bearing cartridge or cap located on the shaft between the bearing and the rotor.

Cleaning Assembled Motor

The interior and exterior of the motor should be kept free from dirt, oil, and grease. Motors may be blown out with dry compressed air of moderate pressure. If possible, however, clean by suction because of the danger of moisture in compressed air and blowing metal chips, etc., into the insulation. Motors operating in dirty places should be disassembled and cleaned periodically.

Cleaning Insulation

Whenever the motor is disassembled for general cleaning, the insulation may be cleaned as follows:

1. Brush windings free of dust, and wash with cloth or brush wetted with carbon tetrachloride. Carbon tetrachloride is very volatile, and will not soak or injure the insulation if not applied too generously. Allow plenty of ventilation, to avoid toxic effects.
2. Dry the insulation by one of the methods explained under OPERATION.

3. When winding is dry and still warm, apply a high-grade insulating varnish by brushing, spraying, or dipping. Bake for 6 or 7 hours at a temperature not exceeding 90 C, or merely allow the winding to dry if a quick and air-drying varnish is used. More than one coat of varnish may be required, depending on the condition of the winding.

The General Electric Company can furnish insulating varnish best suited for definite operating conditions. Consult the nearest G-E office.

Collector Rings (Wound-rotor Motors Only)

The collector rings are sometimes slushed at the factory to protect them while in stock and during shipment. The brushes have been fastened in a raised position. Before putting the motor into service, the brushes should be set down on the collector surface.

Keep the rings clean and maintain their polished surfaces. Ordinarily the rings will require only occasional wiping with a piece of canvas or nonlinting cloth. Do not let dust or dirt accumulate between the collector rings.

Brushes (Wound-rotor Motors Only)

See that the brushes move freely in the holders and at the same time make firm, even contact with the collector rings. The pressure should be between 2 and 3 lb per square inch of brush surface.

When installing new brushes, fit them carefully to the collector rings. Be sure that the copper pigtail conductors are securely fastened to, and make good contact with the brush holders.

Air Gap (Sleeve-bearing Motors)

When the air gap of a sleeve-bearing motor, as measured with a tapered air-gap gage, is less than the minimum value given in the table below, the bearing linings may need replacement:

APPROXIMATE MINIMUM AIR GAP

Frame Number	Minimum Air Gap in In.
203 to 326 incl	0.008
364 to 559 incl	0.014
6323 to 6339 incl	0.014
561 to 579 incl	0.020

(Ball-bearing Motors)

Ball bearings do not wear gradually; rather, if they fail, they do so completely in a very short time. Therefore, there is no need to check air gap on a ball-bearing motor.

Locating Troubles

If trouble is experienced in the operation of a motor, make sure that:

1. The bearings are in good condition and are lubricated properly.
2. There is no mechanical obstruction preventing rotation.
3. The air gap is substantially uniform.
4. All bolts and nuts are tightened securely.

In checking for electrical troubles, be sure:

1. That voltage is actually available in all phases at the motor terminals.
2. That line voltage and frequency correspond to the values stamped on the motor nameplate. (Refer to paragraph on "Allowable Voltage and Frequency Range.")
3. That the overload protective devices are in proper condition.
4. That all connections and contacts are properly made in the circuits between the control apparatus and the motor.
5. That the motor is not excessively overloaded. This may be checked by comparing line amperes with the full-load ampere rating stamped on the motor nameplate.

Renewal Parts

When ordering renewal parts give quantity, catalog number if available, description of each item required, and the model number of the motor.

Requests for additional copies of these instructions or inquiries for specific information should be addressed to the nearest sales office of the General Electric Company.

APPARATUS DEPARTMENT

GENERAL ELECTRIC

SCHENECTADY, N. Y.

10-47 (110M)

Supersedes GEH-790L

PRINTED IN U.S.A.

Instantaneous Auxiliary Relays

TYPES

HMA11A	HMA12A	HMA13A	HMA15A
HMA11B	HMA12B	HMA13B	

The type HMA relay is an instantaneous auxiliary device whose contacts are opened and closed by the movement of a hinged armature. The following models are supplied for operation on all standard voltages both a-c and d-c. All back connected relays are supplied either with or without cover; front connected models are available without cover only. Internal wiring diagrams for all models are shown on the reverse side of this sheet.

The HMA11A is a back connected relay having double-pole double-throw contact arrangement. The two moveable contacts are electrically separate and are held in position on the armature by means of a textolite contact carrier and spring housing. The HMA11B is similar to the HMA11A except that it is front connected.

The HMA12A is a back connected model and has a single-pole, double-throw, double-break contact arrangement. The moving contact consists of a contact bridge mounted directly on the armature by a spring and post arrangement. In a closed position the moving contact bridges either the front or back set of contacts. The HMA12B is similar to the HMA12A except that it is front connected.

The HMA13A and HMA13B are similar respectively to the HMA12A and HMA12B except that the moving contact bridge has been wired to a terminal stud so that the relay has two normally open and two normally closed contacts with the moving contact common to all four.

The HMA15A is similar to the HMA11A except that it has a special holding coil winding and has but one circuit opening contact.

INSTALLATION

The relay can be mounted on either a horizontal or vertical surface. Insulating bushings for steel panel mounting will be supplied at no extra charge if they are specified in the order. The outline and drilling plan of each model is shown on the other side of this sheet.

ADJUSTMENT

All relays are properly adjusted at the factory. Relays for direct current service are adjusted to pick up at 60 per cent of their rating when cold and 80 per cent when hot. Relays for alternating current service are adjusted to pick up at 80 per cent of their rating.

Normally it should not be necessary to make any further changes in these adjustments. If, however, the correct pick-up is not realized, adjustments can be made by changing the tension of the armature restraining spring. This is accomplished by bending the projecting spring holder on the armature stop. The spring tension should not be so low that the back contact wipe is sacrificed.

CONTACTS

The contacts of the HMA relay are self-aligning and should not require adjustment. If it becomes necessary to clean the silver contacts, use a thin fine file. Never use such material as emery paper or crocus cloth as they imbed non-conducting material in the contact surface.

INTERRUPTING RATINGS OF CONTACTS IN AMPERES

Volts		Single Break	Double Break
A-C	D-C		
NONINDUCTIVE CIRCUITS			
...	6-32	15	30
...	48	10	20
...	125	1.5	3
...	250	0.25	0.5
115	...	20	30
230	...	13	25
460	...	5	10
INDUCTIVE CIRCUITS			
...	6-32	7.5	20
...	48	3	7.5
...	125	0.75	1.0
...	250	0.1	0.25
115	...	15	15
230	...	10	10
460	...	5	5

BURDENS

Volts	Frequency Cycles or D-c	D-c Resistance Ohms (25 C)	Watts (25 C)	Volt-amperes
6	D-C	5.5	7	....
12	D-C	21	7	....
24	D-C	81	7	....
32	D-C	146	7	....
48	D-C	335	7	....
125	D-C	2160	7	....
115	60	270 (d-c)	5.5	9.5
230	60	1030 (d-c)	5.5	9.5

GENERAL ELECTRIC

SCHENECTADY, N.Y.

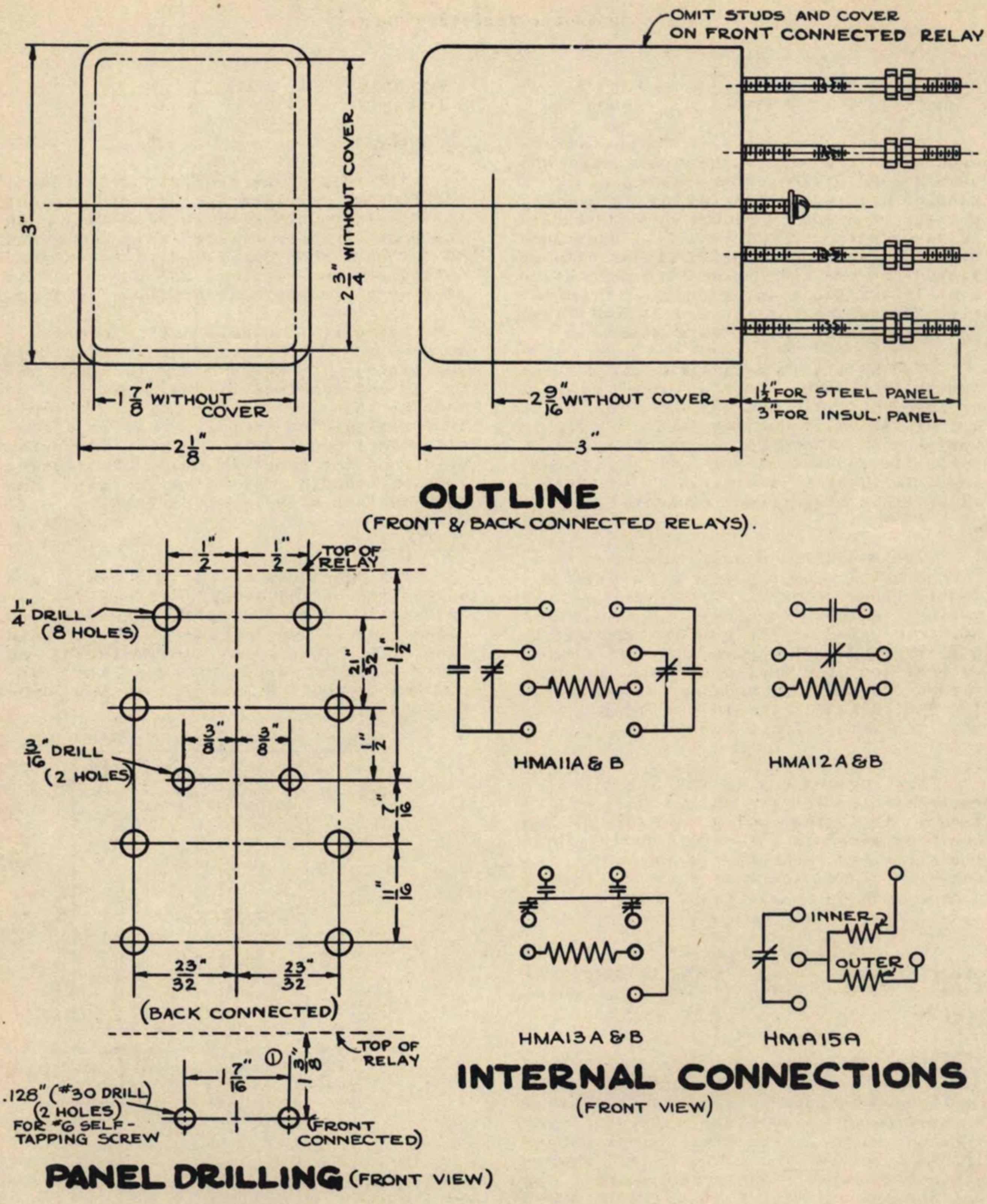


FIG. 1 OUTLINE, PANEL DRILLING, AND INTERNAL CONNECTIONS OF TYPES HMA11A-B, HMA12A-B, HMA13A-B, AND HMA15A RELAYS (K-6209564)

INSTRUCTIONS

INSTRUMENT TRANSFORMERS

DRY TYPE

GENERAL ELECTRIC
SCHENECTADY, N.Y.

INSTRUMENT TRANSFORMERS

DRY TYPE

The several types of transformers covered by these instructions include indoor and outdoor instrument transformers, metering outfits, portable instrument transformers, split-core current-measuring sets, and auxiliary transformers. These instructions apply also to Type Y transformers, which are not strictly standard but which utilize the mechanical construction of standard transformers. For information on the installation and care of dry-type transformers with unusual ratings of frequency, secondary voltage, current, etc., consult the nearest Sales Office of the General Electric Company. When any special information is requested, give the complete nameplate data in order to identify the transformer.

HANDLING

When unpacking and handling the transformer, exercise care not to damage the insulation. Make an inspection to see whether any damage has occurred during shipment. Transformers that are reshipped to the point of installation, even though this be done by truck, should be supported only by the core or mounting supports. Do not use the bushings or leads for handles.

DRYING OUT

Transformers that have been subjected to submersion or have been stored for some time in a damp place should be dried out previous to installation. When drying out is necessary the following method should be used:

Allow the transformer to stand not less than 12 hours in a room of approximately even temperature.

Measure the resistance of the windings and record the room temperature.

Short-circuit the primary winding and apply voltage to the secondary winding through such controls that sufficient current will flow in the windings to raise the temperature to approximately 80 C. This temperature should be maintained until the transformer is dry.

To determine the temperature of the winding (approximately) assume that for each per cent increase in resistance the temperature rise of the winding is 2½ C. Find the temperature rise and add this to the starting (room) temperature: the result will be the final temperature.

The amount of current necessary to obtain this temperature varies because of the variations in losses and copper densities in the different types of transformers. It is advisable to start with a current not greater than 2 amperes in the secondary of a potential transformer and not greater than 5 amperes in the secondary of a current transformer, and gradually raise this current until the proper heating is obtained. Increases of current should be made cautiously with regular observation of the rise of temperature of the winding. The rise of temperature should not exceed 6 C per half hour.

When facilities for measuring the resistances are not available the temperature may be taken by placing the bulb of a spirit thermometer on each coil as close to the winding as the insulation will permit. The bulb of the thermometer should be covered with clean dry cotton waste so that the bulb will have as nearly as possible the actual temperature of the coil. In the case of current transformers of high current capacity the actual temperature of the primary winding can be quite closely obtained by placing the bulb of the thermometer directly on the primary terminal.

Do not use mercury thermometers.

TESTING

Dielectric Tests

If it is desired to make insulation tests after the drying out period, or at any other time, these tests should be made in accordance with the ASA standards for transformers, regulators, and reactors (superseding A.I.E.E. standards No. 4 and No. 14). These rules should be strictly followed, both as to the value of test voltage and in the method of application.

Polarity Tests

Convenient methods for testing polarity are given in A.S.A. Transformer Standards, and also in the N.E.L.A. Metermen's Handbook.

Ratio and Phase Angle Tests

Refer to N.E.L.A. Metermen's Handbook and General Electric Company's publication, GEA-601, Instrument Transformers.

MOUNTING

When connecting instrument transformers into power or distribution lines, it is important to make the connection in a manner to avoid placing line strains upon the terminals of the transformers.

Where the primary leads consist of cables, as in the case of certain outdoor transformers, the connection should be made in such a manner so as not to bend the leads sharply where they enter the bushing. The connection should also be so made as to prevent swaying of the cables.

Where the primary leads are brought out through stud-type bushings or so-called fixed terminals, care should be exercised to prevent either longitudinal or transverse strains upon the bushings.

Instrument transformers of "transformer less primary" (window) type should be installed in such a manner that the weight of the transformer is not carried by the bus. Holes are provided in the angle core clamps which may be used for fastening the transformer either to a flat surface or to mounting brackets. No brackets are furnished with the transformer because of the wide variety of mounting conditions.

For high-current transformer ratings, 2000 amperes and above, there may be some interference from the field of the return bus unless the bus centers are kept at a minimum distance of 15 in. apart; for ratings above 5000 amperes this distance should not be less than 24 in. In case this type transformer is used with more than one primary turn, the loop should be at least 24 in. in diameter. Care should be taken to see that the secondary leads are twisted closely together and carried out without passing through the field of the primary conductors. It is not necessary that the bus exactly fill the window, but the bus or buses should be centralized.

CONNECTIONS

The resistance of all primary and secondary joints should be kept as low as possible to prevent overheating at the contacts, and particularly in the case of current transformer secondary circuits, to prevent an increase in the secondary burden.

Secondary Leads

When planning installations of current transformers, the resistance voltage drop of the secondary leads should be included in calculating the secondary volt-ampere burden carried by the transformer. This total burden should be kept within limits suited to the transformers used. For ordinary conditions, secondary leads whose resistance does not exceed that of 100 feet of leads of No. 10 B.&S. copper wire (200 feet of wire) are satisfactory. This resistance is 0.2 ohm, requiring 5 volt-amperes at 5 amperes.

In the case of potential transformers the voltage drop in the secondary leads may affect the indications of the connected instrument and meters. For the usual conditions 50 feet of leads of No. 10 B.&S. copper wire (100 feet of wire) are satisfactory.

The above instructions regarding the length and size of the leads to be used should be considered as general. In cases where instruments and instrument transformers have been furnished as a unit by the factory, no change should be made in the length or size of leads which might change the volt-ampere burden in them. If any change is needed consult the nearest Sales Office of the Company.

Secondary Burdens

When calibrations are furnished with transformers, it is important that the connected burden to be in agreement with the burden used in calibration. If it becomes necessary or desirable to change the connected burden, and if there is any question regarding the effect of the change in the accuracy of the transformer, the nearest Sales Office of the Company should be consulted. Questions regarding the maximum allowable burdens should also be referred to the Company's nearest Sales Office.

If transformer calibrations are required, it is important that complete information be furnished the Company, including the number of devices to be connected in the secondary of each transformer, the rating of the device and type if the device has more than one current or voltage, capacity, size, and length of leads to be used, the frequency of the circuit, and the method of connection.

Secondary Terminals

Most indoor current transformers are supplied with an enclosed secondary terminal block which can be sealed. When shipped, the cover of the terminal block is in the reversed position because the short-circuiting device between the secondary terminals is closed.

The procedure for making secondary connections is as follows:

Remove the cover, attach the service leads, open the short-circuiting device by loosening the screw or nut and turning the bridge 90 degrees counterclockwise, and then retighten the screw or nut. Turn the cover 180 degrees from the shipping position, and reinstall it on terminal block. The cover cannot be replaced after the service leads are in place until the short-circuiting device is opened.

Some transformers have their secondary terminals arranged for conduit connection. This conduit connection can be made from the bottom, top, or either side, by removing the terminal cover and changing the cover support to the desired position. The position of the secondary terminals should not be changed.

Grounding

The casings and frames of instrument transformers should always be grounded. The secondaries should also be grounded close to the transformers. If, because of special connections, grounding the secondary appears impracticable, the matter should be referred to the General Electric Company. No. 2 B.&S. copper wire is recommended to ground casings and frames, particularly of outdoor transformers where arcovers are more likely to occur. Not smaller than No. 12 B.&S. copper wire should be used to ground the secondaries. Grounding the feet of instrument transformers also grounds the cores, casings and frames.

If it is necessary to change the secondary connections, be careful not to disturb ground connections.

Polarity

In wiring instrument-transformer circuits, it is necessary to maintain the correct polarity relation between the line and the devices connected to the secondaries. For this reason, the relative polarity of the windings of each transformer is indicated by a marker H_1 on or near one primary terminal, and a marker X_1 near one secondary terminal; and in most cases by white bushings or markings of white paint. Where taps are present, all terminals will be marked. The primary leads will be H_1, H_2, H_3, etc., in order, and the secondary terminals X_1, X_2, X_3, in order, and the tertiary, if present, Y_1, Y_2, Y_3, in order, H_1 indicating the same instantaneous polarity as X_1 or Y_1.

Significance of Polarity Markings

When connection is made to a secondary terminal having a polarity marking similar to a given primary terminal, the polarity will be the same as if the primary service conductor itself were detached from the transformer and connected directly to the secondary conductor. In other words, at the instant when current is flowing toward the transformer in a primary lead of a certain polarity, current will tend to flow away from the transformer in the secondary lead of similar polarity.

When connecting instrument transformers with meters or instruments, refer to the Instructions furnished with the meters or instruments involved.

MAINTENANCE

After instrument transformers for indoor installation have been installed, they should need no care other than seeing that they are kept clean and dry. Transformers for outdoor installation should receive the same care in operation as power transformers of similar design and of similar voltage rating.

Considerable care should be exercised to make and keep the resistance of all contacts in the secondary circuit as low as possible.

Note:—Always consider current transformers as a part of the circuit to which they are connected, and touch only the secondary leads, and such portions of the transformer as are properly grounded.

Do not open the secondary circuit of current transformers while the transformer is connected in a line circuit, since by so doing the core may be permanently magnetized, and voltages dangerous to human life are likely to be induced across the secondary terminals. To remove any device from the secondary circuit of a current transformer when current is flowing through the primary, the secondary of the transformer should first be short-circuited, and care should be taken not to disturb the ground connection of the secondary of the transformers.

FUSES

Potential transformer fuses are intended primarily to protect the line rather than the transformer, although the modern fuse will afford protection to the transformer in a large number of cases. With the exception of the current-limiting fuse, Type EJ-1, potential transformer fuses are not designed to open the maximum short-circuit currents which may flow when a short circuit occurs in the transformer. For this reason, current-limiting resistors should be used in series with the fuse when necessary to limit the current to a value which the fuse can interrupt satisfactorily.

Replacing Fuses

Since many potential transformers are furnished with two fuses, the fuse in the grounded side should be replaced by a brass tube of the same size as the fuse or by some solid connection.

The fuses of Type E-32 and JE-2 potential transformers, 3000 volts and below, are supported by a hinged cover. If it is necessary to replace a fuse while the transformer is connected to an operating circuit, the cover should be opened by an insulated hook. After the new fuse is inserted, the cover should be closed also by means of the insulated hook, which should be of sufficient length to prevent the operator from being burned in case a short circuit exists in the transformer. The cartridge fuse may be replaced by the EJ-1, Size A.

In testing fuses for continuity of circuit, not more than 0.25 ampere should be used.

In replacing the EJ-1 fuses or in substituting the EJ-1 for the ES-1 or the cartridge fuse, care should be taken to select a fuse unit with the nearest voltage rating above line-to-line voltage of the circuit regardless of the rated voltage of the transformer. Do not attempt to overinsulate with fuse units of higher voltage ratings, as undesirable overvoltages may result. One permissible exception to this general rule is the use of the Size A, Type EJ-1 fuse in Type JE-32 or JE-2 transformers. In this case the Size A fuse can be used on either 2300-volt delta circuits or 2300/4150-volt grounded "Y" circuits.

Fuses can be refilled at the factory, provided they show no serious external defects.

DEMAGNETIZING

If by accident a current transformer becomes magnetized, it should be demagnetized in the following manner before being used for precision work: Connect at least 50-ohms resistance in series with the meters or instruments in the secondary circuit. Bring the primary current up to as near full load as possible and gradually reduce the secondary resistance by one-ohm steps until it reaches zero, being careful not to open the secondary circuit in the process.

DIFFERENTIAL PROTECTION

Standard General Electric current transformers may be used for differential protection through a considerable range of burden and overcurrent. This range is limited by the difference in burden, the maximum overcurrent, the mechanical and thermal short-time rating. Information regarding these points may be obtained from the nearest Sales Office of the Company.

INDIVIDUAL TYPES OF TRANSFORMERS

Outdoor Instrument Transformers

Bushings of outdoor instrument transformers sometimes become broken. Where the transformer is of the compound-filled construction such as Types K-78, K-81, JK-2, JK-6, JK-8, JK-10, JK-12, E-26, etc., the bushings can best be replaced by returning the transformer to the factory. When the casing is not filled with compound, such as Types WF-6 and E-36 (3000 volts and below), the bushing can be easily replaced by removing the bottom of the transformer casing.

Conduit connections can be made to the secondary of the Type WF-6 and Type E-36 by loosening the screws which hold the bushing in place, removing the bushing, and inserting conduit fitting in place of the porcelain bushing.

Metering Outfits

Metering outfits are an adaptation of standard current and potential transformers mounted in housings, suitable for indoor and outdoor service. This arrangement combines the transformer units, necessary wiring and, in some cases, the meters under one casing.

The standard primary test voltage for outdoor metering outfits (as specified for combined units by the American Institute of Electrical Engineers) is 15 per cent lower than the lowest required of any individual transformer.

Portable Transformers

When used under ordinary conditions portable transformers both potential and current except split-core current transformers, will not vary more than 1 per cent from their marked ratio. When better accuracy is required, the ratio and phase angle certificate should be used. By means of this certificate corrections can be made to within 0.1 per cent on ratio and to within 3 minutes on phase angle.

Portable potential transformers, Types E-6 and E-9 have terminals arranged with thumb nuts. Double-rated transformers have four primary terminals. Connecting links are used to make connections for the different ratios. Care should be exercised to clamp the links firmly in place in order to obtain good contacts.

The Types R-2 and R-3 current transformers have no primary windings. The cable carrying the current to be measured is threaded through the opening in the transformer core. One or more turns of the primary cable may be used to give different ratios. The ratio of the transformer with different numbers of primary turns is given on the connection nameplate attached to the transformer. If several primary turns are used, they should be distributed around the core. The voltage rating (2500 volts) of the Types R-2 and R-3 transformers is based on a single conductor passing straight through the transformer. If several primary turns are used, the primary cable should be insulated for the full voltage of the circuit.

The Type P-3 current transformer has a self-contained primary. Changes in ratio are made by metal links located on the top of the transformer. Connections for various ratios are indicated by the diagram shown on the nameplate. Care should be exercised in changing connections to clamp the links firmly in place in order to obtain good contacts.

The Types PR-1 and JP-1 current transformers are a combination of the Types P-3 and R-2 construction. For the lower ratios, the transformers have a self-contained primary. For the higher ratios the self-contained primary should be disregarded, and the primary should consist of a cable insulated for the full voltage of the circuit, passed through the opening in the core, as many turns being made as are necessary to obtain the desired ratio as shown on the connection nameplate. The same general instructions as are given above for the Types P-3, R-2, and R-3 apply also to the Types PR-1 and JP-1.

All portable current transformers, except the split-core type, are provided with a short-circuiting switch on the secondary. This switch should always be closed whenever it is necessary to open the secondary circuit with the transformer connected in the line. **This short-circuiting switch should always be opened after making connections.**

Split-core Current Measuring Sets

Split-core current transformers, Types G-4 and G-5, are intended to be used only with the instrument and leads with which the transformer is calibrated. The scales on the ammeters are marked to read primary amperes direct, and the ammeters should not be used to measure current unless used with the transformer with which they are calibrated. Changes in ratio are made by turning the rotating switch on the ammeter.

Split-core current transformers have no voltage rating, and must not be used around any conductor which is not insulated for the full voltage of the circuit.

The ground core surfaces must be kept clean and free from any dirt. A very slight opening between the two halves of the core will affect the calibration of the set. Current-measuring sets consisting of a split-core current transformer calibrated with an indicating ammeter and leads will have an accuracy of plus or minus 2 to 3 per cent, and with a recording ammeter and leads an accuracy of plus or minus 3 to 5 per cent.

A current adapter is used with the split-core transformer for measuring small currents. With the correct size of terminals attached to the adapter, insert it in place of the fuse in the cutout. Clamp the split-core transformer into the round loop of the adapter and read the ammeter. Compute the line current from the formula on the nameplate of the adapter. The use of the current adapter does not affect the accuracy of the current measuring set, and it may be used with sets having either the indicating ammeter or the recording ammeter.

12-42 (51M)
Filing No. B6400

PRINTED IN U.S.A.

GENERAL INSTRUCTIONS FOR MAGNETIC CONTROLLER

INSTALLATION

Unpack the equipment carefully, as small parts may be thrown away with the packing material.

Check the nameplate rating of the controller and make sure that its horsepower, voltage, frequency, etc., are the same as those on the nameplate of the motor with which the control is to be used.

Mount the panel vertically so that, when power is cut off, the contactors will open by gravity. Panels should be mounted on a flat surface, and care should be taken not to twist or warp the back when mounting. The supports of open controllers and the enclosures of enclosed controllers should be grounded. The conduit connection to the case of enclosed controllers is usually considered sufficient grounding protection.

The sealing surface of the magnet frame and armature of a-c contactors with clapper-type magnets is spread with grease or oil to prevent rusting in shipment. The grease or oil should be removed when the contactor is put into service, but the surface may be wiped occasionally with a thin rust-resisting oil.

Before power is applied, operate each contactor and relay by hand to see that the moving parts operate freely without binding. See that all electrical interlocks are clean and make positive contact when closed.

Inspect the connections of wires or buses to studs, to be certain that they are tight. The nuts may have loosened during shipment.

Cast-grid resistors are sometimes shipped with corrugated paper packed between the individual cast grids, to prevent breakage in shipment. Remove this packing before putting the resistor into service.

Resistor boxes should always be mounted with the grids in a vertical plane and located to permit free ventilation. To keep the heating at a minimum, it is recommended that 6-in. spacers be used between boxes of grids when stacked and that the stacks be 12 in. apart. Such arrangement is desirable when continuous or heavy intermittent duty is expected, and essential when boxes are stacked over six high. Slow burning or noninflammable wire should be used in connecting to resistor terminals, to withstand the heat from the resistor.

A diagram showing the connections of the panel and of the resistor is shipped with each equipment. All terminals to which external connections are to be made are numbered on the equipment and indicated on the wiring diagram.

For controllers having current transformers, there may be temporary connectors across overload relays if the heaters or coils are not mounted at the factory, or across terminals in the current transformer secondary circuit. Before applying power to the controller, remove all such connectors, see that all overload heaters or coils are properly mounted, and that the secondary circuit of the current transformers is not open.

Generally it is advisable to test the panel with the motor armature leads disconnected in order to check the operation and sequence of closing of the contactors. Series contactors cannot be operated unless the motor armature is connected in circuit.

ADJUSTMENTS

The adjustments of the contactors or relays on the magnetic controller are explained on the individual instructions sheets for each device. The relation of the devices to each other and their functions are explained in the instructions for the complete controller.

Contactors are designed to operate properly if the line voltage is within 85 to 110 per cent of the panel nameplate rating for a-c circuits and within 80 to 110 per cent for d-c circuits. Wider ranges require special devices. Where there is a continuous 10 per cent increase in voltage, suitable coils should be ordered, because with this increase in voltage there is an increase in wattage and in the heating of the coil. This will not cause immediate failure of the coil but the deterioration of the insulation is more rapid and the ultimate life of the coil is shortened. There is also an increase of about 20 per cent in the pounding effect resulting in more rapid wear of the armature,

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.

magnet parts, and contacts. The armatures should seal when the proper voltage is applied to the coils and should open by gravity when the power is cut off. The contacts of a single-break clapper-type contactor should, when closed, make line contact near the bottom of the face. On opening, the final break will be near the top. The rolling and wiping motions when closing and opening keep the contacts in good condition.

Mechanical interlocks are so adjusted that with one contactor in the sealed (closed) position, there is a very small play on the other contactor. This play must not allow the moving contacts of the second contactor to touch the corresponding stationary contacts when the contacts of the first contactor are just touching.

Replace all covers and arc chutes on individual devices before the panel is placed in service. Be sure that all devices, such as dashpot relays, that require oil, are provided with the right grade and the right amount. If the complete controller is immersed in oil, fill the oil tank with the grade of oil required up to the oil line (usually painted on the inside of the oil tank). If oil is added above this mark, it will overflow when the tank is lifted into position. If an oil gage is furnished, check the oil level after the controller is submerged in its normal position.

MAINTENANCE

Inspect all parts at regular intervals. Keep all parts free from dirt, oil, and grease. Replace the contacts when worn.

Do not lubricate contacts, as lubrication shortens their life. Both copper and silver contacts will become darkened and somewhat roughened in normal operation, but this should not interfere with their performance, and does not indicate that the contacts should be filed. In general, contacts will not need attention during their normal life, but if prominent beads form on the surface due to severe arcing, the contact faces may be dressed with a fine file. Do not use sandpaper or emery cloth.

Should parts become worn so that adjustments cannot be maintained, new parts should be used.

Frequent inspection should be made of all nuts and connection wires on panels and resistors, particularly when subjected to vibration.

Grid resistor units should be kept clamped tightly together.

Some rules that most good maintenance men follow, and are to be recommended, are:

1. Become thoroughly familiar with the circuit and the operation of each new controller.
2. Use the wiring diagram and keep it handy. Many service men frame these diagrams and keep them near the controllers to which they apply.
3. Have a convenient portable instrument for use in checking voltage, current, resistance, etc. Its use will indicate conditions which, if corrected at once, will keep the equipment operating efficiently and satisfactorily.
4. Prepare a list of items to be checked at each inspection and, in making an inspection, follow the list to be sure that each point is covered. Of equal importance is the preparation of the schedule for conducting regular inspections and the following of the schedule. Casual inspections conducted at odd times are inadequate.
5. Keep on hand an adequate stock of renewal and repair parts. General Electric will furnish a recommended list of parts, if such a list was not included in the Instructions book accompanying the controller. This list can be modified as experience dictates. The cost of carrying spare parts is small, when compared with the cost of lost production occasioned by shutdowns.
6. Buy spare parts made by the manufacturer, to save time and trouble. Parts made by other manufacturers may appear to be the same as the original parts, but may not meet the specifications in important details which cannot be detected by inspection.

FAULTY OPERATION

First, renew any necessary parts. Refer to the controller wiring diagram, trace out all the connections and examine all coils, connection wires, and resistors for burned out, broken, or loose parts. If local electricians cannot overcome the trouble, communicate with the nearest office of the General Electric Company, explaining in detail the nature of the trouble and giving the complete nameplate rating of the device.

RENEWAL PARTS

When ordering renewal parts, give the complete nameplate rating of the individual device and state the name and catalog number of the parts, if possible, or send a sample or sketch of each part required. If extra contacts and spare voltage coils are kept on hand, delays will be avoided when such parts require renewal.

APPARATUS DEPARTMENT, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

11-47 (30M)

Supersedes GEH-75B

PRINTED IN U.S.A.

INSTRUCTIONS

PLUNGER RELAYS

TYPES PAA, PAC, PAV, PBA, PBC, AND PCV

Switchgear

GENERAL ELECTRIC

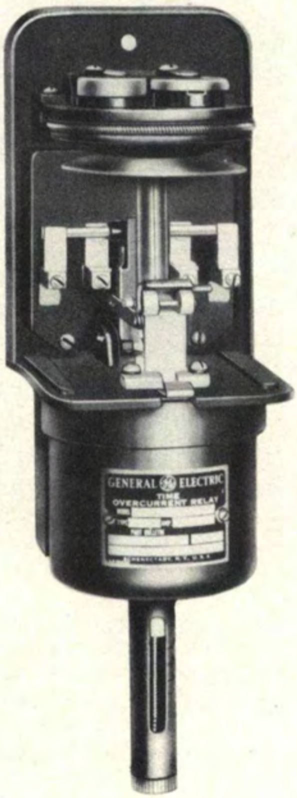


Fig. 1. Time Relay

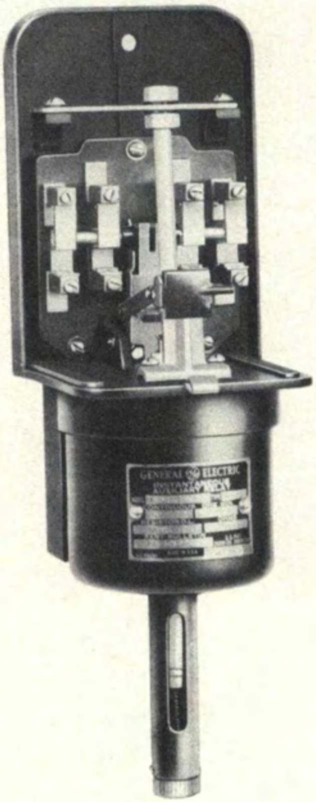


Fig. 2. Instantaneous Relay

PLUNGER RELAYS

TYPES PAA, PAC, PAV, PBA, PBC, and PCV

The Types PAA, PAC, PAV, PBA, PBC, and PCV plunger relays are designed to protect against overcurrent and undervoltage and also for use as auxiliary devices. The operation of these relays depends upon the action of a magnet coil in attracting or releasing the plunger, when predetermined values of voltage or current are present in the circuit to which the coil is connected. By means of a snap-toggle mechanism the operation of the contacts is quick-acting on the upstroke of the plunger. These contacts can be arranged in several ways which, with the use of a coil suitable for the particular purpose in view, adapt these relays to a large number of applications.

INSTALLATION

Before installing, the cover should be removed, and the relay inspected to make sure that the toggle snaps quickly when the plunger is raised slowly by hand, and that the plunger drops down freely to its normal position when released.

It may be more convenient to adjust the contacts before mounting the relay than afterward. See ADJUSTMENTS.

The relay should be mounted on a vertical surface, preferably in a location free from excessive vibration, dirt, moisture, or corrosive fumes.

ADJUSTMENTS

See that the die-cast cam at the front of the relay bears evenly against the two rollers; the supporting holes in this cam are slotted for adjustment. Make sure that the screws holding this cam are tight, because these partially determine the amount of wipe on the back contacts.

Contacts

The stationary contacts can be placed in either of two positions, one of these being toward the back of the relay and the other toward the front. These positions may be readily obtained by loosening the screw on the front of the contact block, removing the stationary contact and replacing it in the desired position.

Lifting the plunger and operating the contact bar solely by hand, see that all the back contacts make simultaneously and all the front contacts make simultaneously. Adjust for this condition, if necessary, by loosening the setscrews and moving the contact piece forward or backward as required. The contact spring should bear lightly against the front stop when the contact is open.

After locking the adjustments, see that the contacts still make simultaneously, and then operate the contact mechanism slowly by means of the plunger and see that each contact has wipe, indicated by the fact that the contact bar holds the contact spring away from its front stop when the contact is closed.

Automatic or Hand-reset

In the construction of Types PAA and PAC relays, the upper portion of the plunger rod is surrounded by two semi-cylindrical die-castings which carry four projecting parts at the bottom spaced 90 deg apart, located under the toggle arms, and two similar parts spaced 180 deg apart, located directly over the toggle arms. These projecting parts or knobs may be adjusted to two positions; when the two upper knobs lie across the toggle arms the contacts are automatically reset by the fall of the plunger, whereas when they are rotated through 90 deg they pass downward between the toggle arms and the contacts remain in the operated position until reset manually by means of the push-rod projection through the front of the cover. This rotation is accomplished by removing the clamping spring at the top of the rod and rotating the semi-cylindrical castings carrying the knobs until the latter reach the desired position. The spring must then be replaced in the recess provided for it.

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.

APPLICATIONS AND CHARACTERISTICS

Type of Relay	Application	Time	*Contacts	Ratings: Volts	Ratings: Amp	Ratings: Freq in Cycles	Reset	Indicating Target	Construction
PAC11A	Over-current	Inst		...	1 to 5	25 to 60	Self or Hand	Yes	The PAC relay can be obtained either instantaneous or with time delay, and with either self- or hand-reset. When arranged for self-reset, the plunger drops at approximately 70 per cent of the current at which it picks up, after the plunger has lifted, until it strikes the toggle. The time delay may be adjusted for any time up to 20 seconds at 125 per cent of its calibration. The low point of calibration is approximately the same as the continuous capacity, while the highest calibration is three times the lowest calibration value. The standard time-delay relay is assembled at the factory to give the delay on pickup with instantaneous drop-out.
PAC12A		Time		...	1 to 5	40 to 60		Yes	
PAC13A		Inst		...	1 to 5	25 to 60		Yes	
PAC14A		Time		...	1 to 5	40 to 60		Yes	
PAC11B		Inst		...	1 to 5	25 to 60		Yes	
PAC12B		Time		...	1 to 5	40 to 60		Yes	
PAC13B		Inst		...	1 to 5	40 to 60		Yes	
PAC14B		Time		...	1 to 5	40 to 60		Yes	
PBC11A	Sensitive Over-current	Inst		...	1 to 5	25 to 60	Hand	Yes	The PBC relay is built in the instantaneous form with either hand- or hand-and-electrical reset only. It differs from the Type PAC in that the plunger is much lighter. The low point of calibration is approximately 50 per cent of the continuous capacity, while the high point of calibration is three times the lowest calibration value.
PBC12A		Inst		...	1 to 5	25 to 60	Hand	Yes	
PBC11B		Inst		...	1 to 5	25 to 60	Hand	Yes	
PBC12B		Inst		...	1 to 5	25 to 60	Hand	Yes	
PBC13A		Inst		...	1 to 5	25 to 60	Hand and Electric	Yes	
PBC13B		Inst		...	1 to 5	25 to 60	Hand and Electric	Yes	
PAV11A	Under-voltage Protection for D-c Circuits	Inst		125 and 250 D-c	.....	....	Self	No	The PAV relay is similar to the Type PAC relay except that it is equipped with a potential coil to fit the device for use as a d-c undervoltage relay.
PAV12A		Time			.....	....	Self	No	
PCV11A	Under-voltage Protection for A-c Circuits	Inst		115, 230, 460, and 575 A-c	.....	25 and 60	Self	No	The PCV relay differs from the above constructions in that it is particularly adapted for operation on a-c voltage and is quiet at rated voltage with the plunger up. It may be obtained either in the instantaneous form or with the time-delay feature. The latter is assembled at the factory to give instantaneous pickup with time-delay drop-out. It has no provision for calibration but will pick up at approximately 80 per cent of rated voltage and drop-out at 30 per cent.
PCV12A		Time							
PCV13A		Inst			.....	25 and 60	Self	No	
PCV14A		Time							
PCV11B		Inst			.....	25 and 60	Self	No	
PCV12B		Time							
PCV13B		Inst			.....	25 and 60	Self	No	
PCV14B		Time							
PAA11A	Auxiliary	Inst		115, 230, 460, and 575 A-c	.....	25 and 60	Self or Hand	Yes	The PAA relay is similar to the Type PAC except that it is equipped with an a-c or d-c potential coil. When used on a-c this relay is suitable for momentary energization only.
PAA12A		Time							
PAA13A		Inst			.....	25 and 60		Yes	
PAA14A		Time							
PAA11B		Inst			.....	25 and 60		Yes	
PAA12B		Time							
PAA13B		Inst		9 to 600 D-c	.....	25 and 60		Yes	
PAA14B		Time							
PBA11A	Bell Alarm and Auxiliary	Inst		115, 230, 460, and 575 A-c	†	25 and 60	Hand	Yes	The PBA relay is similar to the Type PBC except that it is equipped with an a-c or d-c potential coil. It is not suitable for continuous energization by alternating current. Current coils are also supplied when connected in series with other coils.
PBA12A		Inst			.....	25 and 60	Hand	Yes	
PBA11B		Inst			.....	25 and 60	Hand	Yes	
PBA12B		Inst		125, 250, and 650 D-c	.....	25 and 60	Hand	Yes	
PBA13A	Auxiliary	Inst			.....	25 and 60	Hand and Electric	Yes	
PBA13B		Inst			.....	25 and 60		Yes	

* Contacts may be changed from normally open to normally closed or vice versa by reversing position of the contact. Electrically separate contacts may be made common by replacing the movable contact bar. All contacts are shown in the de-energized position.

† One-minute rating of d-c coil in amperes: 1.5, 2.8, 6, 12, 25, 30, and 80.

TIME DELAY

Time delay is obtained by means of a bellows and air valve located at the top of the plunger rod. The bellows is composed of a rubber compound which must not be lubricated, and which is not appreciably affected, either in its action or in its durability, by high or low temperature. The rate at which the air is expelled by the upward stroke of the plunger and is returned on the downward stroke is governed by a calibrated disk at the right-hand side of the bellows controlling the air valve, the latter being located directly in front of the Bakelite drum upon which the disk rotates. This disk is arbitrarily marked from one to ten and the valve mechanism is so arranged that when the numeral one lies over the valve opening the time delay of the relay is at its minimum value; as the disk is rotated so that higher numerals lie vertically over the valve aperture the time delay increases and reaches the maximum time setting of the relay at the numeral ten. (See Fig. 3.)

The setting of the left-hand disk, which is not calibrated, determines whether the delay brought about by the bellows will occur on the upward stroke of the plunger, on its downward stroke, or on both. By raising the clip which holds this disk in place, and removing the latter, two valves are displayed one of which contains a removable poppet, while the other does not. The action of the poppet is as follows:

When the poppet is placed in the left-hand valve opening, with the dowel pin on the cover seated in the recess at the back of the molded part, the time delay takes place on the upward stroke of the plunger and there is no time delay on the downward stroke.

When the poppet is placed on the right-hand valve opening, with the dowel pin still seated in the recess at the back of the molded part, the action is reversed, the time delay now occurring on the downward stroke, while the upward stroke is practically instantaneous.

With the poppet still in the right-hand valve opening, but with the disk replaced so that the dowel now rests directly on top of the poppet, instead of in the recess previously described, the time-delay action of the relay occurs on both the upward and downward strokes.

In making any of the above adjustments care should be taken to see that the leather washer under the disk is properly seated when the latter is replaced.

Fig. 3. Disks for Adjustment of Time Delay

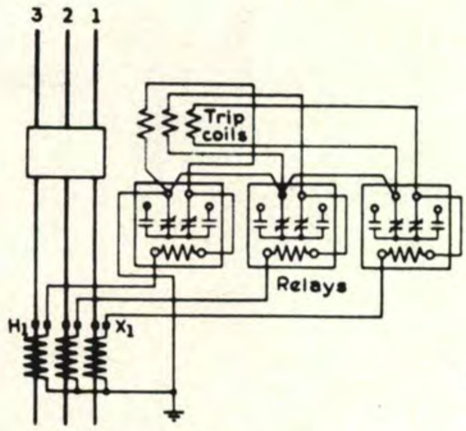
OVERCURRENT SETTING

The current at which the plunger operates is predetermined by the height at which it rests in the calibrating tube at the bottom of the relay. The groove in the lower end of the plunger should be set opposite to the value in amperes at which it is desired that the relay shall operate. This setting is accomplished by turning the knurled nut until the plunger groove rests opposite the desired tripping current.

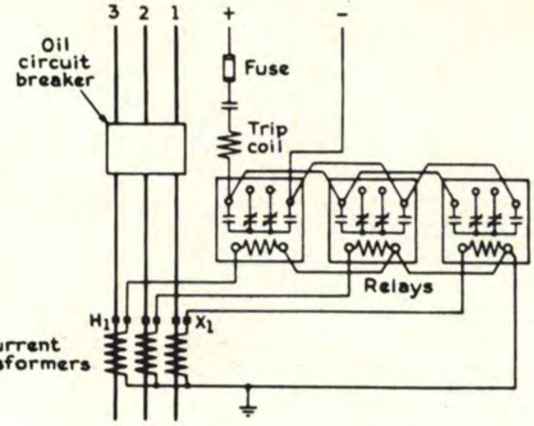
From the variety of adjustments enumerated above, and the number of coils and arrangements of contacts available, the almost universal field of application of these relays, where the plunger type is desired, will be readily apparent. For convenience, certain details of construction of the various types are given in the tabulation on page 4.

The overcurrent relays Types PAC and PBC are equipped with current coils. The others are provided with potential coils, except certain forms of the Type PBA relay which are intended for operation in series with a circuit breaker trip coil; these relays are provided with coils suitable for this purpose.

All relays, except the undervoltage Type PCV, are provided with targets. These targets are plainly visible, orange-colored semaphores which come into view when the plunger rises to operate the relay. They are reset manually by



Using circuit-opening contacts for transformer tripping



Using circuit-closing contacts for d-c tripping

Fig. 4. Connection Diagrams for Types PAC11A and PAC12A Relays

means of a push-rod extending through the front of the cover.

Contact Rating

By choosing the proper contacts the over-current relay can be used for direct tripping by the current transformer, or it can be used to trip the breaker indirectly from a separate d-c power supply.

Each contact of the relay will carry 5 amperes continuously or 75 amperes for one-half second. To avoid burning the contacts the trip circuit should be interrupted by an auxiliary switch on the circuit breaker, instead of by the relay contacts, when a tripping source other than the current transformer is used.

The contacts of the circuit-opening relay, used for direct tripping from the current transformer, will operate successfully on secondary currents up to 50 amperes. Beyond this value circuit-closing contacts, in conjunction with a battery or other suitable tripping means, should be used.

Any one contact will safely interrupt currents in noninductive circuits not in excess of those given in the following table:

Volts	SNAP ACTION†		NONSNAP ACTION††	
	Amperes			
	A-c	D-c	A-c	D-c
12	..	6.0	..	3.0
24	..	4.0	..	2.0
48	..	2.5	..	1.25
125	10	1.0	2.5	0.5
250	7	0.4	1.0	0.2
600	3	0.1	0.0	0.0

† All instantaneous and time contacts that open on the upstroke of the plunger.
†† Time contacts that open on the downstroke of the plunger.

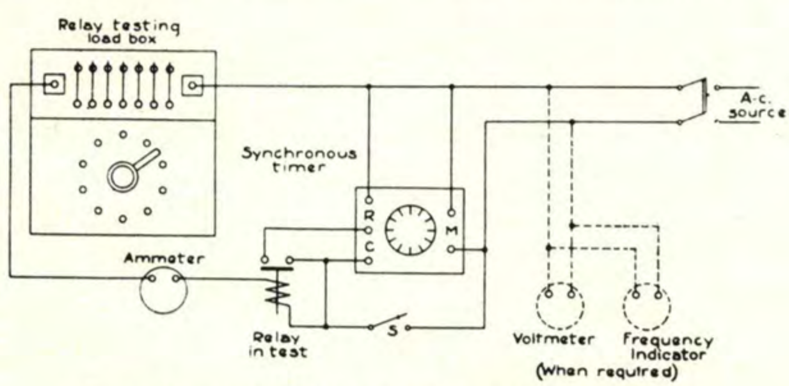


Fig. 5. Connections for Testing a Circuit-closing Relay Operated from Same Supply as Type MF-2 Synchronous Timer

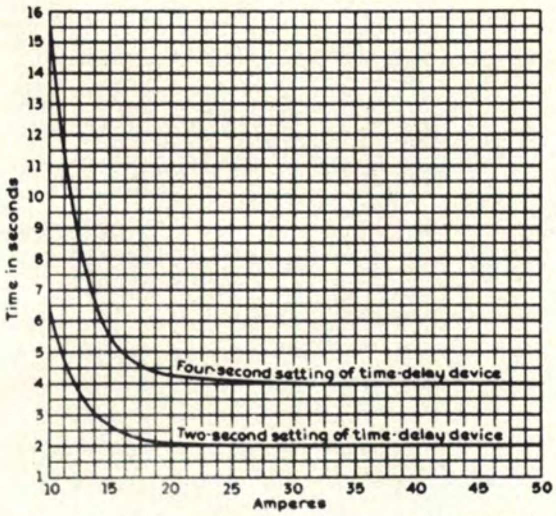


Fig. 6. Characteristic Time-current Curves of Type PAC Overcurrent Relays with 5-amp Coil; Plunger Setting at 8 Amperes with Two Different Settings of Time-delay Device

Secondary Burden

The burden imposed upon the current transformer by the 5-ampere coil, which is the most commonly used, is approximately 22.5. volt-amperes at 5 amperes, 60 cycles.

Periodic Tests

It is advisable to test the relays periodically to insure their positive operation. Typical testing connections for an overcurrent relay are shown in Fig. 5.

Renewal Parts

When ordering renewal parts, write to the nearest Sales Office of the General Electric Company giving the quantity, catalog number if available, a complete description and name-plate rating of each item required.

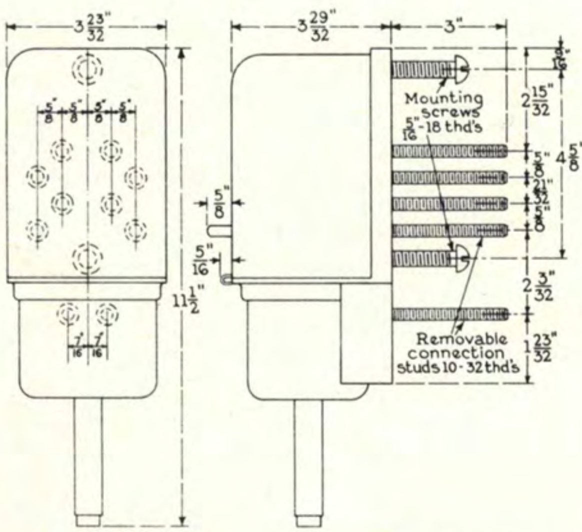


Fig. 7. Outline and Dimensions of Types PAA, PAC, PAV, PBA, and PBC Relays (Number of Studs Varies with Different Types)

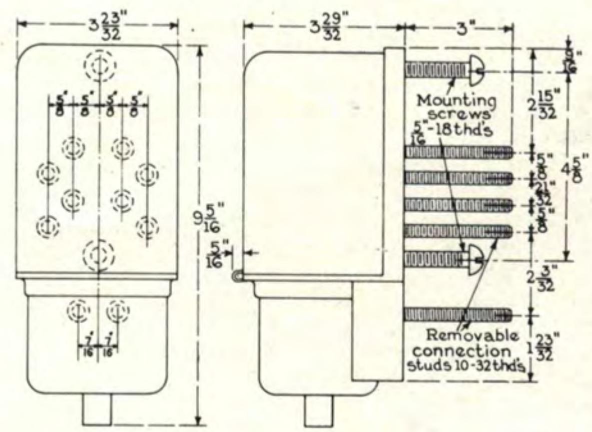


Fig. 8. Outline and Dimensions of Type PCV Relays (Number of Studs Varies with Different Types)

<u>INSTRUCTIONS GEI-18370-C</u>

PRESSURE RELIEF DEVICE

FOR

POWER TRANSFORMERS

GENERAL ELECTRIC COMPANY

SCHENECTADY, N. Y.

April 1945 Supersedes GEI-18370-B

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.

PRESSURE RELIEF DEVICE

This pressure relief device is used on top of the main cover of power transformers for the purpose of relieving any sudden pressure such as may accompany an arc under the insulating liquid. The device is used on completely sealed, gas-seal and gas-oil-seal transformers.

The pressure relief device may be installed on a manhole cover or directly on the main cover. Refer to Fig. 1 which shows the parts of this relief device with the device flange installed on a manhole cover. The relief diaphragm (Item 2) is a thin disc of molded material (G-E compound 2029B) firmly held between clamping rings with a gasket joint. These clamping rings are the flange (Item 1, on the manhole cover and the ring (Item 3). A metal cap or cover (Item 4) provided over the diaphragm is held down by a relief pin. The underside of this cover has a grid with its edges located just above the diaphragm. A metal lid (Item 7) held in place by three guide studs is provided over the complete diaphragm assembly to protect it from the weather. Should a sudden pressure occur within the transformer tank, the relief diaphragm will be forced up against the several edges of the grid, breaking the relief pin and allowing the cap to lift. (The relief pin is designed to break at approx. 10 pounds tension). This permits the diaphragm to come against a cutting edge which immediately ruptures the diaphragm. This process also lifts the protective metal lid and the pressure is relieved. After this, the cap and protective lid drop back in place again to close the diaphragm opening, thus reducing the possibility of moisture entering the transformer tank after the diaphragm has been ruptured.

To renew the relief diaphragm after it has been ruptured it is necessary to remove the protective lid by unscrewing the three guide studs from the cover flange. Lift off the metal cap that has the relief pin in the center. Remove the clamping ring by taking out the six hex. head screws and remove the broken diaphragm. When putting in a new diaphragm (Item 2) a new gasket must be used in the flange (Item 1). Brush the gasket on both edges and one side with a thin coat of G-E compound 880 or 1276 and allow to set. They apply a fresh coat of the compound to the gasket ring in the metal flange and put the gasket in place. No compound should be used on the gasket surface which comes against the diaphragm. Put the new diaphragm (Item 2) in place over the gasket. Remove the broken part of the relief pin from the central bar of the clamping ring (Item 3) and then bolt clamping ring firmly in place over the diaphragm. Replace the metal cap (Item 4) over the diaphragm with the edges of the grid down. Remove the broken part of the relief pin from the cap by taking out the small brass screw and washer (Item 5). Install new relief pin by inserting it through central hole in cap (Item 4) and carefully screwing it in place, using very light twisting effort on the screw. For this reason the relief pin is designed to be screwed in with the fingers.

Replace the washer and small brass screw (Item 5) to lock the relief pin. Replace the protective lid (Item 7) over the relief cap (Item 4) making sure that the treated pressboard disc (Item 6) is in place between the cap and the lid. The purpose of this disc is to provide a moisture proof covering over the head of the relief pin. Screw the three guide studs into the flange to hold the protective lid in place. Be sure the two rubber bumper washers are in place on each guide stud. Adjust the height of the three guide studs to 3 inches between the underside of the bolt and the top of the clamping ring as shown in A, Fig. 2. Tighten lock nut to maintain adjustment. One of the rubber bumper washers on each stud can be pushed down against the lid to hold lid firm.

When this pressure relief device is used on a *Pyranol transformer to be installed indoors a high metal cover is used over the pressure relief in place of the protective lid. This cover has a flnage at the top with a large round opening and a temporary plate is provided over the opening, bolted on with six screws. When the transformer is installed the temporary plate must be removed and a gas absorber or a vent pipe to the outside air should be installed on top of the cover. (Refer to B, Fig. 2). Use the six screws and lockwashers to fasten the gas absorber or vent pipe to the flange at the top of the cover.

The relief diaphragm assembly is removed for foreign shipment and a temporary cover is used over the opening. The assembly can be installed on the cover as previously explained for installing a new diaphragm. A new gasket must be used.

For domestic shipments the pressure relief device is left assembled in place on the transformer and a temporary round wood block 1-3/4" thick is placed under the protective lid. When a high metal cover is used over the relief device on a Pyranol transformer, a temporary wood block 6" long is used under the metal cover. These temporary shipping blocks must be removed when the transformer is installed and the protective lid or cover must be replaced. The recess in the center of the relief cap for the relief pin is temporarily covered with a sealing tape. This tape can be removed.

*Registered Trade-mark for G-E Askarel

When installing the transformer examine the relief diaphragm to be sure it is intact. To do this it will be necessary to remove the protective lid, or the cover if provided for vent pipe connection. Remove the relief pin and metal cap and examine the diaphragm. Replace the cap and relief pin as previously explained, also replace the protective lid or cover.

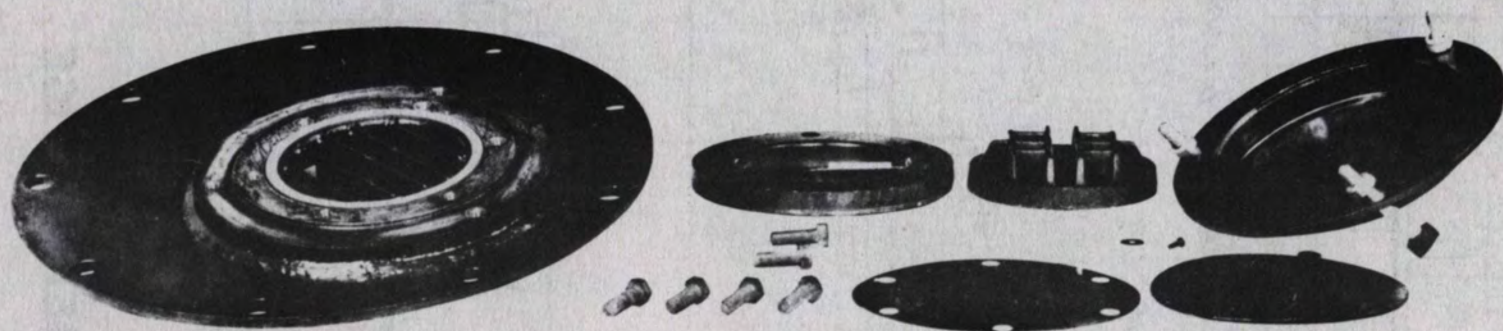
A pressure-vacuum gauge (scale 3 lbs. vac. to 5 lbs. press.) is provided at the top of completely sealed transformers. It is usually mounted on one of the top cooler tube headers or on the cover. This gauge provides an indication of the condition of the transformer tank seal. When the transformer is in service and carrying load the gauge will indicate a pressure which will vary depending on the temperature of the transformer. With the transformer out of service and at a low temperature the gauge will indicate a vacuum. When the temperature of the transformer is 25 C the gauge should show approximately zero pressure. If the gauge remains at zero under load or low temperature conditions of the transformer, a leak in the transformer seal is indicated.

The sealed type transformer is designed to be sealed at zero pressure at 25 C and under all normal conditions the pressure, plus or minus, in the tank will be well within the limits of the gauge scale, which might be reached only under extreme conditions.

The pressure relief diaphragm can be installed on the tank cover, sealing the tank, when the temperature of the transformer is approximately 10 degrees above or below the nominal 25 C. However, at the first opportunity, the tank should be vented by opening an air vent valve near the top of the tank when the transformer is at 25 C. Close air vent valve tight to seal tank. This also applies when installing the pressure-vacuum gauge if it has been removed for shipment.

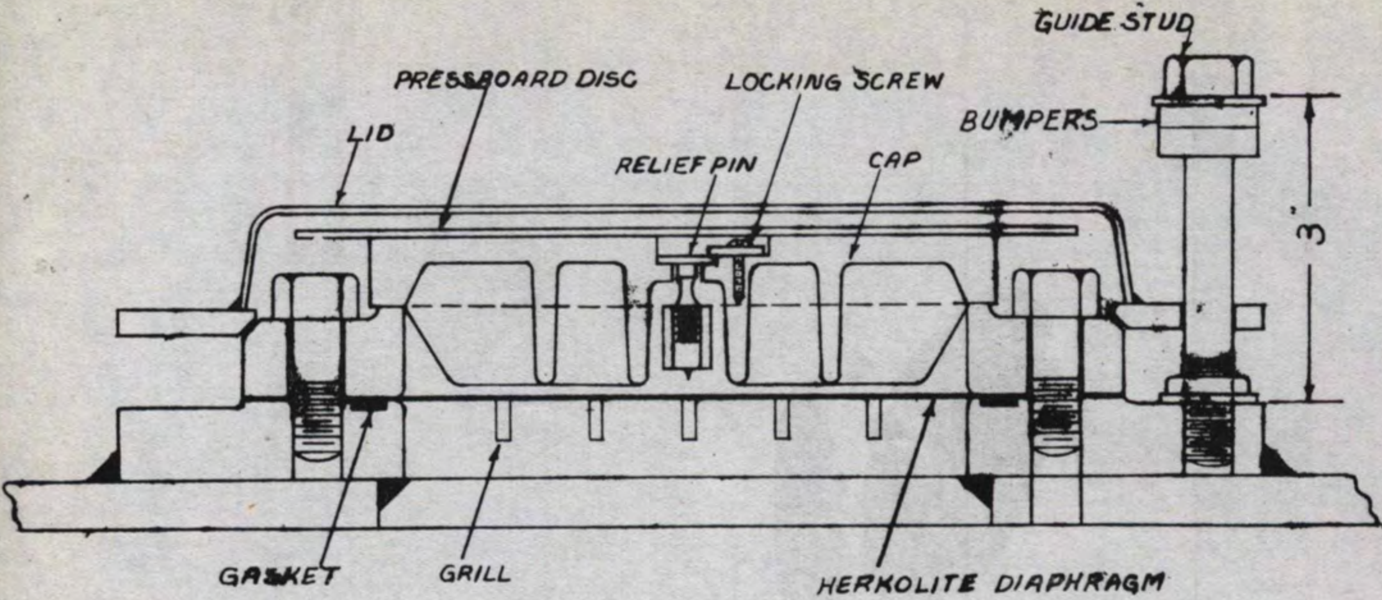
REFERENCE

PRINTED IN U.S.A.

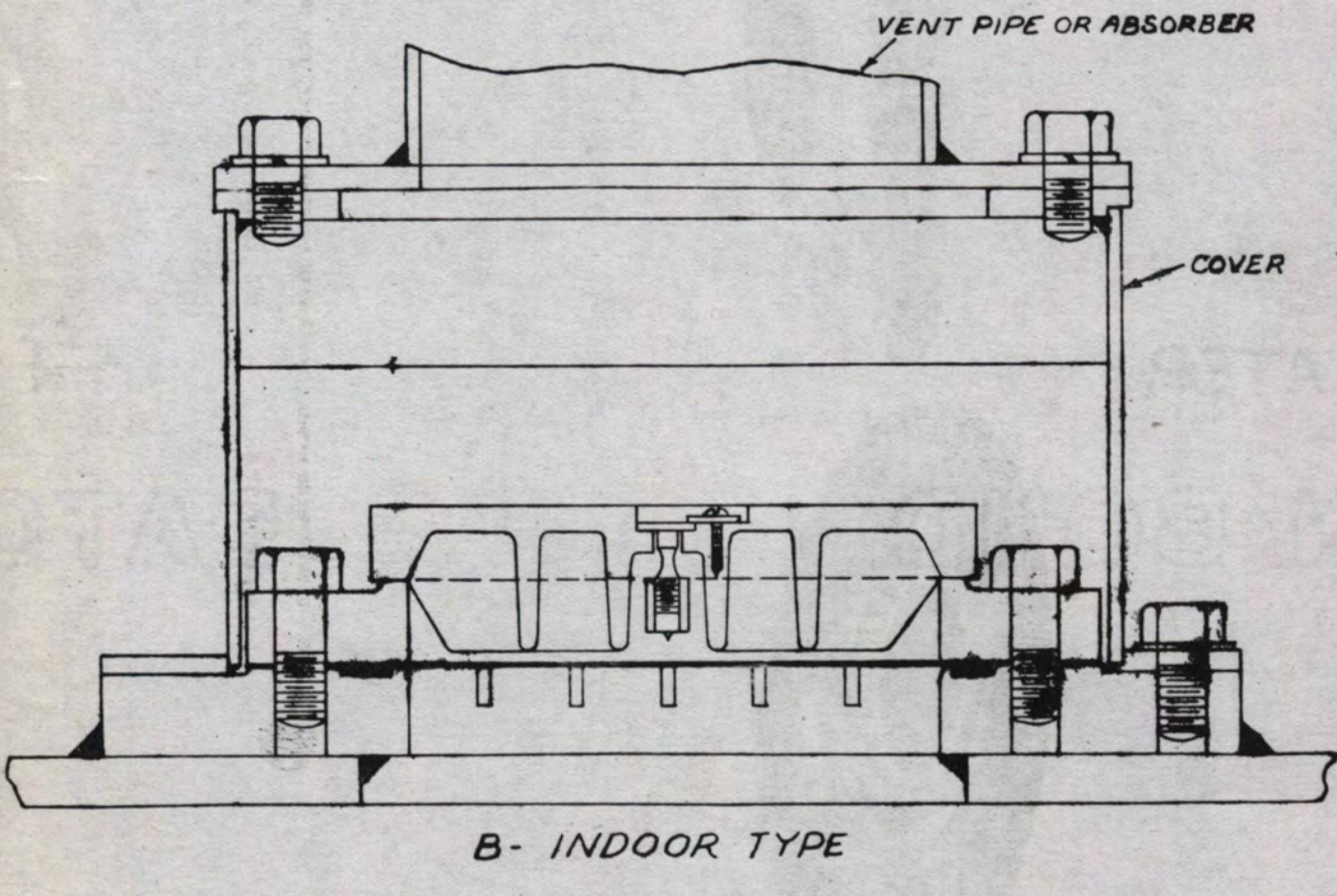


790746 DISASSEMBLED MANHOLE COVER WITH PRESSURE RELIEF, FOR TRANSFORMER.

FILING NO.5155 672 E331.8 9-11-42



A-OUTDOOR OR INDOOR TYPE



B- INDOOR TYPE

PRESSURE RELIEF DEVICE

FIG. 2

K-8397807

IF YOU REQUIRE SERVICE

IF AT ANY TIME you find it necessary to repair, recondition, or rebuild your G-E apparatus, there are 25 G-E service shops whose facilities are available day and night for work in the shops or on your premises. Factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E apparatus. If you need parts only, immediate shipment of many items can be made from warehouse stock.

The services of our factories, engineering divisions, and sales offices are also available to assist you with engineering problems. For full information about these services, contact the nearest service shop or sales office listed below:

APPARATUS SERVICE SHOPS

Atlanta, Ga. . . . . 496 Glenn St., S.W.
Baltimore 30, Md. . . . . 920 E. Fort Ave.
Buffalo 11, N. Y. . . . . 318 Urban St.
Charleston 28, W. Va. . 306 MacCorkle Ave., S.E.
Chicago 80, Ill. . . . . 849 S. Clinton St.
Cincinnati 2, Ohio . . . . 215 W. Third St.
Cleveland 4, Ohio . . . . . . 4966 Woodland Ave.
Dallas 2, Texas . . . . 1801 N. Lamar St.
Denver 5, Colo. . . . . 3353 Larimer St.
Detroit 2, Mich. . . . . 5950 Third Ave.
Houston 1, Texas . . . . 1312 Live Oak St.
Johnstown, Pa. . . . . 841 Oak St.
Kansas City 8, Mo. . . . . 819 E. 19th St.
Los Angeles 1, Calif. . . . . . 6900 Stanford Ave.
Milwaukee 3, Wisc. . . . . . . 940 W. St. Paul Ave.
Minneapolis 1, Minn. . . . . 410 Third Ave., N.
New York 14, N. Y. . . . . 416 W. 13th St.
Philadelphia 23, Pa. . . . . 429 N. Seventh St.
Pittsburgh 6, Pa. . . . . 6519 Penn Ave.
St. Louis 1, Mo. . . . . 1110 Delmar Blvd.
Salt Lake City 9, Utah . . . 141 S. Third West St.
San Diego 1, Calif. . . . . 2045 Kettner Blvd.
San Francisco 3, Calif. . . . . . . 1098 Harrison St.
Seattle 4, Wash. . . . . 1508 4th Ave., S.
West Lynn 3, Mass. . . . . 920 Western Ave.
Youngstown 3, Ohio . . . . . . 121 E. Boardman St.

APPARATUS SALES OFFICES

Akron 8, Ohio . . . . 335 S. Main St.
Albany 1, N. Y. . . . . 90 State St.
Amarillo, Texas . . . . 701 E. Fifth St.
Atlanta 3, Ga. . . . . 187 Spring St., N.W.
Bakersfield, Calif. . . . . 211 E. 18th St.
Baltimore 1, Md. . . . . 39 W. Lexington St.
Bangor, Maine . . . . 77 Central St.
Beaumont, Texas . . . . 398 Pearl St.
Binghamton, N. Y. . . . . 19 Chenango St.
Birmingham 2, Ala. . . . . . . 600 N. Eighteenth St.
Bluefield, W. Va. . . . . Appalachian Bldg., P.O. Box 447
Boston 1, Mass. . . . . 140 Federal St.
Buffalo 3, N. Y. . . . . 535 Washington St.
Butte, Mont. . . . . 20 West Granite St.
Canton 1, Ohio . . . . 700 Tuscarawas St., W.
Cedar Rapids, Iowa . . . . . . 203 Second St., S.E.
Charleston 28, W. Va. . 306 MacCorkle Ave., S.E.
Charlotte 1, N. C. . . . . 200 S. Tryon St.
Charlottesville, Va. . . . . 123 E. Main St.
Chattanooga 2, Tenn. . . . . . . 832 Georgia Ave
Chicago 80, Ill. . . . . 840 S. Canal St., P.O. Box 5970A
Cincinnati 2, Ohio . . . . 215 W. Third St.
Cleveland 4, Ohio . . . . . . 4966 Woodland Ave.
Columbia 23, S. C. . . . . . . 1225 Washington St.
Columbus 15, Ohio . . . . 40 S. Third St.
Dallas 2, Texas . . . . 1801 N. Lamar St.
Davenport, Iowa . . . . 511 Pershing Ave.
Dayton 2, Ohio . . . . 25 N. Main St.
Denver 2, Colo. . . . . 650 Seventeenth St.
Des Moines, Iowa . . . . 418 W. Sixth Ave.
Detroit 2, Mich. . . . . 700 Antoinette St.
Duluth 2, Minn. . . . . 14 W. Superior St.
El Paso, Texas . . . . 109 N. Oregon St.
Erie 2, Pa. . . . . 10 E. Twelfth St.
Evansville 19, Ind. . . . . 123 N.W. Fourth St.
Fairmont, W. Va. . . . . 511 Jacobs Bldg.
Fergus Falls, Minn. . . . . 102 W. Lincoln Ave., P.O. Box 197
Fort Wayne 2, Ind. . . . . 127 W. Berry St.
Fort Worth 2, Texas . . . . . . 408 W. Seventh St.
Fresno 1, Calif. . . . . Tulare and Fulton St.
Grand Rapids 2, Mich. . 148 Monroe Ave., N.W.
Greenville, S. C. . . . . . . 106 W. Washington St.
Hagerstown, Md. . . . . Professional Arts Bldg.
Hartford 3, Conn. . . . . 410 Asylum St.
Houston 1, Texas . . . . 1312 Live Oak St.
Indianapolis 4, Ind. . . . . 110 N. Illinois St.
Jackson, Mich. . . . . 120 W. Michigan Ave.
Jackson 1, Miss. . . . . 203 W. Capitol St.
Jacksonville 2, Fla. . . . . 237 W. Forsyth St.
Johnstown, Pa. . . . . 841 Oak St.
Kansas City 6, Mo. . . . . . 106 W. Fourteenth St.
Knoxville 08, Tenn. . . . . 602 S. Gay St.
Los Angeles 54, Calif. . . . . 212 N. Vignes St.
Louisville 2, Ky. . . . . 455 S. Fourth St.
Madison 3, Wisc. . . . . 111 S. Hamilton
Manchester, N. H. . . . . 839 Elm St.
Medford, Ore. . . 2015 E.Main St., P.O. Box 1349
Memphis 3, Tenn. . . . . 8 N. Third St.
Miami 32, Fla. . . . . 25 S.E. Second Ave.
Milwaukee 3, Wisc. . . . . . . 940 W. St. Paul Ave.
Minneapolis 2, Minn. . . . . 12 S. Sixth St.
Mobile 13, Ala. . . . . 54 St. Joseph St.
Nashville 3, Tenn. . . . . 234 Third Ave., N.
Newark 2, N. J. . . . . 744 Broad St.
New Haven 6, Conn. . . . . 129 Church St.
New Orleans 12, La. . . . . 837 Gravier St.
New York 22, N. Y. . . . . 570 Lexington Ave.
Niagara Falls, N. Y. . . . . 253 Second St.
Norfolk 10, Va. . . . . 229 Bute St.
Oakland 12, Calif. . . . . 409 Thirteenth St.
Oklahoma City 2, Okla. . . . 119 N. Robinson St.
Omaha 2, Nebr. . . . . 409 S. Seventeenth St.
Philadelphia 2, Pa. . . . . 1405 Locust St.
Peoria 2, Ill. . . . . 410 Main St.
Phoenix, Ariz. . . . . 435 W. Madison St., P.O. Box 4006
Pittsburgh 22, Pa. . . . . 535 Smithfield St.
Portland 3, Maine . . . . 477 Congress St.
Portland 7, Ore. . . . . 920 S.W. Sixth Ave.
Providence 3, R. I. . . . . Industrial Trust Bldg.
Raleigh, N. C. . . . . 336 Fayetteville St.
Reading, Pa. . . . . 31 N. Sixth St.
Richmond 17, Va. . . . . 700 E. Franklin St.
Roanoke 11, Va. . . . . 202 S. Jefferson St.
Rochester 4, N. Y. . . . . 89 E Ave.
Rockford, Ill. . . . . 122 S. First St.
Rutland, Vt. . . . . 38½ Center St.
Sacramento 14, Calif. . . . . 1107 Ninth St.
St. Louis 2, Mo. . . . . 112 N. Fourth St.
Salt Lake City 9, Utah . . . . 200 S. Main St.
San Antonio 5, Texas . . . . . 310 S. St. Mary's St.
San Diego 1, Calif. . . . . 861 Sixth Ave.
San Francisco 6, Calif. . . . . 235 Montgomery St.
San Jose, Calif. . . . . . 177 W. Santa Clara Ave.
Seattle 11, Wash. . . . . 710 Second Ave.
Shreveport 39, La. . . . . 803 Jordan St.
Sioux City 13, Iowa . . . . 507 Sixth St.
South Bend 11, Ind. . . . . 112 W. Jefferson Blvd.
Spokane, Wash. . . . . S. 162 Post St.
Springfield, Ill. . . . . 607 E. Adams St.
Springfield 3, Mass. . . . . 1387 Main St.
Syracuse 2, N. Y. . . . . 113 S. Salina St.
Tacoma 1, Wash. . . . . 1019 Pacific Ave.
Tampa 6, Fla. . . . . 1206 North A St.
Toledo 4, Ohio . . . . 420 Madison Ave.
Tulsa 3, Okla. . . . . 320 S. Boston Ave.
Utica 2, N. Y. . . . . 258 Genesee St.
Washington 5, D. C. . . . . 806 Fifteenth St., N.W.
Waterbury 89, Conn. . . . . 111 W. Main St.
Waterloo, Iowa . . . . 716 Water St.
Wheeling, W. Va. . . . . 40 Fourteenth St.
Wichita 2, Kan. . . . . 102 S. Broadway
Williamston, N. C. . . . . Town Hall
Worcester 8, Mass. . . . . 507 Main St.
Youngstown 3, Ohio . . . . 25 E. Boardman St.

Hawaii: W. A. Ramsay, Ltd., Honolulu **Canada: Canadian General Electric Company, Ltd., Toronto**

APPARATUS DEPARTMENT, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

6-47 (1M)

PRINTED IN U.S.A.

INSTRUCTIONS

PYRANOL TRANSFORMERS
INCLUDING
PYRANOL IMMERSED
CURRENT-LIMITING REACTORS

GENERAL ELECTRIC

TABLE OF CONTENTS

PYRANOL TRANSFORMERS

INCLUDING

PYRANOL IMMERSED CURRENT-LIMITING REACTORS

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.

PYRANOL

Pyranol* is a cooling and insulating liquid which is noninflammable, chemically stable, and nonsludging. Pyranol supplied for use in transformers is straw-yellow in color, and has a Saybolt viscosity of about 54 seconds at 37.8 C (100 F).

Mineral oil is completely miscible in transformer Pyranol and affects its noninflammable characteristics. Since it is practically impossible to separate the two liquids after they have been mixed, it is important that contamination with any petroleum oils be avoided.

Materials which are not soluble in Pyranol have been selected for use in constructing Pyranol transformers. No materials should be used in contact with transformer Pyranol except those approved by the General Electric Company.

PYRANOL IMMERSED CURRENT-LIMITING REACTORS

A Pyranol immersed current-limiting reactor differs from a Pyranol immersed transformer in that it usually has no core. It generally consists of one winding immersed in Pyranol in a standard transformer tank.

The following instructions, given for transformers, apply to these reactors.

INSTALLATION

Inspection

Before installing, inspect the transformer carefully for damage which might have occurred in transit. Tighten any parts which may have worked loose, such as nuts and leads. Inspect the lead seals which are used to seal the valves at the base of the tank. They should be unbroken when the transformer is received.

*Registered trade-mark for G-E askarel.

Pyranol transformers are pressure-tight and are normally shipped completely assembled in their tanks filled with Pyranol, ready to install.

Pyranol used for filling transformers should have a dielectric strength of 30 kv or higher. When the dielectric strength of Pyranol in transformers in service reaches 25 kv or lower, it should be filtered in accordance with the section on "Drying and Filtering Pyranol."

If the dielectric strength is very low, or if there is other evidence of free water, the core and coils should also be dried in accordance with instructions on "Drying Pyranol Transformers." Under certain temperature conditions, the Pyranol may condense into drops on the under side of the pressure-relief diaphragm. These drops should not be mistaken for free water.

Methods of sampling and testing Pyranol are covered in the section on "Sampling Pyranol."

If the transformer is to be operated at a high altitude (3000 feet or more above sea level) open a fitting above the liquid level, either the top sampling valve on the side of the tank or the filling plug in the cover, in order to equalize the internal and external pressures at approximately 25 C before it is placed in operation.

If a transformer must be opened for inspection out-of-doors on a damp or stormy day, proper precautions should be taken to prevent the entrance of moisture.

Occasionally, due to weight or space limitation, it is necessary to ship Pyranol transformers filled with gas.

When transformers are shipped filled with gas, the following procedure may be found useful. A ¼-in. pipe connection will be found on the cover fitted with a plug so that a gage reading four to five pounds may be fitted to this connection to determine if the gas in the tank still remains under pressure. If a positive pressure is shown on the gage, the core and coils are dry and it should be unnecessary to dry out the transformer. Inspect the coils, the inside of the tank, and underneath the cover for moisture; if any is found, dry the transformer.

Before permitting the gas to escape, the core and coils should be at the same or higher temperature than the surrounding air; otherwise moisture will condense on the internal parts. The core and coils of a transformer shipped in this manner should be immersed in Pyranol before being exposed to air because the insulation is more susceptible to moisture after such complete drainage for shipment. The gas should be forced out by opening the vents and slowly filling the tank with Pyranol through the bottom valve. Regardless of the method followed, the core and coils should be brought up to or above the temperature of the surrounding air before opening the tank for any reason.

Note that the inert gas used in shipment is very little lighter than air and must be completely dissipated before anyone is allowed to enter a tank.

Handling

Lugs or eye nuts are provided for lifting the complete transformer and, when necessary, additional nuts and eyes are supplied for lifting the various parts. Transformers should be lifted by means of the lugs provided on the side of the tank and proper spreaders should be used to obtain a vertical lift. The cover of the transformer should be bolted securely in place to prevent buckling of the tank wall.

When necessary, transformers are provided with means for lifting with jacks, either by means of special jack bosses welded to the transformer case, or by an extension of the base of the transformer. In no case should the transformer be moved or lifted by placing jack or tackle under the drain valves, radiator connections, or other attachments. When rollers are used, skids should be provided to distribute the stress over the base.

Foundation

The only foundation necessary for the installation of Pyranol transformers is a level floor strong enough to support the weight. If the transformers are supplied with removable junction boxes, the boxes may be detached to facilitate lowering the tanks into vaults.

If the transformer is equipped with a diaphragm mounted in the side of the tank, the transformer should be so placed that the diaphragm is not facing an aisle or passageway.

Connections

Do not change connections on a transformer that is under excitation or make any connection except those authorized by the diagram or nameplate accompanying the transformer.

Tap leads on some transformers are connected to a ratio adjuster, the handle of which may extend through the cover or through the side of the tank or it may be under the cover. When the ratio-adjuster handle is brought out through the main cover or the side of the tank, the exposed mechanism is protected by a ratio-adjuster cover. This cover must be in place to avoid the entrance of moisture.

Leads not in use should be insulated from ground and from all other leads.

Regardless of the floor or foundation on which the transformer is placed, unless prevented by special operating conditions, the tank should be grounded permanently and effectively by connecting to the grounding lug at the bottom of the tank.

A good permanent low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all, since it gives a false feeling of safety to those working around the equipment and may result in loss of life or damage to the apparatus.

When a transformer or autotransformer is specially designed for use on a system having a solidly grounded neutral, be sure that the neutral lead, as indicated on the nameplate, is permanently and solidly grounded without resistance. In transformers specially designed for this service, whether single-phase or three-phase, the neutral lead is usually brought out through a bushing of a lower voltage rating than the line bushings. If the neutral is not solidly grounded, sufficient voltage may appear from neutral to ground to cause arc-over of the neutral bushing.

A transformer or an autotransformer is occasionally grounded through a low impedance or a tuned impedance of a higher value. In such instances the neutral bushing is of sufficient insulation strength to meet the specific conditions. Special instructions accompany units for such applications.

A single-phase transformer suitable for Y operation on either the high- or the low-voltage side may be so connected on either side, but not simultaneously on both sides unless precautions are taken to suppress third harmonic voltages.

Two transformers of similar voltage rating may be operated safely in multiple when they have the same polarity, ratio, phase rotation, and angular displacement, and approximately the same per cent impedance.

When desiring to operate transformers in multiple that are not of identical design, communicate with the nearest sales office of the General Electric Company for information. Be sure to give serial numbers of the transformers that are to be operated in multiple.

Every transformer should be protected from lightning disturbances by some form of direct stroke protection and an approved lightning arrester should be installed as near as possible to the transformer to be protected. Provide the arrester with an efficient ground.

Pressure Test

Pressure test all Pyranol transformers before placing them in service. Subject the tanks to an internal pressure of five pounds per square inch when the installation is completed, using dry compressed air or dry nitrogen introduced through the filling hole in the cover. When this pressure has been attained, shut off the supply and allow the transformer to stand for 12 hours. Observe the pressure reading during this period and examine the tank and fittings for leaks. If the pressure holds constant, the joints are satisfactory. Leaks above the Pyranol level may be located by applying a solution of soap and glycerin to all gasketed joints, pipe fittings, and cable connections.

Cooling Coils on Water-cooled Transformer

The cooling coils are thoroughly dried before shipment, and all traces of moisture are removed by means of a hot-air blast. Do not remove the caps from the terminals of the coils until ready to install or test them. Never circulate water through the coils unless the tank is filled with Pyranol as moisture might condense on the coil and later be absorbed by the Pyranol.

After the tank is filled with Pyranol, make a final pressure test on the cooling coils at about 150 lb per sq in. The best method is to use dry air pressure, so that any leaks may be located by observing bubbles in the Pyranol. If air is not available, fill the coils with Pyranol and apply pressure. After obtaining pressure, disconnect the supply, and after a half hour determine whether any fall in pressure is due to a leak in the coil or in the fittings at the ends of the coils.

Gaskets

For gasket materials and methods of applying see the section on "Gaskets."

Storage

Before storing a transformer, check it to see that the Pyranol is at the proper level. Renewal coils and insulation should also be stored under Pyranol in a container that can be sealed from the air. The storage room should be clean and dry and, when possible, without extreme temperature changes. Before a transformer is placed in service from storage, instructions given under "Inspection" should be observed, particularly with regard to moisture.

MAINTENANCE

In general, from the standpoint of maintenance, operation, overvoltage protecton, and overcurrent protection, Pyranol transformers should be treated the same as oil-filled transformers. Specific instructions on items peculiar to Pyranol transformers are given in sections which follow.

Handling Pyranol

Transformer Pyranol may be handled in the same manner as mineral oil. Continued exposure to liquid Pyranol may produce local skin irritations. Cleanliness among workmen handling Pyranol constitutes an adequate safeguard against such effects. Ordinary medicinal washes will remove any irritation caused by Pyranol coming in contact with an open cut or skin abrasion. A drop of castor oil will neutralize any irritation caused by contact of liquid transformer Pyranol with the eyes. As with most volatile materials, exposure to concentrated Pyranol vapors in unventilated rooms should be avoided.

Transformer Pyranol must be handled in containers, pipes, all-metal hose, etc., which are free from oil, grease, pitch, or other foreign materials, since these contaminate the liquid and decrease its noninflammable properties. It is desirable that all such apparatus used in storing or transporting transformer Pyranol be maintained for exclusive use with Pyranol, as it is extremely difficult to remove all traces of oil or other Pyranol contaminants from equipment of this type.

All-metal hose must be used in handling Pyranol instead of rubber-lined hose, since rubber is affected by Pyranol.

Filling Transformers

Although all Pyranol transformers are shipped filled with Pyranol, it may be necessary to refill a transformer. If so, proceed as follows:

Before filling the transformer make sure that joints are tight. Open all air vents.

In order to prevent aeration of the Pyranol, it is preferable to fill the transformer through the drain valve with a filter press. Fill to the 25 C mark on the gage or up to the lower sampling valve if no gage is provided

Baked-on Glyptal paint is resistant to the action of Pyranol. Air-cured Glyptal paint used for touch-up work in the factory and for repainting in the field, however, requires a rather long curing period. Therefore, care should be taken to remove all traces of Pyranol that is spilled or dripped on the outside of the transformer.

Gaskets

Gaskets installed on Pyranol transformers should be made of special cork or other approved material furnished by the General Electric Company.

In applying a replacement gasket, proceed as follows:

1. Remove all traces of the old gasket material and cementing compound adhering to the gasket surface.

2. Brush the gasket surfaces which are to be joined and the surfaces of the gasket itself with G-E Compound No. 880 (use G-E Compound No. 1276 on small distribution transformers) and allow to dry.

3. If a cover gasket is being replaced, brush the bottom surface of the gasket and the tank gasket surface with the compound and set the gasket in position on the tank, using clamps or weights at frequent intervals to obtain the best possible adhesion to the metal. Allow the compound to set at least an hour so that when the weights or clamps are removed the gasket will not slip. After the weights are removed, brush the top surface of the gasket and the cover gasket surface with the compound. Bolt or clamp the gasket surfaces together immediately with uniform pressure at all points until the spring washers, if any, are flat or until clamps are reasonably tight. After four hours, give a second tightening until the same conditions are met.

4. If a bushing or similar gasket is being replaced, steps 1 and 2 should be followed, after which all the surfaces should be given a second coat of the compound. Bolt or clamp the gasket surfaces together immediately with uniform pressure at all points until they are reasonably tight. Give a second tightening after four hours.

Extra gaskets and cementing compounds for Pyranol transformers should be obtained from the General Electric Company.

When assembling pipe fittings, clean the threads thoroughly to remove all oil, grease, Pyranol, old compound and dirt. Apply a coating of G-E Compound No. 880 or No. 1276 to the threads and screw the mating parts tightly in place.

Periodic Inspection

After the first few days of operation, the top and bottom Pyranol should be tested for dielectric strength. Refer to the section covering "Method of Taking Samples and Testing Pyranol."

Pyranol samples may be drawn and tested on the same schedule as transformer oil. The inspection should be systematized and accurate records kept. If, at any time, the Pyranol tests below 25 kv, at room temperature, a filter press may be used to restore the dielectric strength to above 30 kv.

If no facilities are available for making dielectric tests, samples may be sent to the General Electric Company, Pittsfield, Mass., in sample bottles obtained from the General Electric Company. Attach a tag to each sample, giving distinctly the serial number of the transformer or drum from which the sample was taken, the date on which the sample was taken, whether the sample was taken from the top or bottom of the transformer, whether the transformer is located indoors or outdoors, the weather at the time of sampling, and the temperature of the liquid at the time of sampling. These samples should be packed carefully to avoid breakage in transit.

Keep the level of the Pyranol in the transformer up to or above the mark on the Pyranol gage, or up to or above the lower sampling valve.

The condition of the external transformer surfaces should be examined at regular intervals. If it is found that weathering is taking place, the surface should be cleaned thoroughly and repainted with a good grade of durable paint recommended by the General Electric Company.

It is recommended that a pressure test be made in accordance with instructions under this subject once a year, or more often for severe operating conditions, to make sure that a complete seal is maintained.

Water-cooled Transformers

The ingoing cooling water should not have a temperature of over 25 C. Supply enough water so that the difference in temperature between the ingoing and the outgoing is not more than 10 C. It is recommended that thermometers be permanently installed in the ingoing and outgoing water connections, so that the difference in temperatures may be readily observed. Where multiple cooling coils are employed, see that the flow through each section is such as to produce the same temperature rise in each.

To prevent condensation, never allow water to flow through any portion of an exposed coil above Pyranol in a transformer.

Nearly all cooling water will in time form scale or sediment in the cooling coil, which materially decreases the efficiency of the coil. This is indicated by a high Pyranol temperature and a decreased flow of water, load conditions and water pressure remaining the same.

Scale and sediment can be removed from a cooling coil without removing the coil from the tank. Disconnect both inlet and outlet pipes from the water system and temporarily pipe the coils to a point several feet away from the transformer, where the coil can be filled and emptied safely. Take special care to prevent any acid, dirt, or water from getting into the transformer.

Blow or siphon all the water from the cooling coil, and pump it full of a solution of hydrochloric (muriatic) acid, specific gravity 1.10. (Equal parts of commercially pure concentrated hydrochloric acid and water will give this specific gravity.)

After the solution has stood in the coil about an hour, flush out thoroughly with clean water. If all the scale is not removed the first time, repeat the operation until the coil is clean, using a new solution each time. The number of times it is necessary to repeat the process will depend on the condition of the coil, though ordinarily one or two fillings will be sufficient.

The chemical action which takes place may be very violent and often forces acid, sediment, etc., from both ends of the coil; therefore, it is well to leave one end partially open to prevent abnormal pressure.

Cooling coils with the ends through the cover will not drain under any conditions. To remove the water, blow them out with air under pressure of from 10 to 100 lb per sq in.

A cooling coil with both ends through the tank near the bottom, or with one end near the top and the other near the bottom, will only partially drain, even with both ends wide open. With such constructions a petcock located on the elbow at the upper end of the coil must always be opened while blowing out with air.

If a water-cooled transformer is to be removed from service, it is recommended that the cooling coil be drained thoroughly, dried by hot air, filled with transil oil, and sealed.

Limiting Temperatures

Do not run an artificially cooled transformer continuously, even at no load, without the cooling medium. If the circulation of the cooling medium is unavoidably stopped, immediately reduce the load as much as possible and keep a close watch on the winding temperature (if a temperature indicator is available) and on the Pyranol temperature.

For continuous full-load and overload operation, refer to ASA guide for loading power and distribution transformers ASA-57.1, -57.2 and -57.3.

Sampling and Testing Pyranol

In the sampling and testing of transformer Pyranol, as with any insulating liquid, strict attention should be given to the cleaning and drying of sampling and testing receptacles.

Samples of Pyranol which is questionable should be submitted to the General Electric Company, Pittsfield, Mass., for laboratory tests. When the factory analysis of a sample indicates soluble contamination of a character that impairs the serviceability of the Pyranol, detailed recommendations for correcting the situation will be made. Oil is the only contaminant usually found in Pyranol which cannot readily be removed by the combination of fuller's earth and paper filtration described in these instructions. It is essential, therefore, that the operator be particularly careful to avoid Pyranol contamination by oil.

The procedure outlined herewith should be followed to obtain consistent results from samples taken either for field or factory tests.

Sampling from Transformers

1. Samples should preferably be taken when the temperature of the transformer is near 25 C. Take samples from outdoor apparatus on a clear day only, and guard against contamination by wind-blown dust, etc.

2. Glass bottles for samples should be obtained from the General Electric Company, Pittsfield, Mass. These will be supplied filled with new transformer Pyranol to prevent contamination of the bottle and to replace the Pyranol which is withdrawn as the sample.

3. If in emergency it is necessary to use other containers than the sample bottles obtained from Pittsfield, only small-neck glass bottles should be used and the following procedure should be followed in cleaning the container.

Rinse sample containers with oil-free gasoline. Then wash them with strong soapsuds, rinse thoroughly with water, and dry in an oven at 105 C to 110 C for at least eight hours. After drying, the bottles must be tightly stoppered with a glass stopper, or with a clean cork protected by clean metal foil.

4. Impurities tending to affect the dielectric strength of Pyranol will in general be at the top of the liquid, and therefore the sample should be taken from the top through the small valve or plug provided for this purpose. Carefully clean the valve or plug and allow enough Pyranol to run out so that any moisture or foreign material which may have collected in the drain pipe, valve, or plug is removed.

5. After the new Pyranol contained in a sample bottle received from Pittsfield is poured into the transformer, allow the sampling bottle to drain thoroughly.

6. Draw a sample into the bottle, leaving sufficient air space to allow for possible expansion of the Pyranol. Carefully seal the container to prevent any exposure of the Pyranol to the atmosphere, using the stopper removed from the bottle.

7. If it is necessary to sample when the transformer is appreciably warmer or cooler than 25 C, the transformer tank should be

vented to the air at the first opportunity that presents itself when it is near that temperature. This should be done so that excessive pressure or vacuum will not result when extensive changes in temperature take place during operation.

Sampling from Drums

1. Take samples from drums after the Pyranol has remained undisturbed for at least eight hours. Samples should be taken only when the Pyranol is at least as warm as the surrounding air. If drums are outdoors, take samples on a clear day only and guard against wind-blown dust, etc. Take a sample from the top of the drum by means of a chemically clean thief. Observe sampling precautions before outlined.

2. Clean the glass thieves in the same manner as the bottles are cleaned and store them in a dust-free cabinet, preferably at a temperature not less than 37.8 C (100 F).

Testing for Dielectric Strength

For testing the dielectric strength of Pyranol the technique as specified by the American Society for Testing Materials in the test method entitled, "The Standard Method of Testing Electrical Insulating Oils" shall be followed. The following precautions and modifications must be observed.

1. Set the spacing of the electrodes at 0.100 inches.

2. The test cup and electrodes should be wiped clean with dry, calendered tissue or clean, dry chamois and thoroughly rinsed with oil-free dry gasoline.

3. Fill the test cup with dry gasoline and make a breakdown test under standard conditions of voltage application (3 kv per second rise). If the dielectric strength is not less than 25 kv, the cup is considered suitable for testing purposes. The usual precautions in handling gasoline should be observed.

4. Immediately after the final rinsing with gasoline, the test cup should be rinsed with the Pyranol under investigation and the test proceeded with at once.

5. The temperature of the Pyranol when tested should be the same as that of the room which should be between 20 C and 30 C (68 F and 86 F). Testing at lower temperature is likely to give variable results which may be misleading.

6. After filling the test cup, the Pyranol should be allowed to stand for three minutes before test in order to allow entrained air bubbles to escape.

7. When making tests, take only one test per filling, filling at least three times and averaging the results.

Drying and Filtering Pyranol

Transformer Pyranol will seldom require filtration because the tank of a Pyranol transformer is sealed. When it is necessary to filter Pyranol to remove moisture or foreign material, the following is the recommended procedure:

The Pyranol purifier consists of a specially proportioned filter press, a positive-volume gear pump, driving motor, combined drip pan and mixing tank, and the necessary piping valve, strainer, gages and drying ovens. Any equipment used for filtering Pyranol should first be thoroughly cleaned to remove foreign material, including oil. Oil contamination should be avoided because oil is completely miscible in Pyranol and cannot be separated by any practical method. It is recommended that wherever possible separate equipment be reserved for the exclusive use of Pyranol.

TO REMOVE MOISTURE FROM PYRANOL OR ANY INSULATING LIQUID A THOROUGHLY DRY FILTERING MEDIUM IS ESSENTIAL. Filter paper and fuller's earth are used for this purpose in the Pyranol purifier, and the effectiveness of the filtering process is proportional to the care and thoroughness with which these materials are dried initially.

Drying the Paper

The filter paper should be separated as it is hung on the rods in the oven, to permit free circulation of air and insure the most rapid drying. The paper should be dried from six to twelve hours (depending upon the condition of the paper and the separation of the sheets), at a temperature of 85 to 100 C. After drying it should be taken from the oven directly to the filter or, if this is not convenient, it may be stored in dry Pyranol for future use. When transferring the paper, care should be taken to handle it as little as possible to avoid the absorption of moisture from the hands and to minimize the time that the paper is exposed to the air. Filter paper exposed in normal atmosphere will reabsorb, in as little time as ten minutes, two-thirds of the moisture that it will ultimately take up from the air.

Drying the Fuller's Earth

The drying of fuller's earth requires temperatures higher than the 85 to 100 C used to dry the filter paper. Placed in pans two or three inches deep, fuller's earth can be dried in from two to three hours, if held at a temperature of 200 C or higher. A temperature of 300 C can be used without impairing the earth. In fact, it dries faster at these high temperatures and gives up a greater percentage of its normal moisture content.

When a high-temperature oven is not available the standard filter-paper oven may be utilized by operating it at a temperature of 125 C and keeping the earth in the oven for about 24 hours in pans not over three inches deep. Filter paper will be physically weakened if subjected to these temperatures and, therefore, cannot be safely dried with the earth.

Handling Dried Filtering Medium

Because any dry filtering medium will reabsorb moisture from the air in a matter of minutes, it is essential that it be protected from contact with the air while being transferred from the oven to the filter press. Where the oven is located immediately adjacent to the filter, the individual sheets of paper and the earth may be quickly transferred from the oven to the filter, but where the oven is located some distance away, the filtering medium, as soon as removed from the oven, should be covered with dry Pyranol, and should remain covered until loaded in the filter. Filter paper or fuller's earth once submerged in Pyranol cannot be effectively re-dried.

Charging the Filter

The frames and plates should be placed alternately and so positioned that, when facing the pump or head end of the equipment, the small projections on their top edges are at the right-hand side.

Three sheets of dry filter paper should be placed between each plate and the adjacent frame, care being taken that the holes in the paper correspond to those in the plates. As soon as they are thus positioned, the plates and frames should be pushed together, to prevent free circulation of air past the paper while the remaining sheets are being inserted. When all the sheets are in position, the press should be clamped securely by means of the compression screws at the back of the assembly.

The charge for the filter should consist of six pounds of 80/300 mesh fuller's earth (the equivalent in volume to a little more than one gallon liquid measure). About a third of this charge should be mixed with five or six gallons of clean Pyranol in the mixing tank. When thoroughly mixed, the valve leading from the mixing tank to the pump and that between the press outlet and the drip pan should be opened, while the other valves should be closed. The motor should then be started to circulate the Pyranol and fuller's earth mixture through the press and thus deposit a layer or cake of fuller's earth on the surface of the filter paper. After the pump has been running about five minutes, the remainder of the six-pound charge of earth may be added gradually to the mixing tank, being careful to stir the mixture thoroughly to prevent any dry lumps of earth being drawn into the pump. The addition of the remainder of the earth will take from 10 to 15 minutes. It is recommended that the outfit be run at least five minutes after the last of the earth is added to make sure that all earth is deposited in the press and that the cake is of proper depth.

The purifier is then ready for use.

Operation

The most effective procedure for filtering is to pump the Pyranol through the filter and into a clean tank. When this is not practical, the circulation method may be used, whereby the impure fluid is pumped directly from the transformer tank through the filter and back to the same tank. In such cases it is recommended that the transformer be de-energized.

Since most of the free water and sediment are usually found near the top surface of the Pyranol, the inlet to the filter should be connected to the top of the transformer tank and the return fluid delivered into the bottom. During the filtering operation any air which has been drawn into the filter press will be discharged into the bottom of the transformer tank and therefore sufficient time (two hours or more) should be allowed for this air to escape before the transformer is re-energized. If these instructions are followed, there should be no difficulty in obtaining a dielectric strength of 30 kv or higher, as measured with one-inch disks set 0.1 inch apart.

Cleaning the Filter

Compressed air passed through the press will release a considerable amount of Pyranol that would otherwise be retained in the earth and filter paper.

To do this, first close all valves except the one leading from the filter press outlet to the drip pan. Then connect a supply of dry, oil-free compressed air to the connection at the press inlet and pass the air through the press until no further Pyranol is discharged into the drip pan. Air pressures as high as 100 pounds can be used; the higher the pressures the more rapidly the Pyranol is forced out.

In addition to saving Pyranol this operation simplifies the subsequent removal of the earth and filter paper. After blowing out the press, the individual frames, with the filter paper held in position on each side, can be lifted from the press intact, and the earth and paper discarded with minimum effort.

Pump

The purifier is equipped with a constant-volume gear pump having a built-in relief valve adjusted to limit the output pressure to 100 pounds per square inch. The higher specific gravity of Pyranol does not permit long or high "suction" lifts, hence it is desirable to so locate the filtering apparatus that the inlet connections will be as short as practical. The Pyranol should preferably flow into the pump by gravity. Where long runs cannot be avoided, the use of large hose will give the best results.

Where it is necessary to filter Pyranol in transformers located in subway manholes or street vaults, space limitations usually make it impractical to lower the purifier into the vault. To maintain full capacity operation under these conditions, it is recommended that a portable auxiliary motor and pump unit be installed in the vault to pump the Pyranol up to the filter.

After the equivalent of several months of continuous service, the abrasive action of the fuller's earth passing through the pump gears may cause considerable wear, particularly if the Pyranol and fuller's earth are not well mixed. The filter is designed for convenient pump replacement and when this wear has advanced to the extent that the output of the apparatus is appreciably below normal, a new pump should be installed. While individual repair parts can be obtained for these pumps, the wear will be found to be so generally distributed over the whole pump that a complete replacement is advisable.

Motor

The 1.5-horsepower motor is geared directly to the pump. Ordinarily, a single-phase, 110/220-volt 60-cycle induction motor is supplied, but motors for other voltages and frequencies or for direct current may be obtained.

Strainer

The strainer is provided to prevent anything of appreciable size from entering and injuring the pump. It is easily accessible and should be thoroughly cleaned at regular intervals.

Electric Drying Oven

The oven for this purifier requires approximately 1400 watts and is designed to operate from either 110-volt or 220-volt single-phase alternating current. The oven is provided with an automatic heat control to avoid overheating the paper and earth. The oven is divided into four compartments, each with rods for suspending the filter paper for drying.

Drying Pyranol Transformers

Pyranol transformers should be dried by the short-circuit method with the transformer kept sealed since loss of Pyranol due to evaporation will result from the temperatures which the transformer must necessarily attain in order to drive off moisture. During the heat run the Pyranol should be circulated through a paper filter press or, preferably, through a filter press with fuller's earth and paper. Either method will remove the moisture from the Pyranol, but the latter will, in addition, remove soluble contaminants from the liquid itself. (Drying will be slower than if it were feasible to thoroughly ventilate the top of the tank because moisture filtration from the hot Pyranol is rather slow at high temperatures.)

A filter press which has been reserved for use with Pyranol is preferable. If, however, in an emergency it is necessary to use a paper filter press which has been used previously for oil, it must be thoroughly cleaned, removing all traces of oil by the use of Pyranol, carbon tetrachloride, naphtha or gasoline. The Pyranol and windings should be heated by short-circuiting one winding and applying suitable voltage and current to the other winding. The desired temperature may be attained by blanketing the tank and the cover should be lagged in order to prevent condensation.

The following table gives the maximum allowable load which may be used with various corresponding maximum allowable top Pyranol temperatures. It is desirable to hold 85 C top Pyranol temperature with 50 per cent load if this is possible. A load of 125 per cent may be used at the start until the top Pyranol reaches 65 C, then reduce the load for obtaining constant temperature in accordance with the following tabulation.

MAXIMUM ALLOWABLE SHORT-CIRCUIT AMPERES IN PER CENT OF FULL LOAD		Maximum Allowable Top Pyranol Temperature
Self-cooled Trans.	Water- and Forced-Pyranol Cooled Transformer	
50	50	85 C
75	60	80 C
85	75	75 C

When heat is generated in the windings, do not allow the top Pyranol temperature to exceed the specified value for a given per cent load, since the windings are at a higher temperature than the Pyranol and damage to insulation will result.

The filtering, if done continually, may keep the Pyranol temperature too low, hence it may be preferable to filter periodically.

The drying should be continued until the dielectric strength of the Pyranol is restored to at least 30 kv when tested with the Pyranol at room temperature.

Spare Transformers

Time and expense will be saved if spare units are kept in readiness for instant use. The following items should be inspected during periods of idleness: Pyranol level, Pyranol dielectric strength, relief diaphragms, fan control and conduit, mercury seals, load-ratio control, also nitrogen-gas analysis for oxygen content, gas supply and control, gas relief pressure alarm (when nitrogen gas seal is used).

Also inspect for condensation in all cabinets, junction boxes, as well as on the underside of covers of apparatus not having conservators or nitrogen gas seal.

LOCAL CONDITIONS AFFECTING THE OPERATION AND LIFE OF TRANSFORMERS

Impure Air

Unless special care is taken, trouble may be experienced with transformers which are installed where abnormal conditions prevail.

Bushings must be kept clean, since the formation of conducting deposits may cause bushing arc-overs.

Transformers near the seacoast should be kept well painted to prevent the corroding of any metal parts by the damp salt air.

Conduit piping leading from the station to the terminal box at the transformer should be sealed to prevent warm air flowing to the box and condensing.

Altitude

If a transformer is moved to a location of a higher altitude, the effects are to increase its temperature rise (if self-cooled) and to lower the arc-over voltage of the bushings due to the decreased air density. These effects must be considered if a transformer is operated at a higher altitude than that for which it was designed.

Standard bushings may be used at any altitude up to 3300 feet. If transformers are to be moved to an elevation higher than 3300 feet, first communicate with the nearest office of the General Electric Company relative to suitability of the bushings.

Transformer Housing

When large self-cooled Pyranol transformers are installed in vaults or compartments, it is necessary to thoroughly ventilate the compartment. Provide cool air inlets in or near the floor and outlets in or near the roof. Have the latter six feet or more above the top of the transformer. The number and size of air outlets required will depend on their distance above the transformer, and on the efficiency and load cycle of the apparatus. In general, provide about 20 square feet each of inlet and outlet opening for each 1000 kva of transformer capacity. If the transformer will be required to operate for considerable periods at continuous full load, the areas of openings should be increased to about 40 square feet per 1000 kva of transformer capacity.

Arrange the air inlets and outlets so that they are permanently open. Do not use as ventilators windows or doors which may be opened and closed by attendants, due to the danger of excessive heating in case they are inadvertently left closed during periods of heavy load or high temperature.

If forced ventilation is used, supply about 5000 cubic feet of air per minute for each 1000 kva of transformer capacity, and conduct the incoming air directly to the transformers so that it will flow up through and around the radiating members of the tank. If this cannot be done and the air is merely moved through the room, provide about 10,000 cubic feet per minute for each 1000 kva.

Do not let the temperature of the room in which the transformer is installed exceed the temperature of the air entering the room by more than 5 C. The entering air should come from the outside, or at least from a source not much warmer than the outside air.

ACCESSORIES

Thermometers

For Small Transformers

The thermometers usually furnished with these transformers are known as Form P. This type of thermometer is attached to the side of the tank near the top, with the bulb extending into the top Pyranol, supported by a short length of capillary tubing.

Each thermometer is equipped with a maximum reading hand which may be reset by rotating the knurled projection in front of the case. Do not turn the maximum reading hand past the instantaneous indicating hand.

This type of thermometer when provided with alarm contacts is known as Form P-2. When this thermometer is shipped from the factory, the alarm contacts are set to operate at 65 C for water-cooled transformers, and at 80 C for self-cooled transformers.

If the bulb interferes with the removal of the core and coils from the tank, the tubing may be bent to one side. Do not bend it at the same place often enough to fatigue the metal.

For Other Transformers

Thermometers for larger transformers are known as Form M. The bulb of this thermometer is located in the top Pyranol with the indicating dial mounted near the nameplate.

The capillary tube passes through the cover of cover-lifted transformers, and through the tank wall on other types. On transformers with the thermometer tube passing through the cover, detach the thermometer dial and place it on top of the cover before removing the transformer from the tank. On other types the cover may be removed without disturbing the thermometer. If the transformer is to be lifted out of the tank, first remove the thermometer bulb from its supporting bracket.

Thermometer readings taken frequently will indicate abnormal conditions affecting the transformer. The reading must not be relied upon as an indication of permissible load, except with the limitations noted under "Limiting Temperatures."

All Form M thermometers are provided with alarm contacts. When these thermometers are shipped from the factory, the alarm contact is set to operate at 65 C for water-cooled transformers and at 80 C for self-cooled transformers. These contacts may be readily adjusted to operate at other points on the scale.

To adjust the alarm contacts of Forms P-2, M-12, or M-121 thermometers, first take off the bezel ring and glass by removing the six clamping screws. Immerse the bulb of the instrument in a fluid at the desired alarm temperature. Loosen the screw holding the cam on the pointer spindle, and rotate the cam until the contacts just close.

To check the setting, lower the temperature of the thermometer bulb approximately five degrees. If the setting is correct, the contacts will open.

To change the alarm adjustment on Forms M-10, M-11, M-14, and M-15 thermometers, unscrew the bezel ring that secures the glass. It will be seen that the circuit is made between a contact on the instrument hand and another carried at the end of a hairspring. This second contact is held in position by an arm which shows the contact setting on the instrument scale. It is held in place by friction. To change the setting, rotate the arm until it points to the desired temperature upon the scale, then replace the bezel.

Thermotel

When a Thermotel is supplied with the transformer, frequent observations should be made, since the Thermotel indicates the maximum percentage of the transformer capacity utilized since the last observation, assuming that the Thermotel was reset at that time. Should an overload occur for a sufficient length of time to produce an unsafe operating condition, the indicating semaphore will be tripped. When this occurs, the semaphore should be reset by moving the small lever at the bottom of the Thermotel to the left. Then make observations from day to day and if the semaphore is tripped the second time, the cause should be determined.

Resetting the semaphore also resets the maximum indicating hand to give an instantaneous reading.

Relief Diaphragm

A pressure relief diaphragm is standard equipment on all Pyranol transformers above 25 kva.

This device consists of a diaphragm made of frangible material, held in place by flanges fastened to the transformer.

In an older type, the diaphragm is held between one flange welded to the transformer and another separate flange by cap screws fitted with lock washers. The diaphragm is protected on both sides by cushioning gaskets.

The technique employed in bolting down this type of diaphragm and making the seal is of prime importance, since the rupture strength of the frangible material depends materially on the care with which this operation is performed.

Clean the gasket surface of the tank flange thoroughly. Coat both sides of the inner gasket with G-E No. 880 or No. 1276 Compound, lay it on the tank flange and place the diaphragm over the gasket, being careful to center it properly. Lay the cushion gasket over the diaphragm and assemble the clamping ring over the cushion, holding it in place with cap screws.

Equal distribution of stress can be obtained by tightening the three alternate cap screws until the spring in the lock washer is almost taken up. The cap screw diametrically opposite the third screw tightened should then be turned until the spring in the lock washer is taken up. The two screws diametrically opposite the other two screws are then to be tightened in the same way. This tightening process is to be repeated until the gasket is compressed to half its original thickness or until there is a space of $\frac{1}{32}$ inch remaining between the grooved flange and the clamping ring.

In a newer type, the frangible material is held between two flanges separate from the transformer. The diaphragm with cushioning gaskets on each side is assembled between these flanges under a press so that uniform pressure around the whole circumference is obtained. This assembly is held together with countersunk flathead screws. In bolting this assembly to the tank a gasket covered with G-E No. 1276 Compound on both sides is placed on the tank flange and the diaphragm assembly is bolted to it with cap screws fitted with lock washers in the manner specified above for the other type of diaphragm. This type of diaphragm is shown in Fig. 1.

Outdoor power transformers are provided with a type of pressure relief which is mounted at the end of a curved pipe on the cover as shown in Fig. 2. The relief diaphragm is a thin disk of molded material (Herkolite) firmly held between gaskets and clamping rings. This relief disk is protected from the weather and mechanical injury by a metal cover held firmly over it by spring tension. Through the edge of this cover opposite the hinge is the relief pin which is screwed into the diaphragm clamping ring to hold the cover closed. This relief pin is made of treated aluminum to prevent corrosion. It will break at 10 pounds tension.

Fig. 1. Section through the Relief Diaphragm

On occurrence of a sudden pressure within the transformer tank the diaphragm will move out against the cover, putting tension on the relief pin which breaks when the tension reaches a predetermined value. As soon as this relief pin breaks, the diaphragm comes against a knife edge centrally located over the front of the diaphragm. This knife edge cuts through the diaphragm which breaks open to relieve the pressure. As soon as the pressure has been relieved, the cover is closed by spring tension, shutting firmly against a rubber gasket. This action prevents any moisture from entering the transformer.

To renew the relief diaphragm after it has been ruptured, it is necessary to take out the cap screws and remove the front clamping ring. There are notches provided under opposite edges of this ring into which wedges can be inserted to separate the flanges. When putting in a new relief diaphragm, a new diaphragm gasket must be used. Brush this gasket on both edges and one side with a thin coat of G-E No. 880 or No. 1276 Compound and allow it to set. Then apply a fresh coat of the compound to the gasket ring in the metal and put the gasket in place. No compound should be used on the gasket surface which comes against the diaphragm. Bolt the clamping ring and cover assembly firmly in place.

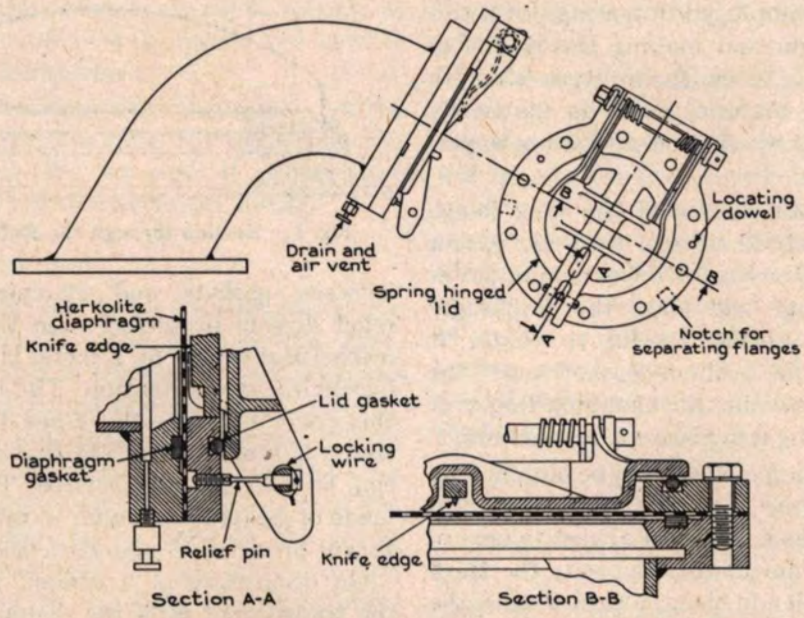


Fig. 2. Pressure Relief for Outdoor Power Pyranol Transformers

Put a new aluminum relief pin through the steel pin in the edge of the cover and screw it into the steel clamping ring. Use a nail in the hole just above the threads of the relief pin to screw it in place, and draw it down only enough so that the head of the relief pin comes against the steel pin in the cover without putting any stress on the aluminum pin. Do not turn the relief pin by its top end. After the relief pin is screwed in place, seal it to prevent tampering by using a piece of copper wire through the hole in the head of pin and passing the wire around the steel pin as shown in Fig. 1.

For shipping purposes the aluminum relief pin is removed and shipped separately with extra pins, gaskets and relief diaphragms. The relief cover is also securely closed with wire. The wire must be removed and the relief pin must be assembled in place as previously described.

Pyranol filled junction boxes on power transformers are provided with a pressure relief similar to one of the types previously described.

Gas Absorbers and Vent Pipes

Pyranol transformers can be installed in a building without fireproof vault, in accordance with the requirements of the 1940 National Electrical Code* since in sizes above 25 kva they are equipped with pressure-relief diaphragms or vents. This diaphragm meets the code requirements for transformers installed in well-ventilated areas. The upper steel clamping ring which fastens the diaphragm to the transformer is provided with tapped holes, arranged to permit the easy attachment of a vent pipe that can be carried to the outside air, to a chimney, or to some other ventilating flue.

Vent Pipe

When a vent pipe is provided for carrying

*LIQUID THAT WILL NOT BURN: A transformer immersed in an approved liquid that will not burn and rated in excess of 25 kva shall be furnished with a pressure-relief vent. If installed in a poorly ventilated place inside of a building, it shall also comply with one of the following conditions:
1. It shall be furnished with a means for absorbing any gases generated by arcing inside the case, or
2. The pressure-relief vent shall be connected to a chimney or flue which will carry such cases outside the building. (Article 4503, section b.)

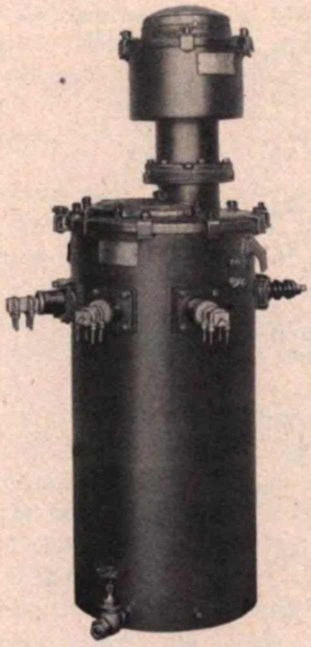


Fig. 3. Pyranol transformer with gas absorber

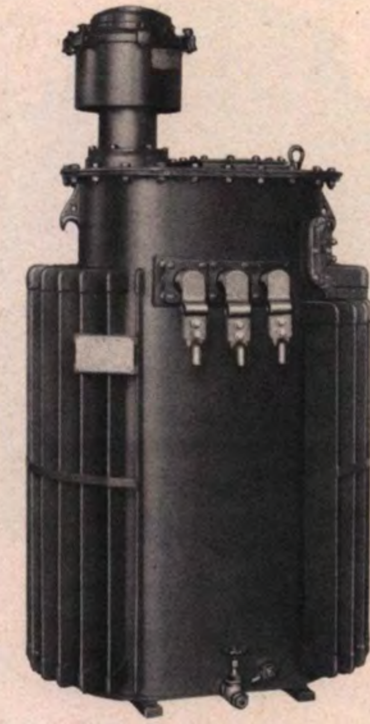


Fig. 4. Pyranol transformer with gas absorber

gases away from a poorly ventilated area, it is recommended that its diameter be no smaller than the clear diameter of the frangible diaphragm to which it is attached; that is, either six or eight inches, as shown in the outline (Fig. 5). It is also recommended that the metal of which the vent pipe is made shall not be lighter than No. 16 gage and that it shall be installed with the minimum of bends in order to provide a free passage of gas. It is further recommended that provision be made for inspecting the diaphragm and for removing any moisture that may accumulate on it. It is preferable that the pipe be so arranged that moisture cannot collect on the diaphragm.

Gas Absorber

Where it is not practical to install a vent pipe, a gas absorber can be installed on the flange over the frangible diaphragm, as shown in Figs. 3, 4, and 6. It is designed to absorb the gases produced by arc disintegration of part of the Pyranol in the transformer: two per cent of the Pyranol in distribution and power transformers, and five per cent for a-c network transformers.

This absorber has a steel tank with a mounting flange at the bottom for attachment to the relief vent of the transformer tank. At the top is a diaphragm, with protecting cover.

Inside the absorber tank are several trays, one above the other, each of which has a perforated steel bottom. The trays are fastened together by a center bolt to facilitate assembly, and the entire group is secured to the absorber tank by two studs. The bottom tray is filled with chipped marble; the upper trays contain G-E Compound A50P9. For transformers over 500 kva, all trays contain the compound.

When an arc in the transformer generates gas and raises the pressure sufficiently to break the diaphragm on the transformer, the gas passes into the absorber and is absorbed by the compound. Liquid carried along with the gas is stopped by the chipped marble and drains back

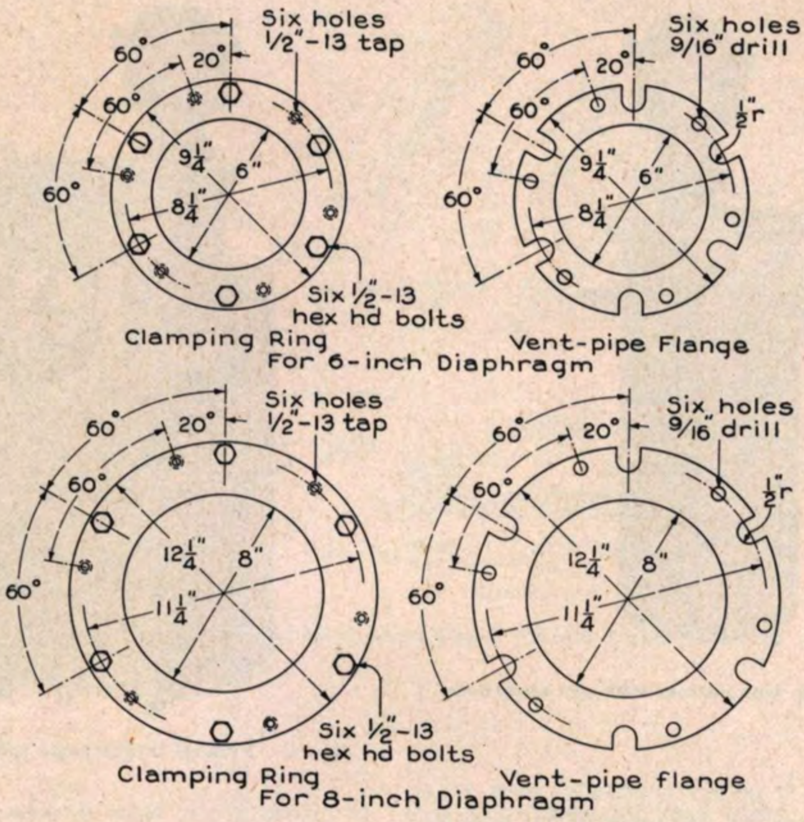


Fig. 5. Vent Pipe Flange Outlines and Dimensions

into the transformer. If the gas exceeds the capacity of the absorber, the top diaphragm breaks.

Application

Under the provisions of the National Electrical Code, it is the responsibility of the local code authority to determine whether vent pipes or absorbers are required for a given installation. Important factors to be considered are: The energy available in the circuit to which the transformers are connected; the type of protective equipment; the area and volume of the room in which the transformers are installed; the ventilation facilities in the room; the number of people employed in the area; and the proximity of the employees to the transformers.

If absorbers are used, it is recommended that one absorber be used with each transformer. If one absorber is connected to two or more transformers by means of a header pipe, there is the possibility that if one transformer fails and sufficient gas is generated to break the glass diaphragm in that transformer, the pressure in the header pipe may also be sufficient to break the diaphragms in the other transformers. Furthermore, if more than one transformer were simultaneously involved in trouble, sufficient gas might be produced to exceed the capacity of one absorber.

The absorber should be inspected at intervals to make certain that the diaphragms are intact and that the compound in the absorber trays has not become damp or caked.

When a gas absorber is supplied, a separate instruction book accompanies the apparatus which describes the installation, operation, and care of the device.

Sampling Valve

Some transformers are provided with a sampling valve in which the height of the intake may be carried to coincide with the rise and fall of the Pyranol level caused by temperature changes. This type of valve makes it possible to obtain a sample at the surface of the Pyranol at any time.

The valve is placed in the tank wall at a point about one inch below the 25 C Pyranol level. The intake pipe is a tube inside the tank located parallel to the tank wall, the end of which may be raised or lowered by rotating the outside part of the valve by moving the handle which extends below it. Note that when the handle points straight down, the intake pipe points straight up and is in position for maximum Pyranol level. The valve is fitted with a knurled nut which may be opened by hand or by the use of a coin or screwdriver.

To take a sample, set the operating handle pointing down, open the valve, and rotate the operating handle slowly until the liquid begins to flow, at which point the rotation should be stopped to assure getting a sample of the surface liquid.

Some transformers do not use the rotating feature, in which case the sample is taken by merely opening the valve, allowing the liquid to flow out.

Pyranol transformers are sealed and no breathing takes place with the rise and fall of the Pyranol level. Thus, when the Pyranol is at a temperature other than 25 C, there is either a pressure or a vacuum within the tank, depending upon whether the temperature is above or below 25 C. For this reason it is advisable to take a sample only when the Pyranol level gage is resting on or slightly above the 25 C mark. If the valve has been opened at any other time and the vacuum or the pressure has been relieved, the valve should again be opened when the Pyranol next passes the 25 C level so that no

Fig. 6. Absorber

abnormal pressure or vacuum will be developed during subsequent changes in temperature.

Ratio Adjusters

Ratio adjusters furnished with transformers are of several types, known as "drum," "plunger," "crab" and "wedge."

Indicating marks on stationary and rotating parts of all adjusters must be in alignment when the adjusters are on the first position.

NOTE.—Do not attempt to change connections by means of the ratio adjuster while a transformer is under load or excitation.

Drum Type

A change in voltage ratio with a drum-type ratio adjuster is made by a partial turn of the handle. Remove the two bolts that hold the handle in place or the cover over the handle and turn until the index line points directly to the desired figure on the dial before connecting the transformer in circuit. After the handle is in the proper position, it should be locked securely by replacing the two bolts, or the cover.

Before removing a power transformer cover, take out the bolts that attach the ratio adjuster to the cover flange, then lift the handle and shaft out of the cover. Do not replace a cover on a tank with the operating rods in place. First assemble the cover and lower the rods through their respective openings, noting that they engage properly with the adjusters, and finally add the cover-operating mechanism to indicate the tap actually in circuit. Indicating match marks on the rods and on the internal structure show the proper assembly of these parts.

Sometimes in reassembling it may be necessary to change the vernier coupling in order to obtain proper alignment of the shafts.

When more than one operating rod is furnished, the rods are numbered in accordance with the nameplate, and are not interchangeable. The slot and pin joining the rod to the operating cap are larger on one side of the rod than on the other to aid in making correct assembly. A vernier coupling is used between the rod and the operating cap to assure that the indicator points directly to the dial number when the adjuster mechanism is in a correct operating position. Be sure that the operating cap does not force the rod down on the mechanism. It should be possible to move the rod slightly up and down and rotate it an equal distance either side after the assembly is completed; otherwise the mechanism might be damaged. If this vertical play is not obtained, remove the metal sleeve from one end of the rod, cut a small amount from the rod and replace the sleeve. Use compound on the gasket in the joint between operating cap and cover, but not on the gasket in the upper part of the cap or on those around the shaft in the stuffing box.

Plunger Type

The plunger-type ratio adjuster provides solid insulation between each tap connection. This insulation must be lifted over the contact members each time the taps are changed.

To change taps, remove the two hex-head bolts in the cap and lift off the cap. Pull up the handle as far as it will come (about seven inches). Rotate the handle until the pointer end is over the desired tap position and then push down into the original position. Tighten the gland and bolt down the cap.

The contactor is of the scraping type and is self-cleaning, but if it is considered desirable to make an inspection, proceed as follows:

Remove the cap, lift up the handle as in changing taps, and turn the contactor to a neutral position. It will stand in this position. Then remove the three studs and take off the clamping ring. Lift straight up on the handle. This will remove the small cover through which the shaft passes, and also the operating shaft and contactor.

When it is desired to remove the transformer cover, the ratio-adjuster contactor should first be removed from the transformer.

Crab Type

If it is desired to remove the core and coils from the tank, the universal joint that ties the operating rod with the shaft should be disconnected. Indicating marks on the adjuster and cylinder should line up when the indicator is on Position No. 1.

When assembling, the position indicator on the cover may be made to agree with the actual position of the adjuster by means of a special position indicator coupled to the adjuster shaft and located near the top of the core.

Wedge Type (See Fig. 7)

A tap position is accurately given by the notched brass indexing disk, located directly under the driving pin. In the fully closed contact position, the large end of the driving pin is adjacent to the indexing notch.

To operate the adjuster, remove the two bolts which hold the operating mechanism cap, lift off the cap and invert it. Fit the inverted cap on the end of the operating shaft and use it as a hand wheel to set the adjuster. To lock the adjuster in position, after setting the adjuster, replace the cap and bolts.

The indexing disk is assembled about a cam which is eccentric with the shaft between tap positions, and concentric only on full contact positions.

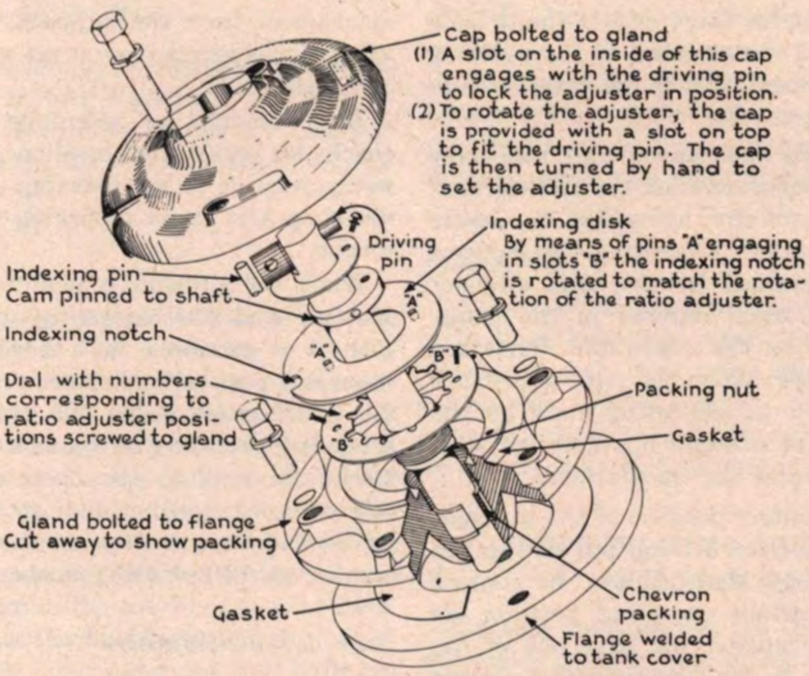


Fig. 7. Details of Operating Mechanism for Wedge-type Adjuster

The unique characteristics of the wedge-type adjuster provide a convenient and easy means of checking the location of the contact wedge and following its motion from one position to the next. The operating shaft turns 300 degrees for each tap change in the 6-point adjuster and 315 degrees for each tap change in the 8-point adjuster.

Starting from an operating position, the contact pressure is reduced to zero during the first 30-degree movement of the shaft. To shift the wedge to a point entering the next operating position requires about ⅔ of a revolution. As there is little or no friction to overcome, the torque will be noticeably small. A 30-degree movement is then required to drive the wedge home and to build up the contact pressure.

The operating position can be identified as the middle of a 60-degree arc of high torque, that is, at the point where this torque passes through a maximum value.

The position of the wedge can also be determined by using a 115-volt lamp in series with the winding containing the ratio adjuster. (Short-circuit the opposite winding or lamp will not light.) The perfect position is midway in the band wherein the lamp shows light. Due to the design, however, the efficiency of the contact is not impaired if the wedge position is a few degrees either side of the perfect setting.

Fig. 7 shows the parts of the operating mechanism and position-indicating device located either on the transformer tank wall or on the cover. Do not disturb the mechanism assembly unless it is necessary to tighten the stuffing box. If the relation of the pins (A) to the slots (B) is changed from the factory setting, wrong contact position and indicated tap change will result.

To tighten the stuffing box, note the indicated position of the adjuster and remove the top driving pin and the cams, being careful not to move the drive shaft. Tighten the packing nut and reassemble the parts. Make sure that the drive shaft has not turned and that the indexing disk is assembled over the cam so that the position indicated is the same as it was originally. In an operating position the large end of the driving pin points toward the numeral in the indexing notch and the numeral cast in the outer circumference in the gland.

If the operating mechanism and insulating rod are shipped separate from the transformer, they must be carefully assembled to assure satisfactory operation. Operating mechanisms and rods are identified by the ratio adjuster number and the serial number of the transformer as shown on the nameplate. **Parts are not interchangeable.** When the ratio adjuster is in Position No. 1, an indicating mark on the insulating rod is in an exact line with mark on the top core clamp of the transformer.

To check the contact position of the adjuster, note the position of the driving pin on the top of the ratio-adjuster shaft. When the contact wedge is in a certain operating position, as shown on the nameplate, the large end of the driving pin points to the corresponding number marked on the top ratio-adjuster head. When the adjuster head is not visible and the contact position unknown, determine its location as outlined above.

Couple the insulating rod to the operating mechanism and lower it through the opening in the tank or cover over the driving pin on the ratio-adjuster shaft. Make sure that the correct rod is used for the adjuster in question as the slots in the lower end of the rod must match the driving pin. The insulating rod should be entirely suspended from the operating mechanism; none of its weight should be carried by the ratio adjuster.

Align the bolt holes in the mechanism gland with those on the tank or cover flange and start one or two bolts by hand to prevent the gland from turning. Check the operating position to be sure that the operating mechanism and the adjuster are in alignment. The large end of the top driving pin on the operating mechanism will point in the direction of the contact wedge and at the same time will indicate the position on the mechanism gland. If the indexing notch on the operating mechanism does not indicate the same numerical position, disengage the mechanism from the adjuster, reset the operating mechanism to line it up with the adjuster and reassemble.

After completing assembly, make a final check to verify the position of the contact wedge relative to the indexing notch, either by the lamp test or by observing the variation in torque.

When the adjuster is mounted in a vertical position and the operating mechanism used with it is mounted in a horizontal position, there is a position indicator on the bracket for the bevel gears inside the transformer tank. When it is necessary to reconnect the drive shaft inside the tank to the operating mechanism, this internal position indicator must be observed and must be set on the same position number as the operating mechanism.

Tests on Ratio Adjusters

It is good policy to test each ratio adjuster to make sure that the positions are correct and that the steps are progressive. This can be done by applying a low voltage to one winding and measuring the voltages on the other winding for each position of the adjuster.

Operation from Floor Level

For hand operation of a ratio adjuster from the floor level (excitation removed) the operating drive is usually brought out through the side of the tank.

This drive is provided with a mercury-seal Pyranol stop to prevent Pyranol leakage from the transformer.

In some cases it is necessary to remove the drive shaft for shipment. In such instances the mercury is shipped separately from the bearing housing and should be installed on assembly of the transformer.

For replacement or installation of the mercury after assembly of drive shaft on transformer, remove the upper pipe plug in the bearing housing and fill with mercury to this level. Replace and tighten plug sealed with G-E Compound No. 880.

BUSHINGS

Replacement bushings for Pyranol transformers should be ordered especially for use in Pyranol. Since instruction books are shipped with bushings, only brief general instructions are given here.

Installation

See that bushings are clean and dry when installed. To expose the insulating material, other than the porcelain, to dirt or moisture is to invite deterioration and possible failure in service. Do not attempt to install the bushings in the transformer during damp or stormy weather without providing adequate means for keeping all moisture out of the transformer.

Bushings not having detachable conductors should be installed in the covers of transformers by first mounting the bushing upon the cover and subsequently connecting the terminals at the lower ends of the cable conductors to their respective leads from the transformer windings.

The small gaskets beneath the terminal cap should be in perfect condition and should be made absolutely tight. A defective gasket or leak from any source at this point will allow water to be brought up into the central tube from where it can run down into the transformer.

Line Connections

When connecting the bushings to the line or external circuit, inspect the terminals or couplings after the connection is made to make sure that they are tight. The line connection must not bring any strain on the terminals which will cause the joints or contacts to become loose. Sufficient flexibility in the connecting leads must be provided to avoid mechanical strains due to expansion or contraction which may break the porcelain. The bushings will support a reasonable weight of connecting conductor, but long spans of unsupported conductor, especially if out of doors, should be avoided.

Bushings should be inspected at regular intervals and kept reasonably free from dust and dirt. In locations where abnormal conditions prevail, such as salt deposits, cement dust, acid fumes, etc., it should be recognized that a special hazard exists, and the bushings should be cleaned regularly to avoid accumulations on the external surface, which may result in flashover.

Connectors

A standard line of terminal connectors for use with both solid and filled bushings has been developed and these parts may be ordered as accessories to the bushings. These connectors provide for attaching cables, rods, tubes, and bars to the various standard bushings.

BUSHING-TYPE CURRENT TRANSFORMERS

Bushing transformers are those in which the secondary coil and core surround a bushing, the conductor of which forms the primary. This secondary coil and core are located either in an adapter outside the main transformer cover or in a cradle suspended from the inside of the cover. These current transformers are used to actuate either relays or ammeters. See nameplate on secondary outlet for turn ratios.

Installation

The bushing current transformers are usually shipped completely assembled in the power transformer, or at least in place in the high-voltage bushing adapters. It is then only necessary to inspect them to see that they are dry. If evidence of moisture is found they must be disassembled and the secondary coil dried by hot air, not exceeding a temperature of 90 C.

If the bushing transformer is shipped separately, assemble it in place with insulation as shown in Fig. 8. Be sure that the coil is right side up as indicated by the word "TOP" painted thereon. Handle the coil carefully so that the edges of the core will not injure the conductor insulation.

Connect the leads to the inside terminals of the outlet block, making sure that the letters on the inside and outside leads correspond.

To assemble the current transformer in the bushing adapter, remove the top of the adapter, fit the transformer into place and replace the adapter, using a cork gasket treated on both sides with G-E Compound No. 880. Bolt the top down squarely to compress the gasket evenly.

On double-section tanks it is sometimes necessary to remove this type of current transformer from the underside of the cover for shipment. In such cases reassemble with the end marked "TOP" uppermost in accordance with Fig. 8. The insulating tube can be pushed up while tightening the jam nut. New plate washers are furnished and should be folded as indicated. Maintain the ⅜-inch overhang of the current transformer inside the supporting plate opening.

Connections and Polarity

Insulate all leads not in use from all other leads and ground. Do not allow the secondary circuit of a current transformer to remain open. It must be closed through a burden or by the short-circuiting links provided for the purpose.

The relative instantaneous directions of primary and secondary currents are as shown in Fig. 9.

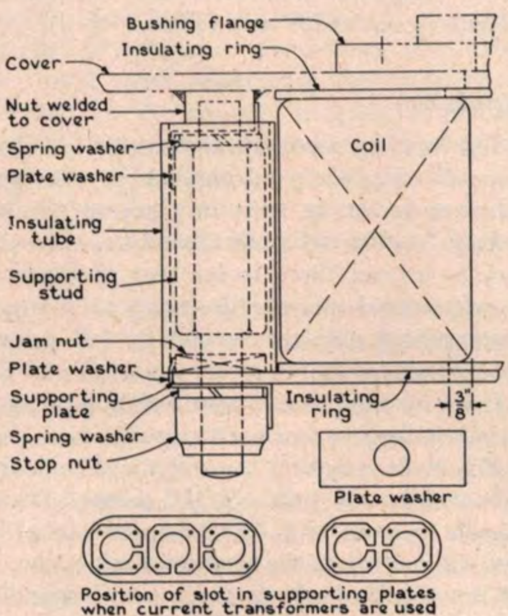


Fig. 8. Current Transformer Support

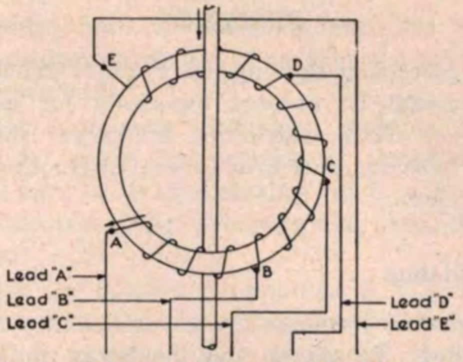


Fig. 9. Schematic Diagram of Bushing Transformer, Showing Method of Marking Leads and Method of Tapping Secondary Winding

PYRANOL IMMERSED AIR-PRESSURE-COOLED TRANSFORMER

This transformer is a Pyranol immersed transformer cooled by jets of air (under pressure) or by free air discharge applied to the cooling surface.

Air for cooling one transformer or a bank is supplied by a unit blower and motor or by small weatherproof outdoor fans which may be hand- or automatically controlled.

All equipment is designed for outdoor service.

The motor and blower and the fan motors require the care usually given such apparatus.

If "Mercoid" controls or Type CR relays are furnished for fan control or breaker trip, they are adjusted at the factory and should not be disturbed. If changes need to be made, recommendations should be obtained from the factory.

It is recommended that the fan control circuit be automatically de-energized whenever the differential relays remove a transformer from service.

When fans are not in use, they should be operated periodically to make sure they are in satisfactory condition.

FORCED PYRANOL TRANSFORMERS

In forced Pyranol cooled transformers, the Pyranol is cooled by circulation (forced) through an external cooler.

NOTE.—The Pyranol must be circulated and cooled at all times regardless of whether or not the transformer is carrying a load.

A special Pyranol cooler is generally furnished as well as a pump and motor. Each requires the care and attention always given such apparatus. The cooler is designed for outdoor installation, and may be installed in either the vertical or horizontal position.

The piping connection should be such that the water passes through the tubes in the opposite direction to the Pyranol flow. This is essential in order to obtain maximum efficiency of heat transfer. It is also essential that the water pressure be kept below the Pyranol pressure to prevent any water entering the Pyranol should a leak develop in the cooler. The coolers in most cases are designed so that this difference will always exist when rated Pyranol flow and water flow are maintained.

One end of the cooler is provided with a floating head, and provision in the piping should be made to allow for the removal of this head.

When forced-air coolers are used instead of water coolers special instructions will be furnished.

As the Pyranol enters the bottom of the transformer under considerable pressure, it is necessary that a Pyranol strainer be used to prevent the discharge of dirt and foreign material into the windings of the transformer.

Therefore, the Pyranol strainer, which is always supplied, should be installed in the cold Pyranol inlet to the transformer. It is well to install a pressure gage on each side of this strainer to determine the pressure drop across the strainer. If the strainer is not kept clean, the Pyranol flow through the transformer may be reduced to such an extent that dangerous temperatures will develop.

The quantity of Pyranol circulated has a direct bearing upon the heating and temperature rise of the transformer. It is very desirable, therefore, that the inlet and outlet temperatures of the Pyranol be measured and recorded to check the quantity of Pyranol flowing.

The top Pyranol is cooled about 15 C during passage through the cooler, and the water temperature increased about 5 C. Usually the water flow is 50 per cent greater than the Pyranol flow.

The tubes in the cooler should be kept clean at all times. To clean, remove the cover plates from each end of the cooler and clean the inside surface with a wire brush.

The external surface of the tube bundle may be cleaned by flushing out with a volatile cleansing fluid that must be dried out by passage of hot air through this section of the cooler.

Coolers may be tested at a pressure of 100 lb per square inch to determine whether there is any leakage.

It is possible to cool the Pyranol from a bank of transformers by using one cooler and one Pyranol pump; but this practice is not favored. In such installations equalizers must be used to obtain proper Pyranol distribution, which is difficult to obtain and uncertain. Also, in case of trouble in one unit, damaged Pyranol would be pumped directly into the good transformers.

A separate cooler and Pyranol pump for each transformer are recommended.

IF TRANSFORMER DOES NOT OPERATE

If a Pyranol transformer fails to operate, it is recommended that the unit be sealed immediately from the atmosphere and the nearest General Electric Company office notified. A sample of the Pyranol should be taken from the top of the transformer and inspected for discoloration and the presence of water. The Pyranol should then be promptly circulated through a Pyranol purifier until the Pyranol is clear and the dielectric strength is normal. Refer to instructions under "Drying and Filtering."

The transformer should be kept sealed and the interior should not be removed for examination until recommendations for examination are received from the General Electric Company. After the examination is made, the interior should again be immersed in the Pyranol and the unit kept sealed until the repair parts are available.

As early as possible, a one-quart sample of the purified Pyranol obtained in accordance with instructions covering SAMPLING PYRANOL, together with information as to the serial number, the rating of the transformer and the results of the inspection of the original Pyranol sample should be sent promptly to the Pittsfield Works of the General Electric Company, Pittsfield, Mass., in order that an analysis and recommendations for repairs can be made.

JUNCTION BOXES

A transformer is sometimes equipped with a junction box, a metal housing that completely incloses the connection between the transformer bushing and the cable. It should be kept filled to the proper level with the insulating medium specified, Pyranol oil, or petrolatum. For the lower voltages air is sometimes used.

Before making the connections, refer to the special instructions furnished with the cable end or cable terminal.

TRUCKS

Bearings, whether bushed or of the roller type, have a ⅛-in. pipe plug provided in the end of the journal. To lubricate the bearing, remove the plug and insert an Alemite fitting. Trucks are shipped with the bearings filled with grease, but the bearings should be inspected and refilled from time to time to prevent corrosion.

LOAD-RATIO CONTROL

Transformers which are equipped with load-ratio control, that is, those arranged to permit a change of taps without disconnecting the load, require the addition of a number of mechanical parts, and call for special electrical connections. Their installation, therefore, needs special attention. For this reason all such transformers are covered by a special instruction book which should be thoroughly read before any attempt is made to assemble or operate such transformers.

RENEWAL PARTS

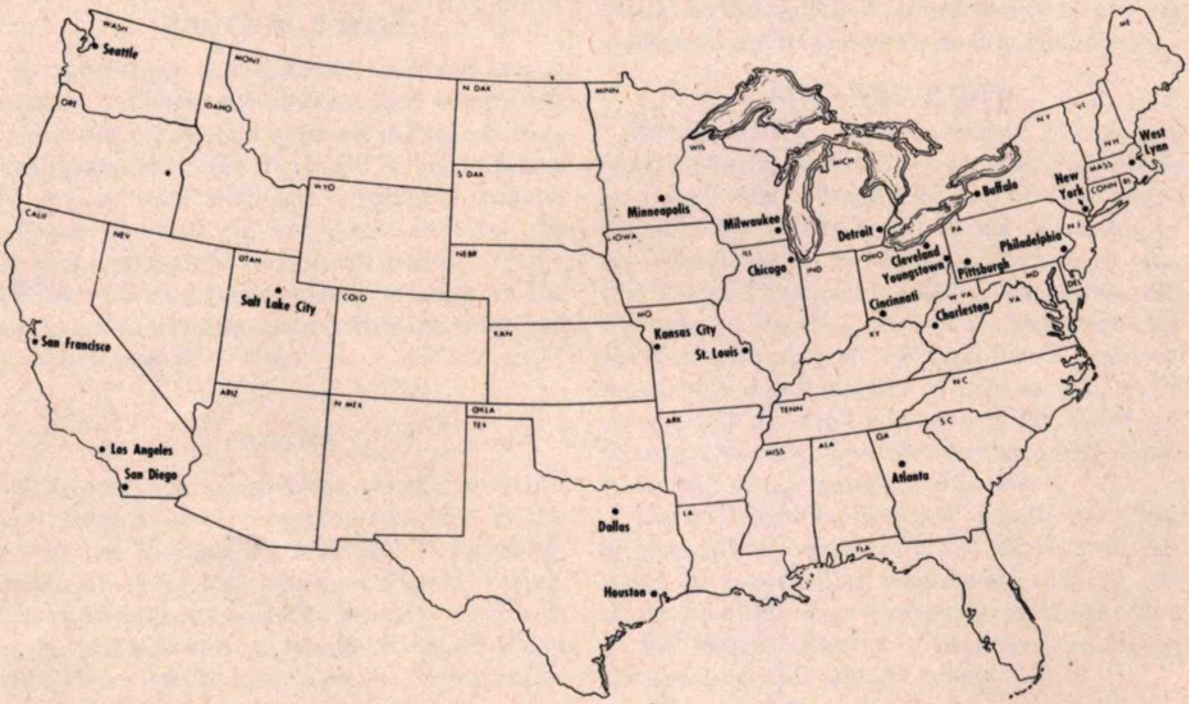
When ordering renewal parts or Pyranol, or when requesting information regarding a particular transformer, always state the serial number. This number will be found on the nameplate of the transformer. On large transformers it also will be found stamped on the top core frame, the top band of the tank, and on the cover directly above the number on the tank band. A sketch showing the exact location of coils, insulation, or other parts required will greatly facilitate the filling of the order. This sketch must always state which side of the transformer is shown.

Any additional information as to the electrical or mechanical construction, operation, or installation of a particular transformer may be obtained by application to the nearest Sales Office of the General Electric Company, mentioning the serial number and the rating.

WHEN SERVICE IS REQUIRED

GENERAL ELECTRIC operates 23 apparatus service shops strategically located and competently manned by trained personnel. Each shop is a complete service unit with modern equipment for repairing, reconditioning, and rebuilding G-E apparatus to factory specifications. The services of these shops are available at any time of day or night for work in the shops or on purchaser's premises.

GENERAL ELECTRIC APPARATUS SERVICE SHOPS



SERVICE SHOP	*ADDRESS*	*DAY PHONE*	*NIGHT PHONE*
Atlanta, Ga.	496 Glenn Street, S.W.	WAlnut-9667	WAlnut-7859
Buffalo 11, N. Y.	318 Urban Street	HU-5849	RI-7579
Charleston 28, W. Va.	306 MacCorkle Avenue, S.E.	2-6177	3-1244
Chicago 7, Ill.	849 South Clinton St.	Wabash-5611	Wabash-5654
Cincinnati 2, Ohio	215 West Third Street	Parkway-3433	Parkway-3433
Cleveland 4, Ohio	4966 Woodland Avenue	EN-4464	EN-4464
Dallas 2, Texas	1801 North Lamar St.	R-9121	L-4111
Detroit 2, Mich.	5950 Third Avenue	TRinity-2-2600	TRinity-2-2606
Houston 1, Texas	1312 Live Oak Street	C-9711	C-9714
Kansas City 8, Mo.	819 East 19th Street	Victor-9745	WAbash-3850
Los Angeles 54, Calif.	733 Banning Street	Madison-7381	Madison-1813
Milwaukee 3, Wis.	940 W. St. Paul Ave.	Marquette-5000	Marquette-5002
Minneapolis 1, Minn.	410 Third Ave., N.	Main-2541	Main-2546
New York 14, N. Y.	416 West 13th Street	Wickersham-2-1311	Chelsea-2-8390
Philadelphia 23, Pa.	429 N. Seventh St.	Pennypacker-9000	Pennypacker-8448
Pittsburgh 6, Pa.	6519 Penn Avenue	Atlantic-6400	Atlantic-6408
St. Louis 1, Mo.	1110 Delmar Avenue	Chestnut-8505	Chestnut-3899
Salt Lake City 9, Utah	141 South Third West St.	4-1892	6-4448
San Diego 1, Calif.	2045 Kettner Blvd.	Franklin-7684	Glencove-5-3675
San Francisco 7, Calif.	361 Bryant Street	DO-3740	DO-3748
Seattle 4, Wash.	1508 4th Ave., South	Elliott-1778	CA-3679
West Lynn 3, Mass.	920 Western Avenue	Ly-3-6000	Ly-3-6008
Youngstown 3, Ohio	121 East Boardman St.	Youngstown-44331	Youngstown-44331

APPARATUS DEPARTMENT

GENERAL ELECTRIC

SCHENECTADY, N. Y.

PRINTED IN U.S.A.

10-46 (2M)

Superseding GEH-1093

INSTRUCTIONS
GEI-21709

INSTRUCTIONS FOR INSTALLING AND OPERATING SMALL KVA SIZE LIQUID FILLED TRIPLEX INDUCTION VOLTAGE REGULATORS

APPARATUS DEPARTMENT
GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

Date: November 21, 1946

INSTRUCTIONS FOR INSTALLING AND OPERATING SMALL KVA SIZE LIQUID FILLED TRIPLEX INDUCTION VOLTAGE REGULATORS

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.

This instruction covers liquid filled triplex induction voltage regulators composed of regulators similar in construction to the small Kva sizes of AIRS regulators shown in instructions GEH-1085 (copy attached).

The triplex regulator is composed of (3) single-phase regulators assembled on a common base with their worm shafts mechanically coupled together with double flexible joints and operated by one driving motor assembled on the middle unit.

The regulator is automatically operated by one set of controls assembled in a weatherproof cabinet on the front of the regulator tank.

The controls are similar to those covered in instruction GEH-1085.

The insulating liquid used in these regulators may be either transil oil or Pyranol.

INSTALLATION

The regulator should be installed in a location that has good ventilation. The support or foundation that the regulator is to rest on should be flat, level, and rigid. The base of the regulator is provided with holes in the corners for bolting to its support.

Before installing, the regulators should be carefully inspected for any damage that may have occurred in transit.

Take samples of the insulating liquid from the top and the bottom of the tank and have them tested. A regulator in which the tests of the liquid shows signs of moisture or has a dielectric strength of less than 30 KV should be dried and the insulating liquid filtered. Detail instructions, obtainable from the nearest General Electric Office, covers the recommended methods to be used for handling, testing and drying of transil oil and Pyranol.

The above instructions apply for any regulators that may have been idle for any length of time.

PRESSURE TESTS

All liquid filled regulators are pressure tested at the factory. When regulators are installed, they should be tested at five (5) pounds per square inch pressure. Use clean dry air or nitrogen introduced through the pressure test valve and hold for twelve (12) hours. If the pressure does not hold for this period of time, examine the gaskets, welds and fittings for leaks. Leaks above the liquid level may be detected by applying a solution of soap and glycerin to all joints and gasketed surfaces.

Synthetic rubber gaskets are used on these regulators. If it is necessary to replace the gaskets, follow the procedure outlined under "Gaskets" in the "Maintenance" section of this instruction.

CONTACT-MAKING VOLTMETER (Voltage Regulating Relay)

Follow the instructions in GEH-1085 for adjusting and operation of the contact-making voltmeter, pages 8, 9 and 11.

MOTOR CONTROL RELAY

Instructions covering the adjustment and operation of the motor-control relay are covered in GEH-1085, pages 10, 11 and 12.

MAINTENANCE

Keep the regulator and controls clean.

Insulating Liquid

Keep the insulating liquid at the proper level. When the liquid is so maintained, all parts of the mechanism that require lubrication will be immersed in the liquid and no further lubrication will be required. Instructions obtainable from the nearest General Electric Office covering the handling, testing and drying of transil oil and Pyranol should be followed.

Gaskets

Synthetic rubber gaskets are used throughout on these regulators. The top flange of the tank is fitted with a gasket cemented to the flange. The bushing gaskets are cemented to the bushing adapter in the tank wall.

If it is necessary to replace any of the gaskets, remove all trace of the gaskets and cement from gasketed surface. Use a synthetic rubber cement and follow the instructions of the cement manufacturer for cementing the new gasket in place. Use only gaskets of a synthetic rubber that has been approved for use in transil oil or Pyranol.

The control cabinet door is provided with a sponge rubber gasket. If it is necessary to replace this gasket, first scrape all of the old gasket and cement off of the gasket surface and clean with gasoline. Wipe the strips of sponge rubber with a cloth dampened in gasoline to remove the talc coating. Cement the new gasket in place with rubber cement following instructions of the manufacturer of the cement.

Contact-Making Voltmeter (Voltage Regulating Relay)

Instructions on the maintenance of the contact-making voltmeter are covered in GEH-1085, pages 16, 17 and 18.

Motor-Control Relay

Instructions on the maintenance of the motor-control relay are covered in GEH-1085, pages 18, 19, 20 and 21.

INTERNAL INSPECTION

To inspect the regulator internally, it will be necessary to remove the tank cover. The cover is held in place by a number of bolts bolted to the top flange of the tank. After the removal of the tank cover, the operating mechanism will be exposed and may be inspected.

For complete inspection of the interior, it will be necessary to remove the unit from the tank as follows:-

1. Set the regulator rotors in the neutral position as is indicated by the pointer on the position indicator.

2. Disconnect the flexible drive shaft from the position indicator shaft by holding the hex section of the coupling nearest to the flexible shaft and loosening the long hex nut, then pull apart.

3. Lower the insulating liquid below the bushing openings in the tank, and after disconnecting the lead connection on the bushings, remove the bushing from the tank wall.

4. Unbolt the cushion assemblies from the tank at each end and lift off the pins.

5. Disconnect the control leads from the terminals in the tank wall. The terminals on the leads and the outside of the tank wall are marked for identification in reassembling.

6. Attach slings to the lifting assemblies on the top of the interior and raise it slowly out of the tank, guiding it so that it does not catch on the position indicator shaft on the block welded to the end tank walls.

Inspection may now be made of the assembled interior.

If complete disassembly is desired, disassemble as follows:-

1. Remove the position indicator shaft from one end unit and the limit switch from the other end unit. Also the motor and top cover as a unit from the middle unit. Remove the covers from the two end units.

2. Remove the screws that hold the worm supports to the top frames and draw toward the back of the regulator to disengage the worm from the worm gear and then toward the end to disengage the coupling between the regulators. The coupling is made in three sections, the middle section is loose and should remain with the supports of the end regulators. The complete disassembly of each unit can be made as instructed in GEH-1085 pages 22 and 23.

The regulators may be reassembled as covered in GEH-1085 pages 23, 24 and 25, except that before they are coupled together, each unit must be set in the exact electrical neutral position and left in that position until they are assembled in the tank and the position indicator coupled to its drive shaft.

To locate the electrical neutral position, each unit should be set in its approximate neutral mechanically and then a low reading ammeter connected across its secondary leads. With the primary excited from a 110 volt source, turn the regulator slowly until zero current is recorded on the ammeter. When this position is reached, be sure that this setting is not disturbed until the position indicator is coupled to its shaft after the regulator is tanked. It is recommended that the low reading ammeter is 0.5 amp full scale.

The interior should be tanked and the cushion assemblies bolted in place.

Set the position indicator pointer on the neutral position and couple it to its drive shaft.

Reassemble the low voltage leads to terminals in tank wall.

Reassemble the high voltage bushing to the tank and connect the regulator leads to the bushings.

Fill tank with its insulating liquid to its proper level and reassemble cover to tank and give pressure test to make sure that cover and bushings are sealed tight.

INSTRUCTIONS

PYRANOL TRANSFORMERS

INSPECTION

Inspect the transformer for possible damage incurred during shipment. Pyranol transformers are always shipped filled with *Pyranol. Inspect for proper Pyranol level. A sample of Pyranol should be taken, preferably from the top, for dielectric test. If the dielectric strength, before placing in service, is below 30 kv, the Pyranol should be filtered. If there are indications that moisture has entered, the transformer should also be dried.

INSTALLATION

If the transformer is equipped with a diaphragm mounted in the side of the tank, the transformer should be so placed that the diaphragm is not facing an aisle or passageway.

When connecting bushings to the line or external circuit, sufficient flexibility in the connecting leads must be provided to avoid mechanical strains due to expansion or contraction which may break the porcelain. While the bushings will support a reasonable weight of connecting conductor, long spans or lengths of unsupported conductor should be avoided.

PRESSURE TEST

Pyranol transformers are designed to operate sealed and when installation is complete, the transformer should be subjected to an internal pressure of 5 lb per square inch using dry air or a dry gas such as nitrogen. If the pressure holds steady, the joints should be satisfactory. Leaks above the liquid level may be located by using a solution of soap and glycerin applied to the joints.

CONNECTIONS AND LEADS

Transformers are shipped connected for the highest voltage shown on the nameplate, unless otherwise specified.

Do not change connections on a transformer that is under excitation, nor make any connections that are not shown on the nameplate or diagram of connections.

Insulate leads not in use from ground and all other leads.

Permanently and effectively ground the tank by means of the grounding lug or screw provided for this purpose near the bottom of the tank unless prevented by special operating conditions.

OPERATION

A single-phase transformer which is suitable for wye operation on either the high-voltage or the low-voltage side may be so connected on either side, but not simultaneously on both sides, unless precautions are taken to suppress third harmonic voltages.

MAINTENANCE

Pyranol must be handled only in containers, pipes, all-metal hose, etc. which are free from oil, grease, pitch, or other foreign material, since these contaminate the liquid and decrease its non-flammable qualities.

Protect the transformer from overloads and overvoltages with suitable and approved protective devices properly located and connected. Refer to the nearest General Electric Sales Office for specific recommendations.

At regular intervals, the level of the transformer Pyranol should be checked and a sample of the Pyranol tested for dielectric strength. If, while in service, the Pyranol tests below 25 kv at room temperature, a filter press may be used to restore the dielectric strength to above 30 kv.

STORAGE

Before storing Pyranol transformers, they should be checked to be sure that the Pyranol is at the proper level. The storage room should be clean and dry and, when possible, without extreme temperature changes. Before placing a transformer in service from storage, follow the instructions given under "INSPECTION," particularly with regard to moisture.

RENEWAL PARTS

When ordering renewal parts, give the following information: a description of the part or parts desired and the rating and serial number taken from the nameplate on the transformer (the serial number may also be found on a fiber tag attached to the coil).

GENERAL

If a failure should occur in a Pyranol transformer, the nearest Sales Office of the General Electric Company should be notified immediately, giving the rating and serial number of the transformer.

More detailed information on the installation, operation, maintenance, protection, sampling, and filtering of Pyranol transformers may be obtained by consulting Instructions GEH-1093, or by application to the nearest Sales Office of the General Electric Company.

*Registered trade-mark for G-E askarel.

APPARATUS DEPARTMENT

GENERAL ELECTRIC

SCHENECTADY, N. Y.

3-48 (500)

PRINTED IN U.S.A.

INSTRUCTIONS

AIR CIRCUIT BREAKER

TYPE AE-1-15

(Formerly Type AE-1A)

GENERAL ELECTRIC
SCHENECTADY, N.Y.

CONTENTS

ILLUSTRATIONS

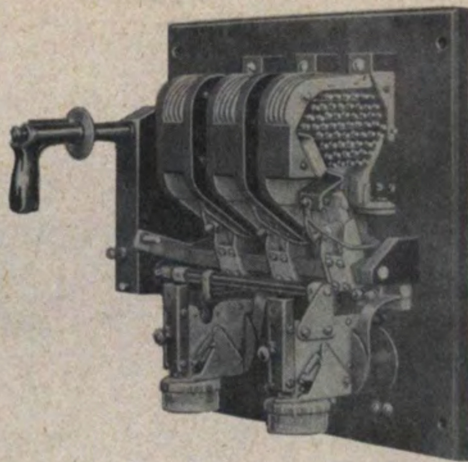


FIG. 1

TYPE AE-1-15 AIR CIRCUIT BREAKER, LIVE FRONT, MANUALLY OPERATED.

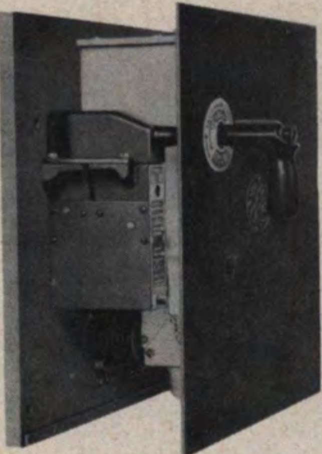


FIG. 2

TYPE AE-1-15 DEAD FRONT, MANUALLY OPERATED.

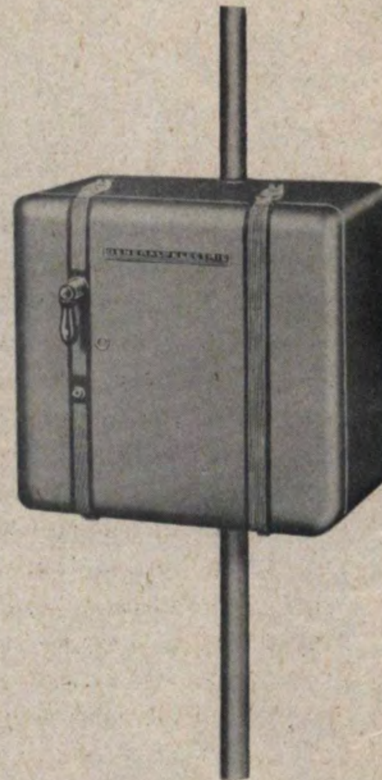


FIG. 3

TYPE AE-1-15 ENCLOSED MOUNTING, MANUALLY OPERATED.

FIG. 4

TYPE AE-1-15 ENCLOSED MOUNTING. REMOVE TWO UPPER SCREWS AND TILT FORWARD TO REMOVE BREAKER.

FIG. 5

TYPE AE-1-15 ENCLOSED MOUNTING TERMINALS AND SOLDERLESS CONNECTORS.

AIR CIRCUIT BREAKER

TYPE AE-1-15

GENERAL INFORMATION

This breaker was formerly designated Type AE-1A to which these instructions generally apply.

Before unpacking, installing or attempting to operate these air circuit breakers, read this instruction book thoroughly and carefully.

The type AE-1-15 air circuit breakers covered by this instruction book are generally used for the protection and control of apparatus and branch circuits, including equipment in buildings industries and power stations. Additional discussions on this breaker will be found in publication GEA-3600.

The type AE-1-15 air circuit breakers are for use on 250 volt D.C. or 600 volt A.C. circuits furnished normally with one, two, three or four poles. Their continuous current ratings are up to and including 225 amperes and maximum interrupting rating is 15,000 amperes. They can be furnished either live front (Fig. 1), dead front (Fig. 2) or enclosed (Fig. 3), either manually or electrically operated, and with various accessories. All breakers are equipped with arc quencher interrupters. Phase barriers are furnished on live front breakers and box type barriers on all dead front and enclosed breakers.

The AE-1-15 breaker is closed by a toggle mechanism operated manually or electrically against heavy springs. It is opened by these springs when a latch is released manually or by tripping devices. The breaker is trip free which assures that it cannot be held in the closed position as long as any tripping device is being operated.

The standard connection arrangement for direct current circuits is to have voltage coils connected solidly to the negative bus or line where possible. The current enters the breaker by upper stud (Pt. 6, Fig. 7), passes through stationary contact (Pt. 1), movable contact and flexible cable (Pt. 24), through series coil (Pt. 16) and out the lower stud (Pt. 12). The movable contact is attached to a main shaft (Pt. 20) which is actuated by a manually or electrically operated mechanism. On the opening of the contacts the arc is magnetically blown upward into an arc quencher (Pt. 28) and is promptly extinguished.

SHIPPING - UNPACKING - STORAGE

TRANSPORTATION DAMAGE

Immediately upon receipt of the circuit breaker an examination should be made for any damage or loss sustained during shipment. If injury or rough handling is evident, a damage claim should be filed at once with the transportation company and the nearest General Electric Sales Office should be promptly notified.

UNPACKING

The circuit breaker should be unpacked as soon as possible after being received as difficulty may be experienced in making claim for damage, not evident upon receipt, if delayed. Care should be used in unpacking in order to avoid damaging any of the breaker parts. Be sure that no loose parts are misplaced or left in the packing material. Blow out any dust or particles of packing material that may have accumulated on the circuit breakers parts. Report any shortage of material at once.

STORAGE

If the circuit breaker is not to be mounted in its permanent location at once, it should be stored in a clean, dry place and preferably placed in an upright position. It should be supported to prevent bending of the studs or damage to the breaker parts. It is best not to cover the breaker with any packing or other material that is apt to absorb moisture which may cause corrosion of breaker parts. A covering of paper will prevent dust from settling on the breaker parts and should be used if the breaker is to be stored for a considerable length of time.

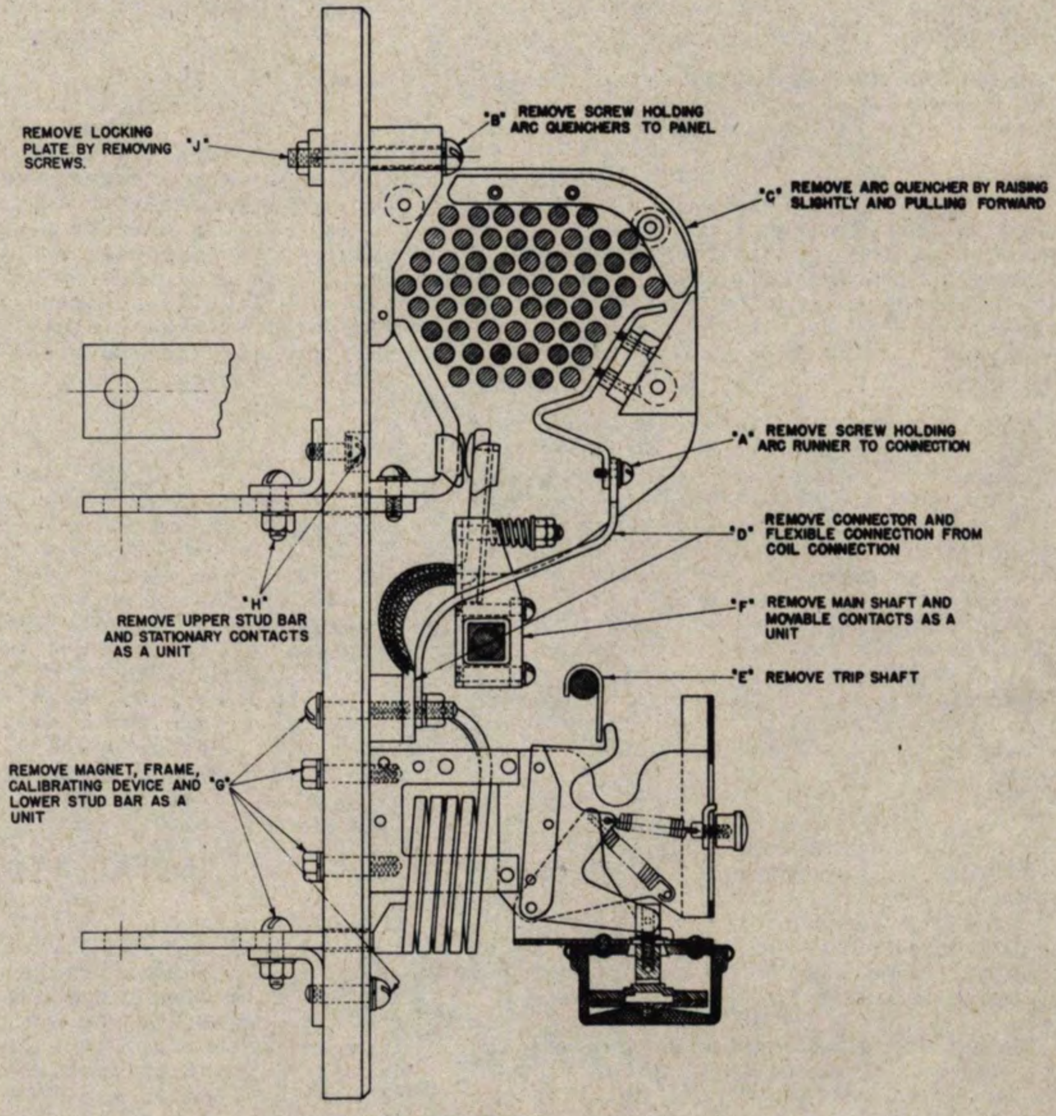
INSTALLATION

LOCATION

An air circuit breaker should be installed in a clean, dry place where it is readily accessible for operation, inspection and proper maintenance. When mounted on a live-front switchboard it should preferably be located at the top of the panel and ample head room should be provided above and in front of the breaker. Breakers mounted in special enclosures for installation in dusty, dirty, or other special locations can be furnished on request to the factory.

BREAKER CONNECTIONS

Most air circuit breakers are shipped on permanent bases or panel sections (with or without enclosures), and the installation consists simply of bolting them to the supporting framework or structure, connecting the current-carrying cables or bus bars to the breakers studs, and completing any secondary control wiring that may be required. The connections to the breaker studs should be firmly clamped or bolted in place to prevent excessive heating. The connecting cables or bus bars should have a current-



REASSEMBLE IN OPPOSITE SEQUENCE
PROGRESSIVE DISMANTLING AND REASSEMBLY INSTRUCTIONS

FIG. 6
INSTRUCTIONS FOR REMOVAL FROM TEMPORARY BASE

6249504

carrying capacity sufficient to limit their temperature rise to that specified for the breaker. If these connecting cables or bus bars are not of sufficient size, heat will be conducted from them to the breaker and the breaker cannot be expected to carry normal rated current without exceeding the specified temperature rise. Connecting cables or bus bars should be supported so that the breaker studs will not be subjected to unnecessary strains.

DEAD FRONT BREAKERS

Breakers equipped with dead front barriers as illustrated in Fig. 2, can be installed on framework or elsewhere without removing the barriers.

ENCLOSED BREAKER

The enclosed breaker (Fig. 3) is easily installed by first removing the cover and the two top mounting bolts in the breaker base (Fig. 4). Tilt the breaker unit forward to disengage disconnects and for removal. Next, mount the box in the desired location and secure the cables in the solderless connectors of the box (Fig. 5). Finally, return the removable breaker unit to the box, and replace the two upper mounting bolts and the cover to complete the installation.

WHILE INSTALLING, OR BEFORE REMOVING THE BREAKER, IT IS IMPORTANT THAT IT SHOULD BE IN THE OPEN POSITION.

TEMPORARY BREAKER MOUNTING

It is always preferable to have an air circuit breaker shipped on a permanent base or panel section. Remounting of the breaker by persons not entirely familiar with its detailed construction may result in misalignment or improper adjustment with resultant unsatisfactory operation. Temporary bases will not be supplied when reverse current trip devices are involved. For those cases where it is found necessary to transfer a breaker from a temporary base to a permanent base or panel, first make sure that the permanent base or panel is properly drilled in accordance with an approved drilling plan furnished by the General Electric Company for the particular breaker. In transferring the breaker, it should not be dismantled any more than necessary to effect the transfer. Sub-assemblies, such as the overcurrent devices, the operating mechanism, etc. should be transferred as units. This will help maintain adjustments and will minimize the possibility of incorrect assembly. A recommended sequence of procedure for transferring an AE-1-15 air circuit breaker given on Fig. 6. It is suggested that this procedure be followed in the order in which the operations are alphabetically arranged. After the transfer has been completed, the alignment of the contacts and the operation of all parts should be checked as described under "Operation", page 4 , and under "Contacts", page 4 .

OPERATION AND MAINTENANCE

After a breaker has been installed, slowly operate it manually several times and observe whether the contacts line up properly and make sure that all parts move freely and in the proper manner without binding.

Manually operated AE-1-15 air circuit breakers covered by these instructions are closed by first turning the operating handle in a counter-clockwise direction from the position of "handle down" to position of "handle up" to reset the mechanism latch, and then turning it in a clockwise direction to position of "handle down" to close the breaker. DO NOT ATTEMPT TO OPEN THE CIRCUIT BREAKER BY COUNTER-CLOCKWISE ROTATION OF THE OPERATING HANDLE. The circuit breaker is opened by pushing on the manual trip button to release the breaker latch.

Electrically-operated AE-1-15 air circuit breakers covered by these instructions may be closed manually by means of an emergency closing handle. To close the breaker, insert this handle in the hole provided for this purpose on the front of the operating mechanism. Push the handle down as far as it will go so that the breaker will be latched closed. The breaker is likewise opened by the trip button, and not by the emergency closing handle. When the breaker opens, it is automatically reset by the falling of the solenoid armature. AFTER CHECKING THE OPERATION MANUALLY BE SURE TO REMOVE THE EMERGENCY HANDLE.

After checking the operation manually as above, an electrically-operated breaker should be operated electrically at rated voltage a few times to make sure that all control circuits are properly connected, and that the closing solenoid closing relay, and electrical attachments are functioning properly. Bear in mind that the solenoid is rated for intermittent service. Reasonable care should be exercised when testing to avoid overheating of the solenoid by repeated operations.

INSPECTION

Periodic inspection of the breaker is recommended. The frequency of inspection will depend a great deal on local conditions but in general, an inspection should be made at least once a year. An inspection should always be made after it is known that the breaker has opened a severe short circuit. If breakers remain opened or closed for long periods at a time, it is recommended that arrangements be made to open and close them periodically several times in succession to keep the contacts and moving parts in good working condition.

CONTACTS

When inspecting the breaker, examine the contacts to see if there has been any severe pitting or burning of the contact

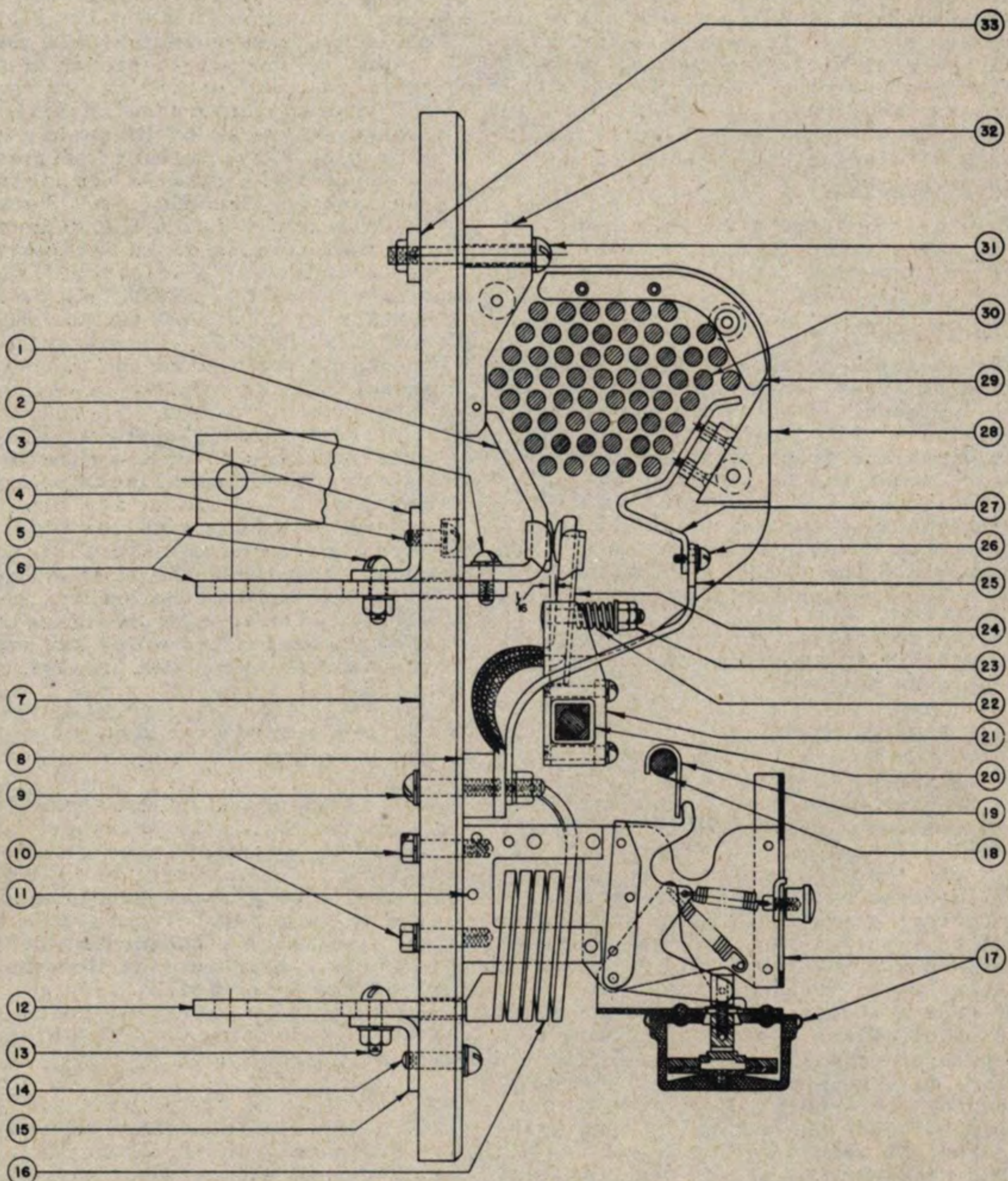


FIG 7
SIDE VIEW OF POLE UNIT

1. STATIONARY CONTACT AND ARC RUNNER
2. SCREW $\frac{1}{4}$"-20 X $\frac{5}{8}$" WITH LOCK WASHER
3. UPPER STUD BRACKET
4. SCREW R.H. $\frac{1}{4}$"-20 X $\frac{7}{8}$" WITH WASHERS
5. SCREW R.H. $\frac{1}{4}$"-20 X $\frac{3}{4}$" WITH HEX. NUT & LOCK WASHER
6. UPPER STUD
7. BREAKER BASE
8. TERMINAL, WELDED TO COIL
9. SCREW R.H. $\frac{1}{4}$"-20 WITH NUT AND WASHERS
10. SCREWS HEX. HD. $\frac{1}{4}$"-20 WITH WASHERS
11. MAGNET
12. LOWER STUD, WELDED TO COIL
13. SCREW R.H. $\frac{1}{4}$"-20 X $\frac{3}{4}$" WITH HEX. NUT AND WASHER
14. SCREW R.H. $\frac{1}{4}$"-20 WITH WASHERS
15. LOWER STUD BRACKET
16. SERIES CURRENT COIL
17. OIL FILM DUAL MAGNETIC OVERLOAD TRIP DEVICE (SEE FIG. 15)
18. TRIP SHAFT
19. TRIP FINGER
20. INSULATED MAIN SHAFT
21. CONTACT SUPPORT ASSEMBLY
22. ADJUSTING SPRING
23. HEX NUT $\frac{1}{4}$"-20
24. MOVEABLE CONTACT WITH FLEXIBLE COPPER BRAID
25. SHUNT CONNECTOR
26. SCREW R.H. #10-32 X $\frac{1}{2}$" AND WASHERS
27. FRONT ARC RUNNER
28. ARC QUENCHER
29. BAFFLES
30. COPPER COOLING PINS
31. SCREW R.H. $\frac{5}{16}$"-18 WITH WASHER
32. MOUNTING BLOCK
33. LOCKING PLATE WITH WELDED HEX. NUT $\frac{5}{16}$"-18 AND SELF TAPPING SCREWS #8

H-49552

surfaces. Rough or high spots should be removed with a very fine, CLEAN file or fine clean sandpaper. (Do not use emery cloth or crocus cloth). Care should be taken to maintain a line contact as much as possible. To check the amount of contact obtained, take contact impressions by holding between the contacts a piece of thin carbon paper with tissue paper on the carbon side and closing the breaker. Open the breaker and examine the impressions made on the paper. Good contact is indicated if a well-defined impression shows for 75% or more of the length of the contact. Good contact is also indicated if a .001 inch feeler gauge cannot be inserted between the contacts for more than 25% of the length of the contact. See also contact pressure and adjustments under "Contacts" Page 4.

LUBRICATION

In general, the breaker operating mechanism requires very little lubrication which should be applied sparingly. Any excess amount of oil on the breaker parts is apt to collect dust and dirt and is to be avoided. A general recommendation for lubrication of air circuit breaker mechanisms is to occasionally use a few drops of a good grade of light machine oil at bearing points, and to wipe off any excess with a clean rag.

OIL-FILM TIME DELAY

If the breaker is equipped with any type of oil-film time delay trip devices, make sure that when the breaker is installed, the oil pots of these devices are thoroughly cleaned and filled with oil to the proper level as marked on the pots. It is important that these oil pots be kept clean and properly filled with fresh oil to the proper level at regular inspection periods at least every six months, and more frequently if service is severe. A small can of oil for use in these pots is furnished with the breaker. Additional oil per General Electric Company specifications P50-HB1-A can be obtained from the factory. When cleaning these oil pots, use kerosene or naptha only, and wipe dry with a clean cloth. Other cleaning fluids may act as a solvent of the material of which the pot is made.

DESCRIPTION OF COMPONENTS AND ATTACHMENTS

Although, under this heading, the adjustable features of the air circuit breaker and its attachments are given, it should be understood that the breaker has already been adjusted, inspected and tested at the factory in accordance with the information given herein. However, it is possible that unusually rough handling, transportation, and operating conditions may have resulted in some loosening or disturbance of the equipment to warrant re-checking and, in some cases, readjustment may be necessary.

CONTACTS

The current through the breaker contacts (Fig. 7) is carried by copper conductors with inserts of high conductivity and arc resistant alloy welded to their faces. To obtain a line contact, both the stationary and movable contacts (Pt. 1 and Pt. 24) are slightly rounded and the method for checking the contact engagement is described in contacts under "Operation and Maintenance". Page 4. The contact pressure is maintained by the compression springs behind the contact arm and adjustment is provided to maintain the proper contact pressure.

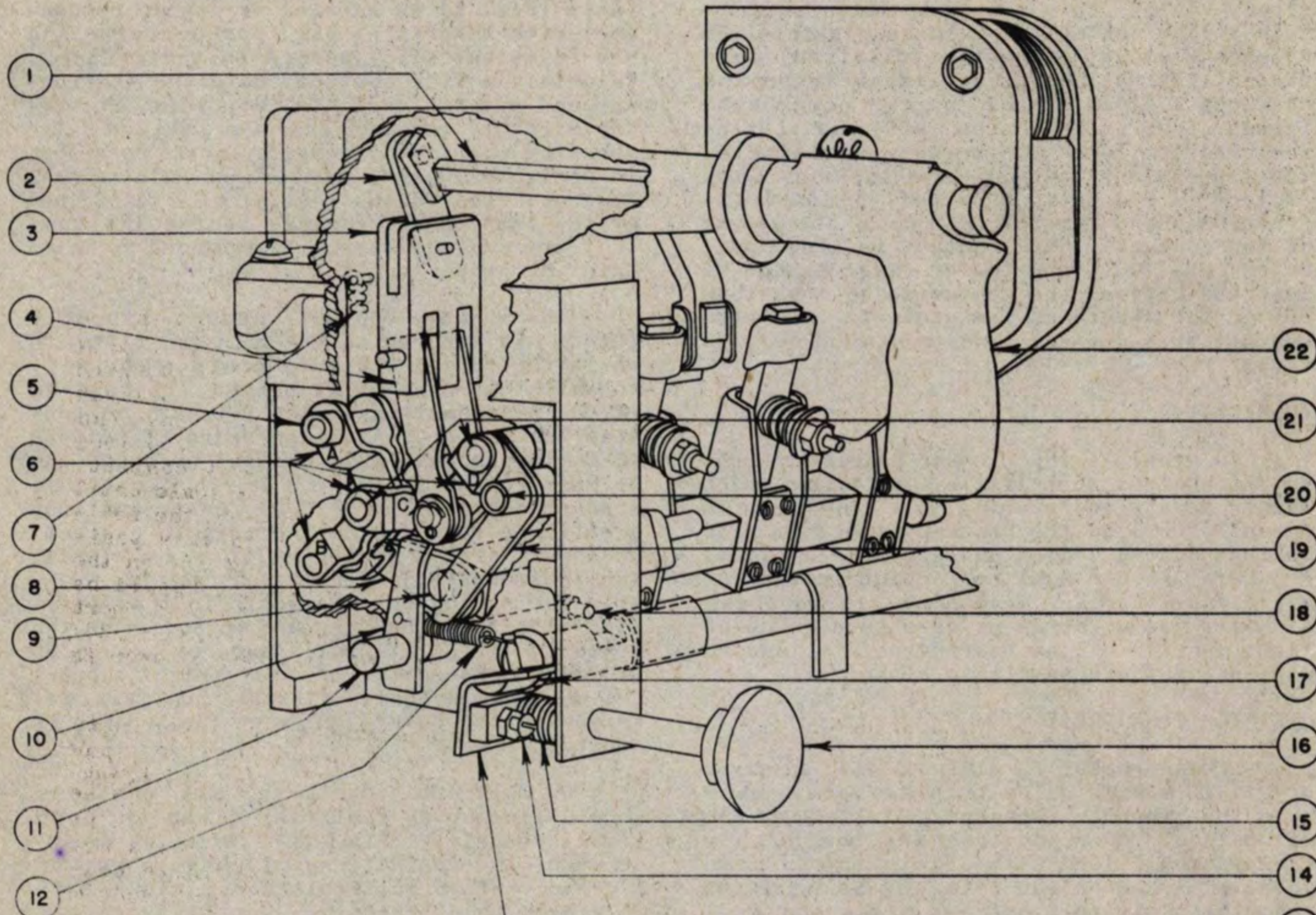
The movable contact support assembly (Pt. 21) is secured to the main shaft (Pt. 20) while the formed flexible braid (Pt. 24), to which the contact is brazed, is held in Pt. 21 by adjusting spring (Pt. 22) to provide the proper contact pressure of between 15 to 18 pounds. This contact pressure can be measured as follows: First close the breaker contacts on a .001" feeler and loop a suitable wire around the movable contact. Then pull with a spring balance scale until the pressure is just relieved from the feeler. The spring balance scale in this position will read the pressure in pounds on the contact. 1/16" minimum clearance should be provided between the movable contact support (Pt. 21) and the formed flexible braid (Pt. 24) as designated on Fig. #7, when the breaker is closed.

On multi-pole breakers, all contacts should line up so that they close or open simultaneously within 1/32". With the breaker open, the contacts should have a gap of 3/4" to 7/8" on multipole and 1" to 1-1/8" on single pole breakers. The breakers are adjusted in the factory to suit these conditions and further adjustment should not be necessary.

ARC QUENCHERS

Arc quenchers are used on live front, dead front and enclosed AE-1-15 air circuit breakers. When used on dead front on enclosed, they are covered with a box-type barrier of insulating compound.

The arc quencher as shown in Fig. 7, consists of a large number of solid copper pins supported between two molded compound sides placed vertically at each side of the breaker contacts. Molded compound baffles (Pt. 29) are used between the side above the pins. The rear arc runner of the stationary contact (Pt. 1) extends into the arc quencher behind the pins and the front arc runner is attached to an insulation block in front of the pins and is bolted to the shunt connector (Pt. 25) after the arc quencher is in place. When the contacts open, the arc is magnetically blown upward into the quencher and among the many copper pins which promptly extinguish the arc. To save burning at



1. ECCENTRIC MANUAL SHAFT
2. LINK
3. LINK
4. PAIR OF CLOSING LINKS
5. PIN MOUNTED IN FRAME
6. TOGGLE LINKS
7. SPRING (SEE FIG. 9)
8. OPERATING CRANK (SEE FIG. 9)
9. INSULATING MAIN SHAFT
10. PROP
11. PIN MOUNTED IN FRAME
12. SPRING
13. TRIP LATCH
14. ADJUSTABLE SCREW AND NUT
15. SPRING
16. TRIP BUTTOM
17. TRIP SHAFT
18. ADJUSTING SCREW RH 10-32 X 1/2" AND NUT
19. TRIP ARM
20. PIN MOUNTED IN FRAME
21. RIVETED OVER PINS
22. MANUAL HANDLE

FIG 8

OPERATING MECHANISM OF TYPE AE-1-15

A.C.B. MANUALLY OPERATED IN TRIPPED POSITION

.49561

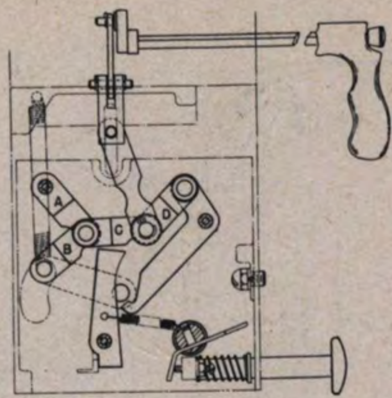


FIG. 9A
TRIPPED POSITION

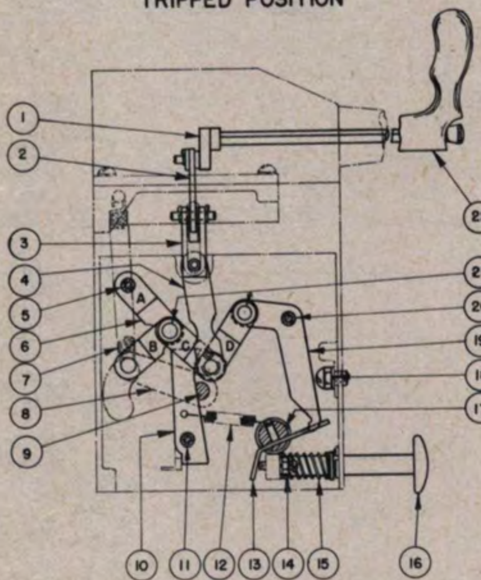


FIG. 9B
RESET POSITION

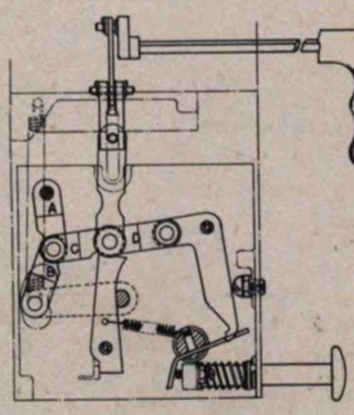


FIG. 9C
CLOSED POSITION
OPERATING POSITIONS OF OPERATING MECHANISM

the contacts, the arc is quickly transferred to the arc runners when the moving contact passes under the front arc runner. In travelling up the arc runners, the arc is lengthened, which together with the cooling effect of the pins and baffles, quickly breaks the arc.

MANUALLY OPERATED MECHANISM

The manually operated breaker mechanism (Fig. 8) shown in the tripped position, is operated by a pistol grip handle (Pt. 22) located at the front of the mechanism. The normal position of this handle is "down" and in order to close a manually operated breaker, it must be turned counter-clockwise approximately 180° to the "reset" position which resets the trip arm (Pt. 19), and then must be turned clockwise to the "down" position to close the breaker. The mechanism is tripped manually by the trip button (Pt. 16), or by tripping devices, which revolve the trip shaft (Pt. 17), to release the trip arm (Pt. 19). When tripped manually or electrically, the handle remains in the "down" position. Therefore, to reclose the breaker, the handle must first be turned counter-clockwise to the "reset" position and then clockwise to the "down" position, as described above.

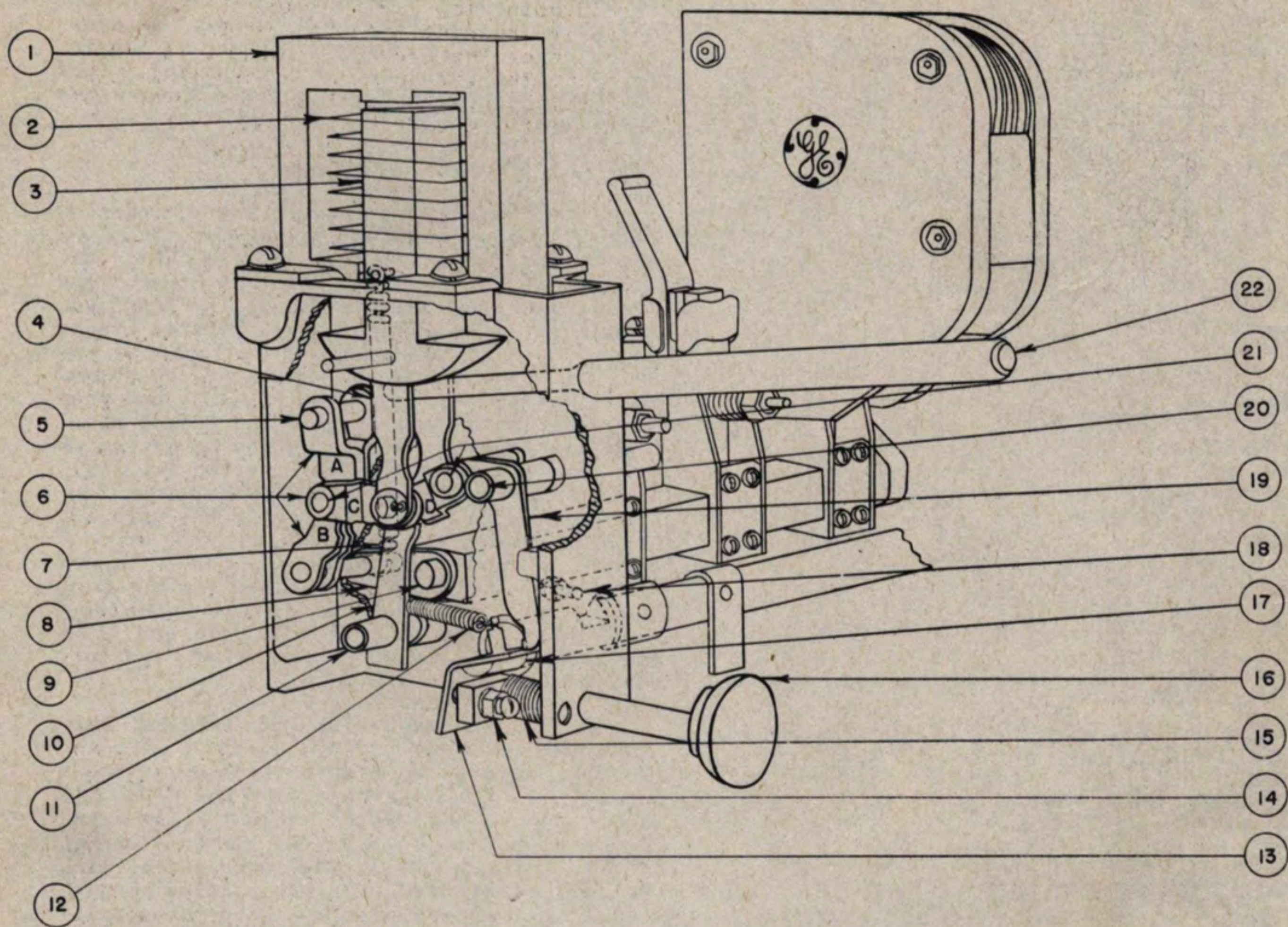
The toggle mechanism consists of four links (Pt. 6A, 6B, 6C, 6D) and the trip arm (Pt. 19) riveted or pinned together as shown in Fig. 8. The upper end of link (Pt. 6A) is pivoted to the frame, as is the lower end of the prop (Pt. 10) and the central point of trip arm (Pt. 19). The lower end of link (Pt. 6B) is pivoted on a pin passing through a slot in the mechanism frame to the operating crank (Pt. 8) which is an arm connected at right angles to the main shaft (Pt. 9). The opening spring (Pt. 7), holds the operating crank up and maintains the contacts in the open position after the breaker is tripped.

In a cycle of manual operation the mechanism parts take three positions as follows:

<u>Tripped Position</u> - In the tripped position (Fig. 9A) the trip arm (Pt. 19) of the toggle mechanism is free of the trip latch (Pt. 13). Other links assume the positions shown. The handle is "down".

<u>Reset Position</u> - When the manual handle (Pt. 22) is turned counter-clockwise to the "reset" position with the handle up (Fig. 9B) the eccentric on the handle shaft (Pt. 1) lowers the pair of closing links (Pt. 4), collapsing the toggle links (Pts. 6C and 6D), causing the trip arm (Pt. 19) to revolve about its fixed pivot (Pt. 20) and engage the trip latch (Pt. 13), because toggle links (Pts. 6A and 6B) are held in collapsed position by spring (Pt. 7).

H-6240560



1. MAGNET
2. CLOSING COIL
3. ARMATURE
4. PAIR OF CLOSING LINKS
5. PIN IN FRAME
6. TOGGLE LINKS A, B, C, D
7. SPRING (SEE FIG. 9)
8. OPERATING CRANK (SEE FIG. 9)
9. INSULATING MAIN SHAFT
10. PROP
11. PIN MOUNTED IN FRAME
12. SPRING
13. TRIP LATCH
14. ADJUSTING SCREW AND NUT
15. SPRING
16. TRIP BUTTON
17. TRIP SHAFT
18. ADJUSTING SCREW RH 10-32 X 1/2" AND NUT
19. TRIP ARM
20. PIN MOUNTED IN FRAME
21. RIVETED OVER PINS
22. EMERGENCY CLOSING HANDLE

FIG. 10

OPERATING MECHANISM OF TYPE AE-1A A.C.B. SOLENOID OPERATED IN CLOSED POSITION

H-6249556

Closed Position - When the manual handle (Pt. 22) is turned clockwise to the "closed" or "down" position (Fig. 9C) the closing links (Pt. 4) are raised to the vertical position extending toggle links (Pts. 6C and 6D), causing the toggle links (Pts. 6A and 6B), to be extended, forcing the operating crank (Pt. 8) downward against spring (Pt. 7) to close the breaker, because trip arm (Pt. 19) is held fixed by trip latch (Pt. 13). At the same time, the spring (Pt. 12) draws the prop (Pt. 10) under the closing links (Pt. 4) to prevent opening the breaker by counterclockwise rotation of the closing handle.

The AE-1-15 breaker is trip free because the toggle links (Pt. 6A and Pt. 6B) cannot be extended to close the contacts by the main shaft (Pt. 9) as long as the trip shaft (Pt. 17) is held in the tripped position by any device. This prevents the trip arm (Pt. 19) from being held in position as shown in Fig. 9B and even if an attempt is made to close the breaker the trip arm simply returns to the position shown in Fig. 9A.

The latch adjusting screw (Pt. 14) should be adjusted on the trip latch (Pt. 13) to provide 1/32" minimum latch engagement with the trip arm (Pt. 19). The trip latch spring (Pt. 12) provides the proper tension between the prop (Pt. 10) and the trip latch (Pt. 13) to insure positive latching and prop seating to prevent the collapse of the toggle links (Pt. 6C and Pt. 6D). The trip arm stop screw should be adjusted to provide 1/16" clearance between it and the trip arm (Pt. 19) when the breaker is in the closed position.

SOLENOID OPERATED MECHANISM

Electric closing of the AE-1-15 breaker is accomplished by a solenoid and a closing relay as shown in Fig. 10 and Fig. 11. These parts take the place of the manual handle, the eccentric manual shaft (Pt. 1) and links (Pt. 2 and 3, Fig. 8) of the manually operated mechanism. The balance of the operating mechanism is the same for both the manually and solenoid operation, as shown in Fig. 10 with the operating mechanism in the closed position, except in reference to resetting. In solenoid operation, the resetting of the trip arm is automatic in that the weight of the falling armature, to which the closing links (Pt. 4) are directly attached, causes the collapse of toggle links (Pt. 6C and Pt. 6D) which duplicates the resetting of the manually operated mechanism.

The solenoid closing coil is designed for momentary operation and reasonable care must be exercised to avoid overheating. For this reason, a cut-off switch is recommended.

An emergency closing handle (Pt. 22) is provided, which may be inserted through a hole in the front of the mechanism frame and placed under the solenoid armature. The electrically operated breaker may be closed manually by pressing down on the emergency handle which raises the armature to allow the prop (Pt. 10) to slip under the closing links (Pt. 4) to hold the breaker closed.

Latch adjustments should be the same as given for manually operated mechanisms.

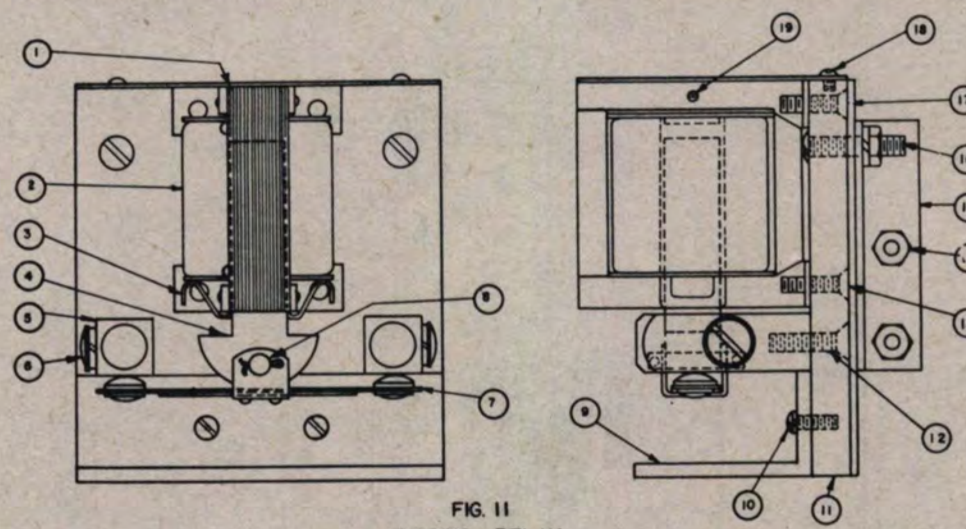


FIG. 11
CLOSING RELAY

1. MAGNET
2. COIL
3. BRASS GUIDES
4. ARMATURE
5. STATIONARY CONTACTS
6. BINDING SCREWS #10 AND LOCKWASHER
7. MOVEABLE CONTACTS ASSEMBLY
8. PIN AND COTTERS
9. INSULATION ANGLE
10. SCREW R.H. SELF TAPPING #8 X 3/8 AND LOCKWASHER
11. BASE
12. SCREW F.H. #10-32 X 3/4
13. SCREW F.H. #8-36 X 1/2
14. SCREW R.H. #8-36 X 1 3/8 LOCKWASHER AND NUTS
15. ANGLE SUPPORT
16. SCREW R.H. #10-32 X 7/8 LOCKWASHER AND NUT
17. INSULATION BARRIER
18. SCREW R.H. SELF TAPPING #6-40 X 3/16
19. SCREW R.H. SELF TAPPING #4 X 1/4

CLOSING RELAY

An electrically operated breaker is equipped with closing relay, Fig. 11, which operates to control the solenoid closing coil circuit so that the closing switch contacts will not be called upon to break the closing current. This relay is mounted directly on the front of the closing coil magnet by angle straps (Pt. 15), screwed to the magnet. No adjustments are required except to keep contacts clean.

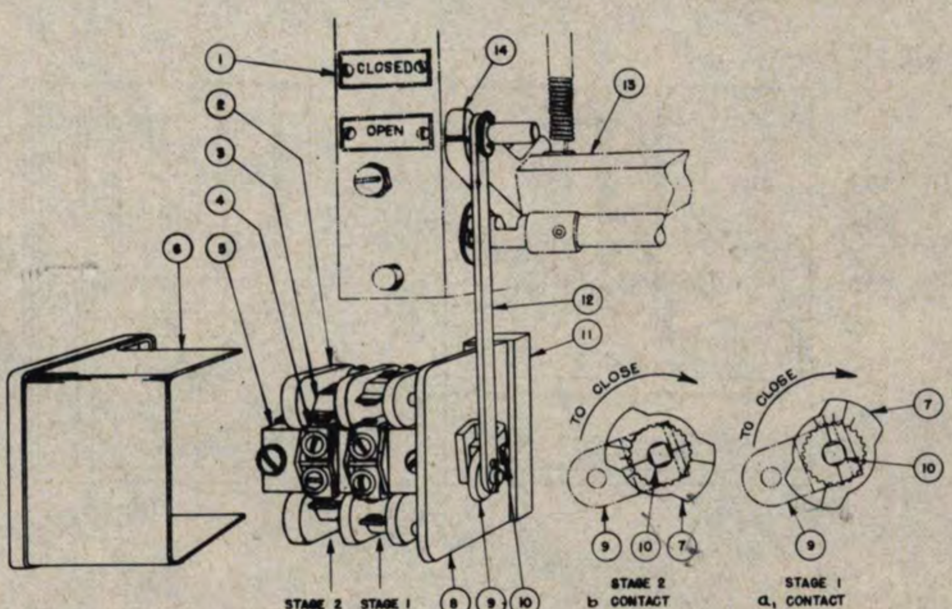
The coil (Pt. 2) is mounted in the magnet (Pt. 1), which is screwed to a separate mounting base (Pt. 11). The coil is held by two brass guides (Pt. 3) between which the armature (Pt. 4) is free to move. The lower ends of the guides are clamped over the magnet and against the coil to keep it firmly in place, and the upper ends are fastened to the magnet by self-tapping screws (Pt. 19). When the coil is energized by the closing of a manually operated push button, or a remote switch or relay contacts, the armature is drawn up into the coil. It carries with it the movable contact strap (Pt. 7) which bridges the stationary contact blocks (Pt. 5) to energize the breaker closing coil and close the breaker. As soon as the coil is de-energized, the armature falls by its own weight and opens the breaker closing circuit at the movable contact strip.

TYPE SB-1 AUXILIARY SWITCH

An auxiliary switch (Fig. 12) is necessary for an electrically operated Type AE-1-15 air circuit breaker and for a manually operated breaker when auxiliary functions are required. It is generally placed on the mounting panel below the operating mechanism and connected to it by crank (Pt. 9) and a link (Pt. 12) attached to an index arm (Pt. 14), which is an extension of operating crank (Pt. 8, Fig. 8). The number of stages and circuits is determined by auxiliary functions desired and the characteristics of the circuits to be controlled, such as remote tripping circuit, indicating lamps, bell alarm, interlocking of breakers, etc.

The SB-1 auxiliary switch is a cam-operated, multi-pole rotary switch provided with "a" and "b" contacts, an "a" contact being one that is open when the breaker is open, and a "b" contact being one that is closed when the breaker is open. The angular placement of the cams (Pt. 7) in steps of 15° on the shaft (Pt. 10) is important in order to make sure that certain contacts are definitely opened or closed before contacts operated by another cam are opened or closed. An "a_1" contact closes definitely before an "a" contact closes.

For detail instructions concerning the SB-1 auxiliary switch see Instruction Book GEI-18080. Each stage of the switch for AE-1-15 breakers has one cam (Pt. 7) and two sets of electrically separate switch contacts These may be wired in series for one circuit, or used for two separate circuits, depending upon the interrupting requirements of the circuits in accordance with the table in the above instruction book.



DIAGRAMATIC CAM ARRANGEMENT (LOOKING AT CRANK END) BREAKER OPEN

FIG. 12

TYPICAL AUXILIARY SWITCH WITH OPERATING LINKAGE

1. OPERATING MECHANISM
2. MOLDED BARRIERS
3. MOVABLE CONTACT ASSEMBLY
4. STATIONARY CONTACT ASSEMBLY
5. STATIONARY CONTACT SUPPORT
6. COVER
7. CAM, ON SHAFT (SEE DETAIL)
8. END FRAME
9. CRANK, PIN, AND COTTER
10. SHAFT (EXTENTION OF OPERATING CRANK PT.8 FIG.8)
11. MOUNTING BLOCK
12. LINK
13. MAIN SHAFT
14. INDEX ARM, PIN, AND COTTER

If changes are to be made in the control operation an approved drawing of the auxiliary switch cam arrangement involved should be optained or a careful sketch should be made of the switch in hand and the above Instruction Book GEI-18080 should be carefully followed.

By changing the position of the cam (Pt. 7) on the shaft (Pt. 10) any stage can be changed from circuit opening to circuit closing contacts.

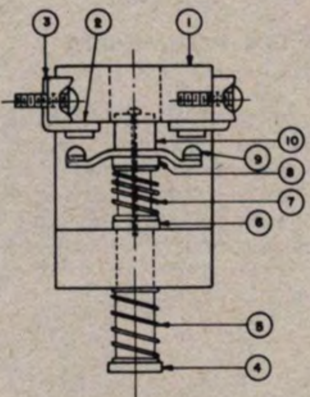


FIG. 13
MANUAL CLOSING SWITCH

1. MOLDED FRAME
2. CONTACT BRACKETS AND STATIONARY CONTACTS
3. TERMINALS AND BINDING SCREWS
4. OPERATING ROD
5. COMPRESSION SPRING
6. WASHER
7. CONTACT SPRING
8. INSULATION
9. MOVEABLE CONTACT STRIP
10. GUIDE

MANUAL CLOSING SWITCH

The manual closing switch (Fig. 13) for electrically operated breakers requires no adjustment other than to insure clean contacts. This switch is mounted on the left side or front of the mechanism and energizes the coil of the closing relay when the switch contacts are closed.

The switch consists of a molded frame (Pt. 1) which supports an operating rod (Pt. 4) on which rides a movable contact strip (Pt.9) and also contact brackets (Pt. 2) which carry the stationary contacts and terminals with binding screws (Pt. 3). A compression spring (Pt. 5) normally holds the rod and movable contact strip in the open position. Contact spring (Pt. 7) holds the contact strip against the stationary contacts when in the closed position.

CUT-OFF SWITCH

The cut-off switch, Fig. 14, is located on the left side of breaker mechanism housing (Pt. 2) and is actuated by pin (Pt. 4) of solenoid operated breakers to close its contacts while the breaker is in the closed

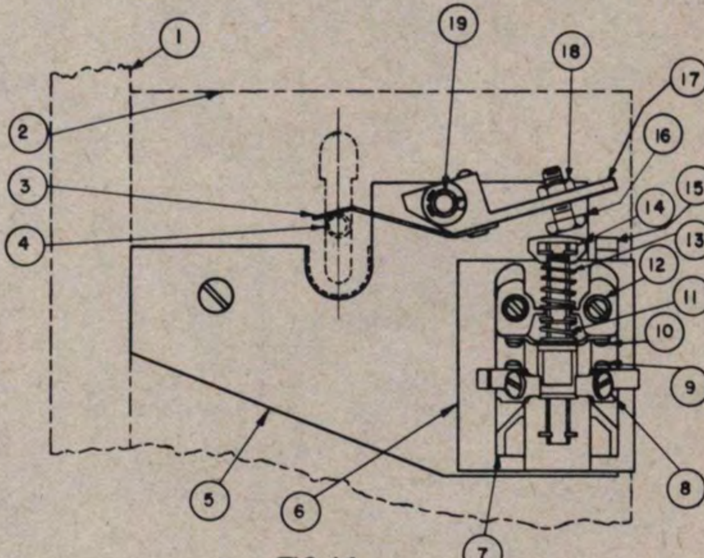


FIG. 14
CUT-OFF SWITCH
WITH BREAKER IN OPEN POSITION

1. MOUNTING BASE
2. OPERATING MECHANISM HOUSING
3. SPRING
4. PIN OF BREAKER CLOSING LINK
5. SUPPORT PLATE
6. INSULATION
7. MOLDED FRAME
8. BINDING SCREWS
9. STATIONARY CONTACTS
10. MOVEABLE CONTACT STRIP
11. CONTACT SPRING
12. MOUNTING SCREWS #6-40 X $\frac{1}{2}$
13. COMPRESSION SPRING
14. OPERATING ROD
15. STOP
16. ADJUSTING SCREW
17. OPERATING LEVER
18. LOCK NUT
19. PIN

position. The purpose of this switch is to provide a circuit to de-energize the solenoid closing coil as described below and prevent damage if the control switch is held in the closed position too long. The contacts of this switch should not close too soon in the closing stroke of the breaker which would de-energize the coil too soon to close the breaker. A cut-off relay with open and closed contacts, not provided with the breaker, must be used with this switch. See wiring diagrams, Fig. 30 and 31.

The switch is mounted on a support plate (Pt. 5) with a sheet of insulating material (Pt. 6) between the switch and the plate and consists of a molded frame (Pt. 7) which supports an operating rod (Pt. 14) on which rides a movable contact strip (Pt. 10). The molded frame also supports brackets which carry stationary contacts (Pt. 9) and binding screws (Pt. 8). A compression spring (Pt. 13) normally holds the rod and moving contact strip in the open position. A contact spring (Pt. 11) holds the contact strip against the stationary contacts when in the closed position. The operating lever (Pt. 17) is pivoted at a middle point to the same support (Pt. 5) by pin (Pt. 19) and carries a flat spring (Pt. 3) which bears against the top of pin (Pt. 4) of the breaker operating mechanism. When the breaker closes, the raising of this pin lowers the adjusting screw (Pt. 16), attached to the operating lever, and forces the cut-off switch into the closed position. This closes a circuit which energizes a cut-off relay which, in turn, de-energizes the closing relay, thus cutting off current from the solenoid coil to prevent damage.

DUAL OIL-FILM MAGNETIC OVERCURRENT TRIP DEVICE.

This device (Fig. 15) automatically trips the breaker under two distinct conditions of overload; first, with inverse time delay for overcurrents in excess of calibration setting and less than ten times rated current, and second, with instantaneous tripping for over-loads exceeding ten times rated current.

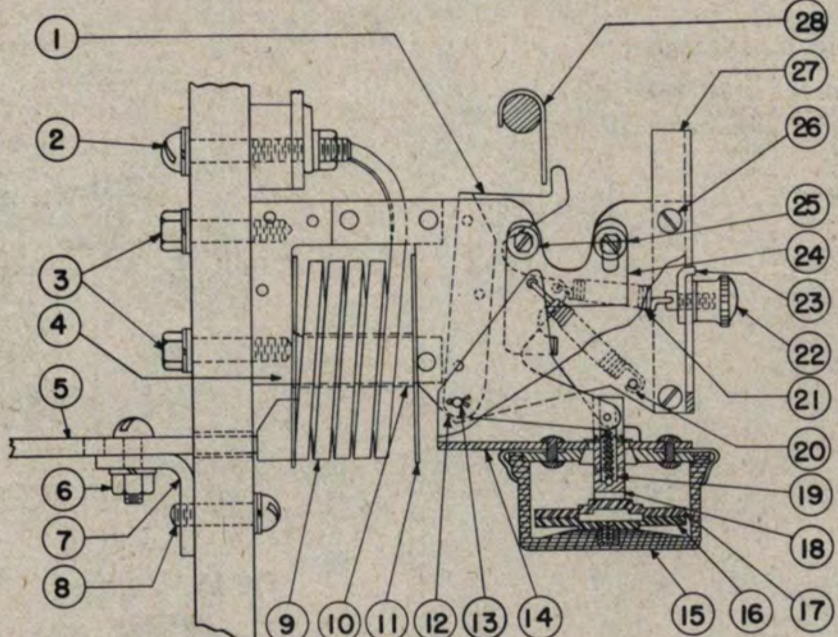


FIG. 15

DUAL OIL FILM MAGNETIC OVERCURRENT TRIP DEVICE

1. ARMATURE ASSEMBLY
2. SCREW R.H. 1/4-20, NUT AND WASHERS
3. SCREW HEX. HD. 1/4-20, AND WASHERS
4. MAGNET
5. LOWER STUD (WELDED TO COIL)
6. SCREW R.H. 1/4-20 X 3/4, NUT AND WASHER
7. LOWER STUD BRACKET
8. SCREW R.H. 1/4-20 AND WASHERS
9. SERIES OVERCURRENT COIL WITH UPPER TERMINAL
10. INSULATING TUBE
11. INSULATING WASHERS
12. FRAME
13. PIN & COTTERS
14. PIVOTED COVER & SUPPORT
15. OIL POT
16. LOWER DISC
17. UPPER DISC
18. SHANK
19. SPRING
20. INSTANTANEOUS TRIP SPRING
21. CALIBRATION SPRING
22. CALIBRATION ADJUSTING KNOB
23. CALIBRATION INDEX & SCREW
24. ADJUSTING STOP
25. SCREWS HEX. HD. 10-32 X 1/2 NUT AND WASHERS
26. SCREWS R.H. 8-36 X 1/4 AND WASHER
27. CALIBRATION PLATE
28. TRIP FINGER

H-6249500

To accomplish inverse time tripping the current in the series coil (Pt. 9) sets up a magnetic circuit which tends pick up armature (Pt. 1) pivoted on pin (Pt. 13), and operate the trip finger (Pt. 28) on breaker trip shaft. The armature (Pt. 1) is restrained by a calibrating spring (Pt. 21) held under tension between the armature assembly and the calibration index (Pt. 23) and also by a thin oil film between upper disc (Pt. 17) which is pivoted to the armature assembly, and the lower disc (Pt. 16) attached to the bottom of oil pot (Pt. 15) which holds the oil in which both discs are immersed. For currents below the calibration setting, the calibrating spring prevents the armature from picking up and no force is exerted to separate the discs in the oil pot. For currents in excess of the calibration setting the magnetic pull on the armature exceeds the restraining force of the calibration spring (Pt. 21) and the excess force tends to pull the two flat disc surfaces (Pt. 16 and Pt. 17) apart by rupturing the oil film between them. Once this oil film is ruptured, the armature picks up and trips the breaker. The time required to rupture the oil film varies inversely with the force applied and hence, inversely with the current through the breaker. Thus, if the overcurrent falls below the calibration setting before the oil film is ruptured the breaker will not open.

For instantaneous tripping by current in excess of ten times normal breaker rating the armature is further restrained by a pair of heavier instantaneous trip springs (Pt. 20) one on each side of the device, attached at one end to the fixed frame (Pt. 12) and at the other end to a cover and support (Pt. 14), pivoted on the same pin (Pt. 13), which supports the oil pot. Thus, if overcurrent demands immediate tripping, the heavier pull on the upper disc lifts the complete oil pot assembly, as these springs yield, without waiting for the rupture of the oil film, allowing the armature to pick up and trip the breaker immediately.

Calibration settings for 100, 125, 150, 175, and 200 per-cent of breaker normal current rating are marked in amperes on the calibration plate (Pt. 27). For general feeder applications, the calibration setting used should be not less than 125 per-cent of the actual load being carried by the breaker.

An adjustment is provided for varying the amount of time delay obtained. This is accomplished by turning the oil pot (Pt. 15) to different time delay settings, which increases or decreases the area of disc surfaces separated by oil film. The smaller the area, the shorter will be the time delay obtained.

The armature air gap is adjusted by an adjustable stop (Pt. 24) which is pivoted to the frame (Pt. 12) by screw (Pt. 25) at one end and set by a similar screw through a slot at the other end. This registers with the pivoted cover and support (Pt. 14) upon which the oil pot is mounted. By raising or lowering the oil pot, the armature air gap is changed because the shank (Pt. 18) is pivoted to both the armature assembly and to the upper disc (Pt. 17). The air gap should not be changed unless means are available for recalibrating the complete device.

To check the adjustment of this device for positive tripping, pick the armature up manually; the breaker should trip when approximately 1/32" air gap remains between the armature and magnet. To obtain this adjustment, bend the trip finger attached to the trip shaft so that the armature engages this finger sooner or later as required.

It is important that the facing surfaces of the discs be clean and smoothe, otherwise the calibration will be affected. If these surfaces are damaged or affected in any way, they should be relapped or made smoothe by rubbing over crocus cloth backed up by a smoothe flat surface.

If a new series coil is required or any considerable repair is necessary, it is recommended that a complete factory calibrated oil-film dual-magnetic overcurrent trip device be supplied.

A typical time-current tripping curve for this device is shown by Fig. 16. This curve is approximate and considerable variation in time delay may be expected depending on the cleanliness of the oil forming the film, the time allowed for resetting, the ambient temperature, etc.

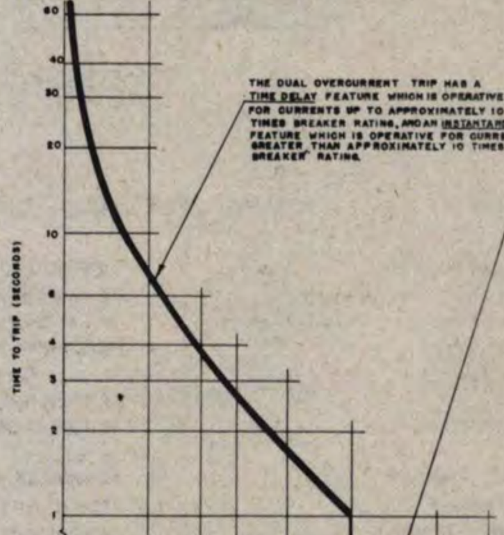


FIG. 16

APPROXIMATE TIME — CURRENT CHARACTERISTIC OF DUAL MAGNETIC OVERCURRENT TRIP DEVICE

(100% CALIBRATION SETTING - MAXIMUM TIME DELAY SETTING)

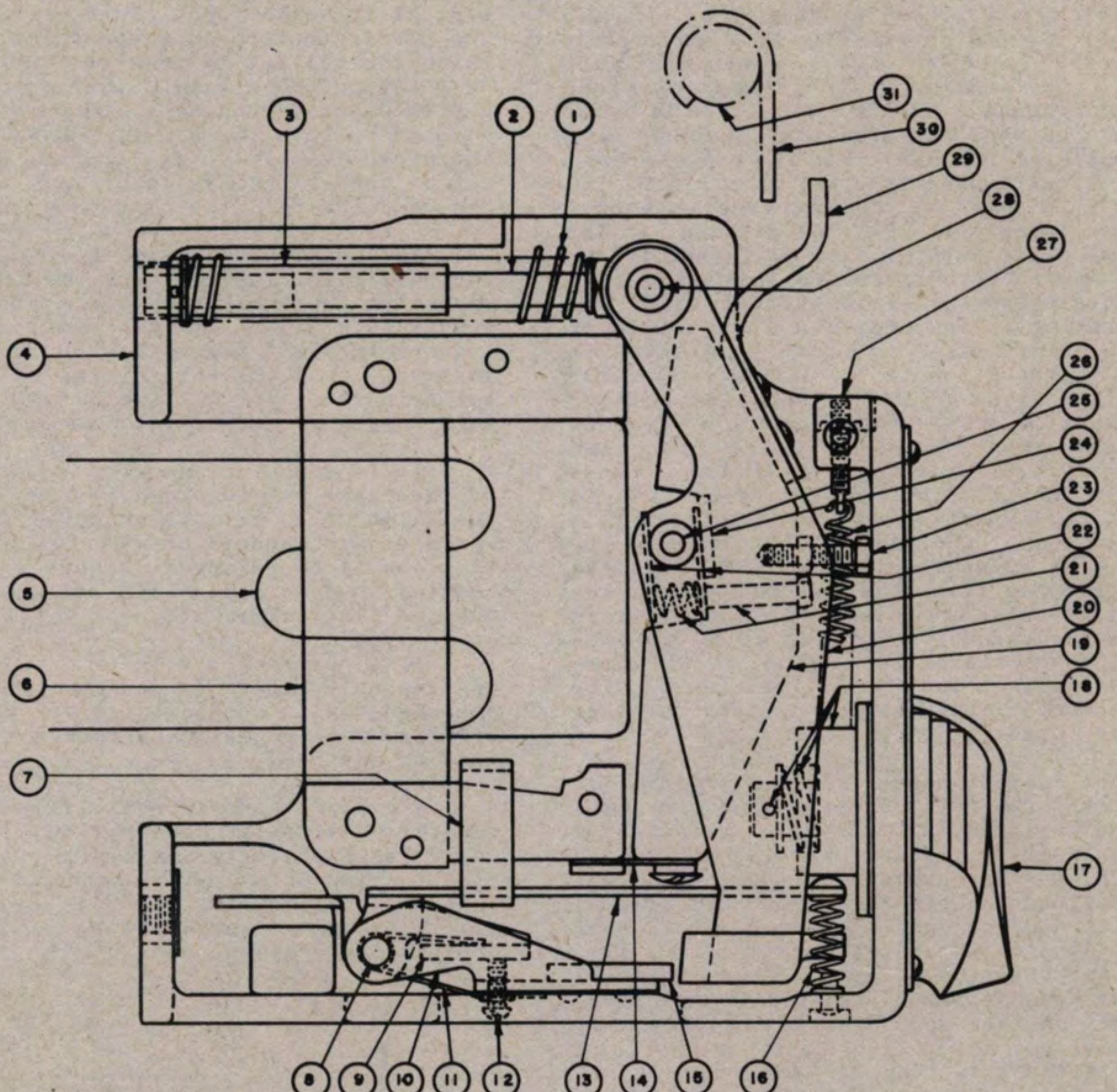


FIG. 17

DUAL THERMAL MAGNETIC OVERCURRENT TRIP DEVICE

1. SHORT CIRCUIT SPRING
2. SPRING GUIDE AND LOCK NUT
3. TUBULAR SPRING GUIDE AND COTTER
4. MOLDED FRAME
5. SERIES COIL
6. MAGNET
7. INDUCTION RING
8. PIN
9. THERMAL TRIP ARM
10. LATCH SUPPORT
11. TORSION SPRING
12. ADJUSTING SCREW
13. BIMETALLIC STRIP
14. SPRING HINGE
15. LATCH PLATE
16. SPRING FOR THERMAL TRIP ARM
17. CALIBRATING KNOB
18. CALIBRATING CAM, SPRING, AND COTTER
19. ARMATURE
20. YOKE
21. ADJUSTING SCREW AND SPRING
22. FLAT BUFFER SPRING
23. ARMATURE ADJUSTING SCREW AND NUT
24. LEATHER BUFFER
25. YOKE AND ARAMTURE PIN
26. RESET SPRING FOR YOKE
27. ADJUSTING SCREW
28. PIN
29. TRIP ARM
30. TRIP FINGER
31. TRIP SHAFT

6249553

DUAL THERMAL MAGNETIC OVERCURRENT TRIP DEVICE

This device (Fig. 17) also automatically trips the breaker under two distinct conditions of overcurrent; first, with inverse time delay when the current exceeds the value of calibrations setting and is less than 12 to 15 times rated current, the inverse time element being obtained by the time required to heat and flex a bimetallic strip, and second, instantaneously when the current exceeds 12 to 15 times the normal breaker rating. It operates on alternating current only, and is principally used for motor protection. The unit is enclosed in a molded frame.

Current in the series coil (Pt. 5) sets up a magnetic circuit which tends to pick up the armature (Pt. 19) and operate the trip finger (Pt. 30) on the trip shaft (Pt. 31). The armature is attached to the lower member of the magnet (Pt. 6) by a spring hinge (Pt. 14) and is restrained by a yoke (Pt. 20) which is pivoted to the center of the armature by pin (Pt. 25) between two flat buffer springs (Pt. 22). The yoke is restrained at the bottom by the latch plate (Pt. 15) and also at the top by two heavy compression short circuit springs (Pt. 1). Current in the series coil induces current in the short circuited ring (Pt. 7), mounted around the lower magnet member, generating heat which is conducted to the bimetallic strip (Pt. 13) which is riveted at one end to the thermal trip arm (Pt. 9) and held at the other end between the calibrating cam (Pt. 18) and the spring (Pt. 16). The thermal trip arm (Pt. 9) is pivoted to the frame on pin (Pt. 8). When sufficient heat has been developed to cause the bimetallic strip (Pt. 13) to bend, with the convex surface downward, the thermal trip arm will tend to revolve about the pin (Pt. 8) and bear against an adjusting screw (Pt. 12) set in the latch support (Pt. 10). also pivoted on the pin (Pt. 8), to cause the latch plate (Pt. 15) to disengage the yoke (Pt. 20) at the lower end and allow the armature to be picked up and trip the breaker. A torsion spring (Pt. 11) is mounted on pin (Pt. 8) to hold the thermal trip arm (Pt. 9) and the latch support (Pt. 10) together against the adjusting screw (Pt. 12). Thus, if the overcurrent falls below the calibration setting before the bimetallic strip is sufficiently bent, the breaker will not be tripped.

Should the overcurrent exceed 12 to 15 times the breaker rating, the yoke will cause the short circuit spring (Pt. 1), supported between pin (Pt. 28) in the yoke and the frame, to be compressed. This allows the armature to be picked up and trip the breaker immediately without waiting for the release of latch plate (Pt. 15) by the heating of the bimetallic strip (Pt. 13) as described above.

The lock nut on spring guide (Pt. 2) controls the compression of the short circuit springs which are adjusted in the factory to provide instantaneous tripping when the current exceeds approximately 12 to 15 times normal breaker rating. The adjustable stop screw (Pt. 23) is secured to the armature (Pt. 19) and provides a stop against the molded case to control the clearance of 1/16" to 3/32" between the latch surface on the yoke and latch plate (Pt. 15) to insure positive reset. The reset spring (Pt. 26) provides the proper tension to yoke (Pt. 20) to insure positive resetting after a tripping operation. The adjusting screw (Pt. 12) controls the latch plate (Pt. 15) engagement and calibration time for a given current by varying the distance through which the thermal strip (Pt. 13) must bend before releasing the latch to trip the breaker.

The calibration adjustment knob (Pt. 17) can be turned to indications as marked on the nameplate to change the calibration range from 80 to 120 per-cent of the breaker rating.

To check the adjustment of this device for positive tripping, pick the armature up manually; the breaker should trip when approximately 1/32" air gap remains between the armature and magnet. To obtain this adjustment, bend the trip finger attached to the trip shaft so that the armature engages this finger sooner or later as required.

FIG. 18

DUAL THERMAL MAGNETIC OVERCURRENT TRIP DEVICE. EXTERNAL VIEW

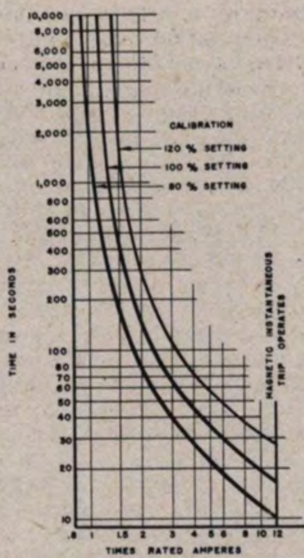


FIG. 19
APPROXIMATE TIME-CURRENT CHARACTERISTIC
OF THERMAL MAGNETIC OVERCURRENT TRIP DEVICE
(STARTING COLD IN 24° C AMBIENT)

There are available other special accessories that can be attached to the extension of the thermal trip (Pt. 9) to perform special functions when the bimetallic strip flexes. These are special and information concerning them should be obtained from the nearest sales office of the company.

A typical time-current tripping curve for this device is shown by Fig. 19. This curve is approximate and variations in time delay may be expected depending on the ambient temperature, the time required for resetting, etc.

INSTANTANEOUS OVERCURRENT TRIP DEVICE (FIG.20)

This device is magnetically operated to trip the breaker instantaneously by the current through the breaker when this current exceeds the value of the calibration setting. Calibration settings for 100, 125, 150, 175, and 200 per-cent of breaker normal current rating are marked on the calibration plate in amperes. For general applications, the calibration setting used should be not less than 125 per-cent of the normal load.

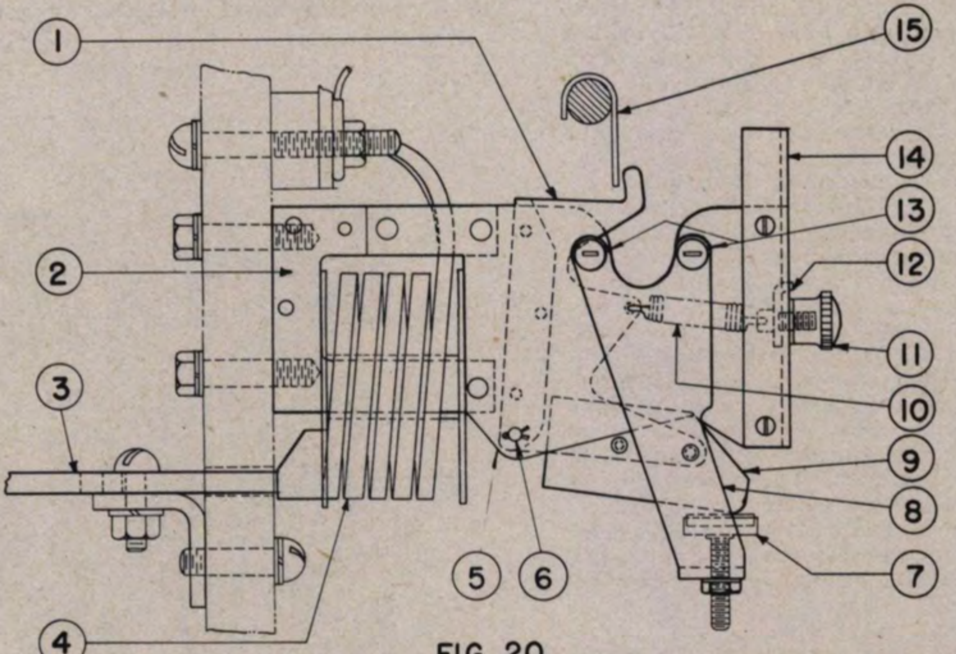


FIG. 20
INSTANTANEOUS OVERCURRENT TRIP DEVICE

1 ARMATURE
2 MAGNET
3 LOWER STUD
4 SERIES COIL
5 FRAME
6 PIN AND COTTER
7 STOP AND HEX NUT
8 SUPPORT FOR STOP
9 STOP PLATE, RIVETED TO ARMATURE ASSEMBLY
10 CALIBRATION SPRING
11 CALIBRATION ADJUSTING KNOB
12 CALIBRATION INDEX
13 SCREW R.H. #10-32 X ½"
14 CALIBRATION PLATE
15 TRIP FINGER

-6249197

This device is similar to the dual oil film magnetic overcurrent trip device without the time delay assembly and support and the heavy instantaneous trip springs. As shown in Fig. 20, the armature has a stop plate or weight (Pt. 9) riveted to it and is pivoted on the pin (Pt. 6) set in the frame (Pt. 5). It is restrained by the calibration spring (Pt. 10) only. The armature air gap is adjusted by raising or lowering the stop (Pt. 7) set in support (Pt. 8) which is attached to the frame (Pt. 5) by screws (Pt. 13).

INSTANTANEOUS SHORT-CIRCUIT TRIP DEVICE (FIG. 21)

According to NEMA standards, all air circuit breakers shall be inherently automatic. Hence, if the type AE-1-15 air circuit breaker is not equipped with time delay or instantaneous overcurrent trip device, it will be furnished with the instantaneous short-circuit trip device. For the type AE-1-15 air circuit breaker, this device is set to operate at 3375 amperes. No adjustment for changing this setting is provided.

The instantaneous short-circuit trip device, Fig. 21, is mounted on the upright portion of the lower stud on the front of the mounting base. It consists of a U shaped magnet (Pt. 5) attached to the stud by flat head screws (Pt. 4) through a spacer (Pt. 2) and a brass plate (Pt. 3) to which is attached a brass rod (Pt. 11). This rod supports the armature assembly (Pt. 9) which includes a guide rod (Pt. 8), the trip arm (Pt. 12) and a brass guide tube (Pt. 13) which slides over the rod (Pt. 11). A compression spring (Pt. 14) sits over this tube in a brass cup (Pt. 15) at one end and against the armature at the other end to force the armature against the calibration nuts (Pt. 10) on the rod (Pt. 11). Guides (Pt. 7) are screwed to the magnet by screws (Pt. 6). Current in the lower stud sets up a magnetic field which picks up the armature and trips the breaker when the tripping value is exceeded.

UNDERVOLTAGE TRIP DEVICE

A direct-acting undervoltage trip device is located on lower right hand side of the breaker base and is available for the type AE-1-15 air circuit breakers covered by these instructions. This undervoltage trip device may be either the instantaneous type (Fig. 22A) or the time-delay type (Fig. 22B). Both types are mechanically reset by the opening of the breaker and their construction is such that they do not release to trip the breaker latch until the voltage has dropped to some value below 50% of the normal voltage rating. For the time-delay type tripping does not occur until approximately three seconds or more after loss of voltage, thus preventing tripping on undervoltages of short duration. See Fig. 29 for typical connection diagram.

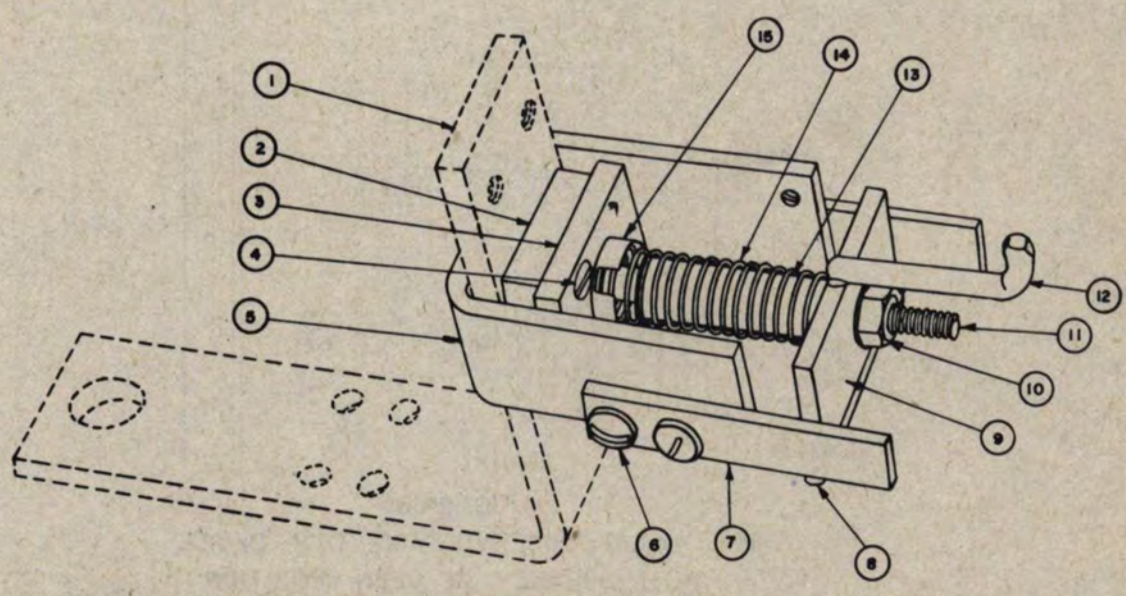


FIG. 21
INSTANTANEOUS SHORT-CIRCUIT TRIP DEVICE

1. LOWER STUD
2. SPACER (IF NEEDED)
3. BRASS PLATE, BRAZED TO 11
4. SCREWS, F.H. 10-32 X 1
5. MAGNET
6. SCREWS, R.H. 10-32 X 7/16 AND LOCKWASHER
7. BRASS GUIDES
8. GUIDE ROD, WELDED TO 9
9. ARMATURE
10. NUTS 1/4-20
11. BRASS ROD, BRAZED TO 3
12. TRIP ARM
13. BRASS TUBE
14. COMPRESSION SPRING
15. BRASS CUP

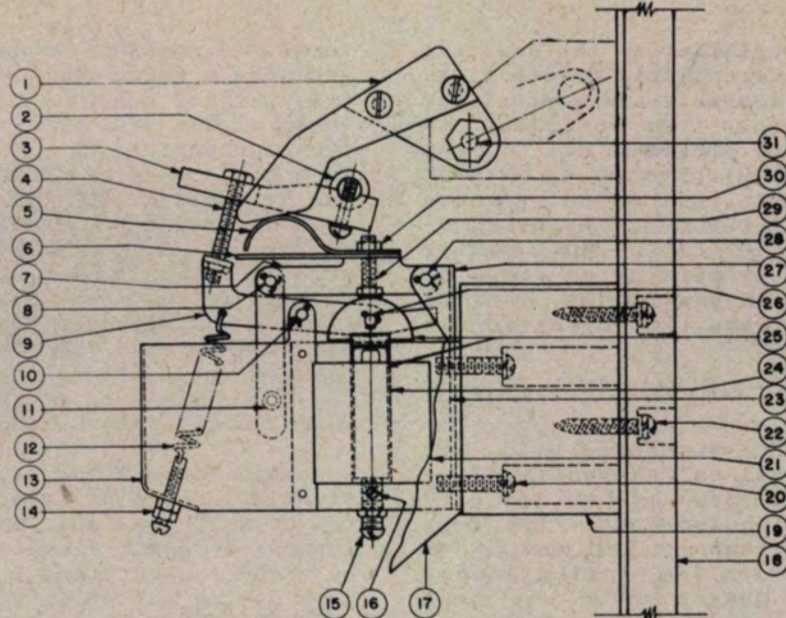


FIG. 22 A

INSTANTANEOUS UNDERVOLTAGE TRIP DEVICE WITH BREAKER IN OPEN POSITION

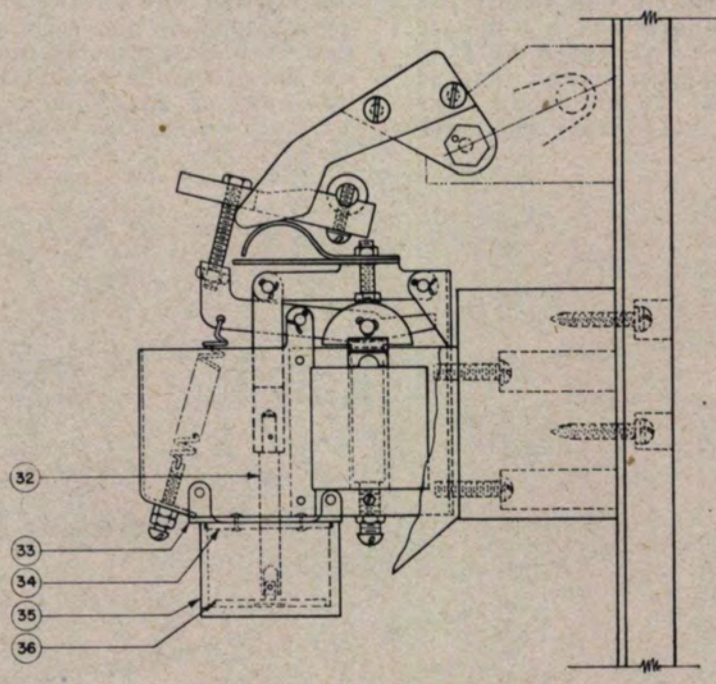


FIG. 22 B

TIME DELAY UNDERVOLTAGE TRIP DEVICE WITH BREAKER IN OPEN POSITION

1. RESETTING ARM
2. BREAKER TRIP SHAFT
3. COMPOSITION TRIP ARM
4. TRIP ADJUSTING SCREW HEX. HD. #10 - 32 X 1 $\frac{3}{8}$" AND NUTS
5. BUFFER SPRING
6. FLAT SPRING
7. RESET LINK
8. PIN AND COTTER PINS
9. TRIP LEVER
10. PIN AND COTTER PINS
11. STOP LINK
12. SPRING
13. FRAME
14. SPRING ADJUSTING SCREW R.HD. #10 - 32 X 1 $\frac{1}{2}$"
15. STOP SCREW R. HD. $\frac{1}{4}$ - 20X $\frac{5}{8}$" WITH HEX NUT (DIRECT CURRENT ONLY)
16. SCREW R.HD. SELF TAPPING #4X $\frac{1}{4}$"
17. BARRIER
18. MOUNTING BASE
19. COMPOSITION SPACING BLOCK
20. SCREW R.HD. #10 - 32 X 1 $\frac{3}{4}$" AND LOCKWASHER
21. COIL
22. SCREW R.HD. SELF-TAPPING #10 WITH WASHER AND LOCKWASHER
23. MAGNET
24. BRASS GUIDES
25. ARMATURE
26. PIN AND COTTER PINS
27. SUPPORT
28. PIN AND COTTER PINS
29. RESET ADJUSTING SCREW HEX HD. #10 - 32 X $\frac{5}{8}$"
30. HEX NUT #10-32
31. MAIN SHAFT
32. PLUNGER
33. FRAME
34. COVER
35. OIL DASH POT
36. DISC

INSTANTANEOUS UNDERVOLTAGE TRIP DEVICE

The function of this device is to trip the breaker when the voltage drops below a predetermined value. As long as this voltage, or greater, is impressed on the coil the armature is held down into the coil and the device has no effect upon closing or tripping of the breaker in any way, but when it drops to approximately 50% of normal, or less, the magnet is weakened and a strong spring causes the breaker to trip. The breaker cannot be reclosed until the necessary voltage returns.

The device (Fig. 22A) is mounted under the trip shaft to the right of breaker poles and on an insulation spacer block (Pt. 19) by screws (Pt. 20) which pass through an insulating barrier (Pt. 17), partly cut away and a support (Pt. 27) into the magnet (Pt. 23). The spacer block is mounted on the front of the mounting base by screws (Pt. 22). The coil (Pt. 21) is mounted in the magnet by two brass guides (Pt. 24) between which the armature (Pt. 25) is free to move. The upper ends of the guides are clamped over the magnet and lower ends fastened by screws (Pt. 16). A trip lever (Pt. 9) is pivoted at a central point to frame (Pt. 13) by pin (Pt. 10) and also attached by tension spring (Pt. 12) to the same frame which is riveted to the magnet. A trip adjusting screw (Pt. 4) connects the trip lever to a trip arm (Pt. 3) which is attached to the breaker trip shaft (Pt. 2). When the voltage fails, or drops below the predetermined value, the spring (Pt. 12) draws the trip arm (Pt. 3) down and at the same time raises the armature out of the coil to exert a hammer blow to trip the breaker. The trip lever is stopped by pin (Pt. 28). As soon as the breaker opens, however, a reset arm (Pt. 1), attached to the breaker main shaft (Pt. 31), is forced downward against the buffer spring (Pt. 5), attached to the reset link (Pt. 7), pivoted to the base (Pt. 27) by pin (Pt. 28), which causes the adjusting screw (Pt. 29) to drive the armature firmly down against the bottom member of the magnet in the case of alternating current application or against set screw (Pt. 15) in direct current application. This resetting is necessary as the pull of the magnet, at 50% to 100% of normal voltage, may not be sufficient to draw the armature down against the spring (Pt. 12). To prevent the trip link (Pt. 7) from springing upward to a vertical position and remaining there on tripping, a stop link (Pt. 11) is hooked under trip lever (Pt. 9) and is attached to the reset link (Pt. 7) by pin (Pt. 8).

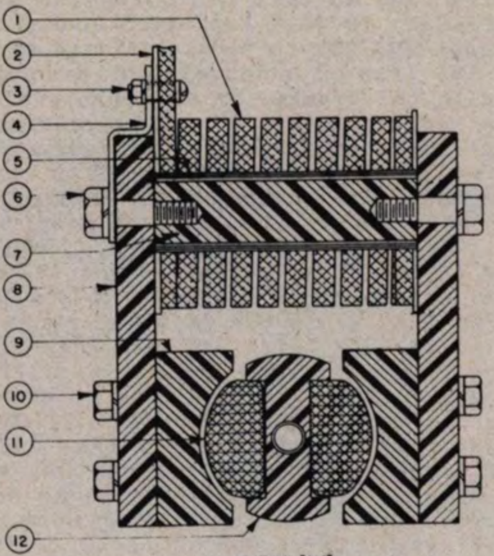
For direct current application, the adjusting brass screw and lock nut (Pt. 15) through the lower member of the magnet are necessary to slightly separate the armature from the magnet to break residual magnetism and allow tripping.

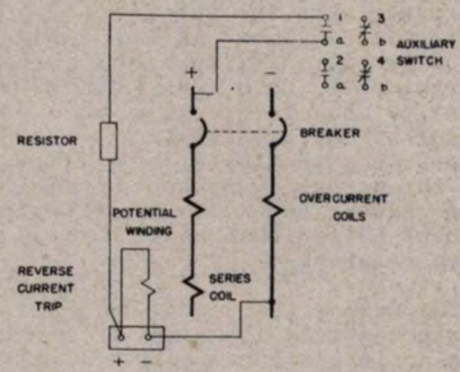
Adjustments consist first, in direct current application, in setting the stop screw (Pt. 15) so that the bottom of armature (Pt. 25) is just separated enough from the magnet (Pt. 23) to breakeresidual magnetism at the time of undervoltage tripping. Then, with the breaker in the open position and the reset arm (Pt. 1) in the reset position, as shown in Fig. 22A, the reset adjusting screw (Pt. 29) should be set to allow 1/32" to 1/8" between the buffer spring (Pt. 5) and the flat spring (Pt. 6) and then lock nut (Pt. 30) should be tightened. With the breaker in the closed position and the coil (Pt. 21) de-energized, turn the trip adjusting screw (Pt. 4) in the trip lever (Pt. 9) until the breaker trips and then continue to turn the trip adjusting screw between 1/2 and 3/4 of a turn more and then lock it in position by lock nut. The spring (Pt. 12) should be adjusted by adjusting screw (Pt. 14) to prevent drop out of armature (Pt. 25) when the breaker is closed and the coil is energized by 50% of normal voltage or more, but to positively trip at 50% of normal or less.

TIME DELAY UNDERVOLTAGE TRIP DEVICE

This device (Fig. 22B) is constructed and operates in the same manner as the instantaneous undervoltage trip device with the addition of the oil film time delay attachment and the omission of the reset link stop (Pt. 11). The time delay attachment consists of disc (Pt. 36) immersed in oil in an oil dash pot (Pt. 35) which is screwed to a cover (Pt. 34) which, in turn, is riveted to its own frame (Pt. 33) and fastened by screws to the frame (Pt. 13) and magnet (Pt. 23). The disc is connected to the reset link (Pt. 7) by plunger assembly (Pt. 32) to delay the tripping of the breaker until the oil film, between the lapped surfaces of the disc and bottom of the dash pot, ruptures. Thus, if normal voltage is restored before the oil film ruptures, the breaker will not open.

First adjust, in direct current application, the clearance of bottom of armature from the magnet by stop screw (Pt. 15) as described in instantaneous undervoltage trip device adjustment. Then, with the breaker in the closed position and the coil (Pt. 21) de-energized, push the armature (Pt. 25) down into the coil to lower the reset link (Pt. 7) and the disc (Pt. 36). Now screw the dash pot cup on the cover (Pt. 34) until the reset link (Pt. 7) begins to lift and then turn it another half turn which should make the cup tight against its seat. If not seated by about a half turn, then turn the adjusting screw (Pt. 29) and repeat until this condition is obtained. Now, when the breaker is opened and the reset arm (Pt. 1) is down, the disc should be pressed firmly against the bottom of the oil dash pot by the buffer spring (Pt. 5) which should now be about 1/32" to 1/8" from the flat spring (Pt. 6). If not, the buffer spring will have to be bent to secure these adjustments. The adjustment of trip adjustment screw (Pt. 4) and the spring (Pt. 12) will be the same as in the instantaneous undervoltage trip device.





WIRING DIAGRAM (REAR VIEW)
STANDARD METHOD OF CONNECTION.
IF BREAKER POLARITY IS REVERSED, POLARITY OF REVERSE CURRENT POTENTIAL COIL MUST ALSO BE REVERSED.

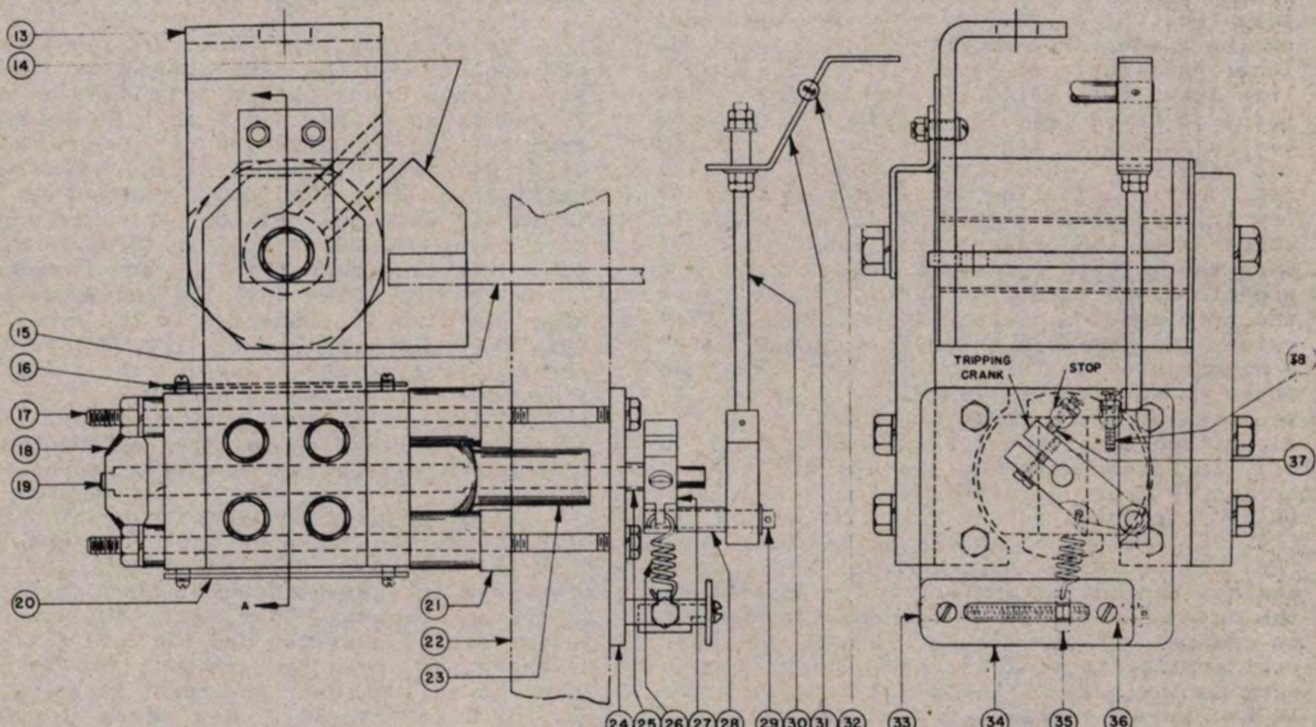


FIG. 23

REVERSE CURRENT TRIP DEVICE (ROTOR TYPE) FOR AIR CIRCUIT BREAKER TYPE AE-1-15

1. COIL AND SLOTTED CONNECTION STRAPS
2. INSULATION WASHER
3. SCREW R.H. $\frac{1}{4}$"-20 X $\frac{3}{8}$" WITH INSULATION BUSHING, WASHERS AND NUT
4. CONNECTION STRAP SUPPORT
5. INSULATION TUBE
6. BOLT, HEX HD. $\frac{3}{8}$-16 X $1\frac{1}{4}$" AND WASHER
7. CORE
8. SUPPORT
9. POLE SHOES
10. BOLT, HEX HD $\frac{5}{16}$"-18 X $1\frac{1}{4}$" AND LOCKWASHERS
11. ARMATURE COIL
12. ARMATURE
13. UPPER CONNECTION STRAP OF COIL
14. SIDE CONNECTION STRAP OF COIL
15. LOWER STUD
16. UPPER DUST COVER
17. STUD, $\frac{5}{16}$"-18 X 9" WITH NUTS AND LOCKWASHERS
18. REAR BEARING, BRONZE
19. ARMATURE SHAFT
20. LOWER DUST COVER
21. SPACER
22. REAR OF BREAKER BASE
23. FRONT BEARING, BRONZE
24. ESCUTCHEON PLATE
25. SPACER
26. CALIBRATION SPRING
27. TRIPPING CRANK
28. SPACER
29. PIN
30. TRIP ROD #10-32 AND ASSEMBLY
31. TRIP LEVER
32. TRIP SHAFT
33. CALIBRATION SCREW, HEX HD. WASHER AND COTTER PIN
34. CALIBRATION PLATE
35. CALIBRATION INDEX
36. COMPRESSION SPRING
37. STOP SCREW, FOR RESET POSITION
38. STOP SCREW, FOR TRIP POSITION

6249554

REVERSE CURRENT TRIP DEVICE (ROTOR TYPE)

A direct-acting reverse current trip device of the rotor type is available for AE-1-15 breakers for direct current application which will trip the breaker when the reverse current exceeds the calibration setting. This device is constructed similar to a bipolar motor with stationary pole pieces, on which is mounted a series coil carrying the breaker current, and a rotating armature on which is wound a potential coil. The magnetic field set up by current in the potential coil together with the field set up by the breaker current in the series coil in the normal direction produces a torque which tends to rotate the armature in a direction to prevent tripping. However, if the current in the series coil is reversed, the torque is reversed to cause reverse rotation which trips the breaker.

As shown in Fig. 23, the motor element is mounted on the back of the breaker base by studs (Pt. 17). The potential coil should be connected to "a" contacts of the auxiliary switch to open the potential circuit when the breaker is open. The armature shaft, (Pt. 19) extends through to the front to operate the tripping equipment. The series coil (Pt. 1) has welded to it an upper connecting strap, (Pt. 13) diagonally slotted, for connection to external load, a welded lateral connecting strap (Pt. 14), also diagonally slotted and a horizontal bar, welded to it, for connection to the lower stud (Pt. 15) of the breaker. The armature shaft (Pt. 19) is supported in bronze bearing castings (Pt. 18 and Pt. 23) which are fastened to the pole shoes (Pt. 9) by studs (Pt. 17). An escutcheon plate (Pt. 24) is mounted on the front of the breaker base by the same studs (Pt. 17) and to it are riveted two posts to support the calibrating plate (Pt. 34), and also two posts to support the stop screws (Pt. 37 and Pt. 38). A tripping crank (Pt. 27) of insulating material is clamped to the extended armature shaft and supports the trip arm assembly (Pt. 30) on pin (Pt. 29). The trip lever (Pt. 31) is fastened by a screw to the trip shaft (Pt. 32) and is free to move over the upper end of the trip rod between properly spaced nuts to permit sufficient travel when the breaker is tripped by other devices. When current passes through the series coil in the normal direction, the armature will tend to revolve clockwise (looking from the front) to force the trip crank (Pt. 27) against the stop screw (Pt. 37). The calibrating spring (Pt. 26) also normally holds the tripping crank against this same screw. But when current passes through the series coil in the reverse direction, the armature will tend to rotate counter-clockwise away from the stop screw and after the calibration setting is reached, the reverse rotation of the armature will raise the trip rod (Pt. 30) and trip the breaker. Stop screw (Pt. 38) stops the reverse rotation. A calibration plate (Pt. 34) is mounted on posts of the escutcheon plate. The calibration screw (Pt. 33) passes through these posts and carries a threaded calibration index (Pt. 35) attached to the calibration spring (Pt. 26). By turning the hexagon head of the calibration screw against the compression spring (Pt. 36) the reverse current setting can be changed.

The tripping crank (Pt. 27) is clamped to the armature shaft so that the potential coil will be located on the horizontal center line of the pole pieces when the crank is resting against stop screw (Pt. 37) which should project approximately 1/16" to 3/32" from its support. When rated voltage is applied to the potential coils and the calibration spring (Pt. 26) is connected, there should be no movement of the armature in the tripping direction. However, if a movement is detected, back-off slightly on the stop screw (Pt. 37) to increase the air gap to pole piece on the trip side. After this adjustment has been completed, the adjusting screw (Pt. 38) can be set to limit the travel of the armature (Pt. 12) so that the tripping crank (Pt. 27) will be stopped slightly above horizontal. In this position, the trip rod (Pt. 30) should trip the breaker with 1/32" overtravel. Slight variations of these adjustments may be necessary to improve the operation of this device.

The adjustment of stop screw (Pt. 37) and tripping crank (Pt. 27) will affect the calibration of the reverse current device, so their settings should not be changed unless facilities for checking calibration are available.

Because the potential must not drop below 80% of normal the potential coil should be connected to a reliable constant potential source, preferably to a station battery bus, if possible.

REVERSE CURRENT TRIP DEVICE - (MAGNET TYPE)

A direct acting reverse current trip device of the magnet and hinged armature type is available for AE-1-15 breakers for direct current applications. It will operate to trip the breaker when reverse current exceeds the calibration setting. The principle of operation is shown diagrammatically by Fig. 24. The device consists of a composite magnet with a series coil on the middle core, which carries the breaker current, and a potential coil on the bottom core. An air gap in the upper leg of the magnet is bridged by an armature which is attracted to the magnet and held by flux from the potential coil alone, or more firmly by potential coil flux plus series coil flux due to current through the breaker in the normal direction. When current passes through the breaker in the reverse direction, the two fluxes are no longer cumulative and the flux across the air gap is weakened sufficiently to allow a spring to pull the armature away and trip the breaker.

The details of the device are shown in Fig. 25A and 25B. The series coil (Pt. 4) is in the same location as the standard overcurrent coil between the lower stud of the breaker and the connection to the movable contact on the front of the breaker base. It is mounted on the middle core of the composite magnet (Pt. 2 and Pt. 6) while the potential coil (Pt. 8) is mounted on the bottom core. The magnet is provided with two thin non-magnetic spacers to provide two small magnetic gaps so placed to cause the greater part of both fluxes to flow through the upper leg of the magnet. The armature (Pt. 10) pivots on pin (Pt. 9) which passes through the supporting frames (Pt. 11). It is held to the magnet when the potential coil is energized and is held more firmly when the magnetic force is increased by breaker current in the normal direction.

When the current in the series coil reverses, the magnetic pull on the armature decreases, and when the reverse current exceeds the calibration setting, the pull is not enough to overcome the pull of the tension spring (Pt. 14) which moves the armature away from the magnet. When the armature is pulled away, it strikes a trigger (Pt. 17) attached to a shaft (Pt. 18) mounted in a bearing plate (Pt. 19). Another trigger (Pt. 20) on this shaft engages a trip finger (Pt. 21) on the trip shaft (Pt. 22) which trips the breaker.

As soon as the breaker opens, however, the armature is at once reset against the magnet by a linkage consisting of a crank (Pt. 24) which is attached to the main shaft (Pt. 23), an insulation link (Pt. 25), and a link (Pt. 26) which rotates on pin (Pt. 27). A torsion spring (Pt. 28) on this pin holds link (Pt. 26) and reset lever (Pt. 29) together by pressure against lugs on each. When the breaker opens, the above linkage at once draws the reset lever (Pt. 29) against the armature (Pt. 10) and forces it against the magnet where it is held by the magnetic pull of the potential coil. The potential coil must be connected in the circuit so that it is continuously energized in order to hold the armature against the magnet when the breaker is open, so that the breaker will not be tripped when an attempt is made to close it. When the breaker is closed the reset linkage moves the resetting arm (Pt. 29) away from the armature so that it will not retard the armature when released by reversed current.

Because the potential must not drop below 80% of normal, the potential coil should be connected to a reliable constant potential source, preferable to a station battery bus, if possible.

When all the poles of a breaker require series coils for overcurrent or other purposes, it is necessary to place the reverse current trip device "off pole", in the location of an additional pole to the right of the regular poles. In this case, the series coil of this device is placed in series with the series coil at the adjoining pole by placing a connection bar between the lower studs back of the mounting base. An upper stud is supplied for connection to the source or the load, as desired. An extension of the main shaft is provided to make provision for the resetting links. In such installations, the current in the series coil will be in the opposite direction from the standard practice in which case it will be important that the potential coil should also be reversed.

For correct operation, the armature and magnet faces must be kept clean. The armature should make line contact with the top leg of the magnet and have an air gap of not over .005" at the lower leg. If adjustments are made to the reverse current device, the calibration should be checked after the adjustments are made.

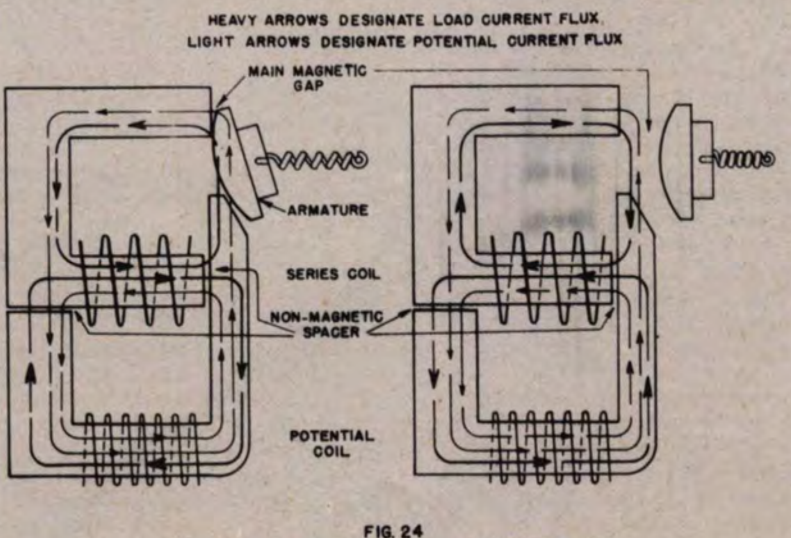


FIG. 24
REVERSE CURRENT TRIP DEVICE (MAGNET TYPE)
DIAGRAMATIC MAGNETIC CIRCUITS

H-6249563

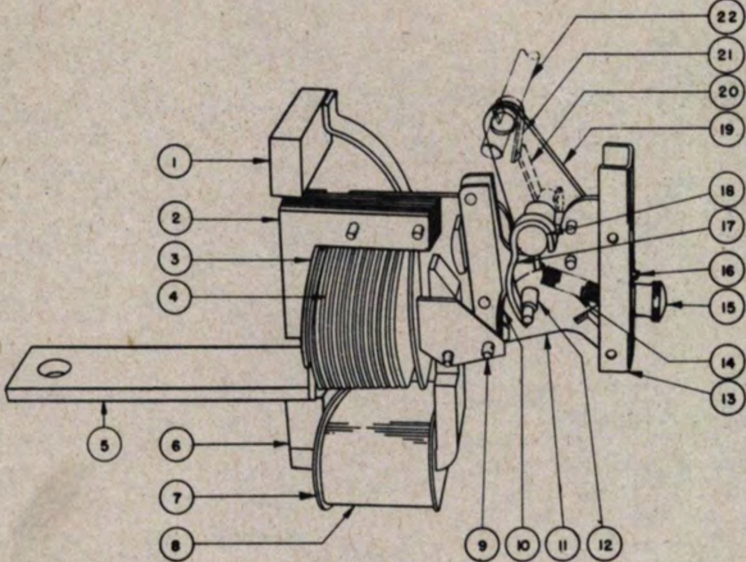
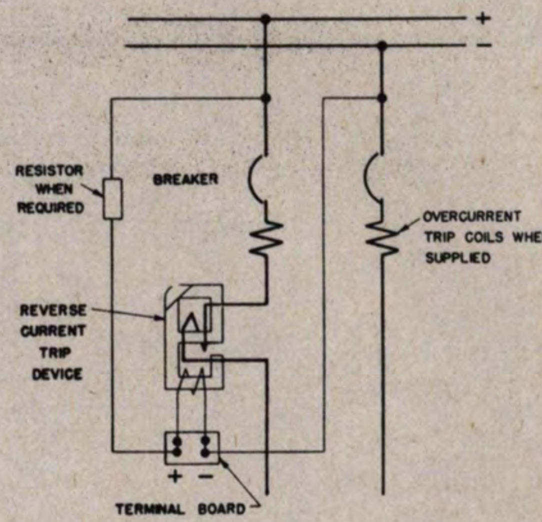


FIG. 25 A
TRIPPED POSITION
(WITH LEFT COVER AND RESET MECHANISM REMOVED)



WIRING DIAGRAM
(BACK VIEW)

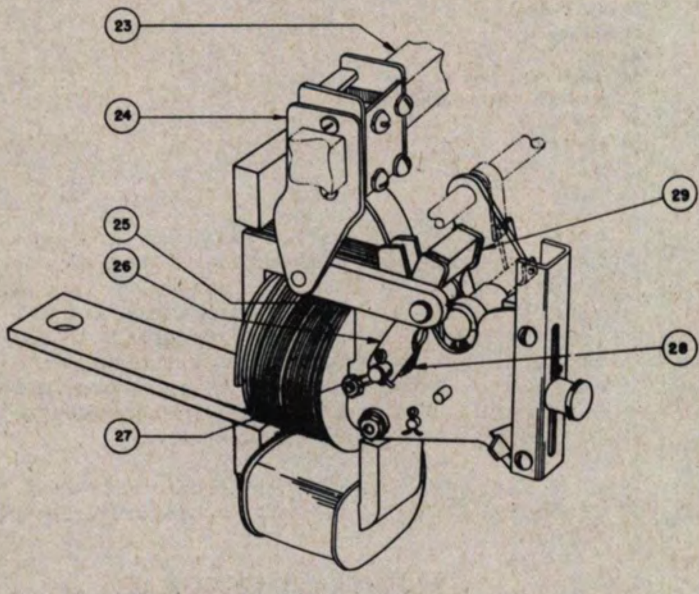


FIG. 25 B
POTENTIAL COIL ENERGIZED AND
BREAKER IN CLOSED POSITION

REVERSE CURRENT TRIP DEVICE (MAGNET TYPE)

1. TERMINAL OF SERIES COIL
2. LAMINATED SECTION OF MAGNET
3. INSULATION
4. SERIES COIL
5. LOWER STUD
6. SOLID SECTION OF MAGNET
7. INSULATION
8. POTENTIAL COIL
9. PIN AND COTTER FOR ARMATURE
10. ARMATURE ASSEMBLY
11. FRAMES
12. STOP PIN
13. CALIBRATION PLATE
14. CALIBRATION SPRING
15. CALIBRATION KNOB
16. CALIBRATION INDEX AND SCREW
17. TRIGGER
18. TRIGGER SHAFT
19. BEARING PLATE
20. TRIGGER
21. TRIP FINGER
22. TRIP SHAFT
23. MAIN SHAFT
24. RESET CRANK
25. INSULATION LINK
26. LINK
27. PIN AND COTTER FOR LINK AND RESET LEVER
28. TORSION SPRING
29. RESET LEVER

H-6249562

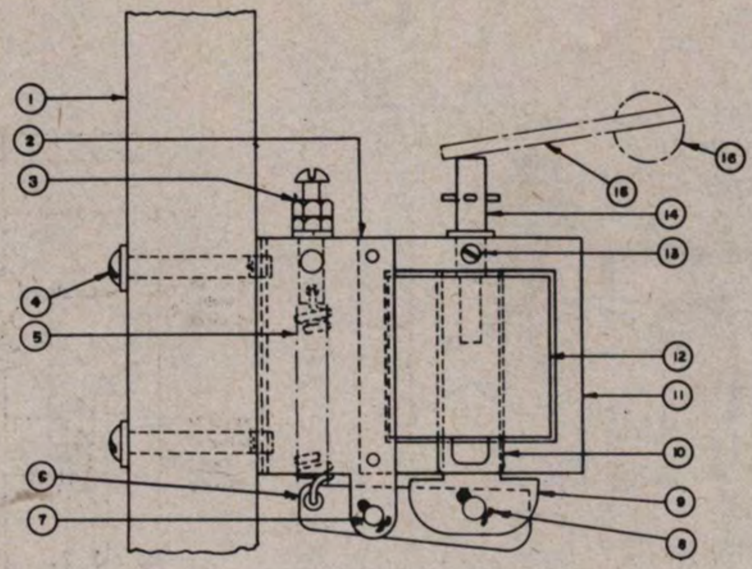


FIG. 26

SHUNT TRIP DEVICE
IN ENERGIZED POSITION

1. BREAKER BASE
2. FRAME
3. ADJUSTING SCREW R.H. 10-32 WITH LOCKNUTS AND WASHER
4. SCREWS R.H. 10-32 AND WASHER
5. ADJUSTING SPRING
6. PIVOT LINK
7. PIN AND COTTERS
8. PIN AND COTTERS
9. ARMATURE
10. BRASS GUIDES
11. MAGNET
12. COIL
13. SCREW SELFTAPPING 4 x $\frac{1}{4}$
14. PLUNGER, COTTER, AND WASHER
15. TRIP LEVER
16. TRIP SHAFT

SHUNT TRIP DEVICE

The function of the shunt trip device (Fig. 26) is to trip the circuit breaker when its coil is energized by the closing of a switch or relay contacts at some remote point. The coil is designed to remain in the circuit only momentarily, hence it should be connected so that the opening of the air circuit breaker contacts will immediately disconnect it from the circuit. Whenever this is impossible, the shunt trip coil should be connected to "a" contacts of an auxiliary switch which will open when the breaker is open.

The device is mounted on the breaker base by screws (Pt. 4) to the right of the operating mechanism and below the trip shaft. The coil (Pt. 12) is mounted in the magnet (Pt. 11), which is riveted to the frame (Pt. 2), and is held in place by two brass guides (Pt. 10) between which the armature (Pt. 9) is free to move. The lower ends of the guides are clamped over the magnet and against the coil to hold it firmly in place and the upper ends are fastened to the magnet by self-tapping screws (Pt. 13). When the coil is energized, the armature is drawn upward into the coil and the trip plunger (Pt. 14), which is fastened to the armature and passes freely through the magnet, is lifted to engage the trip lever (Pt. 15) attached to the trip shaft (Pt. 16) which trips the breaker. When the coil is de-energized, the adjusting spring (Pt. 5), which is fastened to the frame by adjusting screw (Pt. 3), pulls on the pivot link (Pt. 6) to draw the armature out of the coil, thus allowing the trip shaft to return to normal position. An insulation barrier extends on both sides of the device and is supported by the mounting screws between the device and the breaker base.

The trip plunger should overtravel between 1/64" to 1/32" after the trip lever is released.

WIRING DIAGRAM

Fig. 27 shows schematic wiring diagram and Fig. 29 shows complete typical wiring diagram for the control of electrically operated AE-1-15 air circuit breakers without cut-off switch and cut-off relay. Similarly Fig. 28 shows schematic wiring diagram and Fig. 30 shows the complete typical wiring diagram with cut-off switch and cut-off relay with direct current control, while Fig. 31 shows the same as Fig. 30 except with alternating current control.

When an undervoltage trip device is provided with the breaker, tripping can be accomplished by opening the potential circuit rather than energizing a shunt trip device from the control circuit.

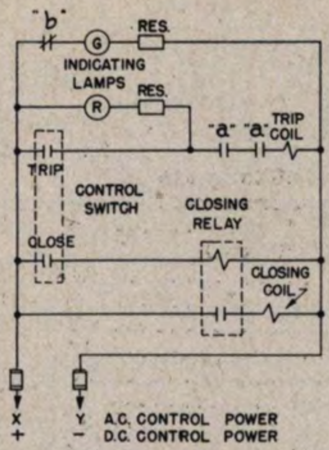


FIG. 27

SCHEMATIC WIRING

FOR SOLENOID OPERATED BREAKER WITH MOMENTARY-CONTACT CONTROL

"a"- AUX. SW. OPEN WHEN BREAKER IS OPEN.
"b"- AUX. SW. CLOSED WHEN BREAKER IS OPEN.
'CUT-OFF'- AUX. SW. OPEN WHEN BREAKER CLOSING MECHANISM IS IN NON-OPERATED POSITION.
-||- CONTACT OPEN WHEN DEVICE IS IN THE DE-ENERGIZED OR NON-OPERATED POSITION.
-|/|- CONTACT CLOSED WHEN DEVICE IS IN THE DE-ENERGIZED OR NON-OPERATED POSITION.

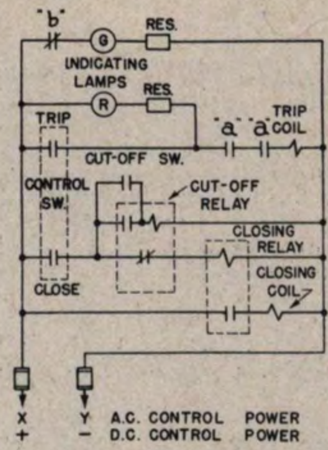


FIG. 28

SCHEMATIC WIRING

FOR SOLENOID OPERATED BREAKER WITH MAINTAINED-CONTACT CONTROL

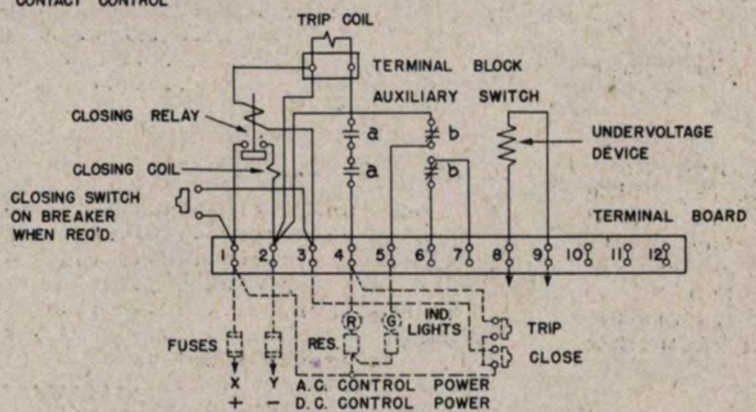


FIG. 29

TYPICAL WIRING DIAGRAM

FOR SOLENOID OPERATED BREAKER WITH MOMENTARY-CONTACT CONTROL

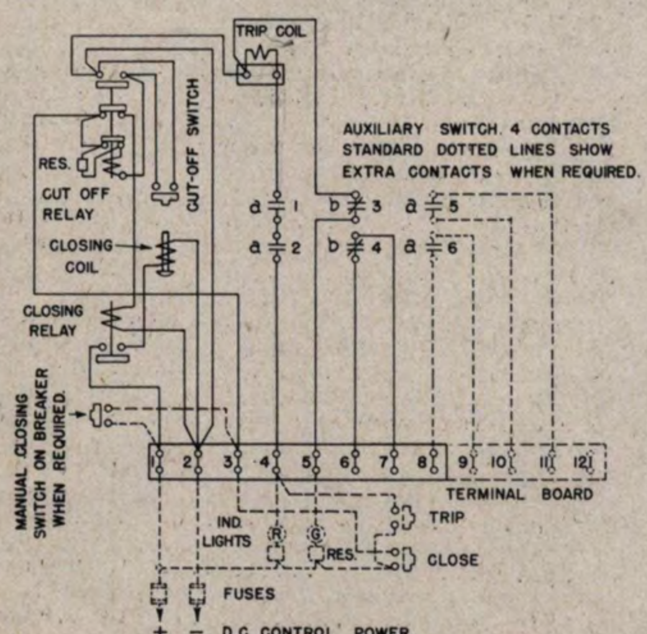


FIG. 30

TYPICAL WIRING DIAGRAM

FOR SOLENOID OPERATED BREAKER WITH MAINTAINED-CONTACT CONTROL

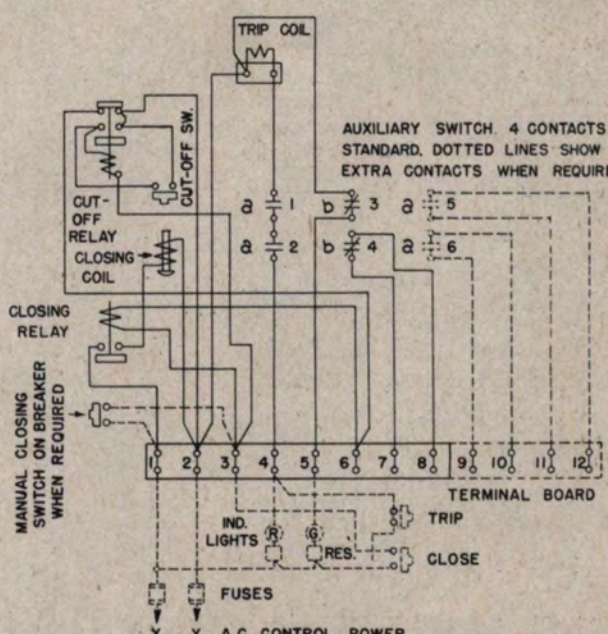


FIG. 31

TYPICAL WIRING DIAGRAM

FOR SOLENOID OPERATED BREAKER WITH MAINTAINED-CONTACT CONTROL

RENEWAL PARTS

Spare parts should be ordered from the nearest Sales Office of the General Electric Company by giving the complete breaker name plate information and the name of the part. Reference should be made to the instruction book giving its number, the piece and figure number of the part desired. If possible, give the General Electric Company's requisition number on which the breaker was purchased.

If several parts are desired as an assembly, reference should be made to each part and instructions included to ship assembled. If the part has not been given a number in any of the figures in the instruction book, it should be referred to as between or adjacent to parts with numbers. A sketch giving approximate size and shape would be helpful in some cases.

Spare parts which are furnished may not be identical with original parts since changes and improvements are made from time to time. However parts which are furnished will be interchangeable with original parts with very little or no extra work beyond that required to install a part identical to the original. If parts identical to original parts are required, the order must state that they are to be identical.

Contacts, Stud and Pole Unit Assembly

Item		Part	Fig.
1	Stationary Contact and Arc Runner	1	7
2	Movable Contact and Flexible Braid	24	7
3	Upper Stud	6	7
4	Screw, R.H.-1/4"-20 X 5/8 with Lockwasher	2	7
5	Upper Stud Bracket	3	7
6	Screw, R.H. - 1/4" - 20 with Washers	4	7
7	Screw, R.H.-1/4"-20 X 3/4" with Hex. Nuts and Washers	5	7
8	Insulated Main Shaft	20	7
	" " "	9	8
	" " "	9	9
	" " "	9	10
	" " "	13	12
	" " "	31	22
	" " "	23	25A-B
9	Contact Support Assembly	21	7
10	Adjusting Spring	22	7
11	Hex. Nut - 1/4" - 20	23	7
12	Screw, R.H.- 1/4" - 20 with Nut and Washer	9	7
	" " "	2	15
13	Screws, Hex.Hd. 1/4" - 20 with Washers	10	7
	" "	3	15
14	Lower Stud (Welded to Series Coil)	12	7
	" " " "	5	15
	" " " "	3	20
	" " " "	15	23
	" " (Welded to Series Coil)	5	25A-B
15	Lower Stud Bracket	15	7
	" " "	7	15
16	Screw, R.H.-1/4"-20X3/4 with Hex. Nut and Washers	13	7
	" " " "	6	15
17	Screw, R.H.-1/4"-20 with Washers	14	7
	" " " " "	8	15
18	Trip Shaft	18	7
	" "	17	8
	" "	17	9
	" "	17	10
	" "	31	17
	" "	2	22
	" "	32	23
	" "	22	25A-B
	" "	16	26
19	Trip Finger	19	7
	" "	28	15
	" "	30	17
	" "	15	20
	" "	21	25A-B

Arc Quencher

Item		Part	Fig.
20	Copper Cooling Pins	30	7
21	Front Arc Runner	27	7
22	Shunt Connector	25	7
23	Screw, R.H. #10-32 X 1/2 with Washer	26	7
24	Baffles	29	7
25	Molded Asbestos Shields and Spacer	28	7
26	Mounting Block	32	7
27	Screw, R.H. 5/16" - 18 with Washer	31	7
28	Locking Plate with Clinch Nut	33	7

Operating Mechanism

Item		Part	Fig.
29	Eccentric Manual Shaft (Manual Operated)	1	8 and 9
30	Link (Manual Operated)	2	8 and 9
31	Link " "	3	8 and 9
32	Magnet (Solenoid Operated)	1	10
33	Closing Coil " "	2	10
34	Armature " "	3	10
35	Closing Links	4	8,9 and 10
36	Pin in Frame	5	8,9 and 10
37	Toggle Links	6A-B C-D	8,9 and 10
38	Spring	7	8,9 and 10
39	Operating Crank	8	8,9 and 10
40	Prop	10	8,9 and 10
41	Pin in Frame	11	8,9 and 10
42	Spring	12	8,9 and 10
43	Trip Latch	13	8,9 and 10
44	Adjusting Screw	14	8,9 and 10
45	Spring	15	8,9 and 10
46	Trip Button and Rod	16	8,9 and 10

Item		Part	Fig.
47	Trip Shaft	17	8,9,10
48	Adjusting Screw R.H. 10-32 X 1/2 and Nut	18	8,9,10
49	Trip Arm	19	8,9,10
50	Pin in Frame	20	8,9,10
51	Riveted Over Pins	21	8,9,10
52	Manual Handle (Manual Operated)	22	8, 9
52A	Emergency Closing Handle (Solenoid Operated)	22	10

Closing Relay

Item		Part	Fig.
53	Magnet	1	11
54	Coil	2	11
55	Brass Guides	3	11
56	Armature	4	11
57	Stationary Contacts	5	11
58	Binding Screws and Washers	6	11
59	Movable Contact Assembly	7	11
60	Pin and Cotters	8	11
61	Insulation Angle	9	11
62	Screws, R.H. #8 X 3/4 Self Tapping and Lockwashers	10	11
63	Base	11	11
64	Screws, F.H. #10-32 X 3/4	12	11
65	Screws, F.H. #8-36 X 1/2	13	11
66	Screws, R.H. #8-36 X 1-3/8 Lockwashers and Nuts	14	11
67	Angle Support	15	11
68	Screws, R.H. #10-32 X 7/8 Lockwashers and Nuts	16	11
69	Insulation Barrier	17	11
70	Screws, R.H. Self Tapping #6-40 X 3/16	18	11
71	Screw, R.H. Self Tapping #4 X 1/4	19	11

Auxiliary Switch

Item		Part	Fig.
72	End Frame	8	12
73	Mounting Block	11	12
74	Cover	6	12
75	Movable Contact Assembly	3	12
76	Stationary Contact Assembly	4	12
77	Molded Contact Support	5	12
78	Molded Barriers	2	12
79	Shaft	10	12
80	Cams on Shaft	7	12
81	Crank with Pin and Cotter	9	12
82	Link	12	12
83	Index Arm, with Pin and Cotter (Extension of operating Crank Pt. 8, Fig. 8)	14	12

Manual Closing Switch

Item		Part	Fig.
84	Molded Frame	1	13
85	Contact Brackets and Stationary Contacts	2	13
86	Terminals and Binding Screws	3	13
87	Operating Rod	4	13
88	Compression Spring	5	13
89	Washer	6	13
90	Contact Spring	7	13
91	Insulation	8	13
92	Movable Contact Strip	9	13
93	Guide	10	13

Cut-Off Switch

Item		Part	Fig.
94	Molded Frame	7	14
95	Mounting Screws, R.H. #6-40 X 1/2	12	14
96	Operating Rod	14	14
97	Compression Spring	13	14
98	Contact Spring	11	14
99	Movable Contact Strip	10	14
100	Stationary Contacts	9	14
101	Binding Screws	8	14
102	Stop	15	14
103	Operating Lever	17	14
104	Adjusting Screw	16	14
105	Lock Nut	18	14
106	Pin and Cotter	19	14
107	Flat Spring	3	14
108	Insulation	6	14
109	Support Plate	5	14
110	Pin of Breaker Closing Links	4	14

Dual Oil Film Magnetic Overcurrent Trip Device

111	Magnet	4	15
	"	11	7
	"	2	20
112	Series Coil with Upper Terminal and Lower Stud	9	15
	" " " "	16	7
	" " " "	4	20
	" " " "	4	25A-B
113	Insulation Tube	10	15
114	Insulation Washer	11	15
	" "	3	25A-B
115	Armature Assembly	1	15
	" "	1	20
116	Frame	12	15
	"	5	20
	"	11	25A-B
117	Pin and Cotters	13	15
	" " "	6	20
	" " "	9	25A-B
118	Pivoted Cover and Support	14	15
119	Oil Pot	15	15
120	Lower Disc	16	15
121	Upper Disc	17	15
122	Shank	18	15
123	Spring	19	15
124	Instantaneous Spring	20	15
125	Calibration Spring	21	15
	" "	10	20
	" "	14	25A-B
126	Calibration Adjusting Knob and Screw	22	15
	" " " " "	11	20
	" " " " "	15	25A-B
127	Calibration Index	23	15
	" "	12	20
	" "	16	25A-B
128	Screws, Hex.Hd. #20 - 32 X1/2 with Nuts and Washers	25	15
	" " " " "	13	20
129	Screws, R.H. #8 - 36 X 1/4 with Washers	26	15
130	Calibration Plate	27	15
	" "	14	20
	" "	13	25A-B
131	Adjusting Stop	24	15

Dual Thermal Magnetic
Overcurrent Trip Device

Item		Part	Fig.
132	Molded Frame	4	17
133	Magnet Assembly	6	17
134	Series Coil	5	17
135	Induction Ring	7	17
136	Armature	19	17
137	Spring Hinge	14	17
138	Yoke	20	17
139	Pin for Yoke and Armature	25	17
140	Adjusting Screw and Spring	21	17
141	Flat Buffer Springs	22	17
142	Leather Buffer	24	17
143	Armature Adjusting Screw and Nut	23	17
144	Reset Spring for Yoke	26	17
145	Adjusting Screw	27	17
146	Trip Arm	29	17
147	Bimetallic Strip	13	17
148	Thermal Trip Arm	9	17
149	Pin	8	17
150	Latch Support	10	17
151	Adjusting Screw	12	17
152	Latch Plate	15	17
153	Torsion Spring	11	17
154	Spring for Thermal Trip Arm	16	17
155	Calibration Knob	17	17
156	Calibration Cam, Spring And Cotter	18	17
157	Short Circuit Spring	1	17
158	Spring Guide and Lock Nut	2	17
159	Tubular Spring Guide And Cotter	3	17
160	Pin	28	17

Instantaneous Overcurrent
Trip Device

Item		Part	Fig.
161	Stop and Hex. Nut	7	20
162	Support for Stop	8	20
163	Trip Plate, riveted to Armature Assembly	9	20

Instantaneous Short
Circuit Trip Device

Item		Part	Fig.
164	Lower Stud	1	21
165	Spacer (if needed)	2	21
166	Brass Plate	3	21
167	Screw, F.H. #10-32 X 1"	4	21
168	Magnet	5	21
169	Screws, R.H. #10-32 X 7/16 With Lockwasher	6	21
170	Brass Guides	7	21
171	Guide Rod, Welded to Armature	8	21
172	Armature	9	21
173	Nuts, 1/4" - 20	10	21
174	Brass Rod, brazed to Brass Plate	11	21
175	Trip Arm	12	21
176	Brass Tube	13	21
177	Compression Spring	14	21
178	Brass Cup	15	21

Undervoltage Trip Device

Item		Part	Fig.
179	Composition Spacing Block	19	22
180	Screws R.H. #10 Self Tapping with Washers	22	22
181	Magnet	23	22
182	Screws, R.H. #10 - 32 X 1-3/4 and Lockwasher	20	22
183	Support	27	22
184	Barrier	17	22
185	Brass Guides	24	22
186	Screws, #4 X 1/4 Self Tapping	16	22
187	Armature	25	22
188	Pin and Cotters	26	22
189	Stop Screw, R.H. 1/4" - 20 X 5/8 with Hex. Nut (For Direct Current Only	15	22
190	Potential Coil	21	22
191	Trip Lever	9	22
192	Pin and Cotters	10	22
193	Stop Link (Instantaneous Only)	11	22
194	Pin and Cotters	8	22
195	Spring	12	22
196	Spring Adjusting Screw #10 - 32 X 1-1/2 with Locknuts	14	22
197	Frame	13	22
198	Trip Adjusting Screw, Hex. Hd. #10-32 X 1-3/8 with Nuts	4	22
199	Composition Trip Arm	3	22
200	Reset Arm	1	22
201	Reset Link	7	22
202	Flat Spring	6	22
203	Buffer Spring	5	22
204	Pin and Cotters	28	22
205	Reset Adjusting Screw Hex. Hd. #10 - 32X5/8	29	22
206	Hex. Nut #10 - 32	30	22
207	Plunger (Time Delay Only)	32	22
208	Frame " " "	33	22
209	Cover " " "	34	22
210	Oil Dash Pot " " "	35	22
211	Disc " "	36	22

Reverse Current Trip
Device (Rotor Type).

Item		Part	Fig.
212	Series Coil with slotted Connection Straps	1	23
213	Magnet Core	7	23
214	Magnet Supports	8	23
215	Pole Shoes	9	23
216	Armature	12	23
217	Armature Coil	11	23
218	Connection Strap Support	4	23
219	Insulation Washer	2	23
220	Screws, R.H. 1/4" X 20 X 3/4" with insulation Bushings, Washers and Nuts	3	23
221	Insulation Tube	5	23
222	Bolts, Hex. Hds. 3/8 - 16 X 1-1/4 with Lockwashers	6	23
223	Bolts, Hex. Hds. 5/16 - 18 X 1-1/4 with Lockwashers	10	23
224	Upper Connection Strap of Coil	13	23
225	Side Connection Strap of Coil	14	23
226	Studs 5/16" - 18 X 9" with Nuts and Washers	17	23
227	Rear Armature Bearing	18	23
228	Front Armature Bearing	23	23
229	Armature Shaft	19	23
230	Upper Dust Cover	16	23

Item		Part	Fig.
231	Lower Dust Cover............	20	23
232	Spacer......................	21	23
233	Escutcheon Plate............	24	23
234	Spacer......................	25	23
235	Calibration Spring..........	26	23
236	Trip Crank..................	27	23
237	Spacer......................	28	23
238	Pin.........................	29	23
239	Trip Rod #10 - 32 and Assembly	30	23
240	Trip Lever..................	31	23
241	Calibration Screw, Hex.Hd. with Washer and Cotter......	33	23
242	Calibration Plate...........	34	23
243	Calibration Index...........	35	23
244	Compression Spring..........	36	23
245	Stop Screw for Normal Rotation....................	37	23
246	Stop Screw for Reverse Rotation....................	38	23

Reverse Current Trip Device (Magnet Type)

247	Laminated Section of Magnet..	2	25A-B
248	Solid Section of Magnet.....	6	25A-B
249	Insulation..................	7	25A-B
250	Potential Coil..............	8	25A-B
251	Armature Assembly...........	10	25A-B
252	Stop Pin....................	12	25A-B

Item		Part	Fig.
253	Trigger.....................	17	25A-B
254	Trigger Shaft...............	18	25A-B
255	Bearing Plate...............	19	25A-B
256	Trigger.....................	20	25A-B
257	Reset Crank.................	24	25B
258	Insulation Link.............	25	25B
259	Link........................	26	25B
260	Pin and Cotters.............	27	25B
261	Torsion Spring..............	28	25B
262	Reset Lever.................	29	25B

Shunt Trip Device

263	Frame.......................	2	26
264	Adjusting Screw, R.H. #10 - 32. with Locknuts and Washer.....	3	26
265	Mounting Screws, R.H. #10 - 32 with Washers........	4	26
266	Adjusting spring............	5	26
267	Pivot Link..................	6	26
268	Pin and Cotters.............	7	26
269	Pin and Cotters.............	8	26
270	Armature....................	9	26
271	Brass Guides................	10	26
272	Magnet......................	11	26
273	Coil........................	12	26
274	Screws, #4-1/4 Self Tapping..	13	26
275	Plunger with Washer and Cotters.....................	14	26
276	Trip Lever..................	15	26

Instructions

TYPE AIRS INDUCTION-VOLTAGE REGULATOR

FOR INDOOR SERVICE

GENERAL ELECTRIC

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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.

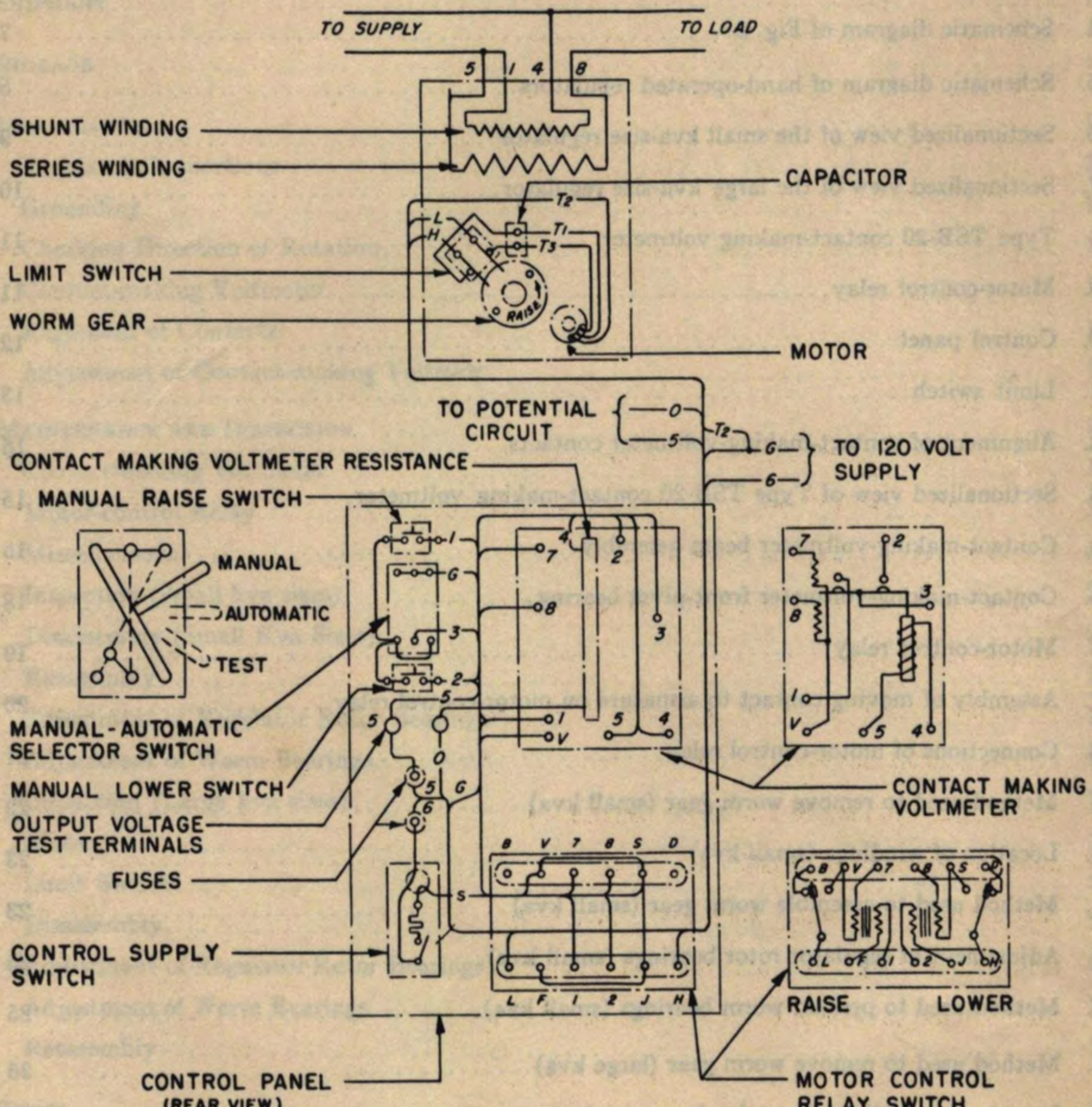


Fig. 1. Typical connection diagram of regulator and auxiliaries (small kva sizes)

TYPE AIRS INDUCTION-VOLTAGE REGULATOR

FOR INDOOR SERVICE

The Type AIRS induction-voltage regulator is a device for automatically maintaining voltage of electrical circuits within predetermined limits. The regulator consists of a movable rotor, on which is wound the shunt winding to be connected across the line, and a stator on which is wound a series winding to be connected in series with the line to be regulated. The voltage in-

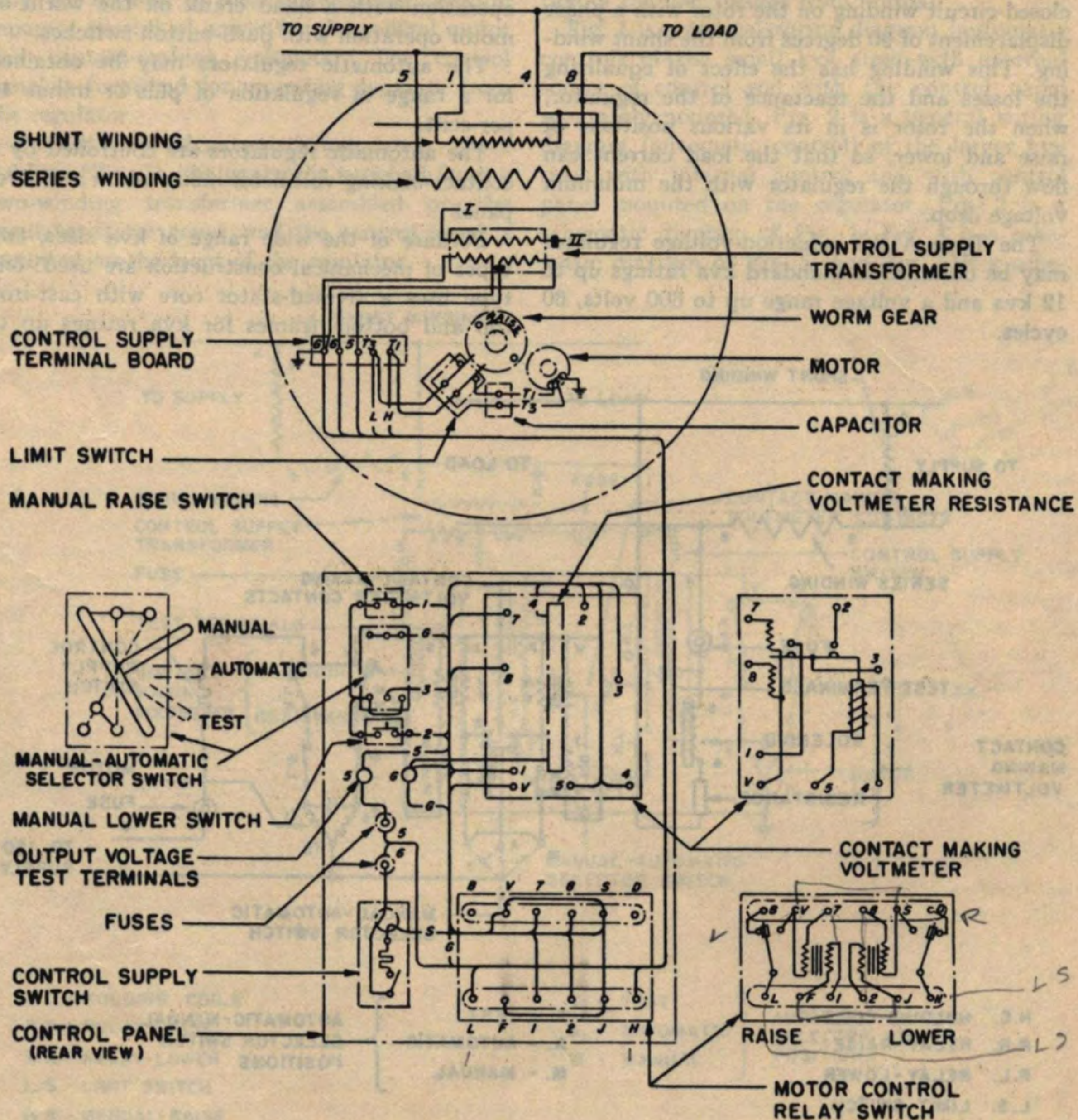


Fig. 2. Typical connection diagram of regulator and auxiliaries (large kva sizes)

duced in the series winding and, therefore, the amount of voltage which is added or subtracted with respect to the line voltage may be varied by changing the position of the rotor relative to the stator.

In addition to the shunt winding there is a closed-circuit winding on the rotor with a phase displacement of 90 degrees from the shunt winding. This winding has the effect of equalizing the losses and the reactance of the regulator, when the rotor is in its various positions of raise and lower, so that the load current can flow through the regulator with the minimum voltage drop.

The Type AIRS induction-voltage regulator may be obtained in standard kva ratings up to 12 kva and a voltage range up to 600 volts, 60 cycles.

There is a wide range of usage for this type of regulator. They may be used for testing purposes with a short-time duty cycle of one hour and with a range of regulation up to 100 per cent lower to 200 per cent raise. The testing-type regulator may be arranged for operation with a hand crank on the worm or motor operation with push-button switches.

The automatic regulators may be obtained for a range of regulation of plus or minus 10 per cent.

The automatic regulators are controlled by a contact-making voltmeter mounted on a control panel.

Because of the wide range of kva sizes, two types of mechanical construction are used: one type uses a riveted-stator core with cast-iron top and bottom frames for kva ratings up to

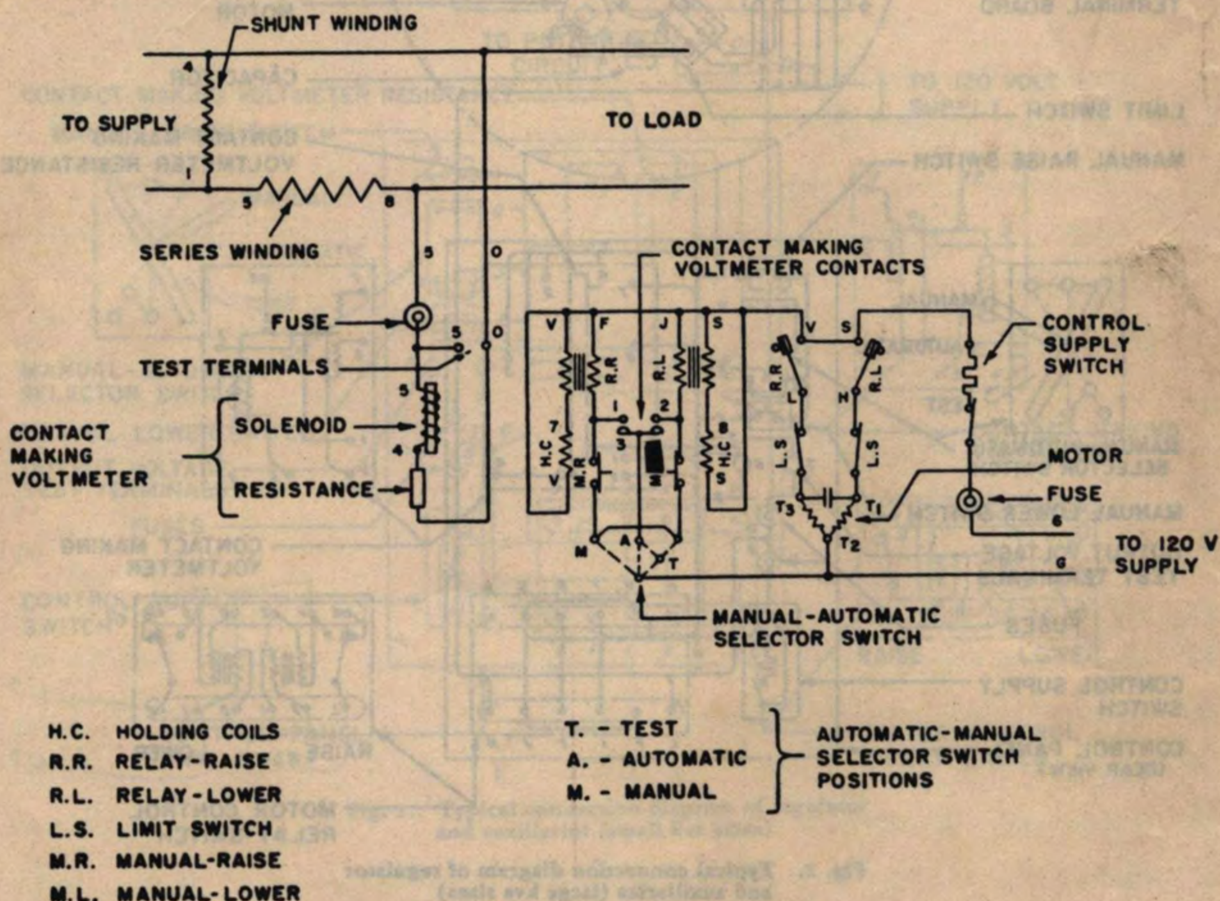


Fig. 3. Schematic diagram of Fig. 1

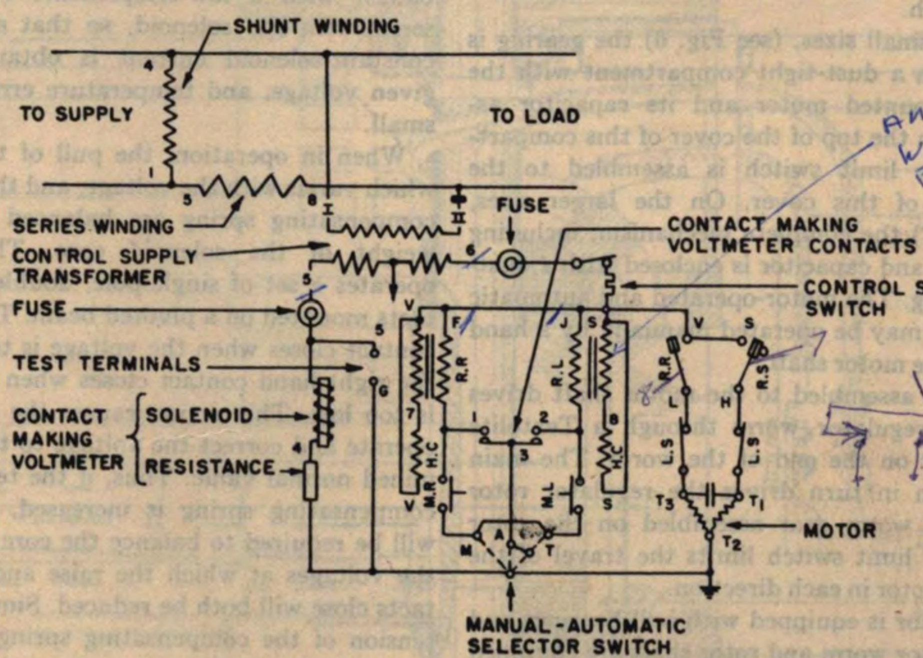
6.0 kva short-time duty; the other has a welded-type construction, similar to that used on the interior of the oil-filled induction regulators for larger kva sizes. These two types of constructions are shown in Fig. 6 and 7.

Automatic regulators up to 3.6 kva sizes (Fig. 6), because of their physical size, require separate sources of power for the control motor and contact-making voltmeter. The control panel is furnished for mounting separate from the regulator.

On kva sizes of automatic regulators above 3.6 kva (Fig. 7), the control is supplied from a two-winding transformer assembled on the regulator-stator cover, and the control panel is mounted on the front of the regulator.

The automatic operation of these regulators is controlled by a contact-making voltmeter, which responds to changes in the load voltage and in conjunction with a motor-control relay, causes the operating motor to rotate the regulator rotor to the position required to correct a deviation of the line voltage from normal.

Fig. 1 is a general wiring diagram (automatic control) of the small kva sizes with external source of control and with the control panel separately nounted. Fig. 2 is a general wiring diagram (automatic control) of the larger kva sizes with internal control and with control panel mounted on the regulator. Fig. 3 is a schematic diagram of Fig. 1; Fig. 4 is a schematic diagram of Fig. 2, and Fig. 5 is a sche-



H.C. - HOLDING COILS
R.R. - RELAY-RAISE
R.L. - RELAY-LOWER
L.S. - LIMIT SWITCH
M.R. - MANUAL-RAISE
M L. - MANUAL-LOWER

T. - TEST
A. - AUTOMATIC
M. - MANUAL
} AUTOMATIC-MANUAL SELECTOR SWITCH POSITIONS

Fig. 4. Schematic diagram of Fig. 2

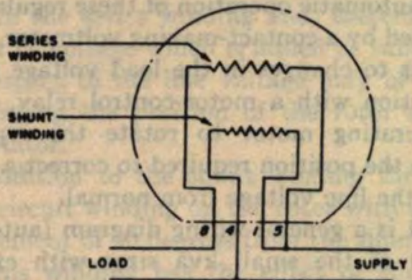


Fig. 5. Schematic diagram of hand-operated regulators

matic diagram of the hand-operated regulators in either construction.

The operating mechanism of the motor and automatic regulators consist of a double worm and worm-gear drive, a capacitor motor, and a limit switch.

On the small sizes, (see Fig. 6) the gearing is enclosed in a dust-tight compartment with the vertical-mounted motor and its capacitor assembled on the top of the cover of this compartment. The limit switch is assembled to the underside of this cover. On the larger sizes, (see Fig. 7) the complete mechanism, including the motor and capacitor is enclosed with a dust-tight casing. The motor-operated and automatic regulators may be operated manually by a hand knob on the motor shaft.

A worm assembled to the motor shaft drives the main-regulator worm through a Textolite worm gear on the end of the worm. The main worm then in turn drives the regulator rotor through a worm gear assembled on the rotor shaft. The limit switch limits the travel of the regulator rotor in each direction.

The motor is equipped with ball bearings and the regulator worm and rotor shaft are equipped with tapered roller bearings.

The Type AIRS automatic regulator is equipped with the following control:

1. Contact-making voltmeter 2. Motor-control relay 3. Automatic-manual selector switch 4. Manual raise-and-lower switches 5. Control-supply switch 6. Output-voltage-testing terminals	Mounted on control panel. Fig. 10
7. Control-supply fuses 8. Motor-reversible, capacitor type 9. Limit switch 10. Control-supply transformer (on large kva sizes only)	Mounted on regulator cover

1. Contact-making Voltmeter, Type TSB-20—See Fig. 8

The Type TSB-20 contact-making voltmeter is both a measuring device and a relay; it continuously measures the regulator-output voltage and controls the operation of the driving motor on the regulator, as required, to maintain that voltage within the preset band.

The sensitive element of the Type TSB-20 contact-making voltmeter is a solenoid with an iron core suspended from a spring. It responds to current changes. To measure voltage, the solenoid current must always be proportional to the voltage.

In the Type TSB-20 contact-making voltmeter, this condition is obtained by using a ballast with a low-temperature coefficient in series with the solenoid, so that substantially constant-solenoid current is obtained with a given voltage, and temperature errors are very small.

When in operation, the pull of the solenoid, which varies with the voltage, and the pull of the compensating spring are balanced against the weight of the solenoid core. This solenoid operates a set of single-pole, double-throw contacts mounted on a pivoted beam. The left-hand contact closes when the voltage is too high, and the right-hand contact closes when the voltage is too low. This action causes the regulator to operate and correct the voltage to the predetermined normal value. Thus, if the tension of the compensating spring is increased, less voltage will be required to balance the core weight, and the voltages at which the raise and lower contacts close will both be reduced. Similarly, if the tension of the compensating spring is reduced, the voltages at which the contacts close will both be increased.

The difference in the voltage value at which the "raise" contacts make and that at which the "lower" contacts make is called the "band width." This can be adjusted by means of the stationary-contact adjustment. Raising the stationary contacts will increase and lowering them will decrease the band width. Above and below the right-hand end of the contact beam are the holding-coil assemblies. Connections are made

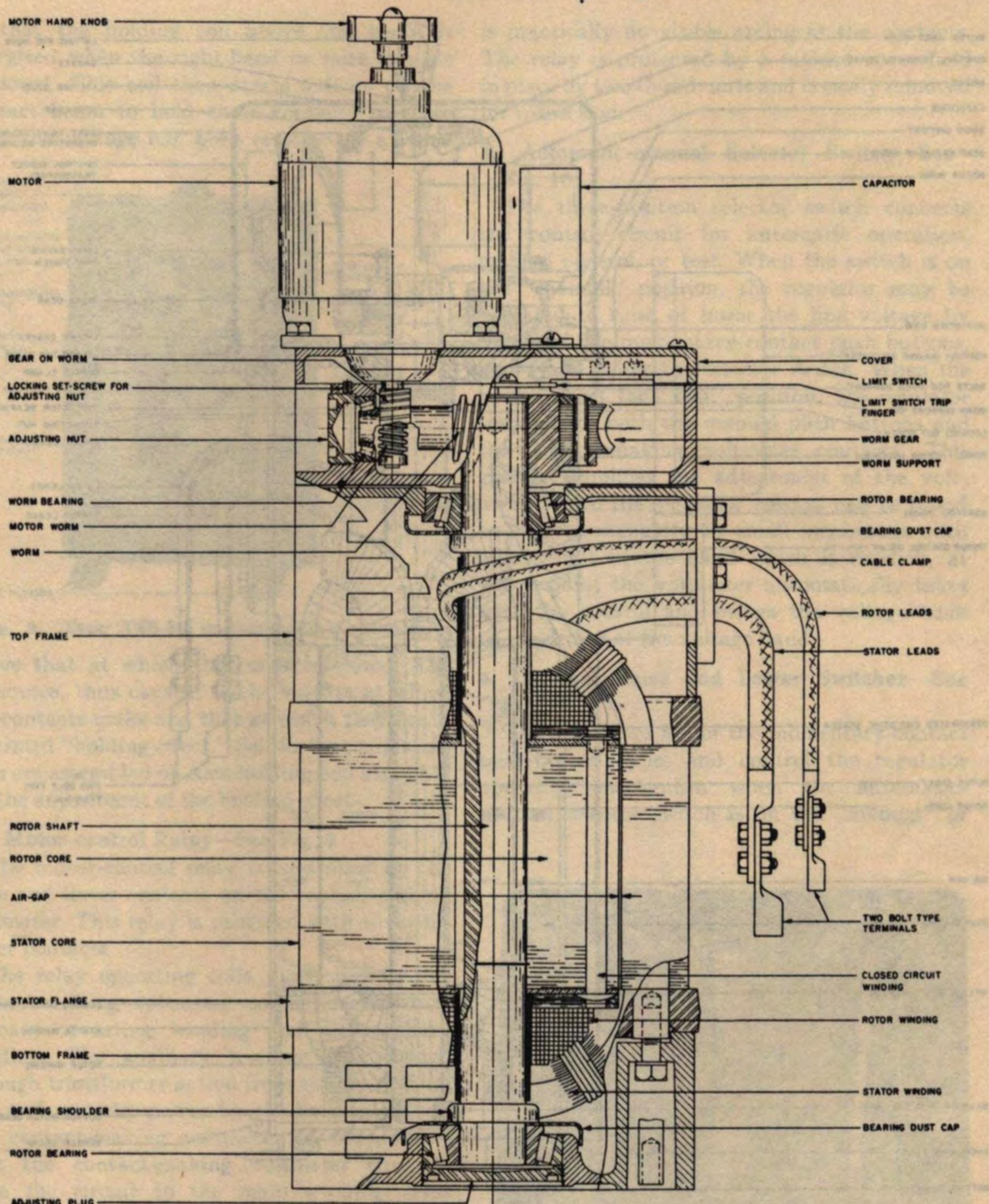


Fig. 6. Sectionalized view of the small kva-size regulator

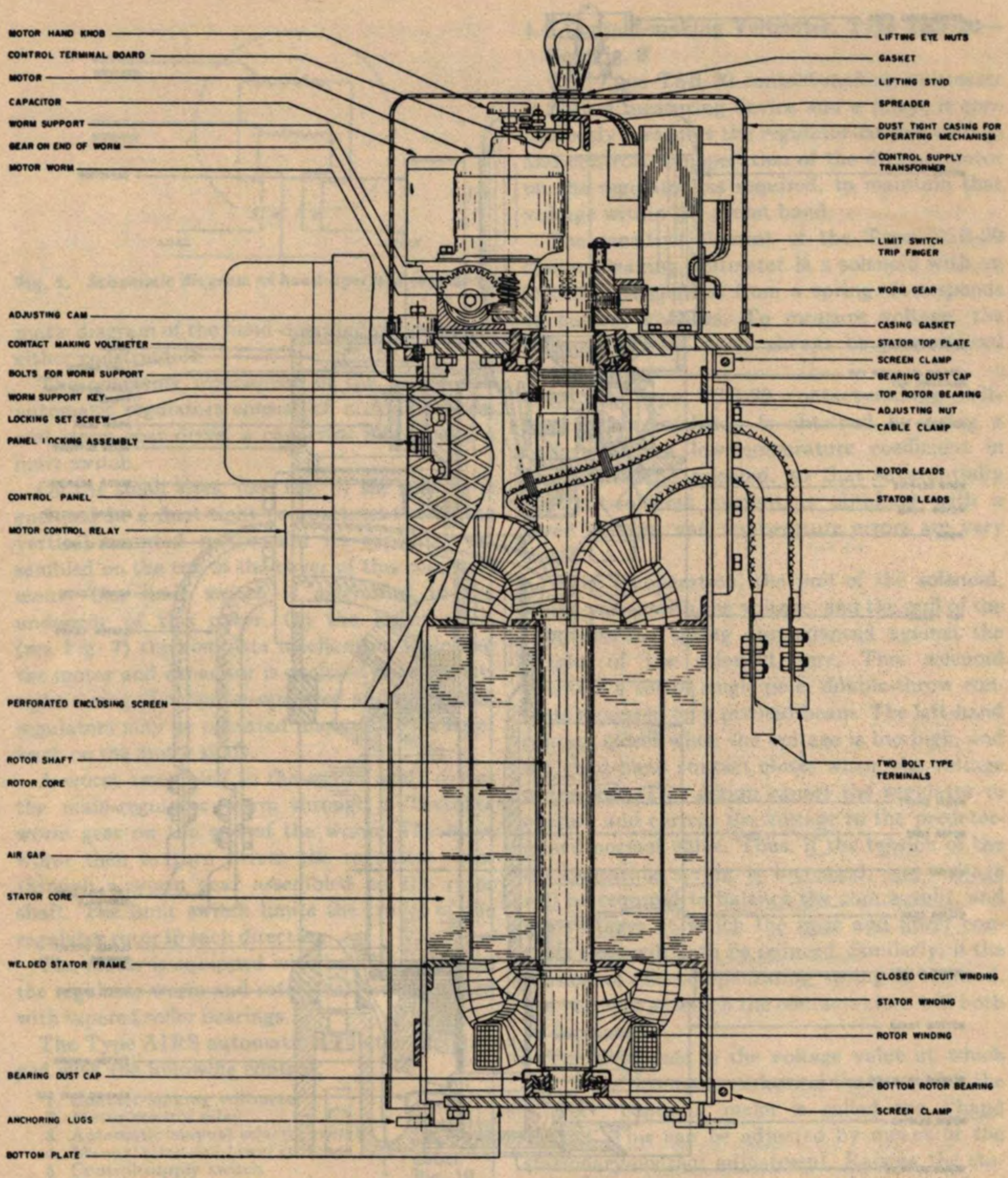


Fig. 7. Sectionalized view of the large kva-size regulator

so that the holding coil above the beam is energized when the right-hand or raise contact is closed. This coil then exerts a force on the contact beam to hold these contacts together until the voltage has been restored to a value

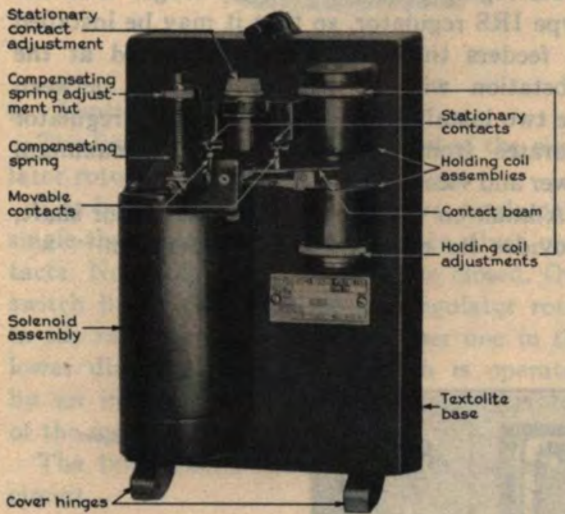


Fig. 8. Type TSB-20 contact-making voltmeter

above that at which the contacts closed. The difference, thus caused, in the voltage at which the contacts make and that at which they break is termed "holding effect." Self-locking adjusting nuts are assembled on each holding-coil assembly for the adjustment of the holding effect.

2. Motor-control Relay—See Fig. 9

The motor-control relay is controlled by the raise and lower contacts on the contact-making voltmeter. This relay is provided with silver-to-silver contacts.

The relay operating coils, controlled by the contact-making voltmeter contacts, consist of a main operating winding and an auxiliary winding. The auxiliary winding is energized through transformer action from the main winding, and provides power for the holding coils of the contact-making voltmeter at the instant that the contact-making voltmeter contacts close the circuit to the main winding. This method of energizing the holding coils, and the extremely low current required for the main relay winding, results in a contact-making voltmeter contact current so small that there is practically no visible arcing at the contacts. The relay is protected by a molded cover held in place by two thumb nuts and is easily removed for inspection.

3. Automatic-manual Selector Switch—See Fig. 10

The three-position selector switch connects the control circuit for automatic operation, manual control, or test. When the switch is on the "manual" position, the regulator may be operated to raise or lower the line voltage by means of the momentary-contact push buttons, above and below the selector switch. When the switch is on the "test" position, the regulator responds to both the manual push buttons and the contact-making voltmeter contacts. This greatly simplifies the adjustment of the voltmeter, since the regulator voltage can be raised or lowered manually by small increments until either limit of the band width is reached, at which point the voltmeter automatically takes over the control and brings the voltage back to the center of the voltage band.

4. Manual Raise and Lower Switches—See Fig. 10

These switches are of the momentary-contact push-button type, and control the regulator operating mechanism when the automatic-manual selector switch is on the "manual" or

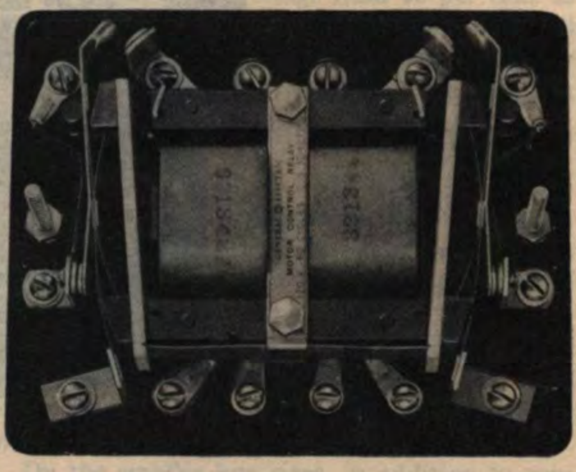


Fig. 9. Motor-control relay

5. Control–Supply Switch—See Fig. 10

This switch is of the enclosed toggle type with thermal overload protection and serves to disconnect the motor circuit from the control supply.

6. Output-voltage Testing Terminals—See Fig. 10

The two voltage-testing terminals on the front of the control panel provide means for reading the output voltage at the regulator terminals.

7. Control–Supply Fuses—See Fig. 10

The control–supply fuses located on the front of the control panel are for the protection of the control supply from a short circuit.

8. Motor, Reversible, Capacitor Type

The driving motor is of the reversible, capacitor, ball-bearing type with unusually high-starting torque for rapid acceleration. The average rate of voltage correction of the Type AIRS regulator is considerably longer than the Type IRS regulator, so that it may be installed on feeders that are already regulated at the substation without causing hunting between the two installations. The Type AIRS regulator operates from maximum raise to maximum lower and vice versa in 40 seconds.

A knob on the upper end of the motor shaft, provides for emergency hand operation.

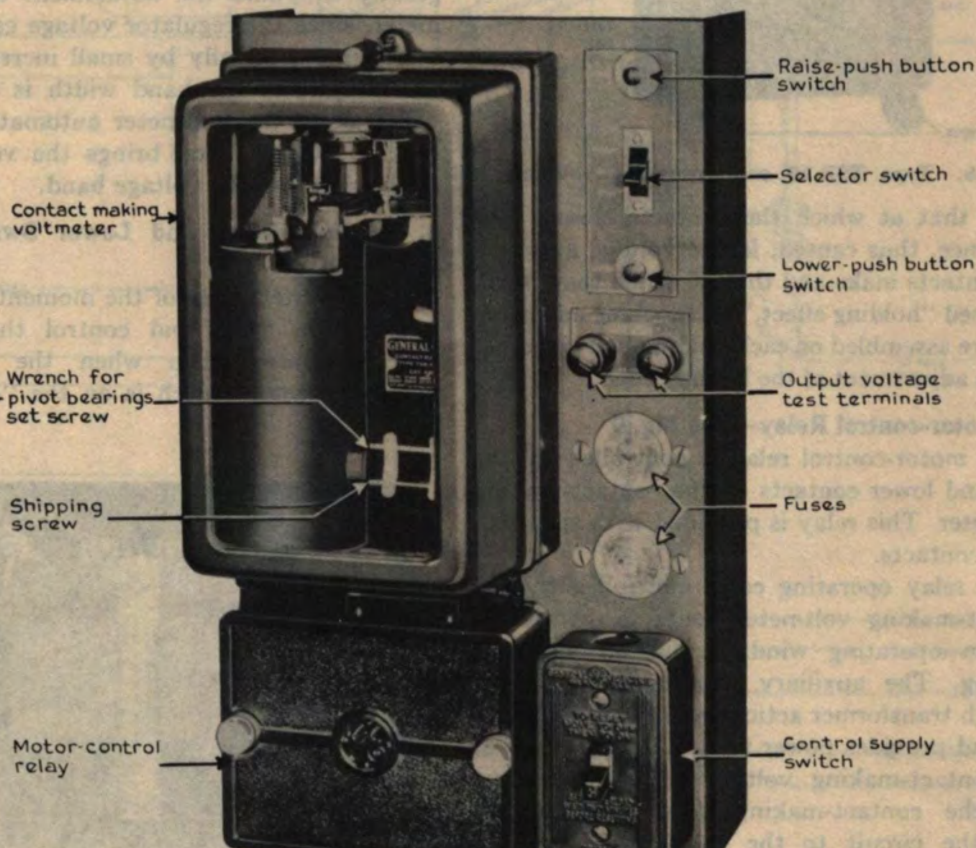


Fig. 10. Control panel

Fig. 11. Limit switch

9. Limit Switch—See Fig. 11

The limit switch limits the travel of the regulator rotor at the maximum positions.

The limit switch consists of two single-pole, single-throw switches with silver-to-silver contacts. Normally these switches are closed. One switch limits the travel of the regulator rotor in the raise direction and the other one in the lower direction. The limit switch is operated by an insulated trip finger assembled on top of the main worm gear.

The limit switch contacts are in the motor circuit.

10. Control Supply

On the small kva sizes, the control supply for the motor may be obtained from any 120-volt, 60-cycle 1.5-ampere capacity source. The control for the contact-making voltmeter should be taken from the load-side regulator terminals for load voltages 120 and 240 volts. Above 240 volts, a potential transformer with a capacity of at least 50 volt-amperes should be used to step down the voltage to 120 volts.

On the large kva sizes, a control-supply transformer is assembled on the stator cover and supplies the power for the control.

This transformer is connected to the load side of the regulator and the voltage varies with the load voltage so that the contact-making voltmeter will hold constant voltage on the feeder.

Line-drop Compensator (Optional)

Since Type AIRS regulators can generally be installed at or near the center of the load, the voltage drop to the load is of a negligible value and has no appreciable effect on the voltage regulation delivered at that point. If it is necessary to install this type of regulator a considerable distance from the load center, line-drop compensation may be required. Regulators with line-drop compensators on the control panels may be obtained.

Shipment

Each regulator is shipped completely assembled. The crating is provided with skids to facilitate handling in transportation. When lifting the crated regulators, slings should be used under the skids on the crate.

Storage

If the regulator is not to be used immediately, it should be stored in a clean, dry place where the temperature is reasonably uniform.

Handling

The uncrated regulators should be lifted with slings attached to the eyenuts on the top. On the large regulators a spreader, equal in length to the distance between the eyenuts, should be used between the slings to prevent deforming the lifting studs.

Installation

Before installing the regulator, see that it is suitable for the circuit that it is to control. All rating data appear on the regulator nameplate. All induction-voltage regulators have a minus ten per cent and a plus ten per cent tolerance in voltage rating, that is, they are so designed that with an input voltage from 90 per cent to 110 per cent of the rated voltage, they will operate over their entire range of raise and lower without exceeding 55 C rise, if neither the kva nor the ampere rating is exceeded.

Connections

The Type AIRS regulators have the shunt and series winding leads brought out through a cable bushing on the back. These leads are provided with two-bolt terminals.

A connection diagram furnished with each regulator (number stamped on the regulator nameplate) gives in detail the connections to be made in connecting the regulator into the line.

On the smaller kva sizes, in addition to connecting the regulator to the line, it will be necessary to connect the control panel to the control leads on the regulator and, also, separate sources of supply for the motor and the control panel should be connected as shown on the connection diagram.

Before connecting an automatic regulator into the line, open the control-suppply switch on the control panel.

Install the regulator in a location that is dry, has good ventilation, and is free from dust and dirt The support for the regulator should be flat, level, and rigid.

The use of fuses in the incoming lines to the shunt winding is not recommended because of the high potential that would be induced in the series winding, if the line connections to the shunt winding were opened while current was flowing in the series winding. In general, the feeder should be disconnected when putting the regulator in or out of service.

Grounding

Induction-voltage regulators should be permanently grounded, using a copper conductor with a cross section at least equal to the maximum-size conductor that connects the regulator to the line.

Checking Direction of Rotation

After the regulator is connected into the circuit, close the control-supply switch on the panel, set the auto-manual selector switch on the panel in the manual position. Operate the regulator in both directions with the manual raise and lower switches, checking the dial on the hand knob on the motor to see that the regulator rotates correctly.

Contact-making Voltmeter, Type TSB-20

The contact-making voltmeter has a dust-tight cover with a glass front. This cover is hinged at the bottom and held at the top by a spring latch. Remove the shipping screw (end painted red) located at the top of the solenoid core and the solenoid case. This shipping screw should be inserted in the clip on the front of the base for future use, in case the voltmeter is de-energized for any length of time or the regulator is moved.

The operation of the voltmeter should be free from sluggishness. This may be determined by observing the operation of the voltmeter-contact beam, which should move freely without jerking or binding. If the movement is sluggish, the bearings should be carefully examined and adjusted as explained under MAINTENANCE.

Alignment of Contacts—See Fig. 12

Both the stationary and movable contacts of the voltmeter are spherical in shape and should meet with a butting contact, that is, the centers of the spheres should be in alignment when the contacts meet.

The spacing of these contacts is shown in Fig. 12. The (B) spacing should always be less than (A). The amount depends upon the voltage-band width and is determined by the requirement that after contact is made and the holding effect has developed the necessary contact pressure, the contact centers will then coincide. The stationary contacts can be adjusted to obtain this condition by moving these contacts slightly to the left or right, by means of the extensions provided on the contact holders. It should be possible to make these adjustments without loosening the screws that hold these stationary contacts into the contact assembly.

Adjustment of Contact-making Voltmeter—See Fig. 13

At the factory, the contact-making voltmeter has been adjusted for a normal load-center voltage of 120 volts with the voltage-band width limits at 119 volts and 121 volts. This band-width adjustment is recommended for all average lighting-feeder applications.

In order to check these settings of the contact-making voltmeter and make such readjustments as the installation may require, an indicating voltmeter should be connected to the output-voltage testing terminals on the control panel. The indicating voltmeter will then show the voltage for which the contact-making voltmeter is adjusted.

A very convenient means for checking the various adjustments of the voltmeter is obtained by utilizing the induction regulator itself to

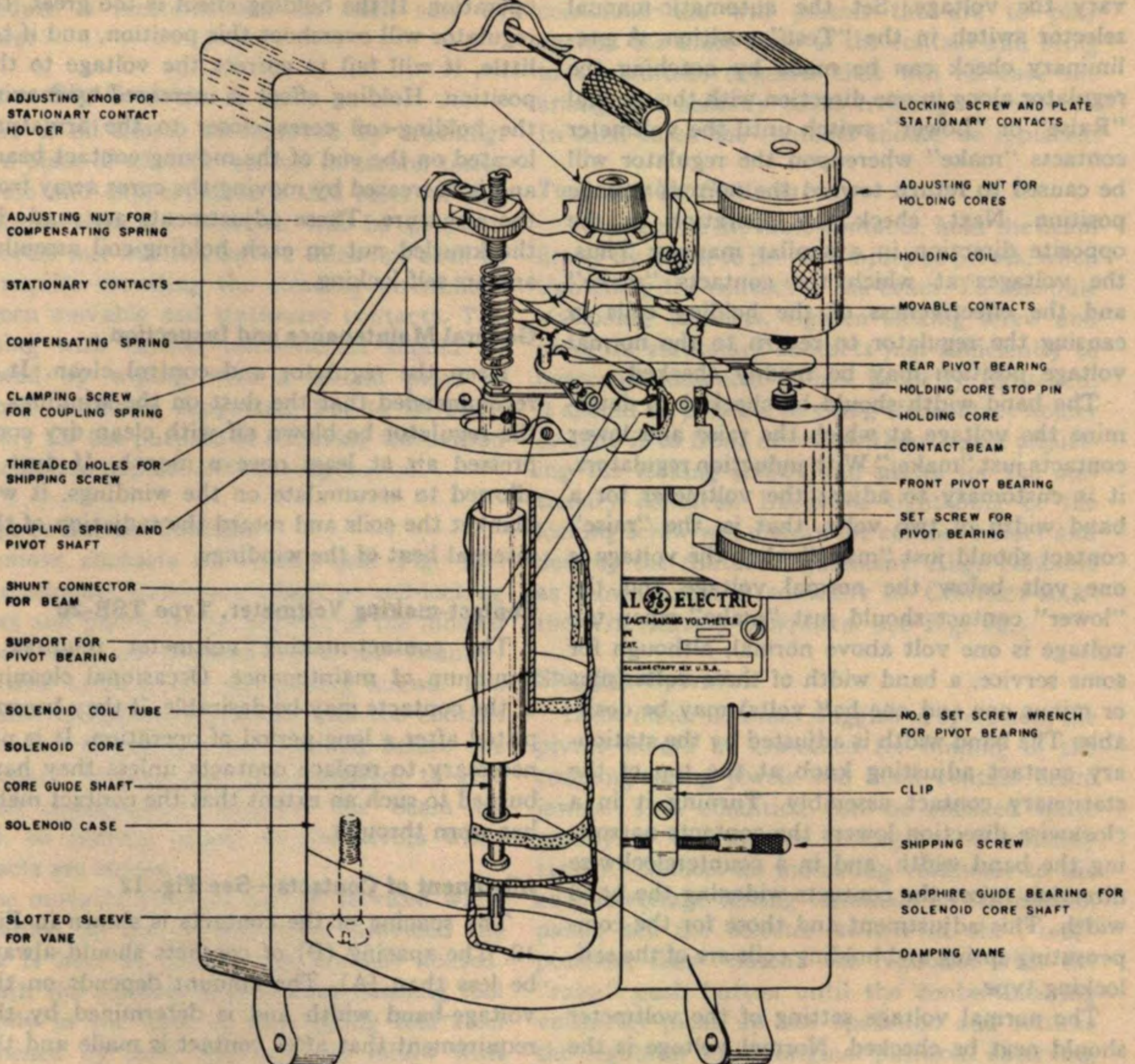


Fig. 13. Sectionalized view of Type TSB-20 contact-making voltmeter

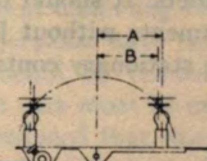


Fig. 12. Alignment of contact-making-voltmeter contacts

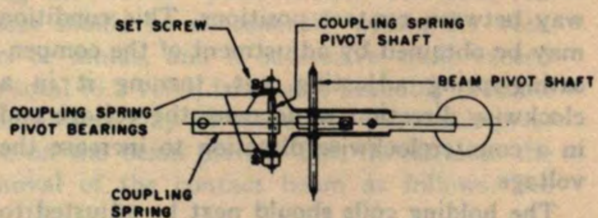


Fig. 14. Contact-making-voltmeter beam assembly

vary the voltage. Set the automatic-manual selector switch in the "Test" position. A preliminary check can be made by notching the regulator along in one direction with the manual "Raise" or "Lower" switch until the voltmeter contacts "make" whereupon the regulator will be caused to return toward the normal voltage position. Next, check the operation in the opposite direction in a similar manner. Thus, the voltages at which the contacts "make" and the effectiveness of the holding coils in causing the regulator to return to the normal voltage position may be readily checked.

The band width should be checked to determine the voltage at which the raise and lower contacts just "make." With induction regulators, it is customary to adjust the voltmeter for a band width of two volts, that is, the "raise" contact should just "make" when the voltage is one volt below the normal voltage and the "lower" contact should just "make" when the voltage is one volt above normal, although for some service, a band width of three volts (plus or minus one and one half volts) may be desirable. The band width is adjusted by the stationary contact adjusting knob at the top of the stationary contact assembly. Turning it in a clockwise direction lowers the contacts narrowing the band width, and in a counterclockwise direction raises the contacts widening the band width. This adjustment and those for the compensating spring and holding coils are of the self-locking type.

The normal voltage setting of the voltmeter should next be checked. Normal voltage is the median of the voltage at which it is desired that the raise and lower contacts shall respectively close. At this voltage, the contact beam should balance in a horizontal position, halfway between contact positions. This condition may be obtained by adjustment of the compensating-spring adjusting nut, turning it in a clockwise direction to decrease the voltage and in a counterclockwise direction to increase the voltage.

The holding coils should next be adjusted to give sufficient holding effect to return the regulator to the normal voltage position after each operation. If the holding effect is too great, the regulator will overshoot this position, and if too little, it will fail to correct the voltage to this position. Holding effect is increased by moving the holding-coil cores closer to the armature, located on the end of the moving contact beam, and is decreased by moving the cores away from the armature. These adjustments are made by the knurled nut on each holding-coil assembly and are self-locking.

General Maintenance and Inspection

Keep the regulator and control clean. It is recommended that the dust on the windings of the regulator be blown off with clean dry compressed air at least once a month. If dust is allowed to accumulate on the windings, it will blanket the coils and retard the radiation of the internal heat of the windings.

Contact-making Voltmeter, Type TSB-20

The contact-making voltmeter requires a minimum of maintenance. Occasional cleaning of the contacts may be desirable, if they become pitted after a long period of operation. It is not necessary to replace contacts unless they have burned to such an extent that the contact metal has worn through.

Alignment of Contacts—See Fig. 12

The spacing of the contacts is shown in Fig. 12. The spacing (B) of contacts should always be less than (A). The amount depends on the voltage-band width and is determined by the requirement that after contact is made and the holding effect has developed the necessary contact pressure the contact centers will then coincide. The stationary contacts can be adjusted to obtain this condition by moving these contacts by means of the extensions provided on the contact holders. It should be possible to make these adjustments without loosening the screws holding the stationary contacts in place: See Fig. 13.

Cleaning Contacts

The surface of the contacts may be dirty or oily, or they may be burned rough, and a separate procedure is recommended for each case as follows:

Dirty or Oily Contacts

Dirt or oil should be removed by brushing. Use a piece of chamois soaked in carbon tetrachloride and supported on a thin piece of flat metal, so that the chamois will be properly supported but will not have a thickness such as will require crowding the cleaning instrument between movable and stationary contacts. The cleaning with carbon tetrachloride should be followed by wiping with a second piece of chamois, similarly supported, but to be clean and dry for the purpose of removing the carbon tetrachloride deposit left by evaporation.

Rough or Burned Contacts

Remove contacts as follows (see Fig. 13): The stationary contacts are held by self-locking screws and plates in the pockets of the molded support and are released by a few counterclockwise turns of the self-locking screws. The movable contacts are screwed into the contact beam and should not be removed before the stationary contacts are first removed, to give greater accessibility. Support the beam by hand, to prevent injury to the pivots when contacts are turned.

The movable contacts can be serviced while assembled on the contact beam provided the beam is held so that pivots are not abused. Smooth the surfaces with a relay-cleaning tool (usually in the form of thin spring tool steel roughened by sand blasting) and follow with the dry chamois cleaner as directed above. Stationary contacts should be smoothed similarly but a spacer should be placed between the back of the contact supporting spring and the contact holder, so that a solid support will be given the contact, to prevent distorting the spring.

If small projections have appeared on the surface, they should be removed with a fine ignition file, but care must be exercised that no scratches are produced that cannot be removed entirely by the cleaning tool. A final cleaning with a chamois should be made. If perforation of the movable-contact metal has occurred, continued use will permit the arc to play against the brass body of the contact and bring to the surface deposits that will increase the arcing and possibly cause freezing of contacts. In such cases the contacts should be replaced.

To Assemble Contacts

To assemble movable contacts, hold the beam firmly by hand, to prevent injury to pivots, when tightening the contact in the beam. To assemble stationary contacts, tighten locking screw and plate for stationary contacts just sufficiently to overcome looseness. When properly tightened, it should be possible to swing the contact holder or slide it to front or rear without again adjusting the locking screws and plates for the stationary contacts. Excessive tightening of the locking screw will distort the contact holder and destroy the contact adjustment. Align contacts as shown under ALIGNMENT OF CONTACT-MAKING VOLTMETER CONTACTS. See Fig. 12.

Sluggish Operation

If the meter becomes sluggish in operation, the pivots should be examined for binding of the coupling-spring jewels and main contact beam jewels. This condition can be checked quite readily if the applied voltage is reasonably steady. Connect an indicating voltmeter to the output-voltage testing terminals on the control panel, set the selector switch in the "test" position, then "notch" the regulator with the "raise" push button until the contact-making voltmeter picks up the operation and returns the regulator to its original position, observing very carefully the voltage on the indicating voltmeter at which the contact-making voltmeter picks up the operation each time. Repeat, using the "lower" push button. The observed values should be consistently within 0.1 volt, plus or minus, and if successive trials exceed the total (0.2 volt), friction is probably present. The binding may be caused by too much pressure on the beam pivots. This necessitates the removal of the contact beam as follows. See Fig. 13.

First, insert the shipping screw in the threaded holes in the top of the solenoid core and solenoid case, making sure that screw threads engage in the solenoid core without disturbing the alignment of the front pivot bearing, second, disconnect the shunt connector for the beam, where it is clamped to the terminal post in the meter base, by loosening the screw to permit pulling the shunt out from under the clamp; third, remove the clamping screw for the coupling spring in the top of the core stem; fourth, loosen the setscrew for the front pivot bearing and push the front pivot bearing to the front of the casting as far as it will go; fifth, disengage the beam-pivot shaft from the front-pivot bearing and remove the beam.

To check for friction in the coupling-spring pivot bearings; first, hold the contact-beam shaft vertical, as shown in Fig. 14; second, tip very slightly from vertical so that the coupling member will start swinging. If the coupling-member movement is hesitant, the pivot bearings may be too tight or the coupling-shaft pivot points may be defective. Third, to correct tightness, loosen the upper pivot bearing, as shown in Fig. 14, by means of the setscrew, set it against the pivot shaft and retighten setscrew, and again check for friction by "swing" of the coupling member. Repeated trials may be necessary to obtain the free swing required, but do not allow end play between shaft and bearings (detected by using the coupling spring as a lever and applying light force against the bearings). No noticeable shift of pivot points should be evident.

If a free "swing" of the coupling member cannot be obtained in this manner, the coupling-shaft pivot points may be defective. Remove the coupling spring and pivot shaft by first loosening the setscrew and moving the upper bearing out far enough to disengage the shaft. Check the pivot points under a 3X magnifying glass. The points should be needle-like and free from cracks and distortion.

NOTE: The position of the coupling spring and its shaft, with respect to the contact beam and its shaft, is located by gage at the factory, and perfect realignment will be assured by disturbing only the one pivot bearing indicated. This is true even if a renewal part is used. Under no circumstances should the bracket sides of the contact beam be bent to make adjustment of the coupling pivot bearings.

The binding may be caused by too much pressure on the beam-pivot shaft. This should be checked as follows.

(Front Pivot-bearing Assembly)

Check the pivot points as explained above for the coupling-spring pivots.

Check front pivot-bearing assembly in accordance with Fig. 15A and then assemble in bracket with beam, in accordance with Fig. 15B, using a feeler gage to check for proper clearance.

Assembly of Contact Beam

Follow the reverse order of procedure outlined under the removal of contact beam. Check the position of the front pivot bearing and its support before and after assembly, to insure alignment and proper end thrust. Do not allow shunt connector for beam to touch solenoid case as this will ground the contact beam.

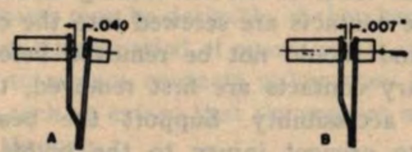
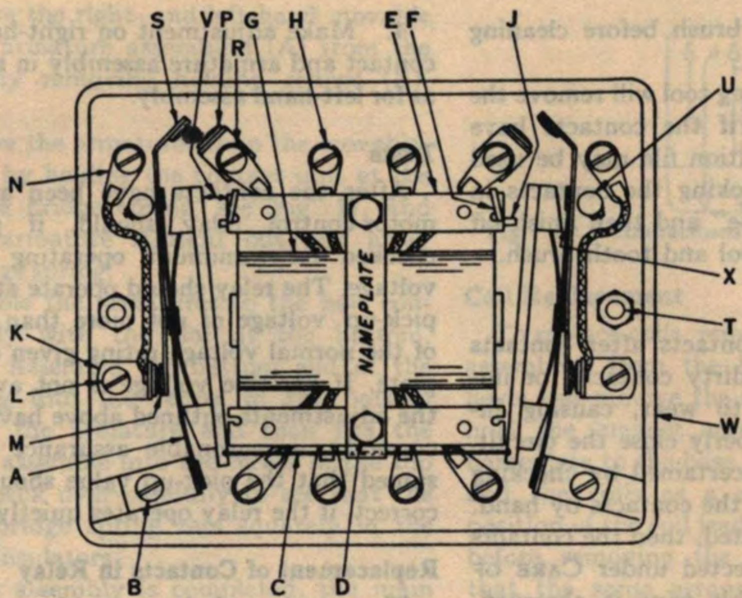


Fig. 15. Contact-making-voltmeter front-pivot bearing

Motor-control Relay—See Fig. 16

The motor-control relay is provided with two sets of silver-to-silver contacts. One set, which is normally open, is used to control the motor circuit and the other set, normally closed, is not used on the Type AIRS control circuit. It is not necessary to replace the contacts or clean them if they show only discoloration, due to the normal effect of arcing. The wiping action in making contact, will keep the actual contact surface clean and insure a good electrical contact. The contacts should be replaced when the contact-face material is burned away, and there is no longer any wiping action. The motor-control relay coils are designed to operate satisfactorily at 80 per cent of their normal operating voltage.



A. MOVABLE CONTACT AND ARMATURE ASSEMBLY.
B. HOLDING SCREW.
C. ARMATURE SPACER.
D. HEX. HOLDING SCREW.
E. MAGNET CORE.
F. POLE SHADER.
G. OPERATING COIL.
H. OPERATING COIL TERMINALS.
J. MECHANICAL ARMATURE INTERLOCK.
K. STATIONARY CONTACT-DYNAMIC BRAKING CIRCUIT.
L. HOLDING SCREW.
M. MOVABLE CONTACT-DYNAMIC-BRAKING CIRCUIT.
N. TERMINAL FOR DYNAMIC BRAKING CONTACT.
P. STATIONARY CONTACT-MOTOR CIRCUIT.
R. HOLDING SCREW.
S. MOVABLE CONTACT-MOTOR CIRCUIT.
T. STUD FOR MOUNTING RELAY AND HOLDING COVER.
U. MOLDED STOP PINS.
V. ARMATURE GAP AT TOP OF MAGNET CORE.
W. MOLDED BASE.
X. GAP.

Fig. 16. Motor-control relay

Servicing of Relay Contacts

The contacts will become discolored from service. This is a natural process where silver-to-silver contacts are used. This discoloration will do no harm, providing arcing does not continue after contact is made. Arcing in the presence of noxious gases or salt air will cause deposits to form on contact surfaces, which will eventually interfere with proper circuit closing.

Care of Contacts

To clean the contacts, use a relay-cleaning tool. This is usually a piece of spring-tool steel that has been sand-blasted or etched to form a very fine rough surface. After cleaning with tool, brush contact with a clean, dry tooth brush. If a gummy deposit is present on the contacts, first brush with a clean tooth brush, moistened with carbon tetrachloride, let dry, then brush with a clean, dry tooth brush before cleaning with the cleaning tool.

In most cases the cleaning tool will remove the roughened surfaces, but if the contacts have become pitted, a fine ignition file may be used to clean up the pits, stroking the contacts in the direction of the "Wipe" and then finish off as above with cleaning tool and tooth brush.

Adjustment of Contacts

Continued arcing of contacts after contacts are closed may indicate dirty contacts, or improper adjustment due to wear, causing insufficient pressure to properly close the circuit.

This may be readily ascertained by checking the "wipe," when closing the contacts by hand. If a good "wipe" is indicated, then the contacts should be cleaned as directed under CARE OF CONTACTS. If no noticeable wipe is observed, the contacts should be readjusted as follows:

(Pin Gage in Clip on Back of Panel.)

1. Insert a pin gage (1/8 inch diameter) in armature gap (V) on left-hand side of core. Exert pressure directly against the center of the armature, not against contact assembly, to hold it firmly against the gage. Move the stationary contact (K) in its groove in the base until it just touches the movable contact (M), then retighten the holding screw (L) firmly.

2. Release the armature and allow contacts (K) and (M) to fully engage. In this position of the movable contact and armature assembly, the flat-steel support that the movable contacts are welded to should just clear (must not exceed 1/32 inch) the molded stop (U) in the base. If this does not clear the molded stop (U) and the contact adjustment checks, it will be necessary to loosen the holding screw (B), very slightly, and then drive the bracket of the contact assembly minutely toward the core to obtain the minimum gap required.

3. Insert a pin gage (1/16 inch diameter) in the armature gap and exert pressure against armature, as in paragraph (1) to hold gage in place. Move the stationary motor-circuit contact (P), in its slot in the base, until it just touches the motor-circuit movable contact (S). Tighten holding screw (R) firmly.

4. Make adjustment on right-hand movable contact and armature assembly in same manner as for left-hand assembly.

Tests

After the contacts have been adjusted, the motor-control relay should, if possible, be checked for minimum operating or pick-up voltage. The relay should operate at a minimum pick-up voltage of not more than 75 per cent of the normal voltage rating given on its nameplate. If variable voltage is not available, and the adjustments outlined above have been made correctly, a reasonable assurance may be assumed that the pick-up value should be nearly correct, if the relay operates quietly.

Replacement of Contacts in Relay

The wearing of the movable and stationary contacts should be uniform and in most cases, both the movable and stationary contacts should require replacement at the same time.

The movable-contact assemblies consist of three flat springs and silver, steel-backed contacts welded together. Fig. 17 shows the contact assembly and the method of assembling the movable contact assembly to the armature.

Before starting to assemble the contacts, the surfaces of the armature and magnet core should be thoroughly cleaned of all foreign matter

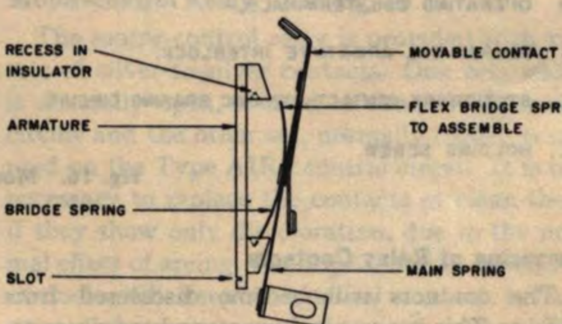


Fig. 17. Assembly of moving contact to armature on motor-control relay

This may be accomplished by using a clean tooth brush moistened in carbon tetrachloride, and when dry, brush again with a clean, dry tooth brush.

1. Remove the right- and left-hand movable contact and armature assemblies (A) from the relay base by removing holding screws (B). See Fig. 16.

2. Remove the armatures from the movable-contact unit by holding the contact unit at the center of the bridge spring, see Fig. 17, and pulling the armature straight out and away from the bridge spring.

3. Assemble the armatures to the new contact assembly with the slot at the bottom, see Fig. 16. Assemble the bottom end of the bridge spring into the recess in the bottom insulator on the armature and then flex the top end and assemble into the recess in the top insulator. Check over carefully to see that the end of the bridge spring sets squarely in the recess in the insulators.

When this assembly is completed, the main spring of the contact assembly should just touch or just clear the bottom insulator and at the top, it should clear the top insulator by at least $\frac{1}{64}$ inch and not more than $\frac{1}{32}$ inch.

If this clearance is not obtained, it will be necessary to remove enough stock from the high edge of the top insulator to obtain the minimum clearance. See Fig. 16.

4. Assemble the movable contact and armature assemblies (A) into the grooves in the relay base with the holding screws (B) loose for adjustment. Insert armature spacer in slot in armatures. Hold the top of armature tight against the magnet core pole face by applying pressure against the center of the armature, and not against the contact assembly Make sure that armature spacer is seated squarely in the bottom of the slot, and the front edge of the armature is approximately parallel with the front surface of the core, determined by the matching of the motor contacts, then tighten firmly holding screw (B). Release pressure from armature and check to make sure that armature spacer is exerting pressure against armature and that there is a very small gap between bottom end of armature and bottom pole face of core. See Fig. 16.

Adjust contacts as described under ADJUSTMENT OF CONTACTS.

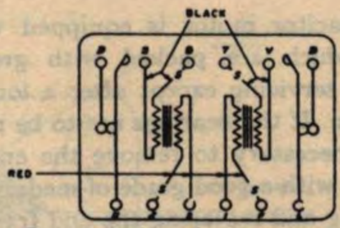


Fig. 18. Connections of motor-control relay

Coil Replacement

To replace coils, remove armature and contact assemblies from the base, disconnect the coil leads and remove the two hex-head screws that hold the magnet core, armature spacer, and nameplate to the base. Remove the magnet core and the coils as a unit. Carefully note the position of the coil leads with respect to the core, before removing the coils from the core, so that the same arrangement of leads may be followed in assembling the new coils to the core. Place the new coils on the legs of the core and reassemble the magnet, coils, armature spacer, and nameplate to the relay base. In assembling this unit to the base, make sure that the coil leads do not interfere with the full operation of the armature interlock. Connect the coil leads to the terminals in the base in accordance with Fig. 18. Identify leads by their color. Reassemble armature and movable contact assemblies. Adjust contacts as described under REPLACEMENT OF CONTACTS and ADJUSTMENT OF CONTACTS.

Miscellaneous

The automatic-manual selector switch, the manual raise and lower push-button switches, and the output-voltage test terminals should not require any servicing.

The control-supply switch is a single-pole, toggle-type switch with silver-to-silver contacts and an overload-heater-type trip. If the switch opens, due to overload, it is necessary to wait two minutes before reclosing to allow heater unit to cool. No maintenance should be necessary.

The control-supply fuses used between the control supply and the automatic controls are standard 15-ampere, Edison screw-base type.

The capacitor motor is equipped with ball bearings which are packed with grease and require no servicing except after a long period of operation. If the bearings are to be repacked, it will be necessary to remove the end frames and repack with a good grade of medium grease. In removing and replacing the end frames, care should be used to see that the preload adjustment is not disturbed.

The capacitor and limit switch should require no servicing.

Inspection (Small Kva Sizes)

To inspect the operating mechanism on the small kva sizes, set the regulator in the neutral, remove the four small screws in the corners of the cover and then lift the cover, with the motor and capacitor in place, off the worm support. The limit switch and control leads are assembled to the underside of this cover. The gearing may now be inspected.

For further inspection, disassemble the regulators as follows.

Motor and Capacitor

The motor is of the ball-bearing type, and the bearings are packed in grease when assembled. No servicing should be required on either the motor or its capacitor.

The bottom frame of the motor is rabbeted to fit into a machined hole in the cover. This hole is slightly larger than the fit on the motor end frame, to allow for adjusting the backlash between the motor worm and the Textolite gear. In reassembling the motor, adjust the backlash between the worm and worm gear to the minimum. This can be accomplished by slightly turning the hand knob on the top of the motor in each direction and moving the motor toward the front of the regulator until only a small amount of backlash remains. Make sure that when the motor is finally bolted down the worm does not bind on the gear and, therefore, impede the free operation of the motor rotor. The motor is designed to operate the regulator at 80 per cent of normal rated voltage.

Remove the four bolts holding the worm support to the top frame. Draw support toward back of the regulator to disengage worm from worm gear and then lift it off the aligning key in the top frame.

Remove the worm gear, as shown in Fig. 19.

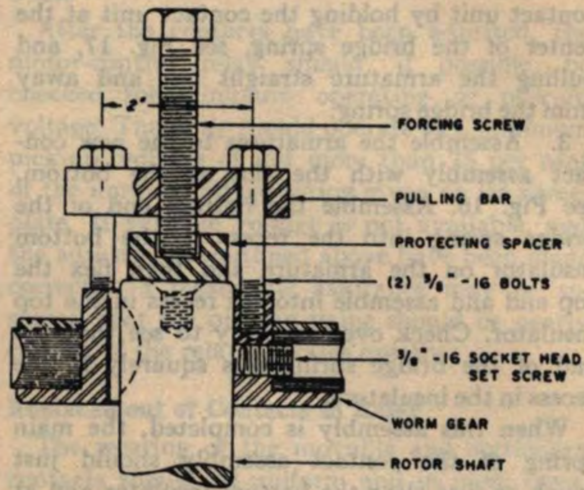


Fig. 19. Method used in removing worm gear, typical of small kva-size regulators

To remove the worm gear from the rotor shaft, loosen setscrew in side of hub.

Use the two ⅜-inch–16 tapped holes in the top of the hub to bolt a heavy steel bar with a threaded hole in center for forcing screw, Fig. 19. Space the bar from the top of the hub to allow the placing of a steel disk on top of the rotor shaft, for forcing screw to work on, so as not to damage center countersink and threads in rotor shaft. By tightening the forcing screw in the center of the bar, the worm gear will be drawn from the rotor shaft. Remove the worm gear key from the rotor shaft.

Remove the cable clamp on the back of the regulator.

Remove the two eyenuts and the two corner bolts and then lift the top frame off the stator.

The rotor may now be removed and complete inspection made.

Below the top bearing and above the bottom bearing on the rotor shaft are assembled dust caps to keep the bearings clean.

To keep the air gap in alignment, a fit is machined in the top and bottom frame and on the top and bottom flanges of the stator core.

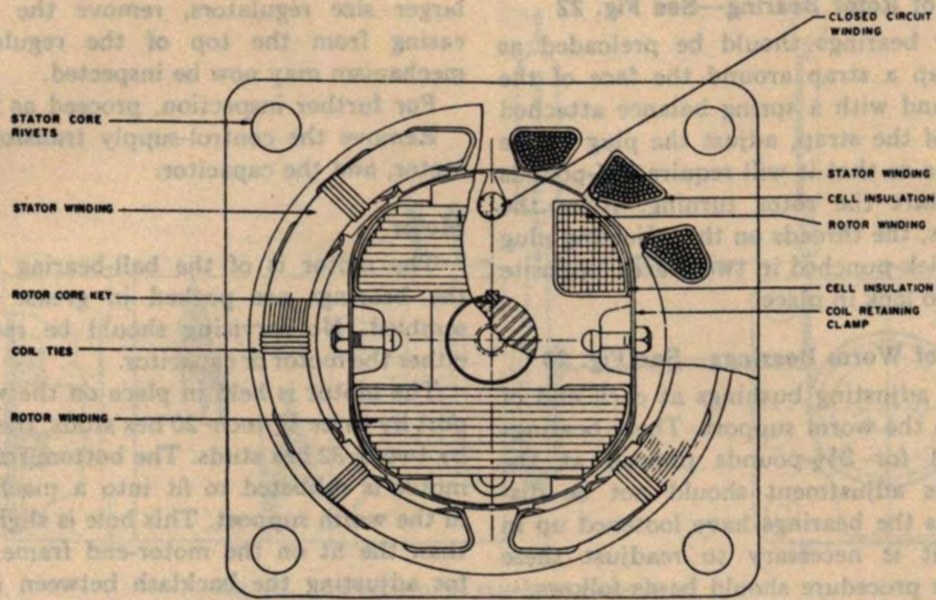


Fig. 20. Location of windings, typical of small kva-size regulators

The bottom frame may be removed by removing the four bolts in the corners.

The location of the windings is shown in Fig. 20.

Reassembly of Regulator (Small kva sizes)

To reassemble regulator, assemble the bottom frame to the stator core, making sure that the fits on the frame and core line up correctly.

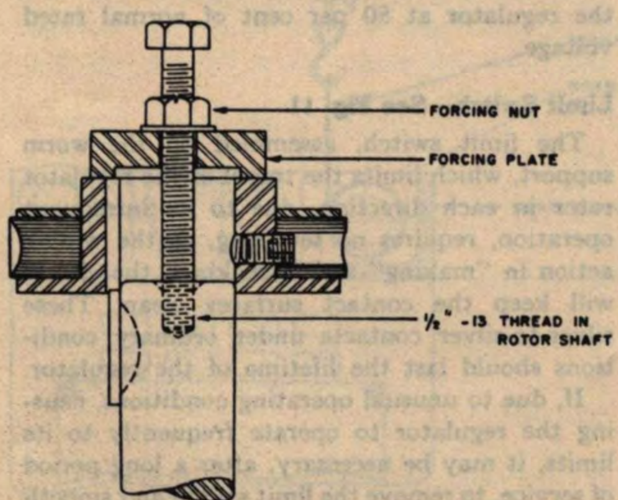


Fig. 21. Method used in assembling worm gear, typical of small kva-size regulators

The bottom bearing cup in the bottom frame is adjustable for properly preloading the rotor bearings. This adjustment is made by a threaded plug in the center of the bottom frame. This adjustment should not be disturbed unless it is necessary to readjust the load on the bearing. This adjustment is covered under ADJUSTMENT OF ROTOR BEARINGS.

Assemble the rotor into the stator.

Assemble the top frame to the stator core, making sure that the fits line up correctly.

Assemble the worm gear on the rotor shaft to its approximate location. See Fig. 21.

Heat the worm gear in an oven, to approximately 100 C. Start the worm gear on the rotor shaft by lightly tapping with a rawhide mallet on the top face of hub of gear only. Use a forcing fixture, Fig. 21, assembled in the ½-inch–13 tapped hole in end of rotor shaft and force gear on shaft to approximate location. To locate correctly, set worm support on top frame and check mesh of worm with gear by coating threads of worm with Prussian blue. The worm gear must mesh accurately for the proper operation of the regulator.

Adjustment of Rotor Bearing—See Fig. 22

The rotor bearings should be preloaded as follows: Wrap a strap around the face of the worm gear and with a spring balance attached to the end of the strap, adjust the plug in the bottom frame so that it will require 3¾-pounds torque to start the rotor turning. After the preload is set, the threads on the adjusting plug should be prick-punched in two places, opposite each other, to lock in place.

Adjustment of Worm Bearings—See Fig. 23

There are adjusting bushings at each end of the worm on the worm support. These bearings are adjusted for 3½-pounds preload at the factory. This adjustment should not be disturbed unless the bearings have loosened up in service. If it is necessary to readjust these bearings, the procedure should be as follows.

Wrap a strap around the worm threads and with a spring balance attached to the end of the strap take up on the adjusting collars until it requires 3½-pounds torque to start the worm turning. Tap each end of the worm, to seat the bearings, and then recheck the torque. After the adjustment is completed, tighten up the setscrews in the side of the casting, to lock the adjusting collars in place.

Reassemble the worm support to the top frame, making sure that the worm meshes on a center line with the worm gear by adjusting the location of the worm gear on the rotor shaft. Replace dowels in worm support and bolt into place.

Assemble cover, with motor, capacitor and limit switch to worm support. Adjust the mesh between the worm on the motor shaft and the gear on the worm to the minimum backlash, and then bolt into place.

Connect a source of 120 volts to leads "T2" and "H" and then to "T2" and "L" and operate the regulator to the limits to make sure that the limit switch operates properly, so as to stop the motor at the maximum raise and maximum lower positions.

Inspection (Large kva sizes)

To inspect the operating mechanism on the larger size regulators, remove the dust-tight casing from the top of the regulator. The mechanism may now be inspected.

For further inspection, proceed as follows:

Remove the control-supply transformer, the motor, and the capacitor.

Motor

The motor is of the ball-bearing type, and the bearings are packed in grease when assembled. No servicing should be required on either the motor or capacitor.

The motor is held in place on the worm support by three ¼-inch-20 hex studs, the capacitor by two 8-32 hex studs. The bottom frame of the motor is rabbeted to fit into a machined hole in the worm support. This hole is slightly larger than the fit on the motor-end frame, to allow for adjusting the backlash between the motor worm and the Textolite gear. In reassembling the motor, adjust the backlash between the worm and worm gear to the minimum. This can be easily accomplished by turning the hand knob on the top of the motor slightly in each direction and moving the motor toward the front of the regulator until only a small amount of backlash remains. Make sure that when the motor is finally bolted down with the hex studs that the worm does not bind on the gear and, therefore, impede the free operation of the motor rotor. The motor is designed to operate the regulator at 80 per cent of normal rated voltage.

Limit Switch—See Fig. 11

The limit switch, assembled on the worm support, which limits the travel of the regulator rotor in each direction, due to its infrequent operation, requires no servicing, as the wiping action in "making" and "breaking" the circuit will keep the contact surfaces clean. These silver-to-silver contacts under ordinary conditions should last the lifetime of the regulator.

If, due to unusual operating conditions, causing the regulator to operate frequently to its limits, it may be necessary, after a long period of service, to remove the limit switch and smooth up the contacts.

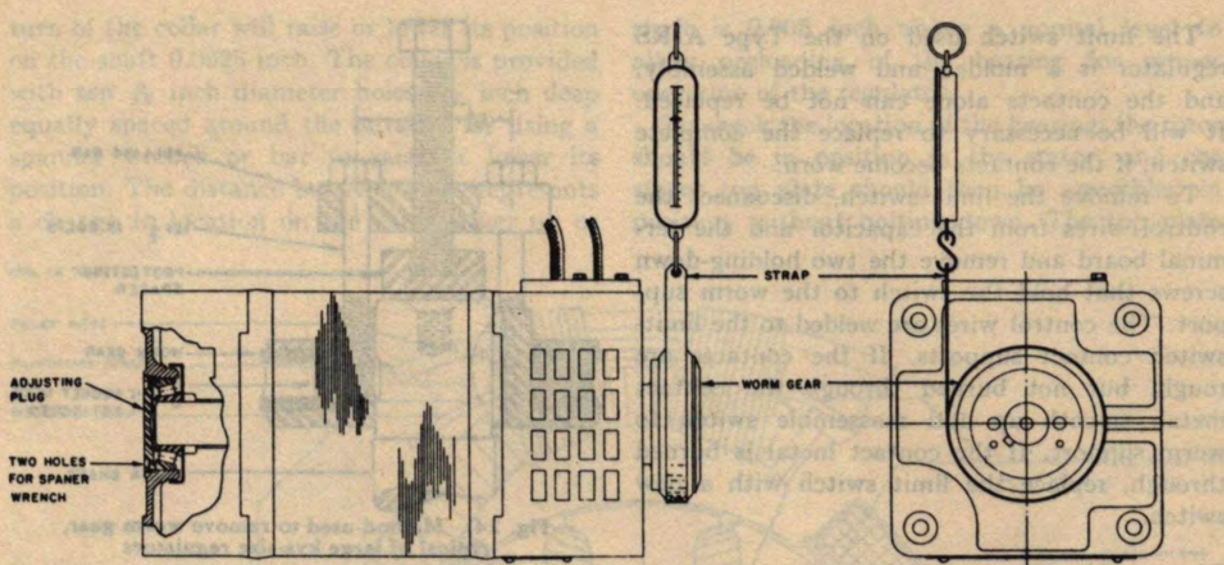


Fig. 22. Adjustment of regulator rotor bearings, typical of small kva-size regulators

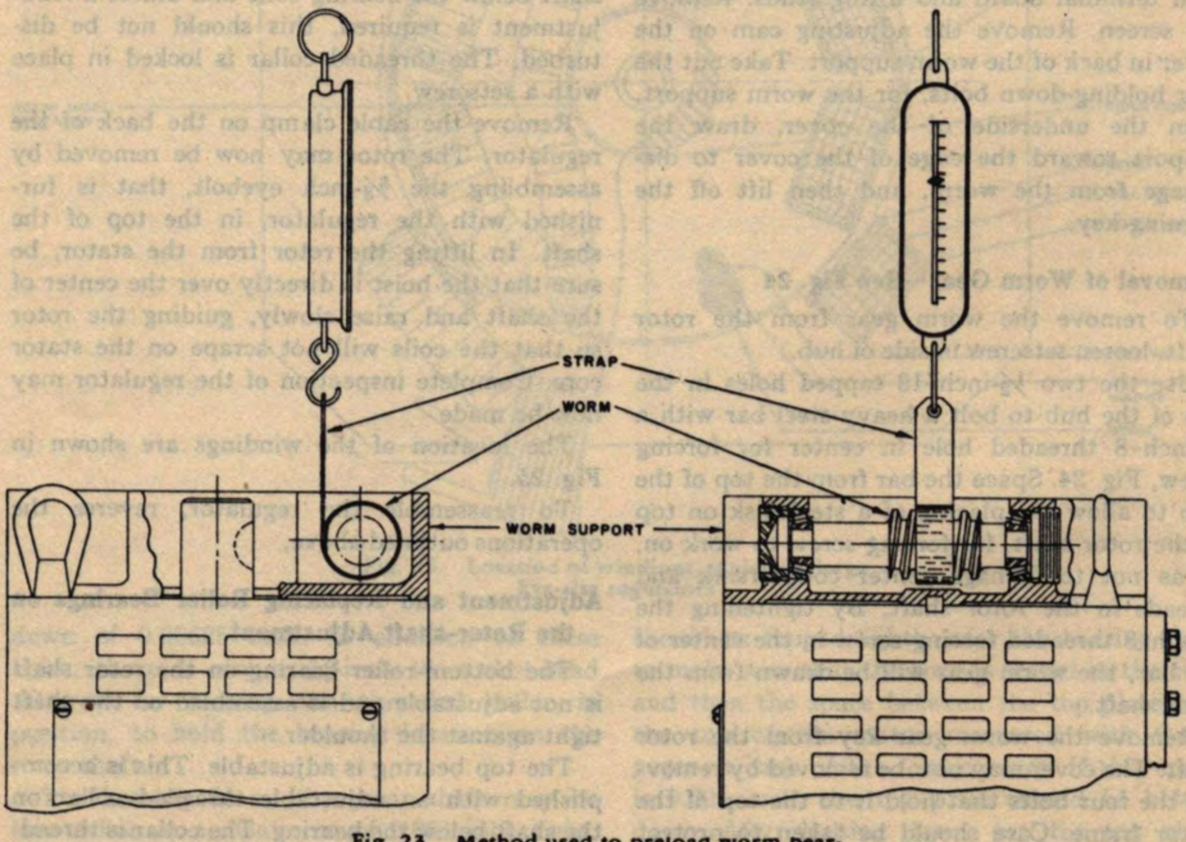


Fig. 23. Method used to preload worm bearings, typical of small kva-size regulators

The limit switch used on the Type AIRS regulator is a molded and welded assembly, and the contacts alone can not be replaced. It will be necessary to replace the complete switch, if the contacts become worn.

To remove the limit switch, disconnect the control wires from the capacitor and the terminal board and remove the two holding-down screws that hold the switch to the worm support. The control wires are welded to the limit-switch contact supports. If the contacts are rough, but not burned through the contact metal, smooth up and reassemble switch to worm support. If the contact metal is burned through, replace the limit switch with a new switch.

Disassembly

Disconnect the control wiring from the terminal board and remove the angle-iron spreader with terminal board and lifting studs. Remove the screen. Remove the adjusting cam on the cover in back of the worm support. Take out the four holding-down bolts, for the worm support, from the underside of the cover, draw the support toward the edge of the cover to disengage from the worm, and then lift off the aligning key.

Removal of Worm Gear—See Fig. 24

To remove the worm gear from the rotor shaft, loosen setscrew in side of hub.

Use the two ½-inch–13 tapped holes in the top of the hub to bolt a heavy-steel bar with a 1 inch–8 threaded hole in center for forcing screw, Fig. 24. Space the bar from the top of the hub to allow the placing of a steel disk on top of the rotor shaft, for forcing screw to work on, so as not to damage center countersink and threads in the rotor shaft. By tightening the 1 inch–8 threaded forcing screw in the center of the bar, the worm gear will be drawn from the rotor shaft.

Remove the worm gear key from the rotor shaft. The cover may now be removed by removing the four bolts that hold it to the top of the stator frame. Care should be taken to protect the bearing cup that will remain in the cover.

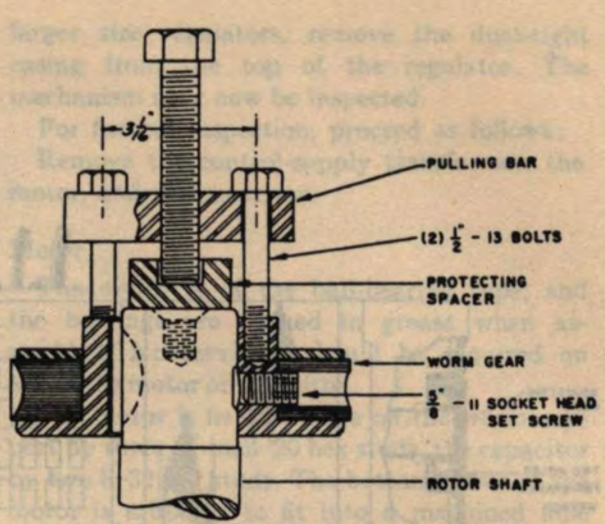


Fig. 24. Method used to remove worm gear, typical of large kva-size regulators

The top roller bearing on the rotor shaft is adjustable by means of a threaded collar on the shaft below the bearing cone and unless a readjustment is required, this should not be disturbed. The threaded collar is locked in place with a setscrew.

Remove the cable clamp on the back of the regulator. The rotor may now be removed by assembling the ⅝-inch eyebolt, that is furnished with the regulator, in the top of the shaft. In lifting the rotor from the stator, be sure that the hoist is directly over the center of the shaft and raise slowly, guiding the rotor so that the coils will not scrape on the stator core. Complete inspection of the regulator may now be made.

The location of the windings are shown in Fig. 25.

To reassemble the regulator, reverse the operations outlined above.

Adjustment and Replacing Roller Bearings on the Rotor-shaft Adjustment

The bottom-roller bearing on the rotor shaft is not adjustable and is assembled on the shaft tight against the shoulder.

The top bearing is adjustable. This is accomplished with an adjustable threaded collar on the shaft below the bearing. The collar is threaded sixteen threads per inch, and one complete turn of the collar will raise or lower its position on the shaft 0.0625 inch. The collar is provided with ten $\frac{5}{16}$ inch diameter holes, $\frac{5}{16}$ inch deep equally spaced around the outside, for using a spanner wrench or bar to raise or lower its position. The distance between holes represents a change in location on the shaft either up or

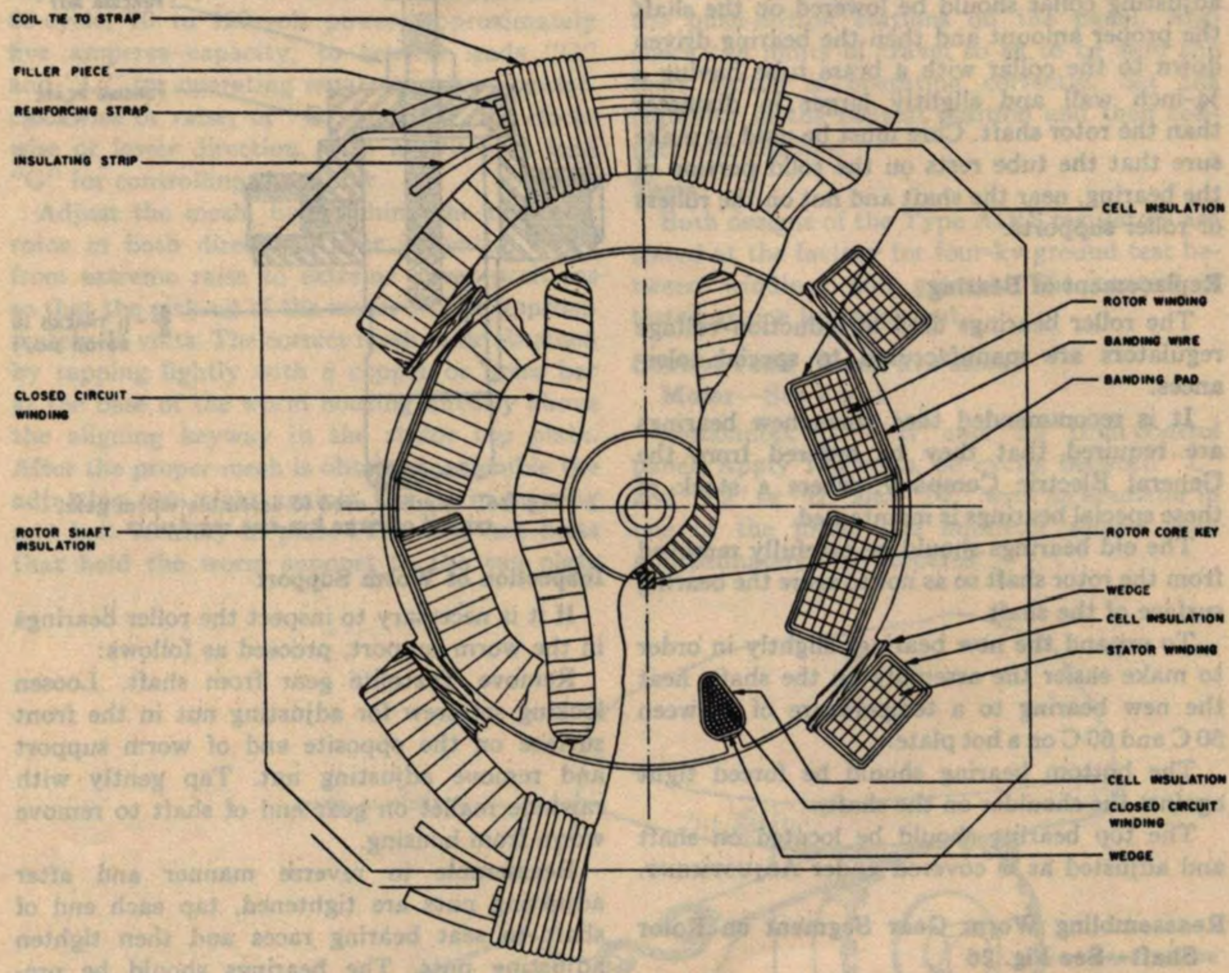


Fig. 25. Location of windings, typical of large kva-size regulators

down of 0.00625 inch. In addition to these holes, there is also a ⅜-inch–16 socket-head setscrew for locking the threaded collar in position, to hold the bearing location on the rotor shaft.

The bearing fit on the rotor shaft may be line-to-line or a maximum of 0.001 inch tight.

The correct location of the bearing on the shaft is 0.005 inch above a normal level to allow preloading of the bearing for proper operation of the regulator.

To check the location of the bearing, the rotor should be in position in the stator, and the stator top plate should then be assembled in position, without bolting down. The top plate should be tapped lightly near the bearing race, to make sure that the cone is seated in the cup, and then the space between the top plate and the top of the stator measured with feeler gages at each of the four corners. If this space is 0.005 inch, the top plate should be bolted down. After bolting down, tap the top plate lightly near the bearing, and then release the four corner bolts and check the spacing on each corner to see that it is correct, before proceeding with the assembly.

If the bearing is too low, it should be forced up with the adjusting collar until the 0.005 inch clearance between the stator top plate and the stator is obtained. If the bearing is too high, the adjusting collar should be lowered on the shaft the proper amount and then the bearing driven down to the collar with a brass tube having a ¼-inch wall and slightly larger in diameter than the rotor shaft. Care must be used to make sure that the tube rests on the solid portion of the bearing, near the shaft and not on the rollers or roller supports.

Replacement of Bearing

The roller bearings used in induction-voltage regulators are manufactured to special tolerances.

It is recommended that when new bearings are required that they be ordered from the General Electric Company, where a stock of these special bearings is maintained.

The old bearings should be carefully removed from the rotor shaft so as not to score the bearing surface of the shaft.

To expand the new bearings slightly in order to make easier the assembly on the shaft, heat the new bearing to a temperature of between 50 C and 60 C on a hot plate.

The bottom bearing should be forced tight against the shoulder on the shaft.

The top bearing should be located on shaft and adjusted as is covered under ADJUSTMENT.

Reassembling Worm Gear Segment on Rotor Shaft—See Fig. 26

Heat the worm gear in an oven, to approximately 100 C. Start the worm gear on the rotor shaft by lightly tapping with a rawhide mallet on the top face of hub of gear only. Use a forcing fixture, Fig. 26, assembled in the ⅝-inch–11 tapped hole in end of rotor shaft and force gear on shaft to approximate location. To locate correctly, set worm support on top stator plate and check mesh of worm with gear by coating threads of worm with Prussian blue. The worm gear must mesh accurately for the proper operation of the regulators. After proper mesh is obtained, the aligning key should be put into keyway in stator top plate and then the worm support should be bolted into place.

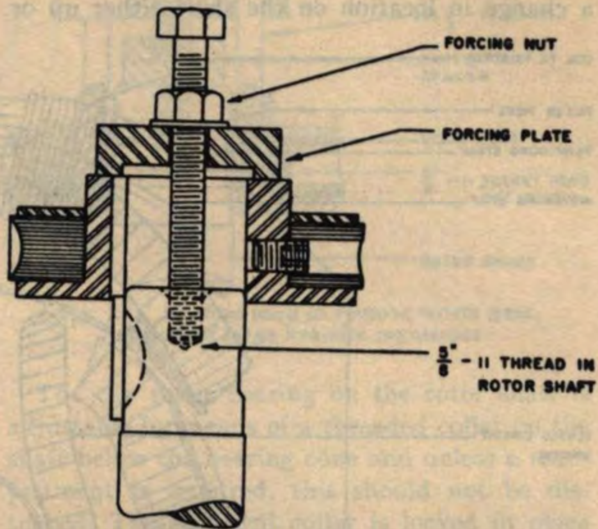


Fig. 26. Method used to assemble worm gear, typical of large kva-size regulators

Inspection of Worm Support

If it is necessary to inspect the roller bearings in the worm support, proceed as follows:

Remove Textolite gear from shaft. Loosen locking setscrew for adjusting nut in the front surface on the opposite end of worm support and remove adjusting nut. Tap gently with rawhide mallet on gear end of shaft to remove worm from housing.

Reassemble in reverse manner and after adjusting nuts are tightened, tap each end of shaft to seat bearing races and then tighten adjusting nuts. The bearings should be preloaded, Fig. 27, as follows

Wrap a strap around the Textolite gear and use a spring balance to measure the torque, tighten the bearing-adjusting nut until the torque, to turn the worm shaft, is not less than two and one half pounds nor more than three pounds. Tap end of shaft with rawhide mallet to insure thorough seating of bearings and check torque. When properly adjusted, lock the adjusting nut with the setscrew in the worm block.

Assemble the motor on the worm support. Adjust the motor worm with Textolite gear for minimum backlash without the worm binding on the gear.

The mesh between the main worm and worm gear segment should be adjusted for correct operation as follows: Connect motor leads to capacitor. Apply a variable source of ungrounded 60-cycle, 70 to 120-volt power, approximately five amperes capacity, to control leads "G" and "L," for operating regulator rotor counter-clockwise or raise, or "G" and "H" for clockwise or lower direction, with a switch in lead "G" for controlling the motor.

Adjust the mesh, by notching the regulator rotor in both directions over its entire range from extreme raise to extreme lower positions so that the pick-up of the motor will be approximately 75 volts. The correct mesh to be obtained by tapping lightly with a copper or brass bar at the base of the worm housing directly above the aligning keyway in the stator top plate. After the proper mesh is obtained, assemble the adjusting cam tight against the worm housing and bolt securely in place The four hex bolts that hold the worm support to the top plate should then be loosened and retightened consecutively to relieve the strains caused when making adjustments. Recheck motor pick-up voltage to make sure that the adjustment is correct.

Set the regulator in the neutral position. Reassemble the dust-tight casing and the control panel. Check the rotation of the regulator from the push-button stations on the panel. Also check the limits of travel so as to be sure the limit switch is operating correctly. Set the regulator in the neutral position and then connect into the line.

Tests

Both designs of the Type AIRS regulators are tested at the factory for four-kv ground test between windings and ground. The control is tested at one kv to ground.

Control Tests (Small kva sizes)

Motor—See Fig. 1

Disconnect "L"—"H" and "T2" from control panel. Apply 120 volts, 60 cycles between "L" and "T2" or "H" and "T2," with an ammeter in one of the lines. The ammeter should read approximately 0.95 amperes.

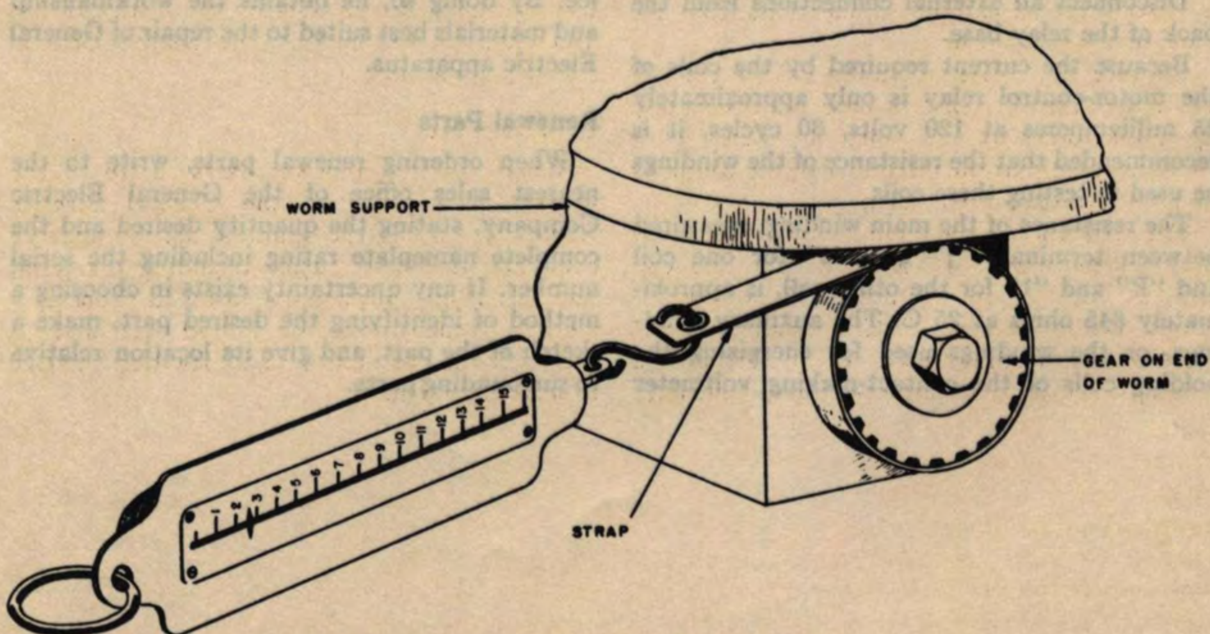


Fig. 27. Method used to preload worm bearings, typical of large kva-size regulators

Motor Capacitor

Disconnect motor leads "T1" and "T3" from capacitor and apply 120 volts, 60 cycles across the capacitor with an ammeter in one line. The ammeter should read approximately 0.55 amperes. Discharge capacitor.

Control Tests (Large kva sizes)

Motor —See Fig. 2

Disconnect leads "L"—"H" between terminal board on regulator and control panel. Apply 120 volts, 60 cycles to "T1" and ground or "T3" and ground with an ammeter in one of the lines. The ammeter should read approximately 1.25 amperes.

Motor Capacitor

Disconnect all of the leads from the capacitor. Apply 120 volts, 60 cycles across the capacitor terminals with an ammeter in one line. The ammeter should read approximately 0.7 amperes. Discharge the capacitor before reconnecting.

Control (All kva sizes)

Motor Control Relay—See Fig. 18

Disconnect all external connections from the back of the relay base.

Because the current required by the coils of the motor-control relay is only approximately 25 milliamperes at 120 volts, 60 cycles, it is recommended that the resistance of the windings be used in testing these coils.

The resistance of the main winding, measured between terminals "J" and "2" for one coil and "F" and "1" for the other coil, is approximately 645 ohms at 25 C. The auxiliary windings, or the windings used for energizing the holding coils of the contact-making voltmeter should be measured between terminals "8" and "S" for one coil and "7" and "V" for the other coil. This value should be approximately 70 ohms.

Type TSB-20 Contact-making Voltmeter—See Fig. 1 and 2

Disconnect all external connections from the terminal studs on the back of the meter.

The current required by the main solenoid coil and the holding coils is so small, it is recommended that the coils be tested by resistance measurement. The main solenoid coil resistance should be measured between stud "4" and "5." This value should be approximately ten ohms at 25 C. The holding or compensating coils should be measured between studs "7" and "V" for the upper coil and "8" and "V" for the lower coil. The value for each coil should be approximately 72 ohms.

Repairs

One of the significant features of the General Electric Company's extensive program is the widespread establishment of service shops. The Purchaser is urged to avail himself of this service. By doing so, he obtains the workmanship and materials best suited to the repair of General Electric apparatus.

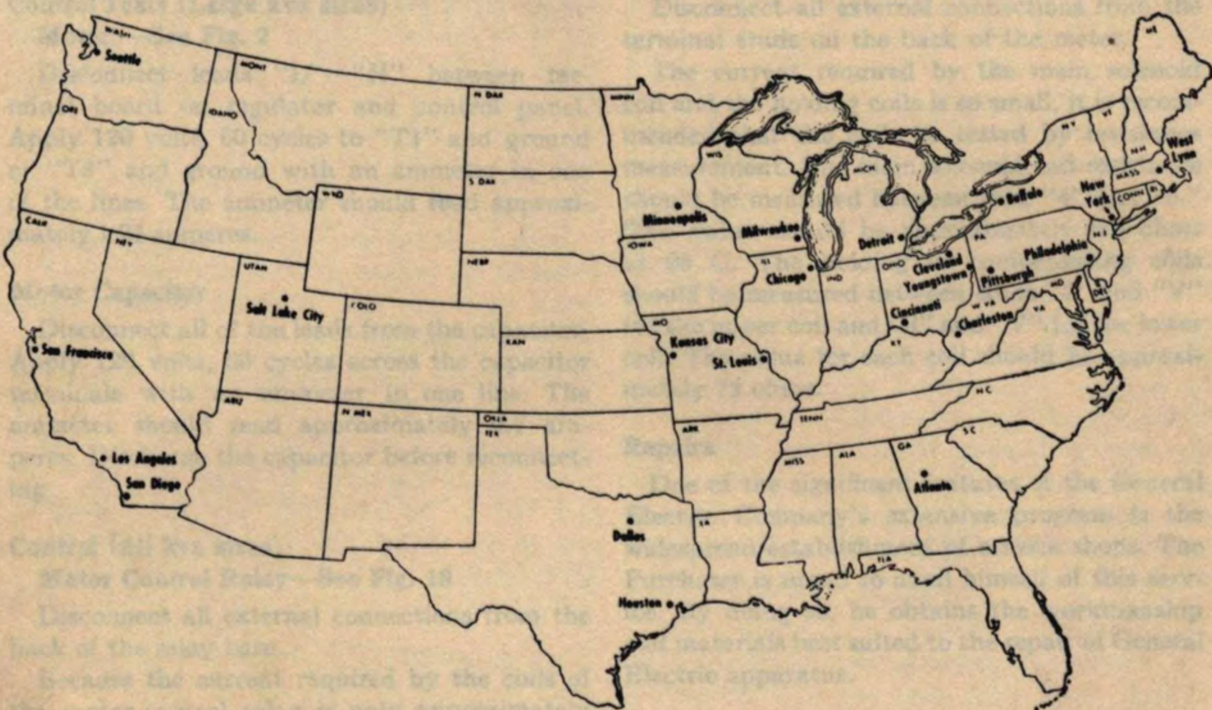
Renewal Parts

When ordering renewal parts, write to the nearest sales office of the General Electric Company, stating the quantity desired and the complete nameplate rating including the serial number. If any uncertainty exists in choosing a method of identifying the desired part, make a sketch of the part, and give its location relative to surrounding parts.

WHEN SERVICE IS REQUIRED

GENERAL ELECTRIC operates 23 apparatus service shops strategically located and competently manned by trained personnel. Each shop is a complete service unit with modern equipment for repairing, reconditioning, and rebuilding G-E apparatus to factory specifications. The services of these shops are available at any time of day or night for work in the shops or on purchaser's premises.

GENERAL ELECTRIC APPARATUS SERVICE SHOPS



SERVICE SHOP	*ADDRESS*	*DAY PHONE*	*NIGHT PHONE*
Atlanta, Ga.	496 Glenn Street, S.W.	WAlnut-9667	WAlnut-7859
Buffalo 11, N. Y.	318 Urban Street	HU-5849	RI-7579
Charleston 28, W. Va.	306 MacCorkle Avenue, S.E.	2-6177	3-1244
Chicago 7, Ill.	849 South Clinton St.	Wabash-5611	Wabash-5654
Cincinnati 2, Ohio	215 West Third Street	Parkway-3433	Parkway-3433
Cleveland 4, Ohio	4966 Woodland Avenue	EN-4464	EN-4464
Dallas 2, Texas	1801 North Lamar St.	R-9121	L-4111
Detroit 2, Mich.	5950 Third Avenue	TRinity-2-2600	TRinity-2-2606
Houston 1, Texas	1312 Live Oak Street	C-9711	C-9714
Kansas City 8, Mo.	819 East 19th Street	Victor-9745	WAbash-3850
Los Angeles 54, Calif.	733 Banning Street	Madison-7381	Madison-1813
Milwaukee 3, Wis.	940 W. St. Paul Ave.	Marquette-5000	Marquette-5002
Minneapolis 1, Minn.	410 Third Ave., N.	Main-2541	Main-2546
New York 14, N. Y.	416 West 13th Street	Wickersham-2-1311	Chelsea-2-8390
Philadelphia 23, Pa.	429 N. Seventh St.	Pennypacker-9000	Pennypacker-8448
Pittsburgh 6, Pa.	6519 Penn Avenue	Atlantic-6400	Atlantic-6408
St. Louis 1, Mo.	1110 Delmar Avenue	Chestnut-8505	Chestnut-3899
Salt Lake City 9, Utah	141 South Third West St.	4-1892	6-4448
San Diego 1, Calif.	2045 Kettner Blvd.	Franklin-7684	Glencove-5-3675
San Francisco 7, Calif.	361 Bryant Street	DO-3740	DO-3748
Seattle 4, Wash.	1508 4th Ave., South	Elliott-1778	CA-3679
West Lynn 3, Mass.	920 Western Avenue	Ly-3-6000	Ly-3-6008
Youngstown 3, Ohio	121 East Boardman St.	Youngstown-44331	Youngstown-44331

APPARATUS DEPARTMENT

GENERAL ELECTRIC

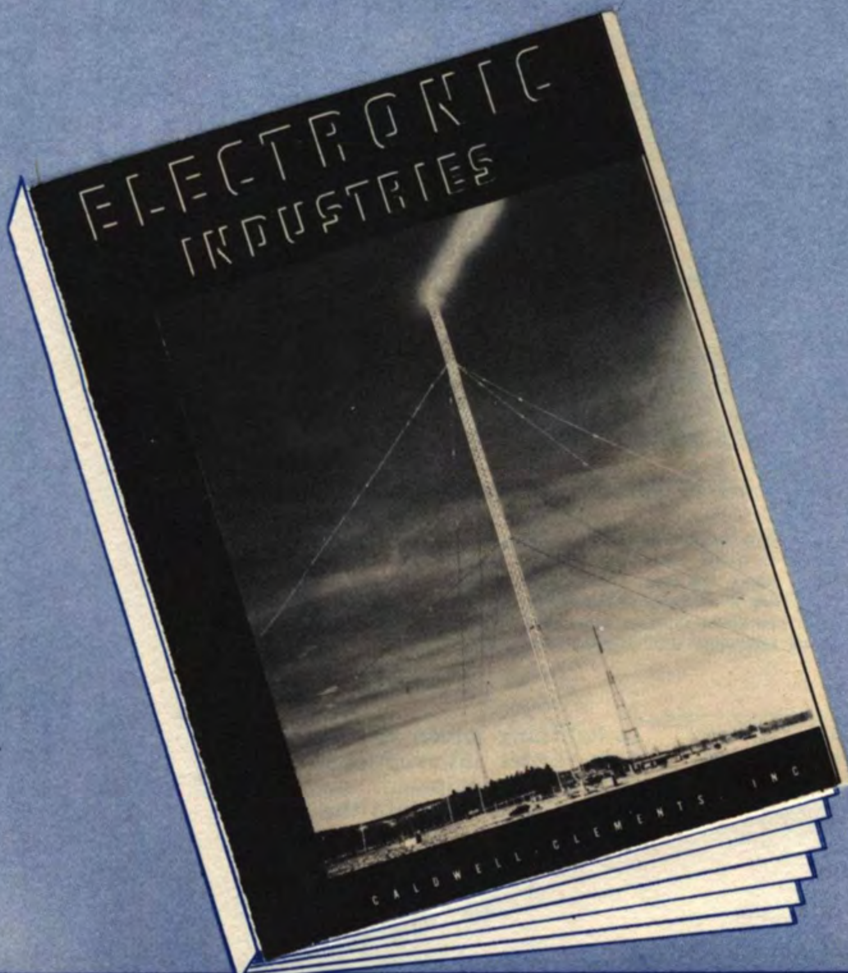
SCHENECTADY, N. Y.

2-47 (8M)

PRINTED IN U.S.A.

PROTECTING AGAINST CARRIER FAILURE

A REPRINT FROM



GENERAL ELECTRIC

EBR-95

PROTECTING AGAINST CARRIER FAILURE

A REPRINT FROM

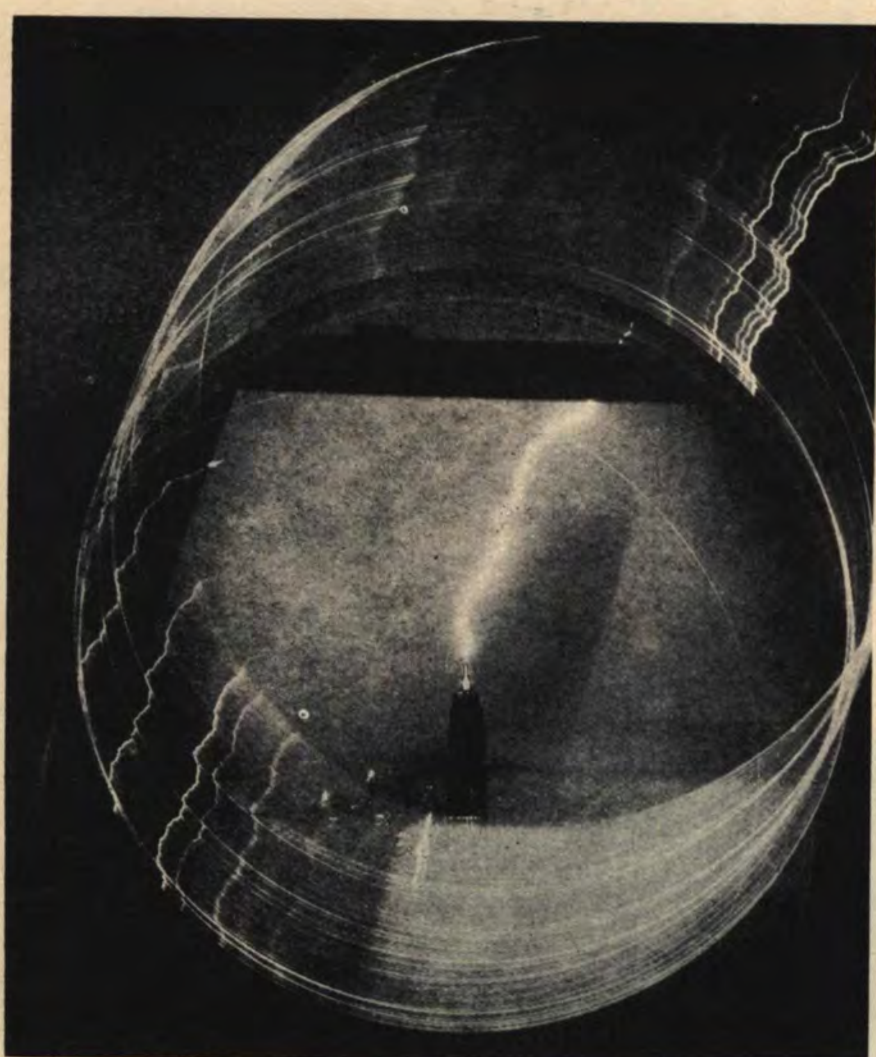
ISSUE OF NOVEMBER 1946

PROTECTING AGAINST

By H. G. TOWLSON

Transmitter Division,
Electronics Dept.,
General Electric Co., Syracuse, N. Y.

Practical methods of insuring against interruptions and loss of broadcast time due to lightning and other causes



WHEN LIGHTNING STRIKES

In this photograph of lightning striking the Empire State Building, the central picture was formed by a fixed lens while the surrounding circles were caused by a rotating lens which can be turned at either ½, 1 or 2 rps. In this photo the lens made slightly over 1 revolution. The overlap can be seen at lower right. This was a multiple stroke consisting of an initial long continuing discharge building up slowly and containing a large number of current peaks (bright streaks), and a shorter continuous discharge beginning with a steep current rise

• Most broadcast station engineers take considerable pride in the efficiency of their methods of operation and are on the alert for means of improvement. One measure of effectiveness, apparent both to the listening public and to the station accountant, is the amount of lost program time. Some failures on the air due to unpredictable breakdown of components are reasonably unavoidable—but a large percentage of potential failures can be minimized or eliminated by use of protective circuits and by systematic scheduling of maintenance.

One of the main sources of trouble is lightning which can cause not only carrier interruptions but destruction of equipment. Rising several hundred feet into the air, the modern vertical radiator makes an effective lightning rod and can be expected to receive several direct hits and numerous induced surges during the season.

Of first consideration, in the case of a series fed tower, is the base insulator which must be protected by a spark gap. Protective gaps to ground usually are supplied with the installation, and the only precaution is to see that they are set close enough to protect the insulator. One method of adjusting the gap is to decrease it to the point where it just flashes with heavy modulation and then to double the spacing for normal operation. The gap electrodes should be cleaned and polished occasionally, especially after storms, so the breakdown setting will not change.

Static Drain Chokes

It is important that there be a conduction path from the tower to ground and from an open wire transmission line to ground. Otherwise, successive surges can charge the system to increasingly higher voltage which eventually must flash to ground. Friction caused by wind, sand or snow storms—even smoke from a passing train—can cause flashovers in a completely insulated system. Fig. 2 shows a commonly used circuit which has a floating tower and transmission line. Fig. 3 is a transmission line termination used in directive systems when a leading phase angle is desired. With base insulated towers, no conduction path to ground exists and must therefore be provided.

It is entirely satisfactory if this path can be found back through the transmitter output circuit—as in the case of an inductively coupled set—or if the usual tower lighting choke acts as a drain, by connecting one side of the light circuit to the tower and grounding one side of the lighting transformer secondary. Otherwise, a copper path must be provided by connecting an rf drain choke across the system to ground.

The design of such a choke is not critical as the normal operating voltage is not great, and the choke impedance can be made so high that the normal current through it will be small. The drain choke can be made of approx. No. 20 dcc wire

CARRIER FAILURE

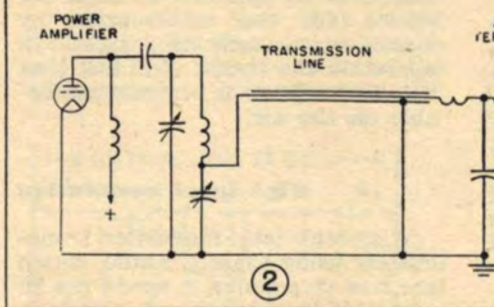


Fig. 2—Common termination which permits tower to float, and requires a static drain choke

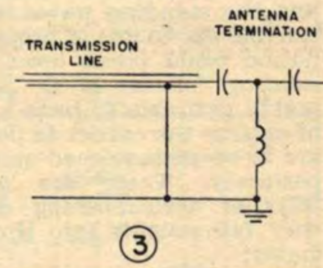


Fig. 3—Another termination circuit which requires use of static drain

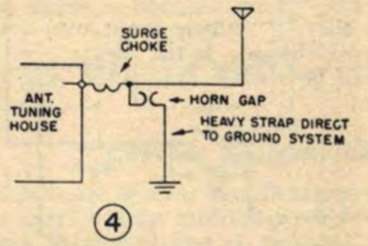


Fig. 4—Arrangement of horn gap and choke coil for protecting against lightning surges

closely wound on a non-hygroscopic form (the first 10 turns should be triple spaced to reduce possibility of breakdown during surges). It is preferable to make the choke rather long and slender to keep the rf voltage per turn low and to keep the distributed capacity down.

For minimum detuning of the circuit which it shunts, the choke should be approximately anti-resonant at the operating frequency of the transmitter. The resonant frequency of a choke can be estimated by calculating its inductance from the usual formula or charts, and its distributed capacity from the approximate empirical equation:

$$C = 1.8\ D$$

Where C = distributed capacity in micro-microfarads

D = diameter of the coil in inches

The resonant frequency then,

$$F = 10^6 / 2\pi\sqrt{LC}$$

Where F = frequency in kc

L = inductance in microhenries

To protect the line terminating equipment, it is advisable to connect a horn-gap from the antenna feeder to ground at the point where the feeder enters the tuning house.

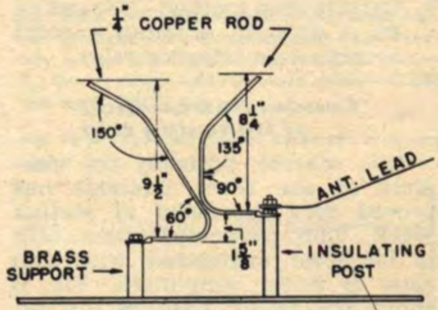


Fig. 5—Horn gap construction that has been successfully used

To increase the effectiveness of the gap it is customary to insert a small choke coil in the feeder on the transmitter side of the gap. This choke can consist of 2 turns wound to 4 in. diameter; No. 4 wire or 3/16 in. tubing makes a rigid self-supporting coil. Fig. 4 shows the connection suggested.

Note that the gap and coil are recommended for grounded tower installations as well as for insulated, as the section of tower below the feeder tap of a grounded tower presents considerable impedance to the lightning surge. Horn-gaps are here specified rather than the commonly used sphere gaps. When a horn-gap flashes, although the transmitter tries to maintain the arc it is automatically cleared due to the inherent design of the horn gap whereas the sphere gap (especially if the balls are mounted in a vertical line as is sometimes done) has much less tendency to clear, and unless other methods are employed to extinguish the arc it may continue until severe damage has been done.

Fig. 5 shows the arrangement of a successful horn-gap based on one described by J. E. Young in Nov. 1937 Broadcast News.

As additional protection to concentric transmission lines, which are especially vulnerable to distruction from lightning surges, it is advisable to use another horn-gap and choke at the tuning house end of the transmission line. With an open wire transmission line it is advisable to use an additional choke

Fig. 6—Circuit using the conduction method of clearing arcs, as applied to low level modulated transmitter

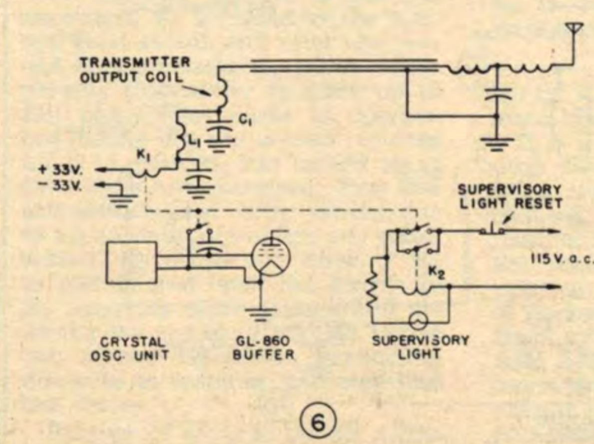
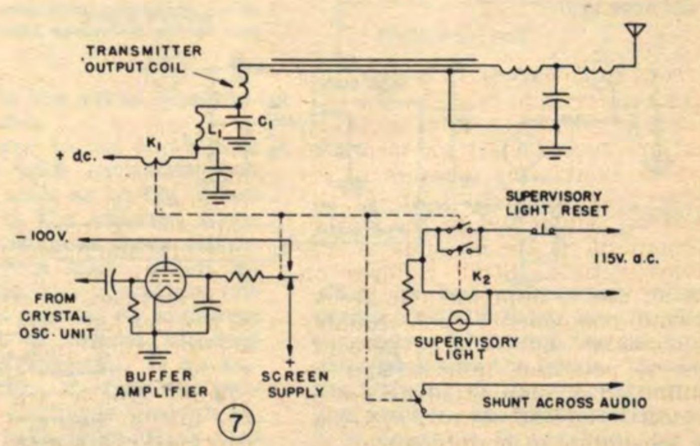
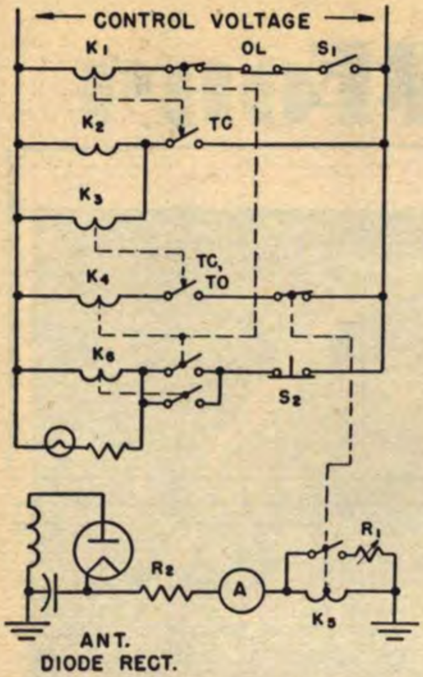


Fig. 7—Conduction method of clearing arc as applied to high level transmitter





K_1, Main rect. start contactor—K_2, Main rect. run contactor —K_3, TC, to relay, 1 sec. timing —K_4, Trip relay aux.—K_5, Diode circuit trip relay—K_6, Supervisory relay—R_1, Drop-out adjusting resistor—R_2, Meter linearity resistor—S_1, Plate on-off switch—S_2, Supervisory light reset

Fig. 8—Circuit illustrating carrier drop method of clearing arcs

and horn-gap at the point where the transmission line enters the transmitter building. This gives protection from voltages induced into the open wire line.

Carrier tripping circuits

The tendency for a transmitter to maintain an arc once a gap has broken down can be largely counteracted by use of the self-clearing horn-gap. At stations where lightning trouble is infrequent, this protection is often sufficient. But most stations find the horn-gap occasionally is slow in breaking the arc, depending on weather conditions, wind direction, etc. Besides increasing the time off-the-air, this condition can result in momentarily high voltages at other points of the system.

With a concentric transmission line the standing waves set up in the line due to loss of proper termination could break down the insulating beads. It is, therefore, highly desirable to have a method of cutting the carrier to permit the arc to be extinguished quickly and positively. There are numerous ways of accomplishing this, and they fall roughly into three categories;

1. Use of a phototube actuated by the arc flash. This method is not recommended as it protects at only one point of the system.
2. Conduction method—Use of the arc itself as a conducting path for current through a tripping relay.
3. Carrier drop method—depending on a drop in antenna current to actuate a tripping relay.

Conduction method of lightning trip

This scheme, probably the simplest of the three methods has proved very successful at station WGY. This particular transmitter is low-level modulated with two class B linear amplifiers. Fig. 6 shows the circuit used. A low reactance capacitor, C_1, was inserted in the ground side of the coupling coil, and the trip relay, K_1, was connected through a small choke, L_1, to the 33 v. dc filament bus as shown. If an arc to ground occurs anywhere along the transmission line, terminating equipment or antenna, current flows through K_1. When K_1 closes, the rf output of the crystal unit is shorted through a blocking capacitor, dropping the transmitter output to a very low level and allowing the arc to extinguish—whereupon K_1 opens and the carrier returns to normal. It is of course necessary that all transmitter stages following the trip relay be biased to near cut-off. K_2 is a supervisory relay which seals in whenever K_1 operates, to show the reason for the interruption by means of an indicating light. In operation the circuit is so fast that the interruption is scarcely noticeable on the air.

High level modulation

With high-level modulated transmitters using Class B Audio, which are now so popular, it would not be advisable to short the rf excitation as is done with the low-level modulated transmitter, since high voltage surges in the modulation transformer and its associated reactor might result. One suggested circuit employs a trip relay to apply high negative bias to a control or screen grid through a resistor-capacitor network of about 0.1 second time constant.

Fig. 7 shows the circuit as applied to a high-level transmitter (General Electric Type BT-25A). Note that an additional contact on K_1 shorts the incoming audio line (in the BT-25A a 15 db pad is inserted) to further protect the modulation transformer. With high-level transmitters located where lightning surges are not frequent, it may be simpler to let the trip relay merely open the holding circuit of the main rectifier plate contactor. However, the resulting carrier interruption will be more noticeable.

Note that with this conduction method no drain choke should be connected across the system, but a drain path is provided through the protective apparatus.

Another approach to the problem is indicated by Fig. 8, this method being directly applicable to either high or low level modulated transmitters. It acts to remove plate

Fig. 9—Carrier drop method with excitation cut-off

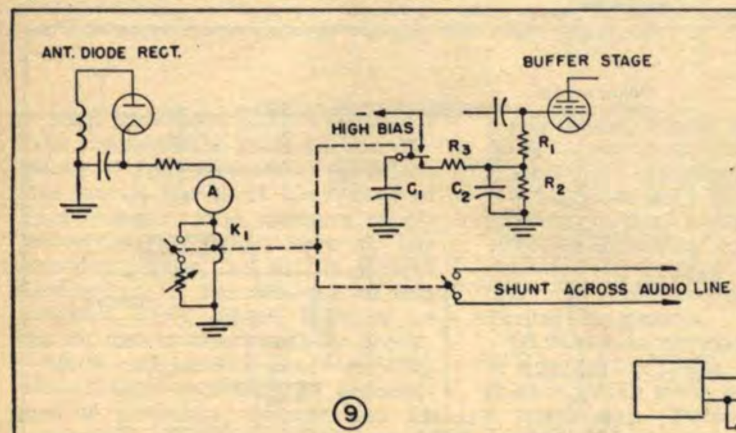
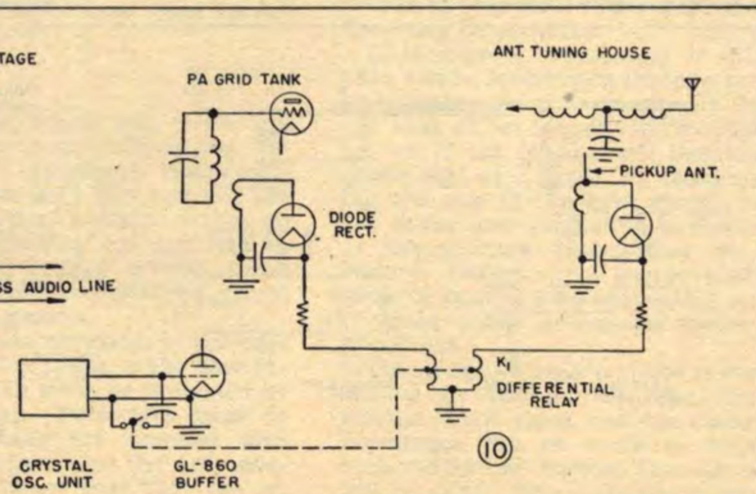
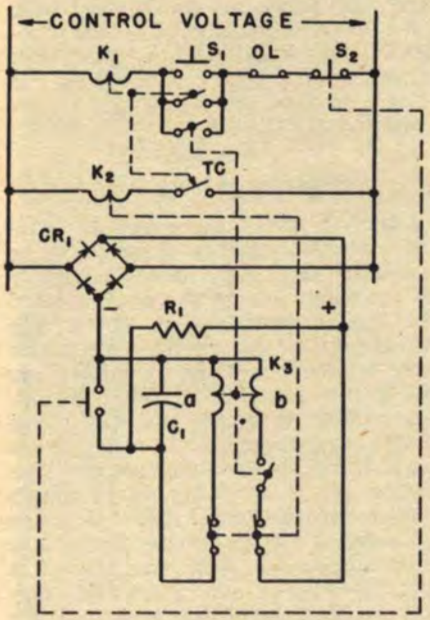


Fig. 10—Modified carrier drop circuit applied to low level modulated transmitter



voltage and so causes a more noticeable interruption than does the excitation removal method. K_1 is the usual main rectifier start contactor whose coil is in series with overload relays, interlock circuits, etc. K_2 is the run contactor controlled by a one second time delay closing contact on K_1. Shunted across K_2 is a relay K_3 which can be of the bellows type to give approximately



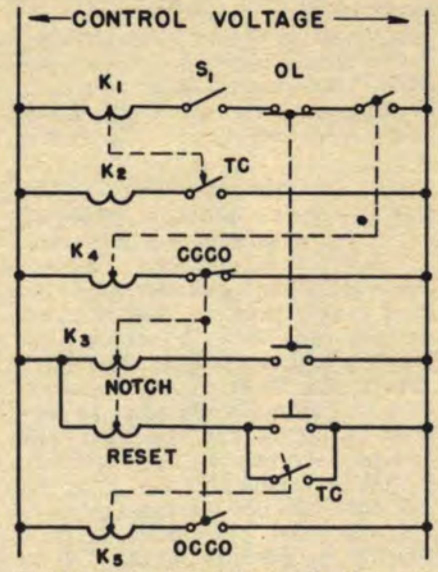
K_1, Main rect. start contactor—K_2, Main rect. run contactor—K_3, Reclosure relay—R_1, Charging resistor 1.5 megohms—S_1, Main rect. on button—S_2, Main rect. off button—CR_1, Copper oxide rect.—OL, Overload relays

Fig. 11—Automatic reclosure circuit giving one reclosure before lockout

one second time delay in both opening and closing a normally open contact. This contact of K_3 is in series with a normally closed contact of K_5, a relay whose coil is in the dc path of a diode rectifier coupled to the antenna circuit (this diode is usually the remote antenna meter rectifier). K_4 has a normally closed contact in series with the coil of K_1.

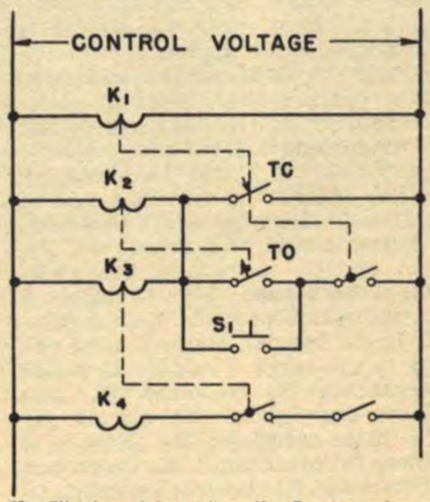
On starting up, K_5 is not yet energized; K_1 is closed by the normal start switch and after one second the circuit to K_2 closes which permits the carrier to come up to full power. K_3 starts to operate, but during the one second required for it to close, K_5 has picked up so that K_4 is not energized. Now if a sufficient carrier drop occurs due to an antenna arc or for any other reason, K_5 drops out allowing K_4 to pull in and open the circuit to K_1 removing plate voltage and allowing the arc to extinguish. After one second K_3 opens, permitting power to be restored, and recycling the device.

Purpose of R_1 is to permit a fine adjustment of the carrier level at which it is desired to have the circuit operate. If desired, K_4 can be tied in with a reclosure circuit so as to recycle only a definite num-



K_1, Main rect. start contactor—K_2, Main rect. run contactor—K_3, Notching relay—K_4, Auxiliary to K_3—K_5, Reset timing relay, 10 secs.—S_1, On-off switch—OL, Overload relays—CCCO, See text—OCCO, See text

Fig. 12—Multi-shot type of automatic reclosure circuit



K_1, Fil. time delay relay—K_2, By-pass relay—K_3, Auxiliary relay—K_4, Plate contactor—S_1, Emergency start button

Fig. 13—Circuit permitting immediate restoring of power following momentary voltage drop

ber of times in the event of equipment breakdown.

If it is desired to use the carrier drop method with excitation cutoff, a circuit such as in Fig. 9 can be used. K_1 is the antenna diode rectifier relay. R_1 plus R_2 constitute the regular grid leak. When K_1 picks up on normal operation, one of its contacts permits C_1 to charge from a point of several hundred volts negative potential. If an antenna arc occurs, K_1 falls out permitting C_1 to discharge through R_3, and apply a high momentary bias on the grid of the buffer tube—this drops the output to near zero and extinguishes the antenna arc. As soon as C_1 has lost sufficient charge, the rf output comes up and K_1 pulls in permitting C_1 to again charge up in readiness for further trouble. R_3 and C_2 permit shaping of the voltage pulse applied to the buffer grid, as discussed previously, and again a contact on K_1 shorts the audio input during periods of no excitation. All rf stages following the buffer are biased to near cut-off.

Carrier drop method

There are several modifications of the carrier drop method which involve balancing the rf voltages at two points. One of these is diagrammed in Fig. 10. K_1 is a relay with two windings excited from diodes coupled as shown. Under normal conditions the two diode currents are equal and the differential relay remains open. However, if anything occurs to upset the linear relation existing between rf voltages at the two points shown, K_1 will operate to short the excitation and break the arc, whereupon K_1 opens and the carrier comes up to normal. If this circuit is applied to a transmitter whose final stage is modulated, one diode could couple to the PA plate tank and the other to the antenna matching equipment.

Another source of outages is from overloads due to 'gas-kicks' in the large tubes and 'arc-backs' in mercury vapor rectifiers. These are

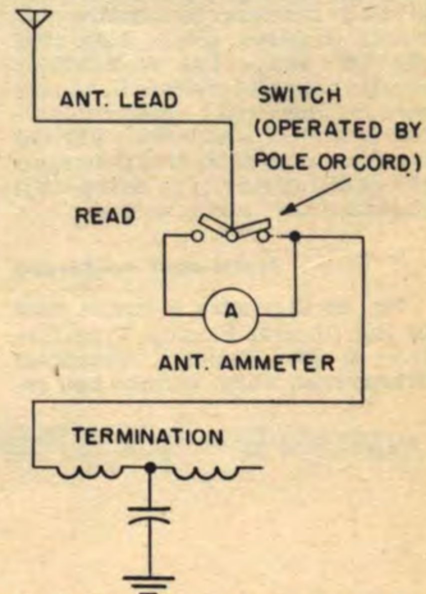


Fig. 14—Circuit for protecting antenna ammeter from burnout when not in use

often of but momentary consequence and the tubes tend to clean themselves by driving the gas molecules back into the anode. However, the tripping of the overcurrent relays removes the plate voltage, and it is desirable to get back on the air with a minimum of lost time. But the system used must be such that if further overloads continue at a rate endangering the equipment, the power must be held off. Two of the more popular of such 'reclosure circuits' will be described.

Fig. 11 shows a 'one-shot' type circuit which is used on the General Electric G-100A 100 kw international broadcast transmitter. In this circuit, K_1 and K_2 are the main rectifier start and run contactors, while K_3 is the reclosure relay operating on dc from the copper oxide or selenium rectifier CR_1. As shown, with K_2 not energized, C_1 is prevented from charging to appreciable voltage because of the shunt across it presented by the 'a' coil of reclosure relay K_3. After K_1 has been energized for about 10 seconds, C_1 has become charged to a voltage sufficient to close K_3.

Now, if an overload occurs, K_1 and K_2 will fall out permitting the two contacts in the coil circuits of K_3 to close. C_1 discharges into the 'a' coil of K_3 momentarily closing it and permitting the 'b' coil to seal itself in. An auxiliary contact on K_3 shorts across the rectifier 'On' button restoring the transmitter to operation. This permits C_1 to again start charging and after 10 seconds to be ready for another reclosure. However, if another outage should occur in less than 10 seconds, the reclosure relay will not operate and it will be necessary to push the 'On' button to restore power. Note that the 'Off' button has an auxiliary contact which discharges C_1 to prevent an undesired reclosure following a normal shutdown. Varying the resistance of R_1 will determine the charging rate of C_1 and permit changing the timing as desired.

Multi-shot reclosure

Fig. 12 illustrates a circuit used in the General Electric Type BT-25A 50 kw Standard Broadcast Transmitter which permits two reclosures before locking out. K_3, the reclosure relay, is of the notching type with an electrical reset coil. This relay has two separate circuits, one of which has the sequence on notching of "closed—closed—closed—open", while the other has "open—closed—closed—open" for reset timing.

If an overload relay operates, the normally open contacts energize K_3 permitting it to advance to its second position (also closed). A second overload will advance K_3 to its third closed position, but a third overload will lock it out on the fourth position (Open). The purpose of the timing relay K_5 is to reset K_3 automatically after 10 seconds providing the fourth (lock-out) position has not been reached, so that overloads over a long period can not 'add up' on the reclosure relay. A reset pushbutton is provided which permits resetting K_3 to position 1 at any time.

Line voltage protection

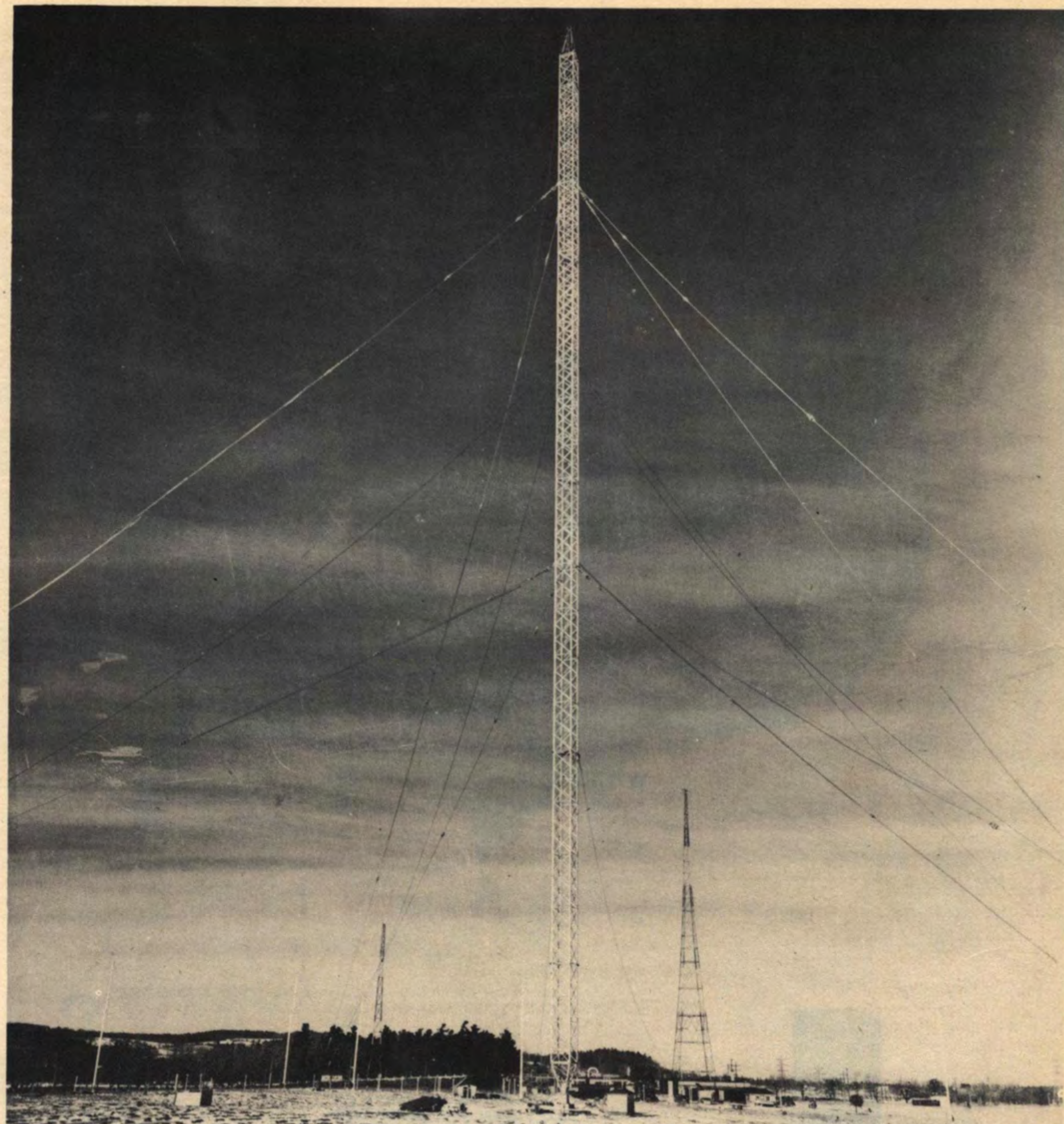
Most modern transmitters use mercury vapor rectifier tubes. As these require a filament pre-heat time of about one minute before application of plate voltage, it is usual to include a time delay relay to hold off plate voltage until this time has elapsed. However, if a momentary line voltage dip occurs of magnitude to drop out the time delay relay it would be necessary in the absence of other circuits to wait until the relay again times out—even though the tubes did not cool enough to require the additional heat time. Fig. 13 shows a circuit which protects against this. K_1 is the regular filament time delay relay—after 1 minute it closes permitting K_2 to close—K_3 also closes completing the circuit for the plate contactor K_4. Now if a power failure occurs, K_1 drops out at once but K_2 requires 2 seconds to fall out. If the power is restored before K_2 has dropped out, K_3 is picked up at once and plate power can be applied. If more than 2 seconds have elapsed before power is restored, K_2 will also have fallen out and it will be necessary to either wait 1 minute for K_1 to again time out or to push the Emergency Start Button. Caution should be used in use of this button as insufficient timing could injure the rectifier tubes. A good rule is to wait approximately one and one-half times the length of time that the filament power was off (up to 1 minute) before using the Emergency Start Button.

Antenna meter protection

Another piece of equipment vulnerable to lightning damage is the antenna ammeter. This is usually a thermocouple instrument located in the antenna lead above the terminating equipment. Due to the low resistance of the thermocouple it is not feasible to short it out. Removing it from the circuit is more satisfactory. A relay or a switch can be used for this purpose. Although it is desirable to use a make-before-break type, this is not absolutely necessary as the rf arc will carry over until the circuit is closed. Fig. 14 shows a simple circuit which has operated well for this purpose.

If a remote meter is used to give indication of antenna current, it usually will be found that the current transformer and thermocouple often used for this are subject to frequent burn-out. A diode rectifier coupled to antenna circuit will be found more trouble free and cheaper to replace.

That such measures have been successfully utilized is attested by the fact that some stations, even of 50 kw power, lose as little as 30 seconds during a broadcast year of 7000 hours. To achieve such a record, it is necessary to give careful attention to details, and it is hoped that the above brief description may prove helpful to station engineers.



"THIRTEEN MILES OF GROUND WIRE"

625-Foot Vertical Radiator Antenna. General side view showing insulated guy wires extending in four directions, and rows of earth on ground which show location of trenches radiating from tower base, in which are imbedded thirteen miles of ground wire. Old antenna supporting towers can be seen in background. Part of G-E Radio Broadcasting Station WGY at Schenectady, N. Y.

G-E offices *everywhere* are at your service! For complete information on the best equipment for every type of broadcasting, special representatives are located at:

ATLANTA 3, GEORGIA
187 Spring Street, N.W.

BOSTON 1, MASSACHUSETTS
140 Federal Street

CHICAGO 54, ILLINOIS
Merchandise Mart

CINCINNATI 2, OHIO
215 West Third Street

CLEVELAND 4, OHIO
4966 Woodland Avenue

DALLAS 2, TEXAS
1801 North Lamar Street

DENVER 2, COLORADO
650—17th Street

KANSAS CITY 6, MISSOURI
106 West 14th Street

LOS ANGELES 54, CALIFORNIA
212 North Vignes Street

MINNEAPOLIS 2, MINNESOTA
12 South Sixth Street

NEW YORK 22, NEW YORK
570 Lexington Avenue

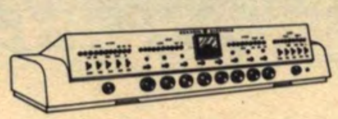
PHILADELPHIA 2, PENNSYLVANIA
1405 Locust Street

SAN FRANCISCO 6, CALIFORNIA
235 Montgomery Street

SEATTLE 11, WASHINGTON
710 Second Avenue

WASHINGTON 5, D. C.
806—15th Street, N.W.

TRANSMITTERS



STUDIO EQUIPMENT

ANTENNAS

ELECTRONICS DEPARTMENT

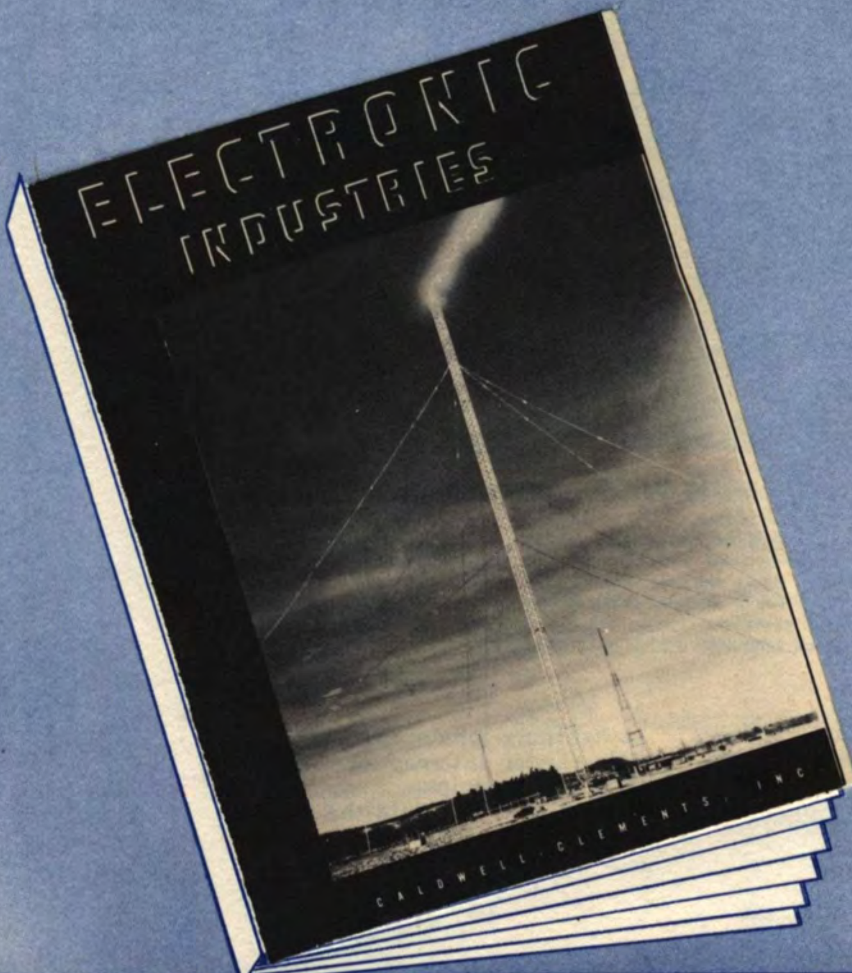
GENERAL ELECTRIC

SYRACUSE 1, NEW YORK

3M-1-47

PROTECTING AGAINST CARRIER FAILURE

A REPRINT FROM



GENERAL ELECTRIC