TYPE

BTA-10F

BROADCAST TRANSMITTING EQUIPMENT

RCA

BTA-10E

OUR TRANSMITTER BTA-5F
SERIAL NO BC-7096

TYPE BTA-10F

BROADCAST TRANSMITTER

MI-7266-C and D

INSTRUCTIONS

Manufactured by

RADIO CORPORATION OF AMERICA
ENGINEERING PRODUCTS DEPARTMENT
Camden, N. J., U. S. A.

Printed in U. S. A.

IB-30141

WARNING

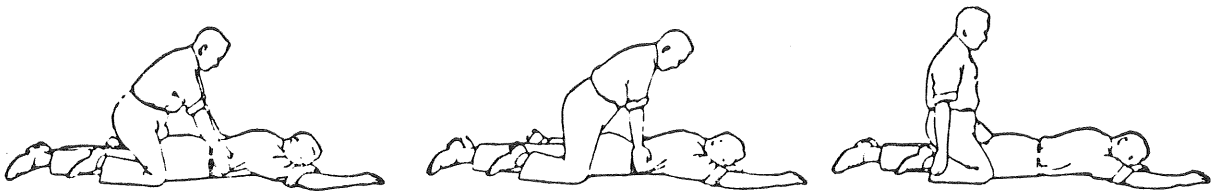
THE VOLTAGES EMPLOYED IN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER HUMAN LIFE. EVERY REASONABLE PRECAUTION HAS BEEN OBSERVED IN DESIGN TO SAFEGUARD THE OPERATING PERSONNEL. AN IMPORTANT PART OF THE PROTECTIVE SYSTEM IS THE SERIES OF DOOR INTERLOCK SWITCHES, AND ANY TAMPERING WITH THESE SWITCHES SHOULD BE PROHIBITED. THE POWER SHOULD BE REMOVED COMPLETELY BEFORE CHANGING TUBES OR MAKING INTERNAL ADJUSTMENTS.

FIRST AID IN CASE OF ELECTRIC SHOCK

1. PROTECT YOURSELF with dry insulating material.

2. BREAK THE CIRCUIT by opening the power switch or by pulling the victim free of the live conductor.

   DON'T TOUCH VICTIM WITH YOUR BARE HANDS until the circuit is broken.



(A) (B) (C)

3. LAY PATIENT ON STOMACH, one arm extended, the other arm bent at elbow. Turn face outward resting on hand or forearm.

4. REMOVE FALSE TEETH, TOBACCO OR GUM from patient's mouth.

5. KNEEL STRADDLING PATIENT'S THIGHS. See (A).

6. PLACE PALMS OF YOUR HANDS ON PATIENT'S BACK with little fingers just touching the lowest ribs.

7. WITH ARMS STRAIGHT, SWING FORWARD gradually bringing the weight of your body to bear upon the patient. See (B).

8. SWING BACKWARD IMMEDIATELY to relieve the pressure. See (C).

9. AFTER TWO SECONDS, SWING FORWARD AGAIN. Repeat twelve to fifteen times per minute.

10. WHILE ARTIFICIAL RESPIRATION IS CONTINUED, HAVE SOMEONE ELSE:

    (a) Loosen patient's clothing.

    (b) Send for doctor.

    (c) Keep patient warm.

11. IF PATIENT STOPS BREATHING, CONTINUE ARTIFICIAL RESPIRATION. Four hours or more may be required.

12. DO NOT GIVE LIQUIDS UNTIL PATIENT IS CONSCIOUS.

TABLE OF CONTENTS

SUPPLEMENTS

COMMERCIAL BULLETINS

SECTION I

Technical Summary

Electrical Characteristics

Type of Emission ..... A-3 (Telephone)

Power Output (40 to 250 ohms grounded load) ..... 10 kw

Frequency Limits ..... 540 to 1,600 kc

Frequency Stability ..... assigned frequency ±10 cycles

Power Supply Requirements:

230 volts, 50 or 60 cycles, 3-phase, capable of supplying normal loads up to 26 kw at 89 per cent power factor and peak loads up to 40 kw at 91 per cent power factor with an instantaneous regulation not exceeding 3 per cent and a slow-time drift of not more than 5 per cent. A separate 115-volt, 50- or 60-cycle, single-phase supply is required for the crystal heaters which consume approximately 30 watts.

Power Input:

Average Program Level (10 kw output) ..... approx. 26 kw

Modulation Factor=1 (10 kw output) ..... approx. 33.5 kw

Type of Modulation ..... High Level—Class "B"

Audio Frequency Input—600 ohms:

Program Level (10 kw output) ..... approx. +4.5 vu

Modulation Factor=1.0 ..... approx. +12.5 vu

Audio Frequency Response ..... Uniform Within ±1.5 db 30 to 10,000 cycles

Audio Frequency Distortion:

Modulation Factor=0.95 ..... not to exceed 3 per cent RMS, 50 to 7,500 cycles

Residual Noise—(Below 100 per cent Modulation) ..... 60 db (unweighted)

Tube Complement

Radio Frequency:

Crystal Oscillators (1V2) 2 RCA-807

Buffer (1V4) 1 RCA-828

Driver (1V5, 1V6) 2 RCA-810

Power Amplifier (1V7, 1V8) 2 RCA-892-R

Audio Frequency:

1st Amplifier (2V1, 2V2) 2 RCA-1620

2nd Amplifier (2V3, 2V4) 2 RCA-828

Driver (2V5, 2V6, 2V9, 2V10) 4 RCA-828

Modulator (2V7, 2V8) 2 RCA-892-R

Rectifiers:

Bias (3V3, 3V4) 2 RCA-8008

Low Power (3V1, 3V2) 2 RCA-8008

Main (7V1 to 7V6) 6 RCA-8008

Mechanical Specifications

Dimensions:

Overall Length	171½ inches
Overall Height	85½ inches
Enclosure Depth	38½ inches
Plate Transformer (oil-filled)	Base 27⅜ x 21, Height 72½ inches
(air-cooled)	Base 34 x 21, Height 26 inches
Modulation Transformer	Base 26 x 20, Height 24½ inches
Modulation Reactor	Base 29½ x 24½, Height 21 inches
Console	Base 60 x 34½, Height 41½ inches
Building Entrance	Minimum 38½ inches wide, 50½ inches high
Maximum Length of Single Unit	89½ inches

Weight:

Transmitter Weight (net approx.)	6,500 pounds
Modulation Transformer	1,138 pounds
Modulation Reactor	1,382 pounds
Plate Transformer (oil-filled)	1,540 pounds
(air-cooled)	735 pounds
Console	393 pounds

SECTION II

Equipment

The complete Type BTA-10F Broadcast Transmitter is identified by the Stock Number MI-7266-C for 60-cycle supply, and MI-7266-D for 50-cycle supply, and contains the following "Master Items":

Qty.	Description	Stock Nos. 60-cycle	50-cycle
1	BTA-10F B/C Transmitting Equipment consisting of:	MI-7098-G	MI-7098-H
	1 R.F. Unit	MI-7259-G	MI-7259-H
	1 Low Power Rectifier Chassis	MI-7253-D	MI-7253-D
	1 Audio Unit	MI-7258-G	MI-7258-H
	1 Modulator Output Unit	MI-7087-B	MI-7087-B
	1 Power Control Unit	MI-7257-C	MI-7257-D
	1 Transmitter Base Assembly	MI-7255-A	MI-7255-A
	1 Enclosure	MI-7256-B	MI-7256-B
	1 Interconnection Jumpers	MI-7077	MI-7077
2	UL-4392 Oscillator Units	MI-19458	MI-19458
2	TMV-129-B Crystal Units (Crystal Ground to Specified Frequency)	MI-7467	MI-7467
**1	Plate Transformer { air-cooled (indoor type)	MI-7088-B	MI-7088-B
	{ oil-filled	MI-7088-A	MI-7088-A
*1	Antenna Tuning Unit { with Monitor Rectifier	MI-28902-B	MI-28902-B
	{ less Monitor Rectifier	MI-28902-A	MI-28902-A
1	Supervisory Control Console	MI-11616	MI-11616
*1	Relay Panel (Audio level change) (Gray)	MI-4309-B	MI-4309-B
1	Installation Material Kit	MI-7268-E	MI-7268-E
1	Miscellaneous Hardware Kit	MI-7474	MI-7474
1	Tool Kit	MI-7086-A	MI-7086-A
1	Touch-up Kit	MI-7499-A	MI-7499-A
†	Set of Tubes	MI-7084-A	MI-7084-A
1	Set of Frequency Determining Capacitors (specify frequency)	MI-19465-B	MI-19465-B
2	Instruction Books	IB-300141	IB-300141
‡2	Installation Notes	IB-30099-1	IB-30099-1

* Optional equipment.
** Specify transformer desired.
† Quantity to be specified by customer.
‡ Shipped prior to transmitter shipment.

SECTION III

Description

The type BTA-10F transmitter has been designed to meet the requirements of the standard broadcast band for a medium-power transmitter representing the latest developments of the industry electrically and mechanically.

Capable of operation over a frequency range of 540 to 1,600 kilocycles, the nominal power output is 10 kilowatts with facilities for instantaneous reduction of output to approximately two kilowatts. Transmitter output may be delivered to a load range of 40 to 250 ohms unbalanced, either transmission line or antenna matching network.

Frequency control is by two Type UL-4392 crystal-controlled oscillators developed specifically for this application. Alternate oscillators may be placed in operation instantaneously by operation of a selector relay which is push-button controlled from the transmitter front panel. The crystals have a low temperature coefficient (less than 1.5 parts per million per degree Centigrade), and are mounted in compensated, temperature-controlled holders, Type TMV-129-B. Both the crystal holders and the complete oscillator assemblies are of the plug-in type. Overall frequency stability is better than ± 10 c.p.s.

Construction

The equipment comprises seven major units or assemblies: (1) radio frequency unit; (2) low power rectifier chassis; (3) audio frequency and main rectifier unit; (4) power control unit; (5) transmitter base (2 sections); (6) transmitter unified front (2 sections); (7) auxiliary equipment, modulation transformer, modulation reactor, and plate transformer. The assembled transmitter is shown in Figure 1. Full access to the equipment is provided through the four front doors. All tubes are replaceable from the front and are visible through the viewing ports.

All frames are constructed of formed welded "U" sections heavily copper plated. At installation the frames are bolted to a heavy channel base which has been built in two sections for convenience in handling. The main interconnecting wire duct is formed into the base.

Vertical chassis construction is employed throughout this transmitter. The first compartment on the left contains the high-power radio-frequency tubes and the output tank. The second compartment from the left contains the low-power radio-frequency, low-power audio-frequency, auxiliary rectifier, and bias rectifier components. The third compartment from the left contains the modulator tubes and the main rectifier components. The compartment on the right contains the contactor panel and a control (relay) panel. Dead front construction is used on all operating controls most of which are located on the control panel which is accessible during operation through the non-interlocked front door. The control circuits are of the latest design, simplified to provide high-speed protection to the equipment with the minimum of complexity and maintenance requirements.

The transmitter front has been built in two symmetrical sections for installation ease and to reduce bulk and weight. All meters, with the exception of two audio driver plate ammeters visible through the port, are mounted in a single line across the panel top. All front panel tuning controls are electric and are unusually accessible since they are mounted on the two center access doors.

Each of the RCA-892-R tubes has an associated individual blower fed from a common air-mixing or plenum chamber which is equipped with a single-unit permanent type air filter. A small blower in the top cover of the plenum chamber provides forced draft circulation for the low-power rectifier chamber. The main rectifier compartment is equipped with a blower which functions when plate voltage is applied to provide a "cold spot" for the envelopes of the main rectifier tubes.

Circuit Design

The complete electrical circuit of the transmitter is shown in the multicolored schematic diagram, Figure 23. The different colors employed for the audio, r-f, power and control circuits greatly facilitate circuit tracing. The antenna tuner and console circuits are described in the supplementary Instruction Books (No. 30168 and No. 30157) which are included at the back of this book. As nearly as possible the schematic diagram has been laid out functionally, broken section lines indicating the chassis on which a given component is mounted, the bottom section indicating the equipment mounted on the front panels. Each circuit component is identified by means of a letter and a following number, the prefix numeral indicating the functional use of the item. This identification of a component is rigidly maintained throughout all drawings, photographs, parts lists and descriptive text.

Prefix Identifications:

1. Radio Frequency.
2. Audio Frequency.
3. Lower Power Rectifiers.
4. Power Control.
5. Front Panel.
6. Auxiliary Power Equipment—External.
7. Main Rectifier.
8. Monitor Rectifier.
9. Control Console.

Letter Identification:

A. Auxiliary Equipment—Indicator Lamps, Blowers, etc.

C. Capacitors—All Types.
E. Relays and Contactors.
L. Reactors.
M. Meters—All Types.
R. Resistors—All Types.
S. Switches—Manual—Push-Buttons, Toggle Switches, etc.
T. Transformers—All Types.
V. Tubes.
X. Sockets.

As an example, 4E3 is a relay in the power control section of the transmitter and is number "3" in that list. Exact location is shown on the photograph of this section, Figure 18; ordering information in the parts list; wiring information on the connection diagram, Figure 31; and the electrical function on the overall schematic, Figure 23, and the control ladder, Figure 24. Thus 4E3 is completely identified in all respects.

Radio Frequency Circuits—The r-f section of the equipment is mounted in the left end of the assembly; the output stage is in the first compartment; the oscillators and drivers are on the left side of the second compartment.

The crystal oscillators employ one RCA-807 tube each. The crystal is connected across the control grid circuit and is shunted by a small vernier capacitor (1C1), permitting adjustment to exact frequency. Final grinding of crystals is made for an identical oscillator so that only very minor adjustments are required. A tapped reactor is employed in the plate circuit, each tap covering a portion of the frequency range as follows:

Tap No.	Freq. range (kc)
1	540- 700
2	700-1,000
3	1,000-1,300
4	1,300-1,600

Taps 5, 6, 7 and 8, which cover frequencies from 1,600 to 3,000 kc, are not used with this equipment. The proper tap should be selected before plate voltage is applied, and if the oscillator should be sluggish in starting the next higher frequency band should be used.

Plate voltage for the oscillator is applied through the selector relay 1E1 controlled by push-button 5S2. The oscillator in use is indicated by pilot lamp 1A8 or 1A9. The oscillator selector relay is of the impulse type and is mechanically latching so that power interruptions have no effect on this circuit.

A single RCA-828 tube is employed in the buffer stage which is tuned by inductor 1L4 and capacitors 1C21, 1C22 and 1C23. 1C24 and 1C25 form a voltage dividing circuit that functions in conjunction with potentiometer 1R11 to furnish a potential for the input circuit of the station frequency monitoring equipment. It is desirable that the concentric feed to this monitor have an outer insulation so that the line may be grounded at one point only to eliminate any possibility of undesired circulating ground currents.

Two RCA-810 tubes operating in parallel furnish driving energy for the modulated amplifier. Inductors 1L7, 1L8, and capacitors 1C30, 1C31, and 1C53 form the plate tank. 1C53 permits adjustment of drive and neutralizing voltage balance. 1L7 is motor driven and front panel controlled for limited range tuning. The motor drive is 1A4, operation of which is controlled by push-button switches 5S4 and 5S5. Neutralizing is accomplished in the circuit 1L6, 1C26, 1C27 and 1C28.

The modulated amplifier (output stage) contains two RCA-892-R tubes operating class "C." The tank circuit is formed by inductors 1L13, 1L16 and capacitors 1C34 to 1C37 inclusive. Output coupling to the load is accomplished through capacitors 1C38 and 1C39. The tank is inductively tuned by 1L16 driven by motor 1A6 which is in turn controlled by push-button switches 5S6 and 5S7. 1L17 in series with the output terminal is used to tune out residual reactances in the transmission line and to permit fine adjustment of the load coupling. The use of inductive tuning (1L17) permits a reasonably wide range of output power control because of its broad characteristics. Over this range the power factor of the plate tank remains very close to unity and permits high plate efficiency.

Power for the output stage is obtained from the main rectifier. All voltages for the preceding stages are developed by the low power rectifier (3V1, 3V2) and the associated voltage divider circuit 3R1, 3R2, 3R3, 3R4 and 3R5.

Coils 1L14 and 1L15, inductively coupled to the output tank, provide voltages for modulation level monitoring and test equipment. Resistors 1R23 and 1R24, controlled in value by relay 1E3, provide equalized voltages for 10-kw and reduced power output operating conditions. Antenna circuits and monitoring rectifiers are discussed in IB-30168 which is included at the back of this book.

Audio Frequency Circuits—The audio-input and driver circuits are mounted on the right-hand side of number two compartment. The third compartment houses the modulators. The modulation transformer is installed directly behind this section.

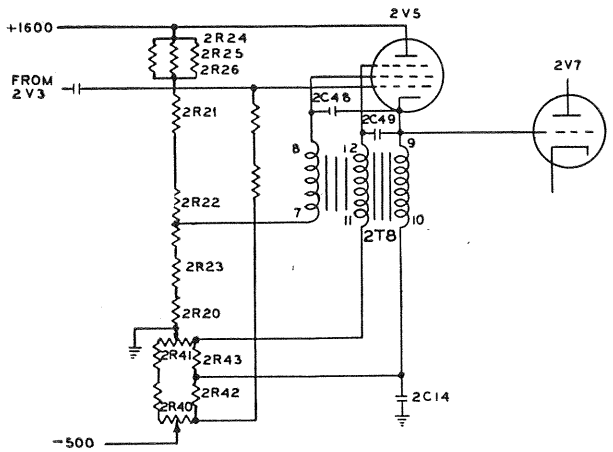
Output of the station speech input equipment is delivered to the input transformer (2T1) at approximately +4.5 vu for 10-kw operation. A frequency equalizing circuit comprised of the series connected components 2L1, 2C52, 2R90, 2R91, and 2R92 is connected across the primary terminals of the input transformer, 2T1. When frequency characteristic control is employed, a 6 db isolation pad must be inserted between the program amplifier output and the transmitter input terminals. If frequency characteristic control is not used the frequency equalizing circuit should be disconnected. The first audio stage employs two RCA-1620 tubes. The feedback voltage from the plate

circuit of the modulator is inserted in series with the secondary windings of the input transformer (2T1). The first audio stage bias potential is controlled by the values of 2R54 and 2R83 at the base of the feedback ladder and 2R3 in the cathode return. Obviously bias is not correct until plate potential is applied to the modulators.

The feedback ladders function as voltage dividers and are connected between the plates of the modulator tubes and ground. They form a portion of the feedback loop which includes all circuits between the secondaries of the input transformer (2T1) and the primary of the modulation transformer (6T3). Hence, the voltage applied to the grids of the first audio stage is the vector sum of the input and feedback voltages.

A 100-120-cycle hum-frequency attenuator (2L2 and 2C9) is included as a part of the first stage output circuit. Next in sequence are two RCA-828 tubes (2V3, 2V4) which are push-pull, resistance coupled on the input side. The output of this stage is push-pull reactance coupled to the input of the third audio stage.

Four RCA-828 tubes (2V5, 2V6, 2V9 and 2V10), connected in a push-pull-parallel cathode-follower circuit, are used in the third audio (modulator driver) stage. In effect the cathode, rather than the plate circuit fluctuates at audio frequencies. The insert is a simplified diagram of a single tube working with its associated transformer windings.



The primary winding of 2T8 acts as the cathode (filament) load. Since the grid of the following stage is directly coupled, fluctuations of the cathode voltage will be impressed upon the control grid of 2V7. In order to duplicate normal pentode operation, the screen and suppressor grids must remain at the same a-c potential as the cathode. This is accomplished by the secondary coils of Transformer 2T8 assisted by capacitors 2C48 and 2C49. This type of circuit permits high drive efficiency and minimizes the effect of grid current flow in the modulator. Since the anodes of the drivers are effectively at low audio potential, metering is accomplished directly in this circuit. For safety precaution it is desirable to isolate the plate milliammeters, 2M1 and 2M2. They are fully visible from the access door viewing port.

Two RCA-892-R modulators (2V7, 2V8) function through the modulation transformer (6T3) and the modulation reactor 6L5 to control the output of the class C stage (1V7, 1V8).

The circuit elements and their physical placement through the audio system are designed to reduce phase shift to such a minimum that the feedback (Beta) loop is inherently stable. Adjacent channel interference is minimized through the use of a rapidly-dropping frequency characteristic beyond the 10-kilocycle band of audio frequencies. Reactor 6L4 and capacitor 6C2 are determinants of this characteristic.

The modulators receive their plate supply from the main rectifier (7V1-7V6); a bias rectifier (3V3, 3V4) with an adjustable voltage divider system and relay (2E2) supplies proper bias potentials for 10- and 2-kw operation. Anode and screen potentials for the preceding stages are procured from the low-power rectifier (3V1, 3V2) and the voltage divider 2R20-2R26.

Rectifiers—Three rectifier circuits are included in this transmitter. The r-f and audio driver stages are supplied from the low-power rectifier (3V1, 3V2). A bias rectifier (3V3, 3V4) supplies the a-f driver and modulator grids and the main rectifier (7V1-7V6) provides power for the r-f output stage and for the modulators. The bias and low-power rectifiers are of the single phase full wave type. The first employs a single section reactor input type filter and the latter a two section reactor input type filter. The main rectifier uses a single section reactor (7L1) input filter with capacitor-charge-limited starting. At the instant of high potential application the filter capacitors 7C1 and 7C2 are isolated from the negative bus by resistor 7R1. After a short delay of approximately one to two seconds, permitting the capacitors to charge without surge, relay 7E1 closes, shorting out the starting resistor 7R1.

Opening of any protective interlock automatically grounds 7C1 and 7C2 through the arm of relay 7E2.

Power change is accomplished by means of primary taps on the plate transformer and resultant reduction in anode potential on the modulator and power amplifier stages. Contactors 4E3 and 4E4 select proper transformer taps and are manually controlled by the power change switch 4S3 and automatically controlled by the notching relay 4E10. Operation of either 4S3 or 4E10 simultaneously controls the modulation monitor circuit, audio input circuit, audio monitor circuit, and modulator bias.

Control Circuits—Figure 24 outlines schematically the complete control circuit of the 10-F equipment. Functional titles of the relays are tabulated below the "control ladder" for easy reference. Diagnosis of circuit faults is most readily accomplished by reference to this diagram. It is well to remember that any given section of the "ladder" originating at control bus No. 1 must, without exception, eventually terminate at control bus No. 2. Should any relay fail to function it is then relatively easy to check for continuity from the relay

toward each control bus until the fault is located. Relay contacts normally closed are shown solid; normally open contacts are clear blocks. Dashed lines connect contact sets of any given relay.

All power for the control circuits is derived from the "control bus" which is fed from the incoming power through a protective De-Ion breaker, 4S5. Power enters the equipment through the main line breaker 4S1 and through current transformers 4T1 and 4T2 which in turn energize the protective "Main Line" overload relays 4E12 and 4E13. A branch circuit at this point serves the main rectifier plate transformer through De-Ion breaker 4S2. 4S2 provides additional protection and at the same time serves as a sectionalizing disconnect so that all control and operation functions may be checked **without** application of potential to the plate transformer, 6T2.

WARNING: THE MAIN RECTIFIER DISCONNECT SWITCH 4S2 SHOULD BE OPEN AT ALL TIMES WHEN SERVICING THE TRANSMITTER.

With 4S1 and 4S5 closed the control circuits are now energized up to the control and filament bus contactor, 4E17. Switches 4S4 and 9S5 must both be closed to start the equipment. Opening either one will completely stop the transmitter. Operation of contactor 4E17 energizes all low-power and rectifier tube filaments and the balance of the control ladder. Proper operation to this point is indicated by illumination of the transmitter panel and control desk FIL. ON pilot lamps 4A3 and 9A13.

With the closing of contactor 4E17, relay 4E6 begins to function. Normally adjusted for a 30-second cycle its contacts remain open for that time preventing application of plate potential to any of the rectifiers until they have reached operating temperature.

Before proceeding further toward the application of plate potentials it is necessary that the bias rectifier circuit be completely energized. All door interlocks (5S1, 5S8 and 5S9), together with the control desk PLATE ON switch 9S4 must be closed. At this junction the transmitter panel and control desk PLATE ON pilot lamps 5A5 and 9A12 should glow if the circuits are functioning properly and the main rectifier capacitor grounding switch 7E2 should operate removing the protective ground from capacitors 7C1 and 7C2 and simultaneously closing the set of normally open interlocks in the primary circuit of the bias rectifier plate transformer, 3T3. If the bias protective breaker 4S12 is closed, anode potential will be applied to the bias rectifiers (3V3, 3V4). Operation of the bias rectifier circuit will energize relay 2E1 thus completing another step in closing the circuit to the low-power-rectifier primary contactor, 4E19. Transmitter panel indicator lamp 5A3 should now glow, thus indicating that current is flowing normally in the bias bleeder circuit.

The circuit is now continuous from control bus No. 2 through the door interlocks (5S1, 5S8, 5S9), the PLATE ON switch 9S4, the bias protective relay 2E1, the rectifier plate delay relay 4E6 and the coil of the hesitating "carrier off auxiliary" relay 4E20 to control bus No. 1. Since the rectifier-surge relay timer 4E8 has not yet functioned, the circuit is completed through its back contacts to relay 4E20 which will, when closed, complete the circuit to the normally closed relay, 4E11. The PLATE ON push-button 5S10 must now be depressed to continue the circuit unless the AUTOMATIC switch 4S13 is closed. If switch 4S13 is closed the operation of the transmitter is termed **automatic;** otherwise it is **manual.** By pressing the push-button of the normally closed PLATE OFF switch 5S11 the circuit to the rectifier contactor 4E19 may be opened, thus removing plate potential from the low-power and main rectifiers. If the AUTOMATIC switch 4S13 is open, relay 4E19 will remain open until the PLATE ON push-button switch 5S10 is pressed; otherwise relay 4E19 will reclose when the PLATE OFF push-button switch, 5S11, is released.

At this point it is necessary to digress to follow the operation of the filament contactor 4E18 for the air-cooled tubes. When contactor 4E17 closes, the individual blower motors 1A5, 1A16, 2A1 and 2A2 for the RCA-892-R tubes (1V7, 1V8, 2V7 and 2V8) will be started. Proper airflow will cause the airflow interlocks 1S1, 1S2, 2S1 and 2S2 to close, thus completing the circuit through the coil of the filament contactor 4E18 operation of which will apply filament power to the 892-R tubes (1V7, 1V8, 2V7 and 2V8) through the contacts of MASTER FILAMENT circuit breaker 4S6 (not shown in Figure 24). Pilot lamp 5A4 should glow when the airflow interlocks are closed.

Assuming that no overloads have occurred, the ratchet type relay 4E10 will be closed. Contacts of the high speed plunger type overload relays 4E12, 4E13, 4E14, 4E15 and 4E16 will normally be closed and proper functioning of the bias rectifier has previously been established. Hence, when contactor 4E18 closes, its normally open pilot contacts will close and the circuit to the low-power-rectifier plate-contactor 4E19 will be completed. When contactor 4E19 operates, the back pilot contacts will close and form a seal around the START push-button switch, 5S10. This operation has no effect if the AUTOMATIC switch, 4S13, is already closed.

Next it is necessary to complete the circuit to either the reduced voltage plate contactor 4E4 or the full voltage contactor 4E3. Note that one of these contactors must be open to permit the other to function because each operating coil is fed through a set of normally closed pilot contacts on the other relay. It has been shown that the control circuits are already energized to terminal G9 at the left of the upper contacts of the bias protective relay, 2E1. Proceeding to the left, contactor 4E19 is already closed but any failure of the 4E19 circuit will of course open the 4E3, 4E4 circuits. Which contactor will be energized is dependent upon the position of the power change auxiliary relay 4E5. If switches 4S3 and 9S2 are closed in the HIGH POWER position and if no overloads have occurred to operate overload relay 4E10, the power change auxiliary relay, 4E5, will be powered and the circuit to the full voltage contactor 4E3 will be completed. If overload relay 4E10 has operated or if either power change switch 4S3 or 9S2 is opened, the power change auxiliary relay, 4E5, will open and the reduced voltage plate

contactor 4E4 will function instead. When the power change auxiliary relay 4E5 is energized the bias change relay 2E2 and the power change compensating relay 1E3 will operate to provide proper bias and correct monitoring voltages for 10-kw operation. When contactor 4E4 is energized pilot lamps 5A8 and 9A9 and the audio power change relays on the MI-4309-B relay panel will also be energized. Input level and monitoring loudspeaker level will now be correct for reduced power operation. If contactor 4E3 operates, the audio relays will be de-energized and pilot lamps 5A7 and 9A10 will function to indicate full power.

When either 4E3 or 4E4 closes, the motor of the rectifier surge relay timer, 4E8, is started. After an interval of approximately two seconds delay, relay 4E8 operates and closes the circuit to relay 7E1 which in turn shorts out the capacitor surge resistor 7R1, permitting normal operation of the main rectifier filter. At the instant plate voltage is applied and before relay 4E8 has completed its cycle, carrier voltage appears at the monitoring rectifier and the "carrier off" relay 4E9 is closed so that operation of relay 4E8 does not disturb the position of relay 4E20.

If, however, the carrier fails at the monitoring rectifier because of an arc on the transmission line or elsewhere, relay 4E9 will open as will relay 1E2. Relay 4E20 will start to open but will not actually break circuit for approximately ¾-second. In the meantime, de-energizing of relay 1E2 removes carrier excitation for 250 milliseconds (sufficiently long to extinguish the arc). Relay 4E9 is then re-energized before relay 4E20 opens and normal operation is resumed without interruption of operating plate potentials. Should the fault persist relay 4E9 will not reclose and relay 4E20 will open thus de-energizing contactors 4E19 and 4E3 (or 4E4) and relay 4E8. The cycle will then recommence as the back contacts on relay 4E8 reclose and will continue to recycle until the fault is cleared automatically or the PLATE ON switch 9S4 or the AUTOMATIC switch 4S13 is opened.

The ratchet type overload relay 4E10 and its auxiliary, 4E11, are the "brain center" of the control circuit. Should a fault cause any one of the overload relays 4E12, 4E13, 4E14, 4E15, or 4E16 to operate, the notch coil on relay 4E10 and the operating coil on relay 4E11 will be energized. The overload relays operate with such a degree of rapidity that the ratchet and pawl device on relay 4E10 would fail to function if the 4E19 contactor circuit were not held open momentarily. Relay 4E11 accomplishes this purpose since it opens instantaneously but does not reclose for approximately 250 milliseconds. A first overload closes the contact on relay 4E10 which completes the circuit to the OVERLOAD pilot lamps 5A6 and 9A11. A second overload notches relay 4E10 a second time and carrier is reapplied and operation proceeds. If a third overload takes place, the normally closed contacts on relay 4E10, in series with relay 4E5, are opened, automatically reducing power. Should a fourth overload occur the normally closed contacts in series with contactor 4E19 are opened and all rectifier plate voltages (except bias) are removed and operation ceases until the transmitter PLATE ON push-button 5S10 or the control desk OVERLOAD switch 9S3 is depressed, thus operating the reset coil of relay 4E10. If the fault persists the transmitter should be turned off until the difficulty is cleared.

After a single overload which does not at once recur, push-button 5S10 or 9S3 should be operated so that single isolated overloads do not act accumulatively on relay 4E10 and result in an unnecessary interruption of program.

Relay 4E7 performs an isolated function which permits transmission to be resumed instantaneously after a power failure of short duration. Without this relay a momentary cessation of power would trip relay 4E6 and it would require 30 seconds to recycle. Relay 4E7 remains closed one to two seconds after power interruption and if the failure is not greater than this interval all circuits will reclose instantaneously after the interruption. Relay 4E7 may be set for a greater "hold in" delay, but after two seconds the rectifier filament requires the usual delay of 30 seconds for protection.

During normal operation relay 1E2 is energized and as a result capacitor 1C42 is continuously charged. Operation of relay 1E2 causes capacitor 1C42 to discharge into the grid circuit of the buffer amplifier, blocking the carrier momentarily. As capacitor 1C42 discharges, the carrier gradually returns to its normal amplitude, depending upon the time constant of the 1C42-1R22 circuit. The CRYSTAL OSCILLATORS OFF push-button, 5S3, is provided to permit operation of the buffer amplifier blocking circuit at will for checking the operation of the r-f stages without excitation. The normally interconnected terminals, P11 and P12, are provided to permit insertion of an auxiliary relay to remove the carrier momentarily when such function is desired.

The operation of the transmitter and control desk pilot lights has been noted in the foregoing description. A thorough knowledge of the physical location and the interpretation of the meaning of ON or OFF for any given light is invaluable for rapid determination of faults and their correction.

Power Supply and Distribution

The power supply for the transmitter itself should be 230-volts, 3-phase, 60-cycles (50 cycles for MI-7098-D), capable of handling loads up to 40-kw at a power factor of approximately 91 per cent. This permits 100 per cent tone modulation and a reasonable percentage of accommodation for test without overloading the power source. No allowance has been made for building requirements: lighting, tower lights, exhaust fans and shop equipment. A single-phase source of 115 volts, 60 cycles is required for the crystal heaters (approx. 30 watts) and provisions should be made for test and speech equipment.

The RCA-892-R tubes are lighted by power supplied from 2-phase Scott-connected high-reactance filament transformers. The use of high reactance current limiting transformers obviates the need of step starting since the units are designed to hold the filament start-

ing current to a safe value (less than 200 per cent of rated flow). The primary of each set of filament transformers is controlled by a 3-gang rheostat to permit voltage adjustment required because of line variations and tube aging. A selector switch, 4S14, permits readings of individual filament potentials of the RCA-892-R tubes. Switches and rheostats are front-panel controlled at the power control panel, the extreme right-hand unit of the equipment.

With the exception of five small relays (1E1, 1E2, 1E3, 2E1 and 2E2) which are located functionally for simplification and optimum performance, all control relays, contactors, and protective breakers are centralized in the power control unit. Power and control circuits are distributed to the balance of the compartments through a channel in the transmitter base designed for this purpose. All terminals to be interconnected have a like designation; for example, terminal H4 at the power control panel connects to terminal H4 on the modulator chassis. Terminal block locations are shown on installation drawing M-429173.

Two types of transformer are available for the main-plate rectifier transformer 6T2. MI-7088-A is an oil-filled transformer for both inside and outside installation. Shelter must be provided for outside use. MI-7088-B is an air-cooled transformer and may be installed inside only.

Either transformer may be used with the BTA-5F or the BTA-10F. A tap switch is provided for raising or lowering the plate voltage 5 percent. Line reactors 6L1, 6L2 and 6L3 (inside the transformer) are connected in series with the primary windings in the full voltage position. Normally shorted, it is advantageous to remove the shorting links from these reactors in installations where the installed KVA capacity is large and the power supply system impedance is low. The reactors have the advantage of limiting the peaks of fault current surges so that the a-c overload relays may function without tripping the main line and plate circuit "De-Ion" breakers. Unless the overall regulation becomes too poor the reactors should be employed as a general protective measure.

The BTA-10F equipment has been designed to deliver 10 kw to the antenna when operating normally, with automatic reduction of this power to approximately 2 kw under fault conditions. In order that the audio input level and the monitoring speaker level may be automatically corrected for power changes in the transmitter, an audio relay panel (MI-4309-B) is furnished for installation in the speech racks. A schematic diagram of this relay panel is shown in Figure 35. Equipment interconnections are shown on the wire chart, Figure 36.

SECTION IV

Installation and Adjustment

Planning the Installation

Each type BTA-10F transmitter equipment includes a complete set of installation drawings dealing with constructional details and suggested typical layouts of the equipment. The numbers of all drawings required for the installation are as follows:

* M-429173	Terminal Board Location.
T-617280	Wire Chart.
* P-714940	Grounding System.
P-714559	Control Ladder.
*W-303537	Transmission Line.
* P-714961	Desk Outline.
* T-617155	Antenna Tuning House.
*TT-601845	Typical Installation.
TT-601832	Overall Schematic.
M-422899	Modulator Output Unit Connections.
* T-601899	Enclosure Extension Layout.
*W-303939	Overall Assembly.
* K-896911	Erection Instructions.
* P-722553	Base Erection Plan.
* T-618453	Enclosure and Frames Erection Plan.

*Shipped with IB-30099-1.

These drawings in turn tabulate the dimensions of all equipment, the locations of terminals, wire sizes and types, conduit requirements and trench dimensions. Utilizing this information, it is possible to lay out a floor plan to suit the requirements of the individual station.

Location

The location of the transmitter should be carefully selected and provision should be made for installing the external connections before the equipment is set in place. The equipment should be installed in a well-ventilated room where there is a free circulation of clean dry air. The ambient temperature should not be allowed to exceed 45° C. Other important factors to consider in choosing a location are (1) adequate illumination, both natural and artificial; (2) provision for incoming power-supply lines; (3) accessibility of good ground connection; and (4) direction of transmission line wiring.

The relative location of the components should follow the general plan outlined in drawing TT-601845. This grouping is designed to permit the shortest and most direct interconnection wiring, using a minimum of floor space. The plate transformer, control console and test-speech equipment racks may be placed at any desired location without affecting the operation of the transmitter equipment; but if this is done, changes in space requirements and in the quantities of wiring materials necessary for connections must be considered.

As an alternate layout to that shown in drawing TT-601845, the plate transformer may be placed directly behind the transmitter. However, if a clear walk-way is required along the full length of the equipment, the distance of the transmitter front from the rear wall must be increased. The oil-filled transformer may be mounted outdoors if suitable shelter is provided. In this instance, high-voltage outdoor type pot-heads must be provided for the primary and secondary cables.

The equipment may be placed directly against the rear wall of the housing structure, if space limitations require such an installation. Openings in the wall must be provided for the air intake to the plenum (air mixing) chamber, and to the high-voltage rectifier blower. The modulation output unit and the plate transformer should then be located in a vault directly behind, or under, the transmitter room. The location should be designed for minimum bus lengths to the modulation transformer.

These equipments have been so designed that all interconnecting wiring (with the exception of that to the plate and modulation transformers) may be installed in wire ducts which are an integral part of the equipment, thus appreciably reducing the time and cost of an installation. To simplify the installation still further, RCA makes available a wire kit containing all the necessary wiring materials for the complete installation shown in drawing TT-601845. This kit may be ordered from RCA Victor Division as MI-7268-E.

To facilitate the planning of special layouts, the material contained in the MI-7268-E kit, together with the maximum permissible run lengths, are listed here. For run details, refer to the wire chart T-617280.

MI-7268-E WIRING KIT

Item	Type and Quantity	Use
1	500 feet, PS496, 600 volt, No. 14 solid, VCLC	For console transmitter control circuits. Maximum permissible horizontal distance of transmitter terminal position "C" to console wire ports is 18 feet. Allowance has been made for risers and connections.
2	100 feet R-F Coaxial cable, K-99208-2	For three runs from terminal position "A" to test equipment racks. Maximum permissible horizontal distance is 25 feet.

Item	Type and Quantity	Use
3	800 feet, No. 12, 600 volt stranded, gray, flame-proof, K-870141-10	For interconnection within the transmitter itself. There will be no variation with placement of equipment. Includes two spare runs.
4	150 feet, No. 0, 600 volt, VCLC, PS-496	For transmitter power supply and plate transformer primary circuits. Based on 6 primary runs of 15 feet each (total length), and 3 feed circuits to meter center of 20 feet each.
5	60 feet, No. 6, 10,000 volt, VCLC, M-429906-11	For plate transformer secondary circuit. Three runs of 20 feet each (total length).
6	650 feet, No. 19, twisted pair, 200 volt, RCL	For all audio circuits. Based on a maximum horizontal run from desk to equipment racks of 20 feet. Allows 2 spare circuits.
7	160 feet, No. 6, AWG bare copper	For grounds.
8	20 feet, copper tubing, ½ inch x .035 wall, PS-35	For transmitter output leads.
9	96 inches, soft copper strap, .043 x 6 inches	For grounds.
10	96 inches, soft copper strap, .043 x 4 inches	For grounds.
11	300 feet, soft copper strap, .032 x 2 inches	For grounds.
12	Set containing:	
	(A) 4 90° elbows	For use with item 7.
	(B) 225 terminals (K-818337-9)	For use with item 3.
	(C) 10 terminals (K-99012-4)	For use with item 5.
	(D) 25 terminals (K-99012-7)	For use with item 4.
	(E) 6 terminals (K-99012-9)	For use with item 7.

Complete ordering information for all cables is given on the wire chart T-617280. If these materials are to be ordered from other than RCA, a considerable time factor must be allowed for delivery, since many of the items are not standard, and are usually not stocked by other manufacturers.

Care must be taken, when ordering VCLC cables, to procure the type containing a cotton braid between the varnished cambric and the lead sheath. Without this braid, the cable ends are very difficult to "make up" neatly. Rubber-covered wire may be substituted for varnished cambric insulated wire, if the former is desired.

The plate transformer supplied with this equipment has a full 10 kilowatt operation rating and may therefore be used with either the BTA-5F or BTA-10F transmitter. It is equipped with a high-voltage ± 5 per cent tap switch, which may be operated from a hand-hole in the transformer case. In addition, the transformer is equipped with series line reactors, in order to limit fault current in those installations where the impedance of the power supply system is unusually low. If the supply system has a normal or a high impedance, the reactors may be shorted out by means of the links provided. Always use the series reactors during test periods unless voltage regulation becomes excessive.

The oil-filled transformer weighs 1,540 pounds and has an oil content of 76 gallons of type C transil oil. The air-cooled transformer weighs 735 pounds. Plans for the transformer installation should be submitted to the local Code Authority and the Board of Fire Underwriters for approval. Such plans should show the location of the transformer, the type of enclosure used, and the facilities for draining oil leakage. (After installation of the oil-filled transformer, a sample of oil should be drained from the case and be cup-tested at 25 kv. The local electric power company usually has facilities for such a test.)

An outline of a grounding system for the equipment is shown on drawing P-714940. Care should be taken that all component parts of the equipment are well grounded; it is a precaution well worth while. If the center of the radiation system is an appreciable distance from the transmitter house, a grounding pit for the station system is recommended. Marble dust is used in conjunction with charcoal in the pit to set up a chemical action which maintains a clean surface on the grounding plates. It is desirable to keep the grounds of the two systems as far apart as installation conditions will permit, in order to minimize the possibility of coupling due to circulating ground currents.

A complete channel base, supplied in two sections for ease of handling, is included as a part of the equipment. This eliminates the necessity of setting channels in the floor. If reasonable precautions are taken to secure a smooth and level floor slab, the channel base may readily be shimmed to secure proper alignment of the transmitter. If a building is being constructed to house the transmitter, it is desirable to install four small sections of I-beam, as shown on the installation drawing TT-601845, on which to mount the modulation transformer and reactor. In the case of an existing building, smaller I-beam or wood sections may be mounted on the floor. It is desirable to adhere to the dimensions shown on the installation drawing, since the connecting busses

for the modulation transformer are pre-formed at the factory. All bus connections for the transformer are furnished as part of the equipment.

Although a built-in wall mounting is shown on the standard installation drawing, the installation may readily be adapted for mounting with grille work. The curved radius sections at each end of the transmitter front-panel may easily be attached to the framework of any standard type of expanded metal grille.

Where a drop wall over the transmitter is planned, particular attention should be given to the details of the assembly drawing W-303939. The top trim member of the transmitter front projects slightly upward to permit blending with the wall.

When planning a building layout, provisions must be made for electrical circuits to the interlock switches on those transmitter enclosure access doors which are not an integral part of the equipment. A power circuit for the transmitter room exhaust fan is also required.

A number of standard makes of exhaust fans for the transmitter room are available. It is desirable to install automatic louvres to work in conjunction with them in order to prevent reversal of the air flow and rain seepage while the fan is idle.

The number of antenna control, monitoring and tower lighting circuits justifies the use of a distribution center at the transmitter building. This is especially true where more than one radiator is required. A distribution center establishes a definite point between the indoor and outdoor installations at which circuits may be isolated for purposes of checking, or from which circuits may be run to additional towers. Normal tower lighting requirements of the present time preclude the possibility of direct control of lighting through the console. A small contactor may readily be inserted to permit any desired degree of flexibility of control. Wiring materials for connections from the distribution center to the tower (or towers) are not included either with the equipment or with the MI-7268-E wire kit. Refer to the wire chart (drawing T-617280) for the type of materials required for these circuits. The wide variation in the requirements for different installations makes it impossible to predict the quantities of material which might be necessary.

A tuning house is highly desirable, especially when multi-element arrays are used, since it offers protection from the weather and the proper facilities for the use of test and measuring equipment. It provides space for mounting the tower lighting equipment and auxiliary intercommunication equipment. An interconnecting phone system (not shown on the schematics) between the transmitter building and the antenna tuning house (or houses) may prove to be of considerable convenience.

The six-wire, open-type transmission line is definitely recommended because of its simplicity. It is economical, both to install and to maintain. The radiation from an open-wire line of this type is negligible, and has no appreciable effect on even the sharpest of directional patterns. Further, the relatively high impedance (240 ohms) of this line offers less loss, and requires less adjustment, in the terminating equipment. Drawing W-303537 shows a standard six-wire transmission line installation. Such a line, when properly constructed, makes an excellent appearance, and in no way detracts from the neatness of a planned installation. A standard bayonet assembly, complete with wire clamps and insulator, is available from RCA, and may be ordered as MI-19421.

In order to secure a properly "dressed" appearance, it is desirable to make neat installations of the cables at the various terminal positions. A photograph of a typical cable form at a multiple terminal block is shown in Figure 2. A lead-sheathed, high-voltage cable termination, and primary power supply lines at their respective terminals, are shown in Figure 3. The high-voltage cable should have the lead sheath skinned back approximately 3 inches. The insulation should then be tapered and wound spirally with lacing twine. Several coats of shellac should be applied over the twine to prevent the entrance of moisture at the end of the cable. The power cables will maintain a symmetrical form if they are laced with a standard Chicago stitch, as shown in the photographs.

The unified front for these transmitters is so designed that the curved end-sections may be moved, and additional sections of front panel (and equipment) may be installed. The manufacturer has available a design for a front section, complete with an enclosure for phasing equipment, to mount at the left of the original front panel, and a similiar section for speech-input and test equipment, to mount at the right. This feature offers the unique advantage of a complete transmitter installation behind a single unified front panel. (See RCA drawing T-601899.)

Unpacking and Assembly

Each transmitter equipment shipped is accompanied by a shipping voucher which lists the complete contents of that shipment. Groups of components are identified by MI (master item) numbers. MI-7266-C lists the entire equipment for the BTA-10F transmitter (60-cycle), and is reproduced in full in Figure 4. Item 1 of this MI lists the r-f unit, MI-7259-G. The packing case for this unit, and associated smaller containers for component parts, are stenciled with MI-7259-G and its sub-division numbers. Thus it is possible to identify the contents of all packing cases and to plan their uncrating systematically. All items listed on the MI sheets should be located before any crates or boxes are destroyed, so that no small items will be lost during unpacking. In some instances, the MI sheet for the small equipment is packed in the carton containing the equipment, rather than with the shipping voucher.

Various components are removed from their operating positions and packed separately for safe shipment. All such parts are individually tagged, each containing the MI number and the item number of the component. The electrical identification of the part will be found on the MI sheet. For example, if a part is identified as MI-7259-G, item 6, a reference to this MI sheet indicates that item 6 is the plate-tank inductor (symbol 1L13) of the power amplifier unit. Following such a pro-

cedure, all component parts may readily be identified and replaced in the transmitters. Reference to the photographs in this Instruction Book will simplify the assembly process still further.

All of the necessary hardware for re-assembly is packed with each unit. In addition, an MI-7474 hardware kit is included in all transmitter shipments. This kit is composed of a complete set of miscellaneous hardware, duplicating all types of nuts, bolts, washers and lockwashers necessary for the transmitter assembly.

All bus connections have been formed and should fit exactly. Before reforming any bus wire, make certain that another, correctly-fitting one is not to be found.

NOTE: IT IS DESIRABLE TO PERMANENTLY LOCATE ALL MAJOR UNITS OF THE EQUIPMENT BEFORE RE-INSTALLING THE COMPONENTS ORIGINALLY REMOVED FOR SHIPMENT.

Details for placement of the channel base sections and assembly of the equipment behind the unified front panel are shown on drawings P-722553 and T-618453 (packed with base assembly). Note that item 2 of MI-7255-A is the right base section, and item 1 is the left base section. The two sections must be so assembled that a wire trough is formed at the center by the junction of the inverted channel members. The driver section compartment of the transmitter (the second from the left, facing the front) is formed by interconnecting the radio-frequency section frame, and the audio section frame. The main tie plate is the low-power rectifier chassis (item 1, MI-7253-D). This chassis, together with the rear trim plate and the top plate (items 5 and 6, MI-7253-D), complete the enclosure for the driver section. The r-f and audio section frames must be carefully placed, so that the distances between mounting holes for the low-power rectifier chassis are in close accordance with the dimensions shown on the overall assembly drawing W-303939. Also, the two sections must be parallel so that the top plate and the rear trim plate will fall readily into place. The distance of 2⅝ inches between the front edge of the channel base and the bottom frame members of the r-f and audio units, as well as the distance of 5¾ inches between the channel base and the power control unit, must be accurately maintained if the unified front is to be mounted with a minimum of difficulty.

The transmitter front panel is shipped in two sections. Item 1 of MI-7256-B is the right section, and item 2 of MI-7256-B is the left section. The front panel has been pre-fitted at the factory; consequently, there should be no difficulty obtaining a fit at the time of assembly. Study the assembly drawing W-303939. There are five tie-plate positions. The tie-plates should not be pulled up tightly until the front-panel alignment is satisfactory along its entire length.

After all units, including the front panel, are in their permanent positions, jumper connections should be installed between the low-power rectifier and its adjacent units, and also between the unified front components and those of the transmitter assembly. Connections should be made as shown on the terminal block location drawing M-429173. These jumper connections are furnished with the equipment. All such connections are made directly between terminals having like designations; therefore, the installation of this wiring should require but little time.

The contactor panel of the power control unit is shipped with solid block mountings at each of its four corners. These blocks should be removed and replaced with the coil springs furnished for this purpose. The springs may be found in a cloth sack which is attached to one of the mounting posts.

If the transmitter is to be installed at a wall opening, as shown in the standard layout, it is desirable to place the modulator output unit (and the plate transformer, if it is to be located at the rear of the transmitter) at the planned location before the rest of the transmitter is assembled in position, in order to avoid the moving of heavy equipment through the wall openings and around the transmitter.

Wiring

Before starting the interconnection wiring a layout plan should be drawn up, so that cables may be formed in the trench. The make-up of these cables should be planned to avoid unnecessary cross-overs as they enter and leave the trench. A few extra hours spent in planning and neatly installing the wiring is more than justified by the resulting improvement in the overall appearance of the installation.

Where lead-sheathed wire is used for connections, the lead sheath should be skinned back from the end of the wire, so that all the sheaths terminate at the same distance (several inches away) from the terminal block. This permits the forming of smaller, neat, simply laced cables. The lead sheaths should be cabled in a rectangular form. They should be spotted together with solder at regular intervals along the run and then well grounded. Several spares should be run in each cable, in order to avoid a shortage of connecting wires due to errors in planning, or to permit the inclusion of additional circuits. As the wires are laid in the trenches, each wire should be tagged at its ends with the terminal connection identification.

When cutting lengths of heavy cables designed for the conduit runs, allow some excess length. It is better to end up with a cable a foot too long than with one two inches short. Also, having some additional length of line facilitates the forming of individual cables.

All of the safety interlocks should be checked for correct operation before high voltage is applied to the transmitter. The air flow interlocks should be checked by obstructing the air flow to each blower, making certain that the interlock "cuts out" when the flow is reduced appreciably. The mechanism may be adjusted by changing the position of the small counter-balancing weight on the air flow damper. The blowers should be started and stopped 10 or 15 times to make certain that the interlocks are functioning satisfactorily—that there is no tendency for them to stick, either at the ON or at the OFF position. The motion of the damper and the mercury switch must be absolutely free. The flexible leads from the switch should be free. The switch should

be so installed in its clip that the switch contacts are aligned vertically, with the large contact in the higher position.

The habit of using grounding sticks before entering the transmitter or its enclosure is an excellent one to acquire at the time the equipment is first placed in operation.

Tubes

Install all tubes in their sockets. The handle bands of the RCA-892-R tubes should be adjusted so that, with the grid terminal of the tube which protrudes from the side of the glass envelope in the required position, the handles will be on a line parallel to the chassis supporting the socket itself. The position of the handle bands may be shifted by first loosening the three screws in the chrome-plated clamp band. After the position of the handle bands has been adjusted the clamping screws should be tightened. There are three filament terminals located on top of the tube, one of which is connected to the center point of the filament. It is important that the largest of the three filament connectors is attached to this terminal. A label illustrating the proper connections is cemented to the chassis adjacent to each filament connector terminal board for the RCA-892-R's.

The radiator fin assembly of each tube contains two drilled thermometer wells. Four thermometers are furnished with each transmitter. In case of breakage, new thermometers may be ordered from the H-B Instrument Company, 2518 N. Broad St., Philadelphia, Pa. Four and one-half inch spirit thermometers, calibrated 50 degrees C. to 150 degrees C. should be specified. These thermometers are especially useful in checking for normal operating conditions during test periods.

Power Frequency Conversion Kits

Frequency conversion kits may be ordered as follows:

MI-7085-A	5F	60 cycles to 50 cycles
MI-7085-B	5F	50 cycles to 60 cycles
MI-7085-C	10F	60 cycles to 50 cycles
MI-7085-D	10F	50 cycles to 60 cycles

The kits contain all parts which are affected by a change in power frequency (motors, relay coils, etc.).

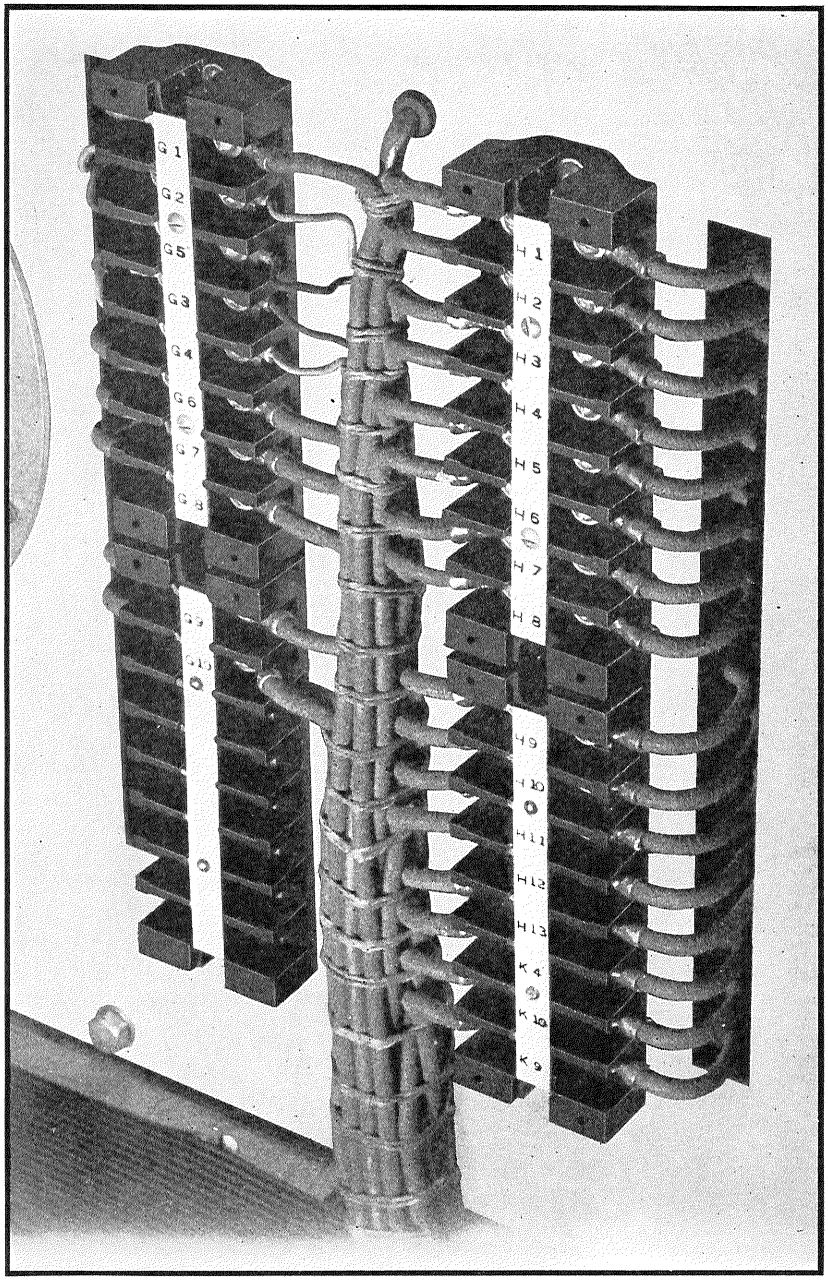


Figure 2—Interconnecting Cable Lacing

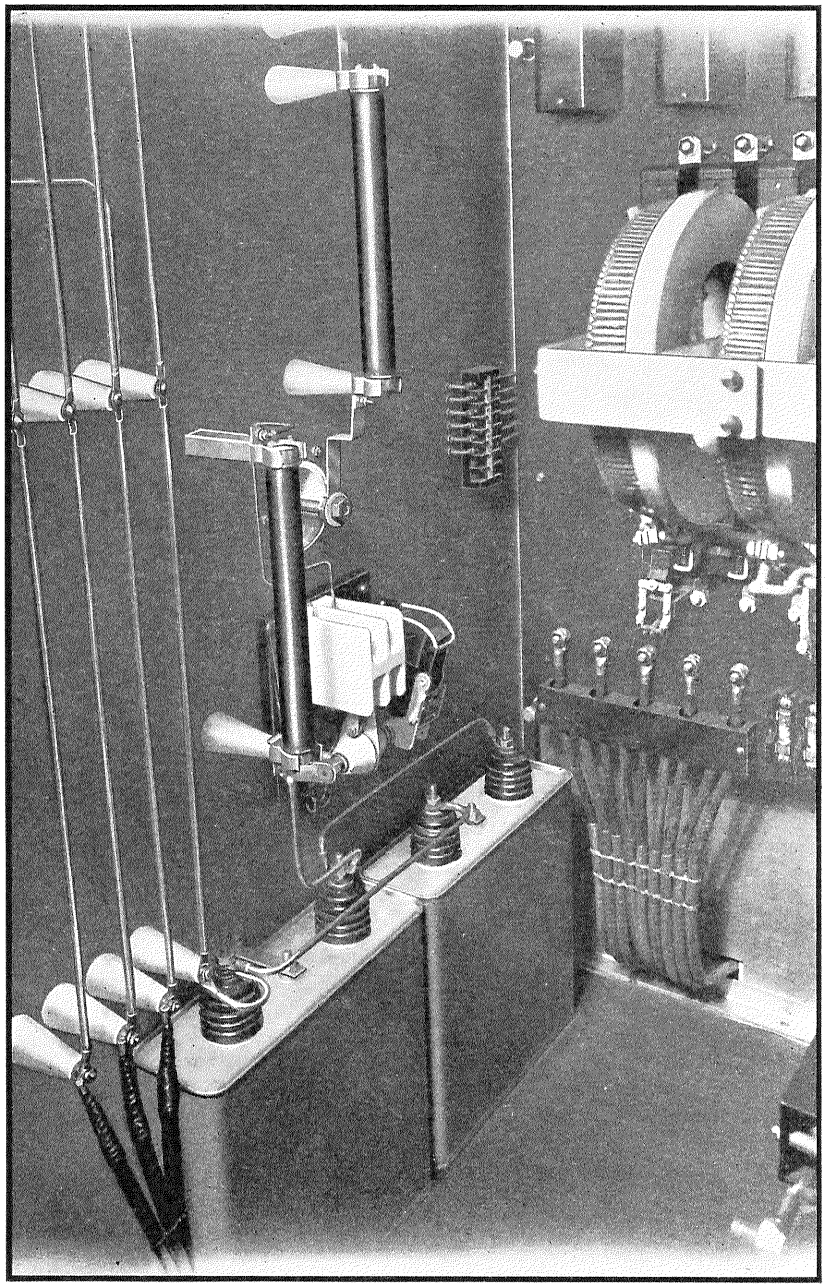


Figure 3—Power Supply Cable Lacing

SHEET #1

LIST OF CONTENTS OF MASTER ITEM 7266-C

MI-7266-C BTA-10F B/C TRANSMITTER EQUIPMENT (230 V., 3 PH., 60 CY.)

ITEM	QUAN.	DESCRIPTION	REFERENCE	PART OR GROUP
1	1	R.F. UNIT (MI-7098-G)	MI-7259-G	SEE NOTE #4
2	1	L.P. RECTIFIER (MI-7098-G)	MI-7253-D	SEE NOTE #4
3	1	AUDIO UNIT (MI-7098-G)	MI-7258-G	SEE NOTE #4
4	1	MODULATOR OUTPUT UNIT (MI-7098-G)	MI-7087-B	SEE NOTE #4
5	1	POWER CONTROL UNIT (MI-7098-G)	MI-7257-C	SEE NOTE #4
6	1	BASE ASSEMBLY, ETC. (MI-7098-G)	MI-7255-A	SEE NOTE #4
7	1	ENCLOSURE (MI-7098-G)	MI-7256-B	SEE NOTE #4
8	1	INTERCONNECTION JUMPERS (MI-7098-G)	MI-7077	SEE NOTE #4
9	1	TOOL KIT	MI-7086-B	
10	1	MISCELLANEOUS HARDWARE KIT	MI-7474	
11	1	TOUCH-UP FINISH KIT	MI-7499-A	
12	2	CRYSTAL OSCILLATOR UNIT	MI-19458	
13	2	INSTRUCTION BOOK (PACKED BY SHIPPING DEPT.)	IB-30141	
14	*	PLATE TRANSFORMER	SEE NOTE	
15	*	ANTENNA TUNING EQUIPMENT	SEE NOTE	
16	*	AUDIO CABINET (RIGHT WING)	MI-7485-E	
17	*	ANTENNA PHASING CABINET (LEFT WING)	MI-7485-F	
18	*	SUPERVISORY CONTROL CONSOLE	MI-11616	
19	*	RELAY PANEL (GRAY)	SEE NOTE	
20	*	INSTALLATION MATERIAL KIT	SEE NOTE	
21	*	CONVERSION KIT (60 CY. TO 50 CY.)	MI-7085-C	
22	*	FREQUENCY DETERMINING PARTS (TRANSMITTER)	MI-19465-B	
23	*	TMV-129B CRYSTAL UNIT	MI-7467	
24	*	SET OF TUBES (TRANSMITTER)	MI-7084-A	
25	*	NAMEPLATE	MI-28180-1	
26	*	INSTALLATION NOTES	IB-30099-1	

*(NOTE) USE THE FOLLOWING INFORMATION FOR ORDERING ITEMS 14 THRU 26 ABOVE:

ITEM 14 SUPPLY ONE. ORDER AS MI-7088-A (OIL FILLED) OR MI-7088-B (AIR COOLED).

ITEM 15 SUPPLY ONE IF & AS REQUIRED BY CUSTOMER'S ORDER. ORDER AS MI-28902-A IF MONITORING RECTIFIER IS NOT DESIRED, OR AS MI-28902-B IF MONITORING RECTIFIER IS TO BE INCLUDED. IN LIEU OF EITHER EQUIPMENT CUSTOMER MAY ORDER SPECIAL PHASING EQUIPMENT. SEE MI-28902-A/B FOR ADDITIONAL ORDERING DATA.

(CONTINUED ON SHEET #2)

COMPILED BY	THIS MI IS USED FOR	DISTRIBUTION	REQUISITIONS	S	REQUISITIONS	S
GMP 3-11-46	B/C XMITTERS	WB CN FN				

0 1 APPROVED BY

15833B

SHEET #2

LIST OF CONTENTS OF MASTER ITEM 7266-C

MI-7266-C BTA-10F B/C TRANSMITTER EQUIPMENT (230 V., 3 PH., 60 CY.)

ITEM	QUAN.	DESCRIPTION	REFERENCE	PART OR GROUP

(NOTE FOR ITEMS 14 THRU 26 CONTINUED)

ITEM 16 SUPPLY ONE IF & AS REQUIRED BY CUSTOMER'S ORDER.

ITEM 17 SUPPLY ONE IF & AS REQUIRED BY CUSTOMER'S ORDER.

ITEM 18 SUPPLY ONE, IF & AS REQUIRED BY CUSTOMER'S ORDER. ANTENNA CURRENT INDICATOR WITH 0-10 DIV. SCALE IS PROVIDED. SPECIAL SCALE MAY BE ORDERED TO MEET ANTENNA CHARACTERISTICS.

ITEM 19 SUPPLY ONE. ORDER AS MI-4309-A (BLACK) OR MI-4309-B (GRAY).

ITEM 20 SUPPLY ONE. ORDER AS MI-7268-B FOR EXPORT SALES OR MI-7268-E FOR DOMESTIC SALES.

ITEM 21 SUPPLY ONE IF & AS REQUIRED BY CUSTOMER'S ORDER.

ITEM 22 SUPPLY ONE. ENG. DEPT. WILL DETERMINE REQUIREMENTS UPON RECEIPT FROM SALES DEPT. OF THE STATION'S OPERATING FREQUENCY & TRANSMISSION LINE IMPEDANCE. FREQUENCY DETERMINING PARTS FOR ITEM 15, IF ORDERED, WILL ALSO BE SPECIFIED BY ENG. DEPT. UPON RECEIPT FROM SALES DEPT. OF TRANSMISSION LINE & ANTENNA CHARACTERISTICS.

ITEM 23 SUPPLY TWO (1 SPARE) IF & AS REQUIRED BY CUSTOMER'S ORDER, & SPECIFY CRYSTAL FREQUENCY AS DETERMINED FROM TRANSMITTER OUTPUT FREQUENCY.

ITEM 24 SUPPLY QUANTITY PER CUSTOMER'S ORDER.

(CONTINUED ON SHEET #3)

COMPILED BY	THIS MI IS USED FOR	DISTRIBUTION	REQUISITIONS	S	REQUISITIONS	S
GMP 3-11-46	B/C XMITTERS	WB CN FN				

0 1 APPROVED BY

15833B

Figure 4—Reproduction of MI-7266-C

Preliminary Adjustments

After the transmitter has been assembled and all the wiring is in place and before power is applied, point-to-point circuit checks should be made. An ordinary electric door-bell or buzzer and battery fitted with a pair of 10 foot leads is an excellent piece of equipment for "ringing out" circuit connections. Be sure the circuit check is direct and not being completed through some circuitous path involving a common ground or the winding of a transformer. It is wise to isolate the circuit by lifting one end of the conductor.

Relays

Before any power is applied to the transmitter the relays described in the following paragraphs should be adjusted in the manner indicated.

2E1—Bias Protective Relay, Type SG. Adjust and lock the No. 4/36 brass screw located in the center of the movable armature so that the face of the armature, upon closing, is separated from the stationary pole piece by a small air gap equal to the thickness of thin cardboard, approximately 15 mils (0.015 inch). It may be necessary to adjust the spring tension on the armature return spring. Since 2E1 is "blocked-in" for the control-circuit check its operation cannot be observed until power is being applied for the R-F tune-up procedure. Should the BIAS pilot light 5A2 fail to glow check to see if relay 2E1 is closed (this relay may be observed through the port of the low-power compartment door). If the relay fails to close stretch the armature return spring slightly to reduce its tension. This adjustment may require two or three operations to secure positive relay action.

4E6—Rectifier Plate Delay Relay—Type TK. The setting mechanism of this relay consists of (1) a gear train which provides three different time settings (50 minutes, 5 minutes and 30 seconds) and (2) a tripping mechanism consisting of a scale plate and two tripping discs. The scale plate has three scales: the 50 minute scale graduated in sub-divisions to 1 minute, the 5 minute scale graduated in sub-divisions to 0.1 minute, and the 30 second scale with sub-divisions to 1 second. The tripping discs mounted in front of the scale plate are equipped with index marking pins for setting to the scale and trip pins which perform the tripping function as they are revolved to a point where they trip the Micarta latch arms and release the contact fingers. Both the gear train and tripping mechanism are mounted on a common shaft at the top of the relay. The gear train is located behind the tripping mechanism and is movable on the shaft; it is held in place by a set screw. Before setting for a predetermined tripping time the sliding gear assembly should be shifted to the ratio desired. A square "Time Setting" plate located adjacent to the gear train is calibrated and the large gear is set opposite the time range desired. By loosening the thumbscrew on the front end of the shaft the tripping discs can now be rotated so the index pins point to the desired scale markings. The adjustment of 4E6 should be: set the large gear of the gear train opposite the arrow for 30 seconds, and rotate both tripping discs until their index pointers are set at 30 seconds on the scale dial. Be sure that the set screw on the gear train and the thumbscrew holding the tripping discs are both tightened securely. (Refer to Bulletins 43-366 and 2465E.)

4E8—Rectifier Surge Relay, Type TK. This is the same type of relay as 4E6. Set the large gear of the gear train opposite the arrow for 30 seconds and rotate both tripping discs until their index pointers are set at 3 seconds on the 30 second scale of the dial.

4E7—Auxiliary Plate Time-Delay Relay, Type CR-2820-1731-A. (Provides a by-pass circuit for Relay 4E6.) This is an instantaneous-closing, time-delay-opening relay in which an escapement mechanism delays the contact opening. The time interval is determined by the position of the pin inserted through the slot in the yoke assembly. This pin is located on the right-hand side of the relay just below the solenoid. It is held in place by a nut. To change the time interval loosen the nut and move the pin down for increased time or up for decreased time. The range of adjustment is from 1 to 4 seconds. For 4E7 move the pin upward toward minimum time so that the contacts open in two seconds after the relay is de-energized. This adjustment may be made without the application of power; the action of the solenoid may be simulated by operating it by hand. Be sure to tighten the locking nut to maintain adjustment. (Refer to Bulletin GEH-1016-A.)

4E11—Auxiliary Notching Relay, Type CR-2820-1731-B. (Provides a time-delay closing interlock for relay 4E10.) This is an instantaneous-opening, time-delay closing relay in which the escapement mechanism delays reclosing. The method of adjustment is the same as that of 4E7. Set the escapement for minimum time. (Refer to Bulletin GEH-1016-A.)

4E20—Auxiliary Carrier-Off Relay, Type CR-2820-1731-A. (Provides a time-delay-opening interlock for relay 4E9.) This relay has the same characteristics as 4E7 and is adjusted in the same manner. Set the escapement for minimum time. (Refer to Bulletin GEH-1016-A.)

4E12 and 4E13—Main Line A-C Overload Relays, Type 12PAC13A-Z. The current at which the plunger operates to trip the contacts is predetermined by the height at which the plunger 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 of amperes at which it is desired that the relay shall operate. This setting is accomplished by turning the knurled nut, located at the lower end of the calibrating tube, until the plunger groove rests opposite the desired tripping current. Set the plungers on relays 4E12 and 4E13 at minimum current (plungers up) for the first power application. When plate power is applied, the plungers should be lowered until they just fail to trip at 100 per cent tone modulation. For maximum protection during normal operation this setting should be reduced so that tripping occurs at the desired program overmodulation level. (Refer to Bulletin GEH-954-A.)

4E14—Power Amplifier D-C Overload Relay, Type 12PAC13A-1. This is the same general type of relay as 4E12 and is adjusted in the same manner.

4E15—Low Power Rectifier A-C Overload Relay, Type 12PAC14A-10. This is the same general type of relay as 4E12 and is adjusted in the same manner.

Arc Gaps

The sphere gaps on the modulation transformer and reactor (6T3, 6L5) should be set at approximately ⅛ to $\frac{3}{16}$ inch and this spacing should be reduced under operating conditions until flash-over occurs at the maximum modulation level which is to be encountered under normal conditions. Continuity through the arc limiting resistor 7R2 should be carefully checked.

The arc gap on the main filter reactor 7L1 should be set at ¼ inch maximum and subsequently reduced to the minimum value that will permit operation without continuous arcing on starting. A momentary arc will occur at the instant potential is applied.

The horn gap at the transmission line terminal should be set at ⅜ inch maximum.

Control Circuit Check

After the preceding adjustments have been made the operation of the control circuits should be checked.

First make certain that all switches and circuit breakers are in the OFF position and that grounding sticks are attached to the high-voltage terminals of the main and low-power rectifiers. Block Carrier Off Relay 4E9 and Bias Protective Relay 2E1 closed. This makes it possible to check all primary-power-excited control circuits, including the plate contactor, without the application of plate voltage.

1. Close the following switches on the Control Console:

FILAMENT ON	9S5
POWER CHANGE	9S2
PLATE ON	9S4

NOTE: The procedure outlined below is not intended as a discussion of the full operation of all elements of the control circuits, but merely as an outline of the obvious sights and sounds connected with their proper operation. During this checking procedure if any part fails to function as indicated, reference should be made to Control Ladder, Figure 24 and the discussion of Control Circuits in the Description section of this book for guidance in locating and correcting the defective circuit.

2. Close A-C MAIN LINE circuit breaker 4S1.
   a. A-C MAIN LINE pilot lamp 4A2 should light.
   b. A-C LINE VOLTS meter 5M16 should read 230 volts.

3. Close CONTROL CIRCUIT ON circuit breaker 4S5 and MASTER FILAMENT circuit breaker 4S6. Rotate A-C SUPPLY VOLTMETER switch 4S8 to positions 1, 2 and 3 and check the balance of the three phases of the a-c supply.

4. Close TRANSMITTER ON switch 4S4.
   a. CONTROL CIRCUIT ON pilot lamp 4A3 should light.
   b. INTERLOCKS pilot lamp 5A5 should light.
   c. BIAS pilot lamp 5A3 should light.
   d. Low power and rectifier tube filaments should light, and after a 30-second delay period,
   e. Relays 4E7, 4E20 and 7E2 should be heard closing.

5. Open and close each access door (except control panel door) to test interlocks.
   a. Parts in 4b and 4e should be de-energized when any door is opened.

6. Close all three blower motor circuit breakers (4S9, 4S10 and 4S11).
   a. All four blower motors should start.
   b. After airflow has been built up, AIRFLOW pilot lamp 5A4 should light.
   c. Filaments of high power tubes 1V7, 1V8, 2V7 and 2V8 should light.

7. Press PLATE VOLTAGE ON switch 5S10.
   a. PLATE VOLTAGE-REDUCED pilot lamp 5A8 should light.
   b. Relays 4E4 and 4E19 should be heard closing.
   c. After 3 seconds delay, Surge Relay 7E1 should be heard closing with a loud report.

8. Throw POWER CHANGE switch 4S3 to HIGH.
   a. PLATE VOLTAGE-REDUCED pilot lamp 5A8 should go out.
   b. PLATE VOLTAGE-FULL pilot lamp 5A7 should light.
   c. Relays 4E3 and 4E5 should be heard closing while 4E4, 4E8 and 7E1 open.
   d. After 3 seconds delay, Surge Relay 7E1 should be heard closing (loud report).

9. Operate by hand Overload Relay 4E12.
   a. PLATE VOLTAGE-FULL pilot lamp 5S7 should go out.
   b. OVERLOAD pilot lamp 5A6 should light.
   c. Relays 4E3, 4E5, 4E8, 4E19 and 7E1 should be heard opening.

10. Press PLATE VOLTAGE ON button 5S10.
   a. PLATE VOLTAGE-FULL pilot lamp 5A7 should light.
   b. OVERLOAD pilot lamp 5A6 should go out.
   c. Relays 4E3, 4E5, and 4E19 should be heard closing.
   d. After 3 seconds, Surge Relay 7E1 should be heard closing.

11. Open TRANSMITTER ON switch 4S4. Throw AUTOMATIC ON-OFF switch 4S13 to ON. Close TRANSMITTER ON switch 4S4.
   a. CONTROL CIRCUIT ON pilot lamp 4A3 should light.

b. INTERLOCKS pilot lamp 5A5 should light.

c. BIAS pilot lamp 5A3 should light.

d. Low Power and rectifier tube filaments should light.

e. Blower motors should start.

f. AIRFLOW pilot lamp 5A4 should light; and after 30 seconds delay,

g. Relays 4E7, 4E20, 7E2, 4E3, 4E5 and 4E19 should be heard closing; and after 3 seconds delay,

h. Relay 7E1 should close with a loud report.

12. Operate by hand Overload Relay 4E13.

a. PLATE VOLTAGE-FULL pilot lamp 5A7 should go out.

b. OVERLOAD pilot lamp 5A6 should light.

c. Relays 4E19, 4E3, 4E5, 4E8 and 7E1 should be heard opening and after 250 milliseconds delay,

d. PLATE VOLTAGE-FULL pilot lamp 5A7 should light.

e. Relays 4E19, 4E3 and 4E5 should be heard closing; and after 3 seconds delay,

f. Relay 7E1 should be heard closing.

g. Note that OVERLOAD pilot lamp 5A6 remains lit.

13. Operate by hand Overload Relay 4E14.

a. Action in Paragraph 12 (except b and g) should recur.

14. Operate by hand Overload Relay 4E15.

a. Action in Paragraph 12 a and c should recur; and after 250 milliseconds delay,

b. PLATE VOLTAGE-REDUCED pilot lamp should light.

c. Relays 4E19 and 4E4 should be heard closing; and after 3 seconds delay,

d. Relay 7E1 should be heard closing.

15. Operate by hand Overload Relay 4E16.

a. PLATE VOLTAGE-REDUCED pilot lamp should go out.

b. Relays 4E19, 4E4, 4E8 and 7E1 should be heard opening.

16. Press PLATE VOLTAGE ON push-button 5S10.

a. PLATE VOLTAGE-FULL pilot lamp 5A7 should light.

b. OVERLOAD pilot lamp 5A6 should go out.

c. Relays 4E19, 4E3 and 4E5 should be heard closing; and after 3 seconds delay,

d. Relay 7E1 should be heard closing.

17. Throw POWER CHANGE switch 4S3 to LOW.

a. PLATE VOLTAGE-FULL pilot lamp 5A7 should go out.

b. PLATE VOLTAGE-REDUCED pilot lamp 5A8 should light.

c. Relays 4E3, 4E5, 4E8 and 7E1 should be heard opening while 4E4 closes; and after 3 seconds delay,

d. Relay 7E1 should be heard closing.

18. Operate by hand any one of the Overload Relays (4E12 to 4E16).

a. OVERLOAD pilot lamp 5A6 should light.

b. PLATE VOLTAGE-REDUCED pilot lamp 5A8 should go out.

c. Relays 4E19, 4E4, 4E8 and 7E1 should be heard opening. After 250 milliseconds delay,

d. PLATE VOLTAGE-REDUCED pilot lamp 5A8 should light.

e. Relays 4E19 and 4E4 should be heard closing; and after 3 seconds delay,

f. Relay 7E1 should be heard closing.

19. Repeat procedure in Paragraph 18 twice more. Result should be the same (except for 18a).

20. Repeat procedure in Paragraph 18 a third time. Action in Paragraph 18 b and c should recur.

21. Press PLATE VOLTAGE ON push-button 5S10.

a. PLATE VOLTAGE-REDUCED pilot lamp 5A7 should light.

b. OVERLOAD pilot lamp 5A6 should go out.

c. Relays 4E19 and 4E4 should be heard closing; and after 3 seconds delay,

d. Relay 7E1 should be heard closing.

22. Press PLATE VOLTAGE OFF push-button 5S11.

a. Result should be the same as in Paragraph 18 (except for 18a).

23. Open all circuit breakers on the control panel and remove the "blocks" from relay 2E1 and 4E9.

All control circuit elements (except for the "blocked" relays 2E1 and 4E9) have now been checked for proper operation.

Filament Voltage Adjustment

All filament transformer primary voltage taps should be adjusted so that the voltage measured at each tube socket does not exceed the rated potential shown in the tabulation of "Typical Meter Readings" by more than five per cent when the supply voltage is at the maximum to be encountered.

To energize the filament circuits close the AC MAIN LINE circuit breaker 4S1, and the CONTROL CIRCUITS ON circuit breaker 4S5, then throw both the TRANSMITTER ON-OFF switch, 4S4, and the FILAMENT ON switch 9S5 to the ON position. The blowers and the filaments of all low-power and rectifier tubes should

now be energized; also the following pilot lights should glow: AC MAIN LINE, 4A2, CONTROL CIRCUITS ON, 4A3, on the transmitter control panel; AIRFLOW, 5A4, on the transmitter control strip; and FIL. ON, 9A13 on the control desk. First check the voltage of the main a-c line on the LINE voltmeter, 5M16. Rotate AC SUPPLY VOLTMETER switch, 4S8, on the transmitter control panel to positions 1, 2, and 3 to connect the voltmeter across each of the three phases. Next check the filament voltage, at the socket, of each tube in the low power compartment using a 0-15V a-c voltmeter. This will include all tubes in the rectifiers, and the low power r.f. and audio stages. When necessary the primary voltage taps must be adjusted to provide the voltage shown in the table of "Typical Meter Readings" on page 31 under the conditions described in the first paragraph of this subject.

Now move the 0-15V a-c voltmeter to the filament terminals of one of the main rectifier tube sockets (7X1-7X6). The primary tap on each of the main rectifier filament transformers (7T1-7T6) should be adjusted so that with the line voltage at a maximum and the FILAMENT VOLTAGE CONTROL-MAIN RECTIFIER rheostat, 4S9, located on the transmitter control panel, set at approximately ¾ full resistance, the socket voltage at each rectifier tube (7V1-7V6) is exactly 5 volts. Under this condition the AC SUPPLY VOLTMETER switch, 4S8, should be rotated to position 4 and the voltage indicated on the LINE voltmeter 5M16 noted. To insure the application of the correct filament potential, this meter indication should be maintained at all times when the transmitter is operating.

New rectifier tubes should be given an initial forming period of not less than 30 minutes during which filament power should be applied. This initial forming period is required to drive mercury globules from the filament and to distribute the vapor properly within the envelope. It is not necessary to repeat this initial warm-up unless the tubes have been replaced or otherwise disturbed. Spare rectifier tubes should be so treated every 90 days.

Lastly check and adjust the filaments of the power amplifier and modulator tubes. To energize the filament circuits of the the RCA-892-R tubes close the MASTER FILAMENT circuit breaker, 4S6.

The power amplifier filament voltage is controlled by the triple-unit rheostat—FILAMENT VOLTAGE CONTROL—POWER AMPLIFIER (4R2) and is indicated on the FILAMENT VOLTS meter 5M14 when the FILAMENT VOLTMETER SWITCH 4S14 is in position 3. The filament voltage should be adjusted to the minimum value that is consistent with the desired distortion characteristic. For new tubes 14.7 to 15.0 volts should be sufficient.

The filament voltage that is applied to the modulator tubes is controlled by the triple-unit rheostats, FILAMENT VOLTAGE CONTROL-MODULATOR NO. 1 (4R3) and FILAMENT VOLTAGE CONTROL-MODULATOR NO. 2 (4R4). The voltage that is applied to the front modulator tube is indicated on the FILAMENT VOLTS meter 5M14 when the FILAMENT VOLTMETER SWITCH 4S14 is in position "2"; the voltage applied to the rear modulator tube is indicated when the switch is in "1." For new tubes approximately 12.8 volts should be sufficient.

Adjustment should also be made for proper filament potential at the monitoring rectifier. See IB-30168 (Type BPA-10 Antenna Tuning Unit) which is included at the back of this book.

Tuning

No attempt should be made to tune the transmitter until after the functioning of the control circuits has been checked.

Before starting the tuning procedure the following adjustments should be made:

(1) **Make certain** that the POWER CHANGE switch 4S3 is in the POWER CHANGE LOW position; the MANUAL AUTOMATIC switch 4S13 in the AUTOMATIC OFF position; the TRANSMITTER ON-OFF switch 4S4 in the TRANSMITTER OFF position; and that all of the other switches on the control panel are in the OFF position.

(2) Connect the high-voltage terminals (H1, H2 and H3) of the plate-power transformer (6T2) to ground.

(3) The transmitter is equipped with four grounding sticks: one in the power amplifier compartment, one in the low-power compartment, one in the modulator compartment, and one at the rear of the transmitter convenient to the high-voltage d-c lines. Using the grounding sticks, connect the high-voltage lines in the power amplifier and modulator compartments to ground.

MAKE IT A HABIT TO USE THE GROUNDING STICKS EACH TIME A HIGH-VOLTAGE COMPARTMENT IS ENTERED. YOUR OWN LIFE MAY DEPEND UPON THIS. DO NOT DEPEND UPON THE INTERLOCKS TO REMOVE THE HIGH-VOLTAGE.

(4) Remove the links which connect terminals W3 and W4 on the left-hand side of the low-power rectifier chassis with terminals W3 and W4 on the low-power r-f chassis.

(5) Remove the link which connects terminal W4 on the right-hand side of the low-power rectifier chassis with terminal W4 on the low-power a-f chassis.

(6) Remove the buffer stage screen voltage dropping resistor 1R10.

WARNING: DO NOT APPLY SCREEN VOLTAGE TO THE RCA-828 TUBES WITH PLATE VOLTAGE REMOVED.

(7) Remove the modulator stage plate voltage dropping resistors 2R52 and 2R53.

Refer to the Tuning Chart (page 22) and set up the r-f circuits in accordance with the values indicated for the operating frequency. The Tuning Chart is intended only as a guide in making preliminary adjustments. Each circuit must be carefully resonated and, where necessary, neutralized for proper operation. The shields of the oscillator units must be removed in order to connect the proper coil tap (indicated in the Tuning Chart) in the plate circuits of the oscillators. To remove the entire oscillator unit, remove the screws which fasten it to the mounting shelf, disconnect the r-f lead from the top, then pull the unit out. Power supply of the unit is through the plug-and-jack board at the rear.

The particular capacitor that should be installed at a given position in the power amplifier tank and output loading circuit is indicated in the following tabulation.

POWER AMPLIFIER PLATE-CIRCUIT

Total Capacitance (mmfd)	Tank Capacitors							
	1C34		1C35		1C36		1C37	
	mmfd	UC-	mmfd	UC-	mmfd	UC-	mmfd	UC-
300	300	3334	300	3334	300	3334	300	3334
266	200	3335	400	3333	200	3335	400	3333
200	200	3335	200	3335	200	3335	200	3335
150	150	3336	150	3336	150	3336	150	3336
120	150	3336	100	3328	150	3336	100	3328
100	100	3328	100	3328	100	3328	100	3328

OUTPUT-COUPLING CIRCUIT

Total Capacitance (mmfd)		Coupling Capacitors							
		230-ohm Line				70-ohm Line			
		1C38		1C39		1C38		1C39	
230-Ohm Line	70-Ohm Line	mmfd	UC-	mmfd	UC-	mmfd	UC-	mmfd	UC-
1500	1500	1000	3330	500	3332	1000	3330	500	3332
1400	1500	800	3331	600	3350	1000	3330	500	3332
1400	1500	800	3331	600	3350	1000	3330	500	3332
1300	1500	800	3331	500	3332	1000	3330	500	3332
1300	1500	800	3331	500	3332	1000	3330	500	3332
1200	1500	600	3350	600	3350				

INTERMEDIATE POWER AMPLIFIER

Neut. Blocking—1C43		Tank—1C30, 1C31	
Capacitance (mmfd)	Dwg. No.	Capacitance (mmfd)	UC-
150	32220-647	1500	3392
150	32220-647	1000	3344
150	32220-647	800	3346
100	32220-598	600	3348
100	32220-598	500	3351
100	32220-598	300	3355

Tuning Chart

OSCILLATOR		BUFFER		INTERMEDIATE POWER AMPLIFIER				POWER AMPLIFIER			
				TANK		NEUTRALIZING		TANK		OUTPUT LOADING	
Frequency (KC)	Oscillator Coil Tap (1L1)	Capacitor Connections 1C21, 1C22, 1C23	Active Turns on 1L4	Individual Capacitance of 1C30 and 1C31 (mmfd)	Active Turns (each side of center) on 1L8	Total Capacitance (mmfd) 1C26, 1C27, 1C28	Active Turns on 1L6	Total Capacitance (mmfd) 1C34, 1C35, 1C36, 1C37	Active Turns on 1L13	Total Capacitance 1C38 and 1C39 (mmfd)	
										230-ohm line	70-ohm line
540 to 650	1	1C21 connected in series with the parallel combination of 1C22 and 1C23. The junction of 1C21 and the combination of 1C22, 1C23 connected to the IPA grid resistors (1R14, 1R15); the other side of the 1C22, 1C23 combination connected to 1C24.	80 to 70	1500	26 *	400 1C26, 1C27 and 1C28 connected in parallel.	See Figure 5	300	See Figure 6	1500	1500
650 to 750	1 and 2		70 to 55	1000	24-26 *	300 1C27 and 1C28 connected in parallel.		266		1400	1500
750 to 850	2		55 to 41	800	22-24 *	200 1C26 and 1C27 connected in parallel.		200		1400	1500
850 to 1050	2 and 3		41 to 30	600	20-24 **	100 1C28 connected in series with the parallel combination of 1C26 and 1C27.		150		1300	1500
1050 to 1350	3 and 4	1C21, 1C22 and 1C23 connected in series. The junction of 1C22, 1C23 connected to the IPA grid resistors (1R14, 1R15); the other side of 1C23 connected to 1C24.	38 to 28	500	16-20 **			120		1300	1500
1350 to 1600	4		28 to 20	300	16-18 **	75 1C26 connected in series with the parallel combination of 1C27 and 1C28.		100		1200	1500
Station Frequency Final Values											

*Unused turns open.

** Unused turns shorted.

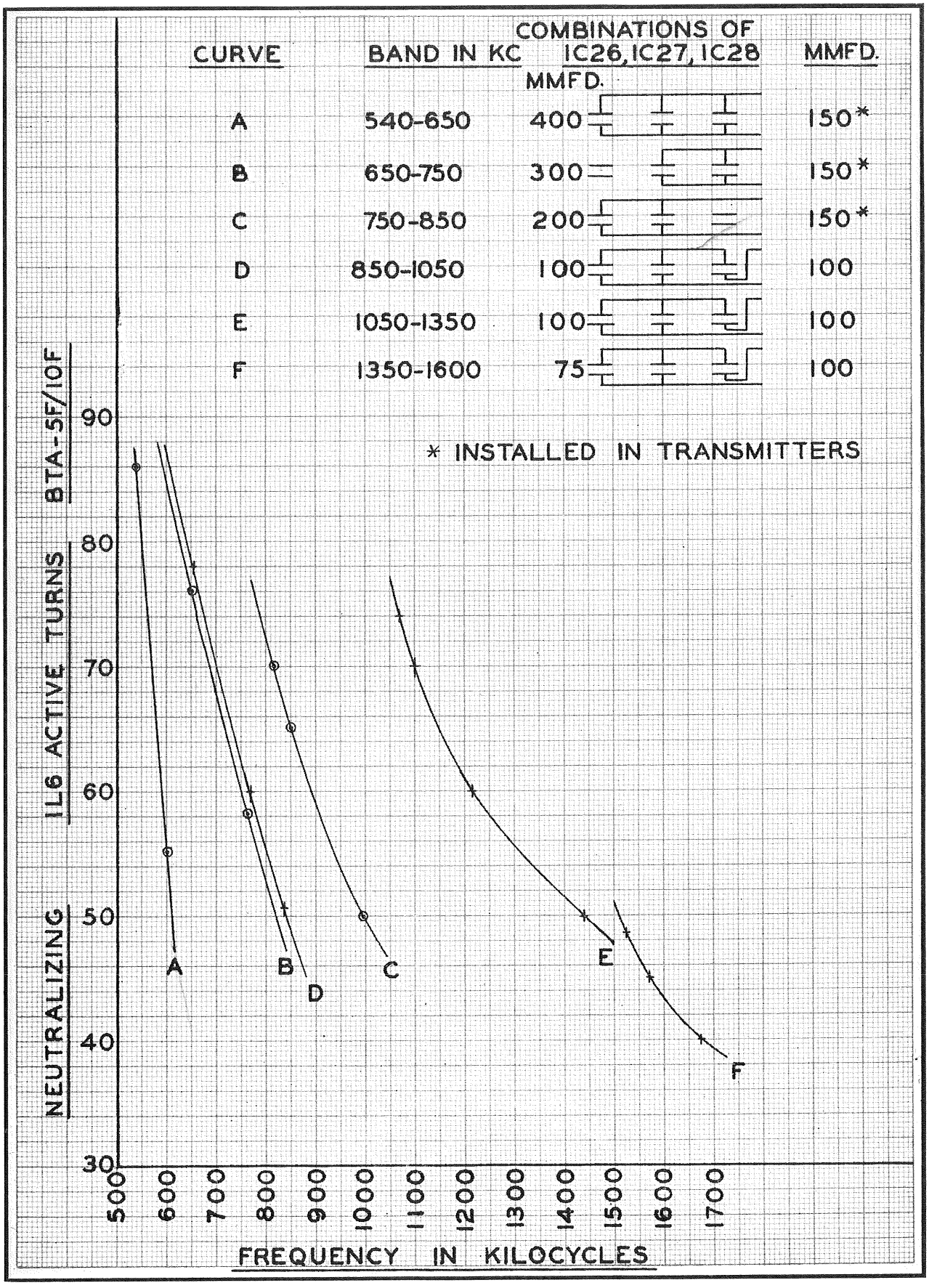


Figure 5—Tuning Chart for 1L6 (S-853816)

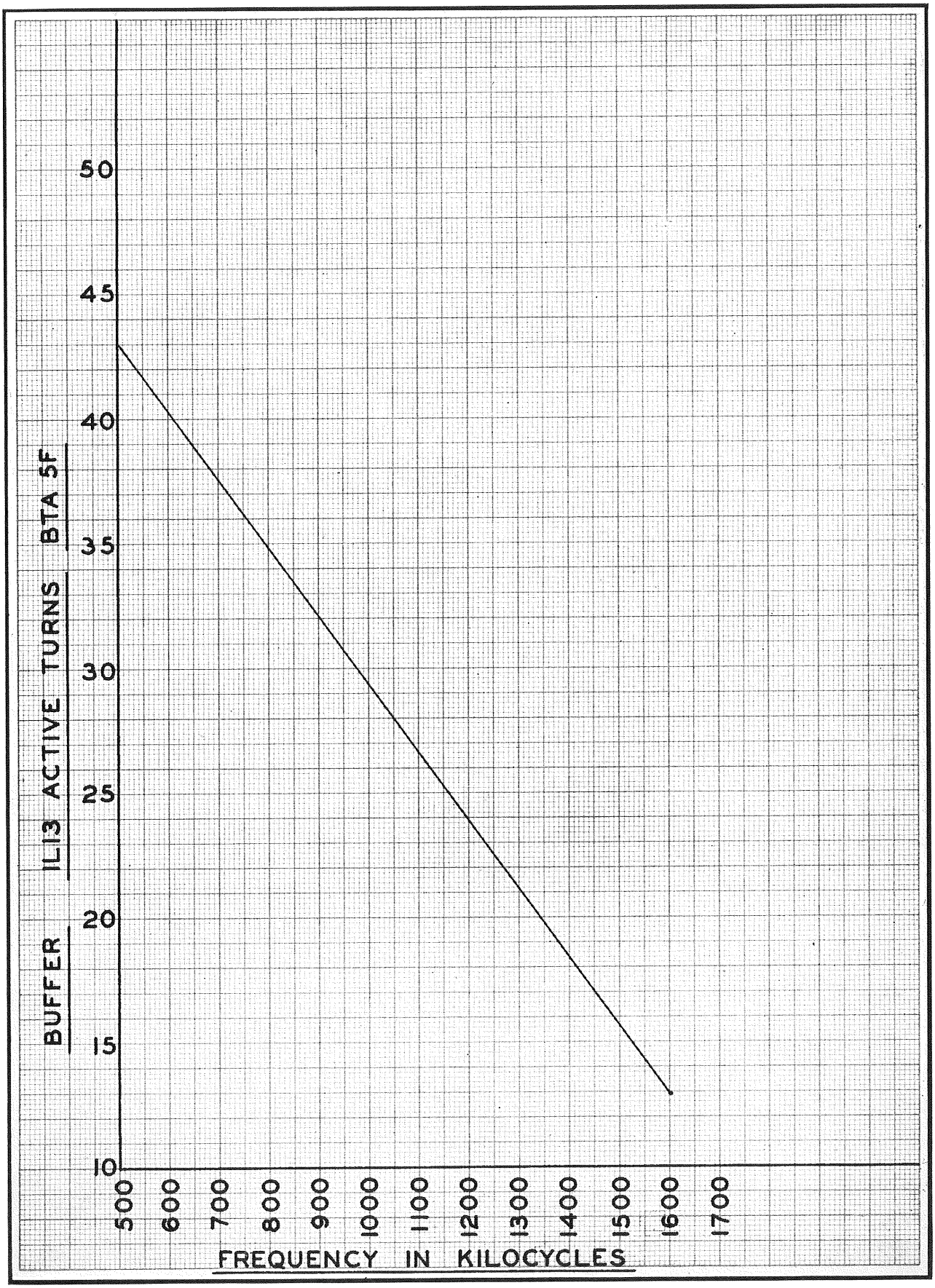


Figure 6—Tuning Chart for 1L13 (S-853814)

R-F Adjustments — Install a TMV-129B Crystal Holder containing a quartz crystal ground to the operating frequency of the transmitter in each of the oscillator units (1A2, 1A3).

Close the control desk FILAMENT ON switch 9S5 and the PLATE ON switch 9S4; then operate the control panel AC MAIN LINE circuit breaker 4S1, the CONTROL CIRCUITS circuit breaker 4S5, and the AUXILIARY RECTIFIER circuit breaker 4S7 to the ON position. Close the high power, low power, and modulator compartment access doors then operate the TRANSMITTER ON-OFF switch 4S4 to the TRANSMITTER ON position. When BIAS pilot light glows, press PLATE VOLTAGE ON push-button 5S10. Oscillator plate current should be indicated on the OSCILLATOR PLATE CURRENT meter, 5M1. Operate CRYSTAL OSCILLATOR SELECTOR switch 5S2 and check the plate current of the second oscillator.

Test the action of the interlocks by opening the access doors one at a time. Opening any access door, except that to the control compartment, should remove all plate voltage from the transmitter.

Press PLATE VOLTAGE OFF push-button 5S11, connect grounding stick and replace the link between terminal W3 on the low-power r-f chassis and W3 on the low-power rectifier chassis, then replace the buffer stage screen voltage dropping resistor 1R10.

NOTE: MAKE CERTAIN THAT THE PLATE CAP IS CONNECTED TO THE RCA-828 TUBE, 1V4.

After resistor 1R10 and link W3 have been replaced, operate the PLATE VOLTAGE ON push-button and tune the buffer-amplifier stage 1V4 to resonance by rotating the plate tank coil 1L4. Resonance is indicated by minimum current indication on the BUFFER PLATE CURRENT meter 5M2 and maximum indication on the DRIVER GRID CURRENT meter 5M3.

With the grids of the intermediate power amplifier tubes (1V5, 1V6) excited, the intermediate power amplifier stage should be neutralized by rotating the neutralizing coil 1L6 to the point at which **minimum** deflection is obtained on the screen of a cathode-ray oscilloscope which is inductively coupled to the intermediate power amplifier plate coil 1L8 or on a 0-100 milliampere r-f meter connected between 1L8 and 1C30. If an oscilloscope or milliammeter is not available, indications of the grid milliammeter 5M3 may be used. Tune the intermediate power amplifier plate tank through resonance by operating the DRIVER RAISE-LOWER switches 5S4 and 5S5. Tuning through resonance will produce a decided rise or fall in the grid current before neutralization. When the neutralization adjustment is correct the grid current will remain constant when tuning through resonance. Recheck the buffer plate tuning for resonance after each readjustment of the neutralizing coil 1L6.

After the intermediate power amplifier stage has been neutralized press the PLATE VOLTAGE OFF push-button and reestablish the connection between terminal W4 on the low-power rectifier chassis and terminal W4 on the low-power r-f chassis. When this link has been reconnected, operate the PLATE VOLTAGE ON button and then tune the intermediate power amplifier stage to resonance by manipulating the DRIVER RAISE-LOWER push-button switches 5S4 and 5S5 located on the modulator compartment door. Resonance is indicated by **minimum** current indications on the DRIVER PLATE CURRENT meters 5M4 and 5M5 and **maximum** current indication on the GRID CURRENT meter, 5M6.

When the tuning of the intermediate power amplifier stage has been completed the neutralizing adjustment should be rechecked. Complete neutralization obtains when maximum grid current occurs simultaneously with minimum plate current. To check this point tune the intermediate power amplifier plate tank through resonance two or three times by operating the DRIVER RAISE-LOWER push-button switches (5S4, 5S5) and observe the current indications on both the Driver Grid and Plate Current meters (5M3, 5M5, and 5M4). Fine adjustments in the neutralizing circuit may be secured by rotating the neutralizing coil 1L6 one-quarter turn at a time. After this has been done operate the PLATE VOLTAGE OFF button.

Now disconnect the transmission line from terminal W14, REMOVE the grounds from the high-voltage terminals of the plate-power transformer 6T2, make certain that the power change switch 4S3 is in the POWER CHANGE LOW position and that the plate caps are connected to the RCA-8008 rectifier tubes (7V1 to 7V6, inclusive) and then close the MAIN RECTIFIER PRIMARY circuit breaker 4S2. Apply reduced plate voltage to the power amplifier stage by pressing the PLATE VOLTAGE ON push-button 5S10. Tune the power amplifier stage to resonance by manipulating the OUTPUT RAISE-LOWER push-button switches 5S6 and 5S7. Approximate resonance is indicated by minimum indication on the PLATE CURRENT meter, 5M17.

CARE SHOULD BE TAKEN NOT TO APPLY POWER TO THE TRANSMISSION LINE UNTIL THE ANTENNA TUNING UNIT HAS BEEN PROPERLY ADJUSTED. ANY MISADJUSTMENT WILL PRODUCE ABNORMALLY HIGH CURRENTS IN THE POWER AMPLIFIER PLATE TANK CIRCUIT WHICH MAY BURN OUT SOME OF THE P.A. TANK COMPONENTS, PARTICULARLY CAPACITORS 1C38 AND 1C39. ALSO SUCH MISADJUSTMENT WILL CAUSE STANDING WAVES TO OCCUR ON THE TRANSMISSION LINE. THESE STANDING WAVES MAY PRODUCE AN ARC BETWEEN THE CONDUCTORS WHICH MAY DAMAGE THE LINE. THIS IS PARTICULARLY TRUE OF THE CONCENTRIC-TUBE TYPE OF LINE WHERE THE CONDUCTORS ARE NOT WIDELY SPACED.

Complete instructions for adjusting the Type BPA-10 Antenna Tuning Unit are contained in IB-30168 which is included at the back of this book.

After the Antenna Tuning Unit has been adjusted in the manner described the transmission line should be reconnected to terminal W14. The transmitter should be restarted and the power amplifier tuning rechecked.

The motor-driven inductor 1L16 should be roughly at its mid-point to permit adjustment for correct load and optimum efficiency. Such a setting may be obtained by adjusting the position of the shorting strap on plate tank coil 1L13 until the roller on 1L16 rests near the mid-point on its coil when the tank circuit is tuned to resonance.

Neutralization may be checked in a number of ways. The simplest and most accurate is to connect a vacuum tube voltmeter across the output capacitors 1C38 and 1C39 and then apply drive after plate voltage has been removed from the final amplifier by operating the MAIN RECTIFIER PRIMARY circuit breaker 4S2 to the OFF position. Capacitor 1C53 should then be connected to a tap on inductor 1L8 by means of its flexible lead and this connection varied until minimum voltage indication on the vacuum tube voltmeter is obtained. Six to eight volts indicate correct neutralization. Resonance should be maintained in the intermediate power amplifier (driver) stage at all times. As an alternate method an oscilloscope may be inductively coupled to the power amplifier tank coil 1L13, and the adjustment made for minimum band width on the screen. A third method is to substitute a 0-500 ma r-f meter for the tank thermocouple 5M8. With grid drive but no plate voltage the meter should not read more than approximately 350 ma with the output load (dummy load or antenna system) connected to the transmitter.

After proper neutralization the plate tank circuit should be checked for resonance. Depress the PLATE VOLTAGE OFF push-button 5S11 and close the MAIN RECTIFIER PRIMARY circuit breaker 4S2. Reapply plate voltage by pressing the PLATE VOLTAGE ON push-button 5S10. By manipulating the OUTPUT RAISE-LOWER push-button switches 5S6 and 5S7, tune for minimum P.A. plate current.

The power amplifier is now ready to be adjusted for proper loading and maximum efficiency. Remember the transmitter is operating in the "Reduced" power position and, therefore, the loading should be based upon these ratings in the "Typical Meter Reading" table. With the plate current at minimum the output load should be slightly below normal requirements. If such is not the case it will be necessary to change the values of output loading capacitors, 1C38 and 1C39. To decrease the loading increase the capacity, and to increase loading decrease capacity. The capacitance suggested in the Tuning Chart for 1C38 and 1C39 serves only as a guide for preliminary adjustment. Specific requirement for the output loading capacitors will depend upon the actual impedance into which the transmitter must work.

Now proceed to adjust the plate tank circuit for maximum efficiency, that is, unity power factor. If 1L16 is rotated (clockwise) to reduce its inductance (making the tank circuit input inductive) it will be found that plate current and output increase. This occurs because the tank inductance setting for minimum plate current does not coincide with unity power factor in the tube load circuit. Maximum efficiency is achieved when the unity power factor condition is realized.

Such a condition will be found in any tank circuit similar to the one used in this transmitter where the kva to kw ratio of the tank current is less than approximately 10. For higher ratios, the two inductance settings (minimum plate current and unity power factor) become practically identical. However, as the tank kva to kw ratio decreases below 10, the separation between the inductance setting for minimum plate current and that for unity power factor increases. The separation in this case is not great and represents but a few revolutions of the variable inductor 1L16.

From the foregoing, it will be evident that the output and efficiency will increase as inductor 1L16 is rotated beyond the "dip" position to the unity power factor condition. Upon passing the latter point, the output will continue to increase but the efficiency will start to decrease. It is desirable to load the final amplifier so that plate current dip is reasonably close to the desired operating plate current. This will permit optimum grid drive efficiency.

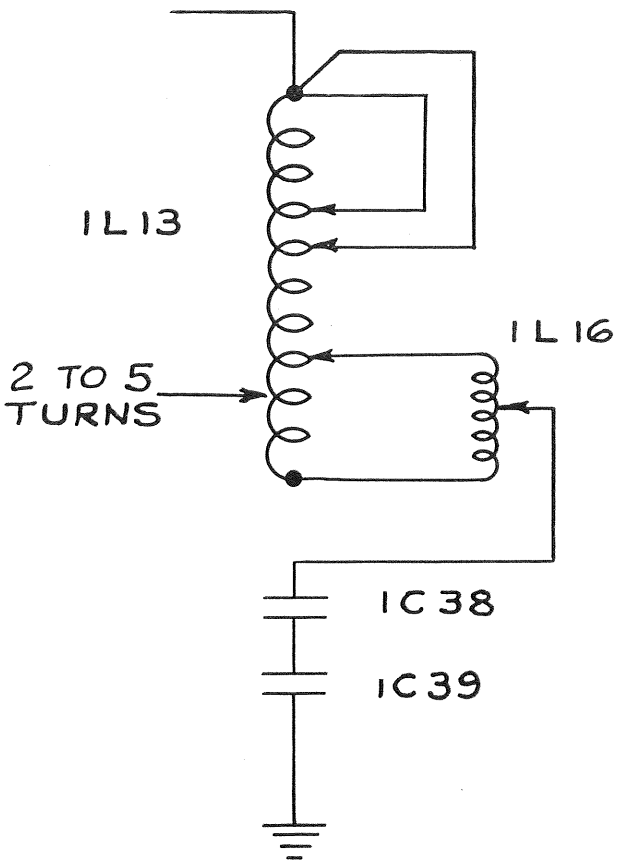
A solution of the mathematics of this tank circuit shows that for tuning in the region of unity power factor, small variations in the setting of inductor 1L16 will produce relatively large changes of the load into which the tube looks. Consequently, it is possible to obtain a considerable variation in power output without appreciably affecting the efficiency, tuning, or modulation characteristics. This tank control, therefore, provides an excellent means of compensating for reasonably wide deviations in output circuit loading and plate supply voltage.

To determine the point of maximum efficiency hold the power amplifier input constant by maintaining a fixed plate current reading on 5M17 and with an r.f. ammeter installed in the transmission line note the change in transmission line current as inductor 1L16 is adjusted. Maximum line current for a given power amplifier plate current indicates maximum efficiency.

After the plate-tank circuit adjustments have been made and if there is no indication whatever of abnormal operation, the power-change switch 4S3 should be operated to the POWER CHANGE HIGH position. Observe the value of plate current at the minimum or "dip" position as indicated upon meter 5M17. If this current is not slightly below the value given in the tabulation of "Typical Meter Readings," it may be assumed that the modulated amplifier is loaded incorrectly and that the output coupling circuit requires further adjustment.

At frequencies above 1400 kilocycles the current in the inductive leg of the power amplifier tank circuit may tend to overload the variable inductor 1L16. When this current exceeds 20 amperes the circuit should be changed to that shown in the diagram on page 25. It should be noted that when the circuit is thus modified the strap which connects the roller guide-rod to the lower end of 1L16 must be removed, otherwise at minimum inductance a short circuit will be presented to the included turns on 1L13.

The output coupling circuit is another important factor governing the power output and efficiency of the transmitter. In this circuit, the coupling capacitors 1C38 and 1C39 are furnished to satisfy a specified line (or load) impedance. Since the reactance of these units controls the loading of the transmitter, it must be calculated for each installation. If the loading is found to be insufficient, as indicated by low plate current, the reactance must be increased (capacitance decreased) to increase the tube load. Obviously, the converse also is true. Small discrepancies in loading may be corrected by shifting taps on the line-terminating inductor 8L1 in the Antenna Tuning Unit.



Tuning of the output coupling circuit to a condition of correct match with the transmission line is accomplished by the series variable inductor 1L17. Since small percentages of mismatch have no effect upon the transmission characteristics, this inductor also may be used to control the loading. This element, however, is much more effective with low load impedance than when high-impedance lines are employed. It has little effect on lines having characteristic impedances greater than 200 ohms and may be removed from the circuit in such cases if desired. The chief value of this inductor is to provide the vernier correction necessary to obtain an exact match to low-impedance lines, since that condition cannot be secured with commercially available steps in capacitance.

A simple check for approximate line matching may be made by inserting an r-f ammeter in series with each end of the transmission line. The currents indicated by the two meters should both lie within 20 per cent of the value of I_L as derived by the formula:

$$I_L = \sqrt{\frac{W}{Z_o}}$$

Where: I_L = transmission line current (amperes)

W = antenna power (watts)

Z_o = characteristic impedance of line (ohms)

The antenna power (W) may be calculated from the equation: $W = I_a^2 R_a$

Where: W = antenna power (watts)

I_a = antenna current (amperes)

R_a = antenna resistance (ohms) measured at the same point as I_a

The r-f pickup coils 1L14 and 1L15 are provided to supply radio-frequency energy for the test and monitoring equipment. The number of turns on these coils should be reduced one turn at a time until the coil itself matches the impedance of the transmission line to the test equipment. Resistors 1R23 and 1R24 may be adjusted so that the output level at the test equipment will not vary with a change in power level of the transmitter. Tuned circuits should **never** be attached to the lines from coils 1L14 and 1L15 unless heavily loaded to prevent excessive selectivity. Such selectivity will clip the high frequency response and cause distortion, thus affecting the quality of the signal which would be supplied to the monitoring and test equipments.

As a final check on operation the CRYSTAL OSCILLATORS OFF push-button 5S3 should be depressed to block the carrier. If all grid currents drop to zero and no plate current becomes abnormal the circuits are stable. As a further check for spurious oscillation proceed as follows: Remove the crystal from one oscillator and throw the CRYSTAL OSCILLATOR SELECTOR switch (5S2) to the position for that oscillator. Tune an ordinary communication receiver (with the BFO on) through the broadcast and communications bands from 550 KC to 3200 KC. Any spurious oscillation will produce an audible beat note in the receiver. Press PLATE VOLTAGE OFF button 5S11 and verify whether signals are originating in the transmitter. If so, make slight adjustments on the Driver Neutralization Coil 1L6 until the indications of spurious oscillation disappear.

After all adjustments have been completed satisfactorily, the antenna current meter 9M1 installed in the console should be calibrated against the antenna ammeter 8M1 in the Antenna Tuning Unit. This check should be made at high power, setting the antenna current meter shunt 4R8 at a position where the readings of both meters are identical. Recheck this calibration at least once each week.

When the transmitter is first "put on the air" one of the several frequency measuring services which are established through the country should be contacted by telephone for the purpose of checking and directing the adjustment of the carrier frequency. Such adjustment is made by tuning the oscillators 1A2, 1A3 to zero beat at the operating frequency of the transmitter by adjusting the vernier capacitor 1C10. This is a screwdriver adjustment which may be made through the hole in the front of the oscillator unit. At the same time that the oscillator units in the transmitter are being checked the frequency monitor should also be adjusted.

It should be observed that the power output and efficiency of the transmitter are controlled by many variables. Of these, the most important are filament

emission, grid excitation, plate-tank tuning, and adjustment of the output coupling circuit. The two latter items have been discussed fully within this section and require no further clarification.

Filament emission of the RCA-892-R tubes is a limiting factor on the output of the modulated amplifier stage. If the filament voltage is abnormally low, the tubes will be incapable of full output because of decreased emission. Similarly, the grid excitation must have sufficient amplitude or optimum efficiency and output will not be realized. The grid current should be within the limits specified in the tabulation of "Typical Meter Readings" (see page 31) to insure proper operation.

A-F Adjustments

Replace resistors 2R52 and 2R53 and the link between terminals W4 on the low-power rectifier chassis and W4 on the low-power a-f chassis, then set the power change switch 4S3 in the POWER CHANGE LOW position.

Apply plate voltage to the transmitter and note the indication of the MODULATOR PLATE CURRENT meters, 5M12, 5M13. These plate currents may rise excessively and possibly "kick-out" the DC OVERLOAD MODULATOR relay 4E16. This reaction would be caused by an oscillation created by reversed feed-back connections. Such a condition may be corrected by interchanging the terminals G2 and G5. After verifying the stability of the audio section, check the plate currents of the various stages as indicated on the FIRST AUDIO PLATE CURRENT meter, 5M9, SECOND AUDIO PLATE CURRENT meter, 5M10, the AUDIO DRIVER PLATE CURRENT meters 2M1 and 2M2, and the MODULATOR PLATE CURRENT meters 5M12 and 5M13. If these currents are not excessive (refer to table of Typical Meter Readings) proceed to adjust and balance the tube voltages for the first three audio stages. Potentials for the plate, screen, and suppressor grids of the low-power audio stages are supplied from the voltage dividing network 2R20-2R26. The d-c potentials of all tube elements should be carefully checked and any necessary readjustments made in the network so that the operating values are within the limits shown in the table of Typical Meter Readings. For minimum distortion the tubes in both sides of the push-pull stages should be carefully balanced. It is important that all of these adjustments are made under static conditions, that is, while no audio signal is applied to the input, unless otherwise noted.

To determine the conditions of balance of the first audio stage measure plate voltages of both tubes **at the tubes** (with respect to ground). Should these voltages be unequal, determine whether this is a tube unbalance by reversing the tubes. If the unbalance follows the tube, substitute tubes until a matched pair is obtained. But if the unbalance is fixed it is probably caused by unequal voltages being fed back from the feed-back voltage dividers attached to the modulator sockets (see Figure 16, Main Rectifier Chassis). Although these "feed-back ladders" are matched at the factory, field replacements of any of resistors 2R54 to 2R83, if not possessing the same tolerance as the original part, might cause some unbalance of the d-c voltage being fed back to the grids of the first audio stage. To balance this feed-back voltage shunt 2R54 or 2R83 (depending upon the ladder causing the unbalance) with a resistance in the range of 0.5-1.0 megohms. The specific value of resistance will be determined by trial.

Tubes in the second audio stage should be adjusted with special care. Here also balance may be obtained by substituting tubes until the plate voltage with respect to ground, as measured **at the tubes,** is the same value for both halves of the stage. In either of these two stages plate voltage differences are understandable in view of the variation in the plate currents drawn by vacuum tubes and also because of the commercial tolerances inherent in the large series plate resistors.

The third audio or driver stage as well as the modulators are balanced by varying the bias voltage. The output of the bias rectifier (1V3, 1V4) is fed to the audio chassis at terminals W6 (negative) and W7 (positive). Resistors 2R48, 2R49, the potentiometers 2R40, 2R41, resistors 2R42, 2R43, 2R44, 2R45 and the potentiometers 2R46, 2R47 form a voltage-dividing network and bleeder system. (See Figure 14, Low-Power A-F Chassis.) The highest negative voltage is fed to the grids of the a-f driver tubes 2V5, 2V6, 2V9 and 2V10. The voltage-dividing network is so arranged that potentiometers 2R40, 2R41, permit a small adjustment of balance on the two sides to provide for variation in voltages required by both audio driver and modulator tubes having slightly different amplification factors. The next lower voltage, obtained from junction points 2R42, 2R43 and 2R44, 2R45 is applied to the grids of the modulator tubes 2V7 and 2V8 and to the cathodes of the a-f driver tubes 2V5, 2V6, 2V9 and 2V10. A still lower voltage, obtained from the junctions of 2R41 with 2R42 and 2R45, is connected to the No. 3 (suppressor) grids of the driver stage tubes 2V5, 2V6, 2V9 and 2V10.

In making the adjustments on these last two stages of the audio system, particular attention should be paid to the balance of the audio driver stage. Since the bias adjustments are common to both stages and tube variations may produce slight unbalances in each of them, the audio driver stage should be balanced and the modulator stage permitted to assume whatever residual unbalance is present.

Since the audio driver stage operates Class B it is well to select four tubes with similar dynamic characteristics and install them before making any adjustments of the static characteristics. To check the dynamic properties of the RCA-828 remove all but **one** tube from the sockets of the audio driver stage. Remove the plate voltage from the modulators by operating the MAIN RECTIFIER PRIMARY circuit breaker, 4S2, to the OFF position. Next apply a small amount of sine-wave audio signal (1000 ∽ tone) to the audio input terminals, G3 and G4, and note the rise in plate current as indicated on one of the AUDIO DRIVER PLATE CURRENT meters 2M1 or 2M2. Be particularly careful not to apply too much audio signal, otherwise excessive plate current will flow. Determine the audio level required to produce

an indication of 150-200 milliamperes on 2M1 or 2M2. Now replace the single RCA-828 with another and again apply the **same** audio level, noting the resultant plate current swing. Repeat this procedure until four matched tubes are secured. Install them in the sockets of the audio driver stage and again close the MAIN RECTIFIER PRIMARY circuit breaker 4S2. Be sure all audio signal is removed from the audio input terminals and proceed to statically balance the stage.

To balance the audio driver plate currents adjust potentiometers 2R40, 2R41 (which are controlled by a common shaft and knob) to the point equal currents are indicated on the AUDIO DRIVER PLATE CURRENT meters, 2M1, 2M2. Next adjust the static level of the audio driver plate currents by varying potentiometers 2R46, 2R47 (also controlled by a common shaft and knob) until the audio driver tubes have the correct value (see the table of Typical Meter Readings, page 31). Counter-clockwise rotation of 2R46, 2R47 decreases bias and increases the static plate current.

For reduced power operation, relay 2E2 operates to move the ground point to the movable arm of 2R41 so that the negative potential on the modulator grids is reduced. At full power the ground point is shifted to the movable arm of potentiometers 2R46, 2R47, thus increasing the bias potential and permitting adjustment for individual tubes. The closer the movable arm is to 2R41, the lower the bias and the higher the static currents will be.

After any readjustment of the modulator grid bias balance or adjustment of the amplitude of the static currents, the voltages of all elements of the driver tubes (2V5, 2V6, 2V9 and 2V10), particularly the No. 2 (screen) grid, should be readjusted to bring the potentials back to their proper value.

Full power voltage may now be applied by operating the power change switch 4S3 to the POWER CHANGE HIGH position, and an audio signal may be delivered to the audio input of the transmitter.

It should be noted that, during tests, sustained 100 per cent modulation at frequencies higher than 3000 cycles should not be permitted for periods longer than five to ten minutes without interruption. This time limit may, of course, be increased with lower percentages of modulation but should be more carefully adhered to as 10,000 cycles is approached. This precaution is necessary because certain phasing elements, which form portions of the feed-back circuit, function under a heavy load only at these higher frequencies. Normal transmission would never produce a load in any way comparable with a sustained high frequency tone.

Hum Control

Under normal 10-kw operating conditions the hum level will be from 60 to 65 db (unweighted) below 100 per cent modulation at 1000 cycles.

Any appreciable increase in hum may be caused by several factors. A defect or failure in the feed-back ladder is a possible source of difficulty, and would cause large increases in hum level. Insufficient grid-drive in the power amplifier may be a source of difficulty. Drive should not be permitted to drop below the minimum value shown in the table of Typical Meter Readings. Large unbalances of the phases of the power supply will account for several decibels increase in hum level. The hum control circuit (2L2, 2C9) in the plate circuit of the first audio stage is designed for 120-cycle resonance. Small variations of the capacitor 2C9 may be necessary to insure optimum 2nd harmonic hum component suppression.

Defective tubes in the audio amplifier chain are always a possible source of excessive hum level.

RCA-892-R filament voltages should be reasonably well balanced. Measured at the filament terminals, the unbalance should not exceed 5 per cent. If outside to center (large terminal) is 11.0 volts the opposite leg should be no less than 10.5 and the voltage across outside to outside terminals should be close to 15.5, indicating a reasonable accurate 90° phase displacement. Filaments should always be operated so that the higher voltage does not exceed the rated 11.0 volts or serious tube life limitation will result. The No. 1 primary terminals on each transformer are provided for 50-cycle operation. In some instances the use of the No. 1 instead of the No. 2 terminal on one of the two transformers for a given tube will result in a more accurate balance of secondary voltages, particularly if the power source is somewhat unbalanced.

Distortion Control

Satisfactory distortion characteristics may be secured at installation and maintained thereafter if reasonable precautions and the following simple requirements are observed:

1. Filament Voltages—The filament voltages of the modulators and final r-f amplifier should be checked frequently and adjusted as necessary. Since increased tube life may be secured by operating at a minimum filament voltage, which must be gradually increased as the tube ages, the minimum value employed is a determining factor on distortion. It is important that the filaments be operated at a voltage slightly above the minimum value which results in increased distortion. For the power amplifier 14.7 to 15.0 will be the minimum for new tubes; for the modulators 12.8 to 13.2 should be sufficient. All filament voltages are important from the standpoint of distortion and tube life. During a normal period of operation, maximum supply line potentials should never cause a filament voltage to exceed its rated value.

2. A-F Plate Voltages—Audio tubes must be operated with proper voltages on all elements if minimum distortion is to be realized. The values given in the table of "Typical Meter Readings" should be satisfactory, although small variations may be necessary to obtain an optimum adjustment.

3. Final R-F Amplifier Grid Excitation—The limits of grid excitation for the modulated amplifier are given in the tabulation of "Typical Meter Readings." Variation of this excitation will afford a fine control of distortion.

4. Neutralization—All of the audio-frequency stages must be accurately neutralized and stable in operation to achieve minimum distortion. The proper method of neutralizing the respective circuits has been described under "Tuning."

5. In circumstances where an absolute minimum of distortion is required two further adjustments are possible. Minimum distortion at the desired modulation frequency may be obtained by shifting the lead between the power amplifier grid-leak by-pass capacitor 1C45 and the tapped grid-leak resistor 1R31 to a tap which is nearer the grounded end of that resistor. An optimum balance will be found for small reduction of both low and high audio-frequencies. For standard operation the connection is made to the end of resistor 1R31 which is farthest from ground.

Secondly an increase in the intermediate power amplifier plate tank kva/kw ratio may offer some improvement and develop compensating distortion components; however, any increase adopted must not permit excessive tank currents in 1L7 and 1L8. A safe maximum is 8 amperes measured between 1L8 and 1C30 or 1C31.

SECTION V

Operation

It is assumed that the circuits of the transmitter have previously been set-up and tuned to the desired operating (carrier) frequency. If not, refer to the previous section and proceed as directed therein.

Manual Starting—For manual operation of the transmitter proceed as follows:

1. Close all circuit breakers (located on the lower half of the transmitter control panel).
2. Throw the AUTOMATIC ON-OFF switch 4S13 into the OFF position.
3. Throw the POWER CHANGE switch 4S3 located on the transmitter control panel and 9S2 on the control desk to the desired position, HIGH or REDUCED.
4. Close access doors to all compartments.
5. Throw the TRANSMITTER ON-OFF switch 4S4, on the transmitter control panel and the FIL. ON switch 9S5, on the control desk to the ON position.
6. Wait 30 seconds until the BIAS pilot light 5A3 glows.
7. Close the PLATE ON switch 9S4 on the control desk and depress the PLATE VOLTAGE ON push-button switch 5S10, located on the door to the modulator compartment.

Manual Stopping—

1. Depress the PLATE VOLTAGE OFF push-button switch 5S11, located on the door to the modulator compartment, or open the PLATE ON switch 9S4, on the control desk.
2. Throw the TRANSMITTER ON-OFF switch 4S4, on the transmitter control panel to the OFF position, or open the FIL. ON switch 9S5, on the control desk.

Automatic Starting — For automatic operation of the transmitter proceed as follows:

1. Close all circuit breakers.
2. Throw the AUTOMATIC ON-OFF switch 4S13 into the ON position.
3. Place the POWER CHANGE switches, 4S3 on the transmitter control panel, and 9S2 on the control desk, in the desired position, HIGH or REDUCED.
4. Place PLATE ON switch 9S4 in the ON position.
5. Close the access doors to all compartments.
6. Throw the TRANSMITTER ON-OFF switch 4S4, on the transmitter control panel, and the FIL. ON switch 9S5, on the control desk, to the ON position.

The transmitter will now start and automatically apply filament and plate power in correct sequence.

Automatic Stopping—

1. Open either the FIL. ON switch 9S5, on the control desk, or the TRANSMITTER ON-OFF switch 4S4, on the transmitter control panel.

When shutting the transmitter down for the night or for an extended period of time during which the equipment is left unattended it is advisable to open the AC MAIN LINE circuit breaker 4S1.

Typical Meter Readings

	Meter	10-kw	Station Log	Reduced Power	Station Log
Oscillator E_f (volts)		6.3	.....	6.3	.....
Oscillator E_p (volts)		320-340	.....	320-340	.....
Oscillator E_{scg} (volts)		165-180	.....	165-180	.....
Oscillator I_p (milliamperes)	5M1	15-20	.....	15-20	.....
Buffer E_f (volts)		10.0	.....	10.0	.....
Buffer E_p (volts)		1090-1150	.....	1090-1150	.....
Buffer E_{scg} (No. 2 grid, volts)		280-300	.....	280-300	.....
Buffer E_{sup} (No. 3 grid, volts)		10-15	.....	10-15	.....
Buffer I_k total (milliamperes)	5M2	70-85	.....	70-85	.....
Driver E_f (volts)		10.0	.....	10.0	.....
Driver I_p (volts)	5M11	1600	.....	1600	.....
Driver I_g (milliamperes, two tubes)	5M3	65-90	.....	65-90	.....
Driver I_k No. 1 (milliamperes)	5M4	250-280	.....	250-280	.....
Driver I_k No. 2 (milliamperes)	5M5	250-280	.....	250-280	.....
Power Amplifier E_f (pos. No. 3, 4S14)	5M14	15-5	.....	15-5	.....
Power Amplifier E_p (volts)	5M15	8900-9200	.....	3850-4000	.....
Power Amplifier I_g (milliamperes)	5M6	300-320	.....	360-380	.....
Power Amplifier I_p (amperes)	5M17	1.475-1.45	.....	0.7 to 0.68	.....
Power Amplifier I_{tank} (amperes)	5M8	6.0-9.5	.....	3.0 to 4.75	.....

Typical Meter Readings (Continued)

	Meter	10-kw	Station Log	Reduced Power	Station Log
1st audio E_f (volts)		6.3		6.3	
1st audio E_p (volts)		120-130		125-135	
1st audio E_{scg} (volts)		100-110		100-110	
1st audio E_k (volts)		23-28		12-20	
1st audio I_k (milliamperes, two tubes)	5M9	5.0-6.0		3.0-5.0	
2nd audio E_f (volts)		10.0		10.0	
2nd audio E_p (volts)		1150-1200		1150-1200	
2nd audio E_g (No. 1 grid) volts		0		0	
2nd audio E_{scg} (No. 2 grid) volts		800-820		800-820	
2nd audio E_{sup} (No. 3 grid) volts		150-180		150-180	
2nd audio E_k (volts)		80-90		80-90	
2nd audio I_k (milliamperes, two tubes)	5M10	175-190		175-190	
3rd audio E_f (volts)		10.0		10.0	
3rd audio E_p (volts)	5M11	1600-1650		1600-1650	
3rd audio E_g (No. 1 grid) volts (measured to cathode)		−120 - −130		−120 - −130	
3rd audio E_{scg} (No. 2 grid) volts (measured to cathode)		730-750		630-710	
3rd audio E_{sup} (No. 3 grid) volts (measured to cathode)		50-65		50-65	
3rd audio E_k (volts)		−190 - −210		−110 - −180	
3rd audio I_p (No. 1, milliamperes, carrier)	2M1	30-40		20-30	
3rd audio I_p (No. 2, milliamperes, carrier)	2M2	30-40		20-30	
3rd audio I_p (No. 1, milliamperes, tone)	2M1	80-90		40-60	
3rd audio I_p (No. 2, milliamperes, tone)	2M2	80-90		40-60	
Modulator No. 1 E_f (volts, position 1, 4S14)	5M14	15.5		15.5	
Modulator No. 2 E_f (volts, position 2, 4S14)	5M14	15.5		15.5	
Modulator E_p (volts)	5M15	8900-9200		3850-4000	
Modulator E_g (volts)		−190 - −210		−110 - −180	
Modulator No. 1 I_p (amperes, carrier)	5M12	0.03-0.05		0.01-0.03	
Modulator No. 2 I_p (amperes, carrier)	5M13	0.03-0.05		0.01-0.03	
Modulator No. 1 I_p (amperes, tone)	5M12	0.65-0.80		0.45-0.65	
Modulator No. 2 I_p (amperes, tone)	5M13	0.65-0.80		0.45-0.65	
Main Line Volts (position No. 1, 4S8)	5M16	230		230	
Main Line Volts (position No. 2, 4S8)	5M16	230		230	
Main Line Volts (position No. 3, 4S8)	5M16	230		230	
Main rectifier filament transformer primary voltage to produce 5.0 volts across secondaries (position No. 4, 4S8)	5M16	210		210	
Power Amplifier and Modulator anode well temperature (tone Modulation) 95° C. to 105° C.					

Note 1—With the exception of E_f all voltages are measured to ground unless otherwise noted.

Note 2—Power Amplifier I_p based on 80 per cent efficiency and 10.52-kw output.

Note 3—R.F. Driver I_k (meters 5M4, 5M5) includes grid current.

Note 4—1st audio I_k is with plate potential on modulators.

SECTION VI

Maintenance

General

The need for service will be kept at a minimum by making tight, permanent connections during the assembly of the equipment, and thereafter keeping the equipment clean and free of dust. At the end of the first six months' period, connections throughout the entire transmitter should be carefully checked and tightened when necessary. Cyclic expansion and contraction due to alternate periods of operation and shut-down tend eventually to loosen some of the connection assemblies.

Clean smoky insulators with a mild solvent such as carbontetrachloride.

Keep power tubes clean to avoid possible puncture of the glass. Tissue paper and alcohol is the most effective combination for this purpose.

Keep terminal boards clean and the terminals tight to avoid possible open or short circuits or burn-outs.

Performance Tests

Periodic performance tests will aid considerably in keeping the transmitter in the best operating condition. In order that the overall distortion may be held within the specified limits, a periodic check of the low power audio stages should be made. Unbalance in any of these stages may cause high distortion. A low emission tube may cause unbalance. Check each tube by replacing with a new tube. In making such replacements it is important that matched tubes be used in each stage. This may be checked by measuring the static or d-c plate and screen grid voltages of the replacement tube and comparing them with similar measurements made on the tube or tubes in the opposite half of the push-pull stage.

High Power Tubes

To make certain that spare tubes are suitable for immediate use, all tubes should be tested on arrival and every three or four months thereafter. Replace any tube in which there is a serious decrease in filament emission.

So far as possible, tube failure should be anticipated by keeping a log of tube life. Use of the tube hour-meter (4M2) provides a simple method of keeping an accurate record of tube life. All meter readings should be recorded and checked against readings previously taken. A ten per cent reduction in plate and cathode current usually indicates a loss of filament emission. The condition of the tube may be checked by replacing it with a tube which is known to be satisfactory and noting the difference in current.

A regular inspection of tube prongs and socket contacts is also necessary if failure is to be avoided. The large power tubes (RCA 892-R's) should be tested in the transmitter. Their filament connectors should be kept tight at all times to prevent heating which damages the seals. Before installing a tube, note whether any foreign material has fallen into the stem opening and lodged between the filament leads. These leads operate at a fairly high temperature so that any foreign material may become charred and cause a puncture of the insulation.

Occasionally one of these tubes will develop a small amount of gas in storage which can be cleaned up by proper methods. The recommended procedure for breaking in the RCA-892-R is as follows: With the tube in the power amplifier, apply low plate voltage without modulation. This is done by throwing the power change switch to the Low-Power position. After a few minutes apply 1000-cycle tone modulation, gradually increasing the percentage of modulation. If no gas flashes occur after 15 minutes of full tone operation, remove the modulating signal, throw the power change switch into the High-Power position, and repeat.

If gas flashes occur during the process, go back to the Low-Power position with no modulation and repeat. Allow the tube to run for a considerable length of time with a low percentage of modulation, and then repeat the foregoing procedure.

When it becomes necessary to replace an RCA-892-R in the modulator, this replacement should be made with a tube that has had from 24 to 48 hours aging as a power amplifier. A spare tube should be broken in for this length of time and should be available in the tube rack.

An RCA-892-R tube that develops a small amount of gas in modulator service may usually be cleaned up by operating it in the power amplifier.

Start new RCA-892-R tubes at minimum filament voltages and increase these voltages as emission falls off. For modulator service, start RCA-892-R tubes with a filament potential of 12.8 to 13.2 volts. For power amplifier service 14.7 to 15.0 volts is the proper starting potential. These values are for full power operation.

Falling off of emission may be detected by performance tests. The symptoms are an increase in distortion, an increase in carrier shift, or both. When emission falls below that required for the maintenance of performance standards, the filament voltage should be raised. Use of the lowest filament voltage consistent with desired performance will assure maximum tube life.

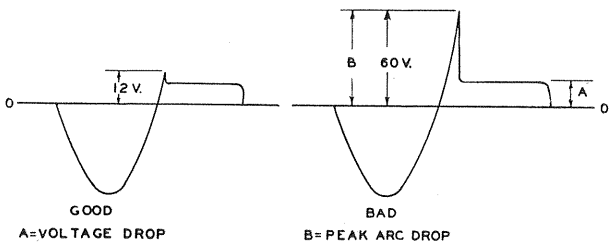
Rectifier Tubes

New rectifier tubes should be formed by operating them with the filament energized for a period of at least 30 minutes before plate voltage is applied. Spare rectifier tubes should be given a minimum of 30 minutes heat run (filament only) before being placed on the shelf. Keep tubes in an upright position and take care to avoid splashing the mercury onto the elements of the tubes. If a tube has been shaken or tipped, reheat before placing in service.

An exact determination of the condition of a mercury vapor tube can be made by inspection of its firing characteristic using a cathode-ray oscilloscope. A faulty tube will fire later and later in the first (conduction) half-cycle, and display a greater reverse-voltage transient. This oscillographic test also may be made in a low-voltage test set-up, provided the tube is loaded correctly. In making this test the oscilloscope should be connected directly across the tube and will then indicate the voltage characteristic of the tube when a-c voltage of 60 to 120 volts (r.m.s.) is applied between anode and cathode. A suitable resistance must be connected in series with the voltage source in order to limit the current through the tube during the conduction half-cycle. For a standard test potential of 115 volts, a 50-ohm resistor capable of dissipating 200 watts continuously will limit the current to approximately two amperes (based on average tube drop of ten volts). Both the oscilloscope and the applied voltage should be connected between anode and filament center-tap terminals of the rectifier tube circuit, with the anode disconnected from the main rectifier circuits. It is suggested that all the measurements be made with a standard applied voltage rather than at constant current.

The oscilloscope must be used without amplifiers and with the sweep self-synchronized with the source. The pattern will then be a reproduction of the full voltage wave across the tube, one-half being sinusoidal during the non-conducting half-cycle and the other half a trace of the instantaneous voltage drop during conduction. At the start of the conduction period, the height of the steep wave-front transient will indicate the magnitude of the peak instantaneous arc drop, which is the criterion of rectifier performance.

Excessive arc drop causes backfiring during operation, and with a little experience in making these observations, eventual failure of a tube can be predicted before excessive backfiring develops. Peak arc-drop voltages generally will range between 12 volts for a perfect tube to 60 volts for one subject to frequent backfiring. Illustrations of typical waveforms are shown in the insert.



Monthly records of arc-drop measurements will provide accurate tube data at roughly 500-hour intervals. When peak arc-drop values in the region of 30- to 40-volts are indicated, more frequent tests may be desirable. Because the oscillographic tests reveal peak arc-drop voltages and give an accurate picture of the firing characteristic, this method of testing rectifier tubes is recommended as being much more valuable than older d-c methods of measurement. If the 115-volt source is a grounded neutral system, it will be necessary to use a 1:1-ratio isolation transformer to prevent distortion due to ground capacitance. Such a transformer should have a rating of not less than 300 volt-amperes. A standard time-interval of two minutes should be allowed for thorough heating of the tube before applying anode voltage during these tests. A d-c ammeter connected in series with the tube will indicate the average current during the conduction period.

Higher peak arc-drop voltages generally will be accompanied by lower average current readings, within certain limits, providing all measurements are made at a standard voltage. This is due to a reduction in the area under the wave as a defective tube fires later and later in the conduction half-cycle. Conduction current data should be recorded simultaneously with the peak arc-drop readings.

Air Filters

The air filter is a permanent one and requires no replacement. However, it should be cleaned at regular intervals varying from one to four months, depending upon the locale of the transmitting station. In some areas, where fine dust frequently exists in the air, it will be necessary to remove any deposit which accumulates on the impeller blades of the blowers whenever the filter is cleaned. Any accumulation of such dust, either in the air filter or on the impeller blades, seriously impairs the efficiency of the air cooling system. In dusty areas, it also is advisable to clean the canvas boots and check the air flow interlock mechanism at regular intervals. The filter itself may be cleaned simply by rinsing it with hot water. When dry, the mesh should be sprayed with 10-W lubricating oil by means of an ordinary insecticide spray gun.

The filter is removable through the transmitter front. The mounting clips may be released by means of thumbscrews at the top of the filter. The plenum chamber cover must be removed for this operation.

Tuning Motor Drives

The tuning motor drive should be lubricated at three month intervals. The motors should be oiled with a good grade of light machine oil. All external gears should have an application of either Fiske Luber-plate 110 or a light cup grease. A drop or two of light machine oil should be applied to the shaft bearings on the variable inductors.

Blower Motors

These motors are equipped with wool-packed bearings and should be oiled at regular intervals with 30 to 70 drops of good light (SAE-20) or medium (SAE-30) mineral lubricating oil. They should be checked at least once every month. The impeller blades should be cleaned thoroughly at such times.

Contactors and Relays

A periodic inspection should be made of all contactors and relays. At such times each contact of every switch and relay should be cleaned. Large contactors may require dressing with a fine file. Do not use emery cloth, as abrasive granules left imbedded in the contact

surfaces may raise the contact resistance and produce a tendency of the contacts to weld. Check operation manually and check contact alignment. See that pole faces are clean and seat securely. Contacts on the PAC type overload relays may become so pitted or out of adjustment that mechanical vibration will cause them to function. A sharp shock on the control panel will indicate if any such condition exists.

Replace broken arc-chutes and magnetic blow-outs. Lubricate the notching relay and synchronous timers. The door interlocks should be carefully inspected, cleaned and a small amount of petrolatum applied after cleaning.

Oil-Filled Plate Transformer

A periodic check should be made to insure that the oil used in the plate transformer, 6T2, is up to the indicated level and to make certain that this oil meets the breakdown requirements. A standard test for the oil used is described in the manufacturer's bulletin (I. B. 65-000) which is reprinted at the back of this book.

Current Transformers

WARNING: NEVER LEAVE A CURRENT TRANSFORMER SECONDARY OPEN. IF IT BECOMES NECESSARY TO REMOVE AN OVER-CURRENT RELAY ACTUATED BY A CURRENT TRANSFORMER, SHORT CIRCUIT THE TRANSFORMER SECONDARY UNTIL THE RELAY IS BACK IN THE CIRCUIT. PERSONNEL MAY BE ENDANGERED BY INDUCED VOLTAGE IF THIS IS NOT DONE.

Sphere Gaps

Protective gaps should be checked daily and kept in a polished condition. If pitted, the spheres should be polished with crocus cloth.

CAUTION: The original spacing should not be exceeded.

The resistor (6R2) connected in series with the safety gap on the modulation reactor should be periodically checked for continuity.

Routine Maintenance Schedule

The most effective method of assuring continuous satisfactory operation of the transmitting plant is to institute a regular schedule of maintenance, recording all data on previously prepared forms so that a continuous record of performance of all parts of the equipment is at hand. The station operating schedule and local operating conditions may affect the frequency of some maintenance functions; therefore, the following recommended schedule may be varied as experience dictates:

ROUTINE MAINTENANCE SCHEDULE
(Always Use Grounding Sticks)

DAILY

1. Make general inspection after shut-down.
2. Make hourly check of power tube filament voltages.
3. Inspect antenna transmission line terminating equipment if there have been heavy static discharges or lightning during the day.
4. If there have been any overloads during the day examine all safety gaps for burning. Clean and reset if necessary.

WEEKLY

1. Inspect interior of the plenum chamber.
2. Inspect all relays.
3. Clean internal parts of transmitter (insulators—etc.)
4. Make general performance checkup (noise, distortion and frequency characteristics).
5. Inspect all blowers.
6. Test air-flow interlocks.
7. Test all door interlocks.
8. Check antenna monitor rectifier tubes.
9. Test operation of notching and overload relays.
10. Clean antenna tuning apparatus.
11. Check all sphere and needle gaps.
12. Test calibration of remote antenna ammeter (s) against direct antenna ammeter.

MONTHLY

1. Clean RCA-8008 tube contacts.
2. Check oil in blowers.
3. Clean all socket contacts.
4. Clean console attenuator contacts.
5. Service high speed relay contacts (PAC and PCV relays).
6. Check air filter.

QUARTERLY

1. Test all spare power tubes in circuit and clean up gassy tubes if any.
2. Operate all spare mercury vapor tubes for 30 minutes (filament only).
3. Make general detailed close inspection of every unit in transmitter with whatever tests of parts seem advisable.
4. Clean air filter, blower impellers and canvas boot
5. Service contacts on variable inductors (1L4, 1L6, 1L7, 1L16 and 1L17).
6. Service all contactors.

SEMI-ANNUALLY

1. Test transformer oil and filter if necessary.
2. Clean transmission line insulators. Inspect all relay contacts and make replacements where required. Clean pole faces on contactors.
3. Test spare tubes and clean up gas if necessary.
4. Tighten all connections in transmitter.
5. Inspect flexible cables to door connections.
6. Service voltmeter selector switches (4S8 and 4S14).

SECTION VII
REPLACEMENT PARTS LIST

When ordering replacement parts, please give Symbol, Description, and Stock Number of each item ordered.

The part which will be supplied against an order for a replacement item may not be an exact duplicate of the original part; however, it will be a satisfactory replacement, differing only in minor mechanical or electrical characteristics. Such differences will in no way impair the operation of the equipment.

R. F. UNIT

Symbol No.	Description	Stock No.
1A1	Crystal holder, TMV129-B (for use with 1A2 and 1A3)	MI-7467
1A2, 1A3	Crystal oscillator	
1A4	Motor, tuning drive	69852
1A5	Motor, air cooling blower	44746
1A6	Motor, tuning drive	69852
1A7	Outlet, convenience	
1A8	Lamp, indicator, oscillator selector, red, 220 volts	
1A9	Lamp, indicator, oscillator selector, green, 220 volts	
	Parts for above:	
	Lamp only	16154
	Red cap only	19897
	Green cap only	44136
	Receptacle only	44997
	Resistor only	44570
1A10	Connector, motor (male)	23225
1A11	Connector, motor (female)	4573
1A12	Fan, L.P. rectifier cooling, 220 volts, 50/60 cycles	
1A13	Outlet, convenience	
1A14	Connector, motor (male)	23225
1A15	Connector, motor (female)	4573
1C1	Capacitor, crystal tuning, variable	16890
1C2	Capacitor, osc. bypass	52428
1C3	Capacitor, osc. bypass, same as 1C2	
1C4	Capacitor, osc. output coupling, 47 mmfd	50358
1C5	Capacitor, osc. filter, .002 mfd	50359
1C11, 1C12	Capacitor, crystal heater bypass, .01 mfd	69857
1C13, 1C14	Capacitor, buffer filament bypass, .01 mfd	69858
1C15	Capacitor, buffer screen grid bypass, .01 mfd	69858
1C16	Capacitor, buffer suppressor bypass, .01 mfd	69858
1C17 to 1C20	Capacitor, IPA filament bypass, .01 mfd	69857
1C21	Capacitor, buffer plate tank, 620 mmfd	69859
1C22, 1C23	Capacitor, buffer plate tank, 300 mmfd	69860
1C24	Capacitor, freq. monitor bypass, .01 mfd	69861
1C25	Capacitor, buffer plate bypass, .02 mfd	69862
1C26, 1C27	Capacitor, neutralizing tank, 100 mmfd	69863
1C28	Capacitor, neutralizing tank, 200 mmfd	69864
1C29	Capacitor, PA grid blocking, .01 mfd	UC-3339
1C30, 1C31	Capacitor, IPA plate tank (frequency determining part)	
1C33	Capacitor, PA filament bypass, .05/.05 mfd, Case 177	UC-3145
1C34 to 1C39	Capacitor, PA Case 111X (frequency determining part)	
1C40	Capacitor, PA plate blocking, .001 mfd	UC-3330
1C41	Capacitor, PA plate bypass, .0002 mfd	UC-3335
1C42	Capacitor, emergency buffer grid paralyzing, 20 mfd	43133
1C43	Capacitor, IPA plate blocking, 150 mmfd	69865
1C44	Capacitor, motor tuning, 1.25 mfd, for 1A4	47329
1C45	Capacitor, PA grid leak bypass, 0.2 mfd	UC-2851
1C46, 1C47	Capacitor, IPA parasitic suppressor, 100 mmfd	69867
1C48	Capacitor, motor tuning, 1.25 mfd (for 1A6)	47329
1C50	Capacitor, PA filament, same as 1C33	
1C51	Capacitor, PA neutralizing, 55 mmfd, Case 111X	UC-3399
1C53	Capacitor, IPA tank balancing, .0002 mfd	UC-3357
1E1	Relay, oscillator selector DPDT, 220 volts, 50/60 cycles	69868
1E2	Relay, "Carrier Off" DPDT, 220 volts, 50/60 cycles	69869
1E3	Relay, power change compensating, modulation monitor and distortion meter	
1F1	Fuse, crystal heater, 1 amp., 250 volts	45919
1F2	Fuse, crystal heater, same as 1F1	
1J1	Plug, oscillator	47317
1J2, 1J3	Socket (for oscillator)	19656
1L1	Coil, oscillator plate tank	50360
1L4	Coil, buffer plate tank, variable	51769
1L5	Coil, IPA grid choke	

REPLACEMENT PARTS LIST (Continued)

R. F. UNIT

Symbol No.	Description	Stock No.
1L6	Coil, IPA neutralizing tank	51769
1L7	Coil, IPA plate tank, variable	
1L8	Coil, IPA plate tank	17038
1L9	Coil, PA grid choke	50667
1L11	Coil, PA plate parasitic suppressor	17230
1L12	Coil, PA plate choke	
1L13	Coil, PA plate tank	
1L14	Coil, modulation monitor pick-up	
1L15	Coil, distortion meter pick-up	
1L16	Coil, PA plate tank, variable	50664
1L17	Coil, PA loading	50664
1L20, 1L21	Coil, PA grid suppressor choke	44934
1L22	Coil, IPA grid suppressor choke	
1L23	Coil, IPA plate choke	
1M1	Thermocouple (part of 5M8)	
1R1	Resistor, osc. grid leak, 150,000 ohms, 1 watt	50361
1R2	Resistor, osc. cathode bias, 680 ohms	50362
1R9	Resistor, buffer grid, 22,000 ohms, 2 watts	13669
1R10	Resistor, buffer, screen grid, 2500 ohms, 25 watts	43425
1R11	Resistor, freq. monitor potentiometer, 1000 ohms	19203
1R12	Resistor, IPA grid leak, 2500 ohms, 45 watts	19205
1R13	Resistor, buffer cathode bias, 200 ohms, 25 watts	43783
1R14, 1R15	Resistor, IPA grid suppressor, 68 ohms, 2 watts	52213
1R16	Resistor, IPA plate dropping, 200 ohms, 200 watts	45914
1R19	Resistor, IPA cathode bias, 50 ohms, 25 watts	19659
1R20	Resistor, IPA cathode bias, same as 1R19	
1R21	Resistor, PA filament, 50 ohms, 45 watts, center-tapped	45144
1R22	Resistor, buffer emergency grid paralyzing, 10,000 ohms	44294
1R23	Resistor, modulation monitor pick-up potentiometer, 800 ohms, 55 watts	44935
1R24	Resistor, distortion meter, same as 1R23	
1R30	Resistor, PA grid suppressor, 100 ohms	17217
1R31	Resistor, PA grid leak, 200 ohms, 150 watts	52039
1R32 to 1R35	Resistor, PA grid leak, 500 ohms	19675
1R36	Resistor, PA filament, c.t., same as 1R21	
1R37	Resistor, PA grid suppressor, same as 1R30	
1R38	Resistor, IPA grid parasitic suppressor, 100 ohms, 2 watts	14162
1S1, 1S2	Switch, air flow interlock (mercury unit)	17219
1T1	Transformer, osc. and buffer filaments, XT-3607	43802
1T2	Transformer, IPA filaments, XT-3606	47791
1T3, 1T4, 1T5, 1T6	Transformer, PA filament	44753
1X1	Socket, osc. tube	18724
1X2	Socket, crystal unit	16889
1X3	Block, fuse, crystal heater	47166
1X4	Socket, buffer	18724
1X5, 1X6	Socket, IPA	45684
1X7, 1X8	Socket, PA tube	17239

AUDIO UNIT

2A1, 2A2	Blower. tube cooling (motor only)	44746
2C1, 2C2	Capacitor, input transformer load, 200 mmfd	69856
2C3	Capacitor, 1st a-f screen grid bypass, 1 mfd, 250 volts	11897
2C4	Capacitor, 1st a-f phasing, 1500 mmfd	69870
2C5	Capacitor, 1st a-f blocking, 8 mfd, 500 volts	17243
2C6	Capacitor, 1st a-f plate filter, 8 mfd, 500 volts	17243
2C7	Capacitor, 1st a-f phasing, same as 2C4	
2C8	Capacitor, 1st a-f blocking, same as 2C5	
2C9	Capacitor, hum circuit, .051 mfd, 2%	69871
2C10	Capacitor, 2nd a-f cathode bypass, same as 2C3	
2C11	Capacitor, 2nd a-f plate filter, 2 mfd, 2000 volts	43850
2C12, 2C13	Capacitor, 2nd a-f phasing, 0.1 mfd	69872
2C14, 2C15	Capacitor, modulator grid bypass	43133
2C16	Capacitor, audio feedback	553263

59053A

REPLACEMENT PARTS LIST (Continued)

AUDIO UNIT

Symbol No.	Description	Stock No.
2C17 to 2C44	Capacitor, audio feedback	
2C45	Capacitor, same as 2C16	
	Feedback divider complete including 2C16 to 2C45 and 2R54 to 2R83	46348
2C46, 2C47	Capacitor, 2nd a-f blocking, 4 mfd, 2000 volts	43849
2C48	Capacitor, modulator driver phasing, .051 mfd, 2%	69873
2C49, 2C50	Capacitor, modulator driver phasing, same as 2C3	
2C51	Capacitor, modulator driver phasing, same as 2C48	
2C52	Capacitor, a-f input compensating, 0.1 mfd, 900 volts	63635
2E1	Relay, bias interlock, DPST	44938
	Coil only	44940
	Contacts only	44939
2E2	Relay, bias change DPDT	44941
	Coil only	44943
	Contacts only	44942
2L1	Coil, a-f input compensating	7268
2L2	Reactor, 2nd a-f	43868
2L3	Reactor, hum circuit	44754
2M1, 2M2	Meter, modulator driver plate current 0-200 ma	69511
2R1, 2R2	Resistor, input transformer load, 24,000 ohms, 1 watt	48661
2R3	Resistor, 1st a-f cathode, 4700 ohms, 2 watts	39156
2R4, 2R5	Resistor, 1st a-f grid, 100 ohms, 2 watts	48927
2R6	Resistor, 1st a-f screen grid voltage divider, 6800 ohms, 2 watts	
2R7	Resistor, 1st a-f screen grid voltage divider, 39,000 ohms, 2 watts	69743
2R8	Resistor, relay shunt (2E1), 40 ohms, 25 watts	45917
2R11	Resistor, 1st a-f plate, 10,000 ohms, 2 watts	69744
2R12	Resistor, 1st a-f phasing, 4700 ohms, 2 watts	39156
2R13	Resistor, 1st a-f plate, same as 2R11	
2R14	Resistor, 1st a-f phasing, same as 2R12	
2R15, 2R16	Resistor, 2nd a-f grid, 200,000 ohms, 2 watts	50703
2R17, 2R18	Resistor, 2nd a-f grid suppressor, 470 ohms, 1 watt	60943
2R19	Resistor, 2nd a-f cathode, 480 ohms, 45 watts, 10%	43855
2R20	Resistor, voltage divider, 380 ohms, 200 watts, 10%, tapped	44748
2R21, 2R22	Resistor, voltage divider, 565 ohms, 200 watts, 10%, tapped	44749
2R23	Resistor, voltage divider, 565 ohms, 200 watts, 10%	45918
2R24, 2R25, 2R26	Resistor, voltage divider, 4000 ohms, 200 watts, 10%	44307
2R27, 2R28	Resistor, 2nd a-f plate, 12,500 ohms, 95 watts, 10%	44751
2R29, 2R30	Resistor, 2nd a-f phasing, 16,000 ohms, 95 watts, 10%	43854
2R31, 2R32	Resistor, 2nd a-f plate, same as 2R27	
2R33	Resistor, multiplier (part of 5M11)	
2R34	Resistor, modulator driver phasing, 1 meg, 2 watts	19685
2R35, 2R36	Resistor, modulator driver grid, 47,000 ohms, 2 watts	17445
2R37	Resistor, modulator driver phasing, same as 2R34	
2R38, 2R39	Resistor, modulator driver grid suppressor, same as 2R17	
2R40	Resistor, variable bias divider, 500 ohms	43856
2R41	Resistor, variable bias divider, 685 ohms (in tandem with 2R40)	43857
2R42	Resistor, bias divider, 630 ohms, 95 watts, 10%	44945
2R43	Resistor, bias divider, 360 ohms, 45 watts, 10%	44946
2R44	Resistor, bias divider, same as 2R42	
2R45	Resistor, bias divider, same as 2R43	
2R46	Control, variable bias divider, 1000 ohms	43861
2R47	Control, variable bias divider, 400 ohms (in tandem with 2R46)	43862
2R48, 2R49	Resistor, bias divider, 200 ohms, 95 watts, 10%	43860
2R50, 2R51	Resistor, modulator grid suppressor, 100 ohms, type CX,1X4	17217
2R52, 2R53	Resistor, modulator plate, 25 ohms, 45 watts	69849
2R54	Resistor, audio feedback, 82,000 ohms	46349
2R55 to 2R82	Resistor, audio feedback, 2.2 meg	46350
2R83	Resistor, same as 2R54	
	Feedback divider complete including 2C16 to 2C45 and 2R54 to 2R83	46348
2R84, 2R85	Resistor, modulator driver grid, same as 2R35	
2R86, 2R87	Resistor, modulator driver grid suppressor, same as 2R17	
2R88, 2R89	Resistor, modulator filament, c.t., 50 ohms, 45 watts	45144
2R90	Resistor, a-f input compensating, 270 ohms, 1 watt	43006
2R91	Resistor, a-f input compensating, 560 ohms, 1 watt	38884
2R92	Resistor, a-f input compensating, 1000 ohms, 1 watt	43004
2R93 to 2R96	Resistor, modulator driver plate suppressor, 10 ohms, 2 watts	43008
2S1, 2S2	Switch, airflow interlock (mercury unit)	17219

REPLACEMENT PARTS LIST (Continued)

AUDIO UNIT

Symbol No.	Description	Stock No.
2T1	Transformer, a-f input, XT-2615-A	19198
2T2	Transformer, 1st and 2nd a-f filaments, XT-3607	43802
2T3	Transformer, modulator driver filaments	47791
2T4 to 2T7	Transformer, modulator filament	44753
2T8	Transformer, modulator driver cathode follower	46398
2X1, 2X2	Socket, 1st a-f tube	19142
2X3, 2X4	Socket, 2nd a-f tube	18724
2X5, 2X6	Socket, modulator driver tube, same as 2X3	
2X7, 2X8	Socket, modulator tube	17239
2X9, 2X10	Socket, modulator driver, same as 2X3	

LOW POWER RECTIFIER

3C1 to 3C4	Capacitor, low power rectifier filter, 10 mfd, 2000 volts	19123
3C5 to 3C8	Capacitor, bias filter, 10 mfd, 600 volts	18501
3L1, 3L2	Reactor, low power rectifier filter, XT-2882	43785
3L3	Reactor, bias rectifier filter, XT-3619	43869
3R1, 3R2	Resistor, low power rectifier divider, 630 ohms, 150 watts	43782
3R3, 3R4	Resistor, low power rectifier divider, 1600 ohms, 150 watts	43784
3R5	Resistor, low power rectifier divider, 1600 ohms, 150 watts, tapped	53829
3T1	Transformer, low power rectifier plate, XT-2738	17553
3T2	Transformer, low power rectifier filament, XT-3609	43801
3T3	Transformer, bias rectifier plate, XT-3618	43867
3T4	Transformer, bias rectifier filament, same as 3T2	
3X1, 3X2	Socket, low power rectifier tube	44755
3X3, 3X4	Socket, bias rectifier tube, same as 3X1	

POWER CONTROL UNIT

4A1	Lamp, indicator, plate supply "on," 22 volts, red	
4A2	Lamp, indicator, main line "on," 220 volts, red	
4A3	Lamp, indicator, filaments "on," 220 volts, green	
	Parts for above:	
	Green lamp cap only	44136
	Red lamp cap only	19897
	Lamp only	16154
	Resistor only	44570
	Receptacle only	44997
4E3	Contactor, full plate voltage, Westinghouse Type DN-330, 3-pole, 100 amperes, 220 volts, 60 cycles, Style 897456 with 1-N.C. Pilot Contact, Type L41, Style 972914, with 1-N.O. Pilot contact, Type L41, Style 972913, Coil 220 volts, 60 cycles, Style 874111	
	Contact only	17539
	Coil only	18221
4E4	Contactor, reduced plate voltage, same as 4E3	
	Contact only	17539
	Coil only	18221
4E5	Relay, auxiliary power change, 1-N.O.-1-N.C. contacts, 220 volts, 50/60 cycles	44941
	Contacts only	44942
	Coil only	44556
4E6	Relay, rectifier plate delay, Westinghouse Type TK, 230 volts, 60 cycles, Style 1059963	
4E7	Relay, auxiliary timer, GE Type CR2820-1731A, 220 volts, 60 cycles, coil 22D2G3	47263
	Contacts only	49010
4E8	Relay, rectifier surge relay timer, same as 4E6	
4E9	Relay, carrier off, 2 N.O. contacts, 220 volts, 50/60 cycles	
	Contacts only	44545
4E10	Relay, overload reset, 230 volts, 60 cycles	45759
4E11	Relay, notching auxiliary, GE Type CR2820-1731B3, 220 volts, 60 cycles, coil 22D2G3	

REPLACEMENT PARTS LIST (Continued)

POWER CONTROL UNIT

Symbol No.	Description	Stock No.
4E12, 4E13	Relay, main line overload, GE 12PAC13A2	
	Coil only	45095
	1 Contact only	17535
	Contact bar only	17536
4E14	Relay, PA plate overload, GE 12PAC13A1	
	Coil only	18220
	1 Contact only	17535
	Contact bar only	17536
4E15	Relay, LP rectifier and bias line overload, GE 12PAC14A10	
	Coil only	45094
	1 Contact only	17535
	Contact bar only	17536
4E16	Relay, modulator plate overload, same as 4E14	
	Coil only	18220
	1 Contact only	17535
	Contact bar only	17536
4E17	Contactor, filament bus control, Westinghouse Type DN-220, 2-pole, 50 amperes, 220 volts, 60 cycles, Style 972863, coil 220 volts, 60 cycles, Style 974135	
	Coil only	45760
	Contacts, set	45761
4E18	Contactor, air-cooled filaments, Westinghouse Type DN-230, 3-pole, 50 amperes, 220 volts, 60 cycles, Style 972866 with 1-N.O. Pilot Contact, Type L41, Style 974335, coil 220 volts, 60 cycles, Style 974135	
	Coil only	45760
4E19	Contactor, low power rect. plate primary, Westinghouse Type DN-220, 2-pole, 50 amperes, 220 volts, 60 cycles, Style 972863 with 2-N.O. Pilot Contacts, Type L41, Style 974335, coil 220 volts, 60 cycles, Style 974135	
	Main coil only	45760
	Main contacts, set	45761
4E20	Relay, carrier off auxiliary, GE Type CR2820-1731A, same as 4E7	
	Contacts only	49010
4F1, 4F2	Fuse, supply voltmeter, 250 volts, 6 amps	
4F3, 4F4	Fuse, filament voltmeter, same as 4F1	
4F5, 4F6	Fuse, monitor rectifier supply, same as 4F1	
4M1	Meter, tube hours, GE Type 94X931, RCA case, 220 volts, 60 cycles	MI-19434
4R1	Rheostat, HP rect. fila., Ohmite, Model R, 500 watts, 25 ohms, Stock No. 0859 per Westinghouse Dwg. A1817	
4R2	Rheostat, PA filaments, Ohmite, Model R, 500 watts, consisting of three 8-inch, 6-ohm plates close-mounted in tandem, less knob	
	3 sections consisting of:	
	Front	44929
	Middle	46082
	Rear	46083
4R3, 4R4	Rheostat, mod. filament, Ohmite, Model N, 300 watts, consisting of three 6-inch, 12-ohm plates, close-mounted in tandem, less knob	18218
4R5	Resistor, 4E14 coil shunt, Ward Leonard, 14 ohms, 45 watts, 4" B-type 206	45756
4R6	Resistor, 4E16 coil shunt, Ward Leonard, 3.84 ohms, 45 watts, 4" B-type 206	45757
4R7	Resistor, 4E9 coil shunt, Ward Leonard, 500 ohms, 5 watts, 2" O-type 300	46589
4R8	Resistor, meter shunt, 3 ohms, 55 watts	45758
4R9	Resistor, 4E15 coil shunt, Ward Leonard, 0.5 ohms, 45 watts, 4" B-type 206	46590
4S1	Switch, main line breaker, Westinghouse, DE-ION Type AB, 3-pole with thermal overload 25 KW at 80% P.F. trip set for 1500 amps, similar to Style 999139	46688
4S2	Switch, plate primary breaker, same as 4S1	
4S3	Switch, power change, DPST, tumbler, black handle, back-connected, Bryant 3982 B/A	
4S4	Switch, transmitter on, same as 4S3	
4S5	Switch, filament bus breaker, Westinghouse, DE-ION, Type AB, 2-pole, 50 amps for 250 volts, with 25 amps trip, DE-ION Style No. 1222004	
4S6	Switch, air-cooled filament breaker, Westinghouse, DE-ION Type AB, 2-pole, 50 amps, 250 volts, with 35 amps trip, Style No. 1222015	
4S7	Switch, LP rect. plate primary breaker, same as 4S5	
4S8	Switch, supply voltmeter, Westinghouse, Type W, Style 519115	
4S9	Switch, mod. blower breaker, Westinghouse, Type DN-W, Class 10-100, Size 0, 2-pole Motor Watchman, Style 967337, with heater A.K.—1.9 Style 366474	
4S10	Switch, mod. blower breaker, same as 4S9	
4S11	Switch, PA blower breaker, Westinghouse, Type DN-W, Class 10-100, Size 0, 2-pole Motor Watchman, Style 967337, with heater A.P.—3.4 Style 966479	

REPLACEMENT PARTS LIST (Continued)

POWER CONTROL UNIT

Symbol No.	Description	Stock No.
4S12	Switch, bias rectifier breaker, Westinghouse, Type DN-W, Class 10-100, Size 0, 2-pole Motor Watchman, Style 967337, with heater A.T.—4.8 Style 966482	
4S13	Switch, automatic operation, same as 4S3	
4S14	Switch, filament voltmeter, same as 4S8	
4T1	Transformer, current for 4E12, Westinghouse, Type KO-200/5, Style 651913	
4T2	Transformer, current for 4E13, same as 4T1	
4V1 to 4V3	Fuse block (double), Westinghouse, Style 822310	

ENCLOSURE

5A1	Lamp, indicator, crystal heater, red color cap	
5A2	Lamp, indicator, crystal heater, green color cap	
5A3	Lamp, indicator, "bias-on," red color cap	
5A4	Lamp, indicator, "air-flow," green color cap	
5A5	Lamp, indicator, "interlocks," same as 5A3	
5A6	Lamp, indicator, "overload," same as 5A3	
5A7	Lamp, indicator, "high voltage"—full, same as 5A3	
5A8	Lamp, indicator, "high-voltage"—reduced, same as 5A4	
	Parts for above:	
	Lamp only	16154
	Red cap only	19897
	Green cap only	44136
	Receptacle only	44997
	Resistor only (for 5A1 and 5A2)	16155
	Resistor only (for 5A3 to 5A8)	44570
5M1	Meter, oscillator plate current, 0-50 ma dc	45908
5M2	Meter, buffer plate current, 0-250 ma dc	45909
5M3	Meter, IPA grid current, same as 5M2	
5M4, 5M5	Meter, IPA plate current, 0-500 ma dc	17233
5M6	Meter, PA grid current, same as 5M4	
5M8	Meter, output tank current, 0-15 amps, rf	
5M9	Meter, 1st a-f plate current, 0-15 ma dc	45912
5M10	Meter, 2nd a-f plate current, same as 5M4	
5M11	Meter, low power plate voltage, 0-2 kv dc with tubular resistor	
5M12, 5M13	Meter, modulator plate current, 0-2 amps, dc	45913
5M14	Meter, filament voltage, 0-20 volts, ac	
5M15	Meter, main plate voltage, 0-12 kv dc	17211
5M17	Meter, PA plate current, 0-3 amps, dc	19910
5R1	Multiplier (part of 5M16)	
5S1	Door interlock	48302
5S2	Pushbutton, oscillator change over	
5S3	Pushbutton, oscillator "off"	44957
5S4	Pushbutton, driver tuning, same as 5S2	
5S5	Pushbutton, driver tuning, same as 5S3	
5S6	Pushbutton, PA tuning, same as 5S2	
5S7	Pushbutton, PA tuning, same as 5S3	
5S8, 5S9	Door interlock, same as 5S1	
5S10	Pushbutton, "Rects. on," same as 5S2	
5S11	Pushbutton, "off," same as 5S3	
5S12	Pushbutton, overload reset, part of 5S10	

MODULATOR OUTPUT UNIT

6C2	Capacitor, coupling, 3 mfd, 12,500 volts	17259
6L1, 6L2, 6L3	Reactor, line series (part of 6T2)	
6L4	Reactor, phasing, XT-2664	17264
6L5	Reactor, modulation, XT-2983	18048
6R2	Resistor, arc-limiting, 200 ohms (part of 6L5)	

REPLACEMENT PARTS LIST (Continued)

MODULATOR OUTPUT UNIT

Symbol No.	Description	Stock No.
6T2	Transformer, plate power	Mi-7088-A
6T3	Transformer, modulation, XT-2685	19913

MAIN RECTIFIER UNIT

7A1 to 7A6	Indicator, main rectifier	17207
7A7	Blower, main rectifier tube base, 220 volts, 50/60 cycles	
	Motor only	43956
7C1, 7C2	Capacitor, 5 mfd, 10,000 volts	19865
7E1	Relay, surge, SPST, 220 volts, 60 cycles	
	Coil only	46022
	Contacts only	46023
7E2	Switch, condenser grounding	45145
	Interlock only	19868
	Solenoid only	45147
7L1	Reactor, main rectifier filter	44404
7M1	Multiplier, main rectifier (part of 5M15)	
7T1 to 7T6	Transformer, main rectifier filament	17224
7X1 to 7X6	Socket, main rectifier tube	44755

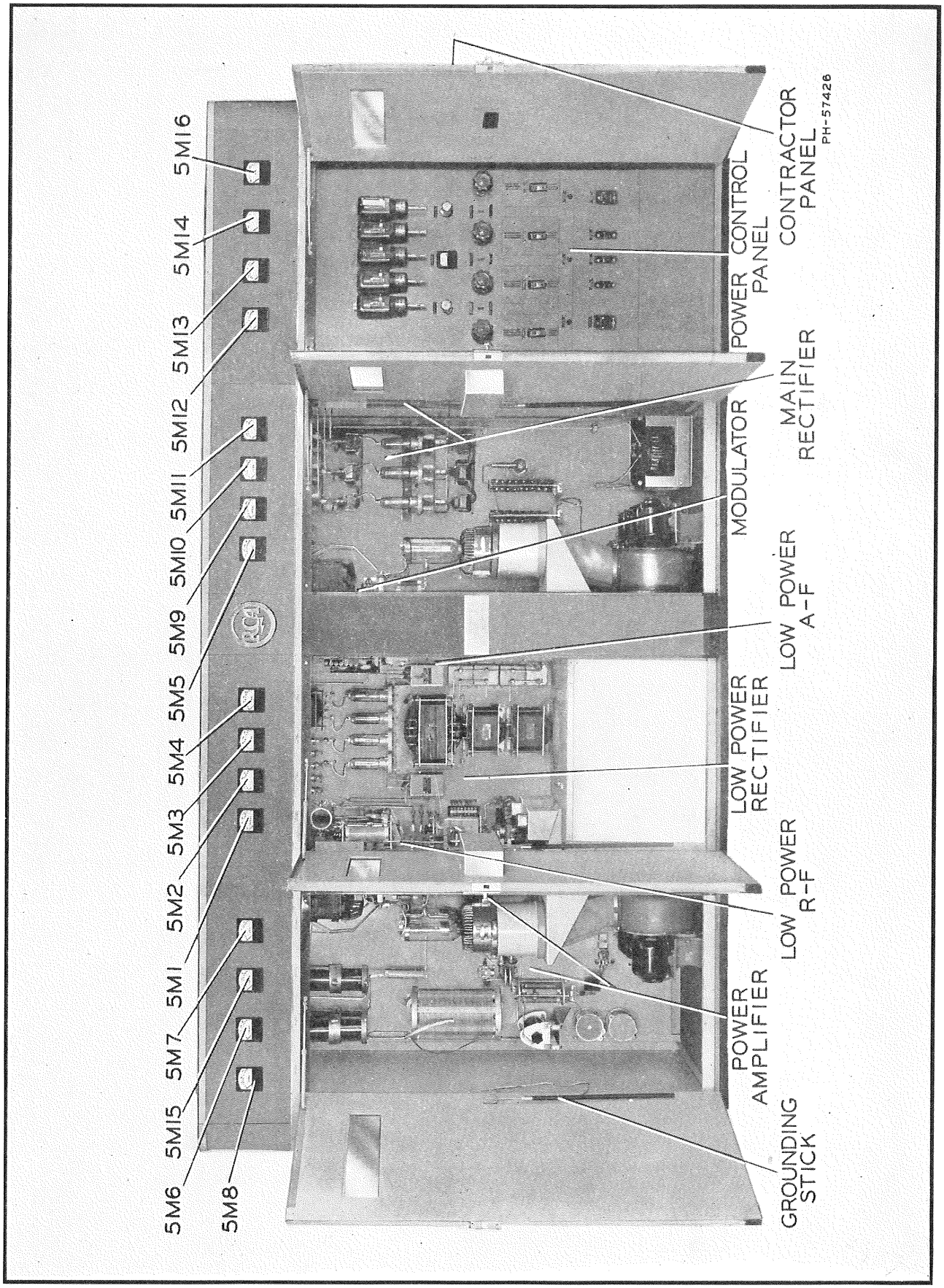


Figure 7—Type BTA-10F Broadcast Transmitter (Front View, Doors Open)

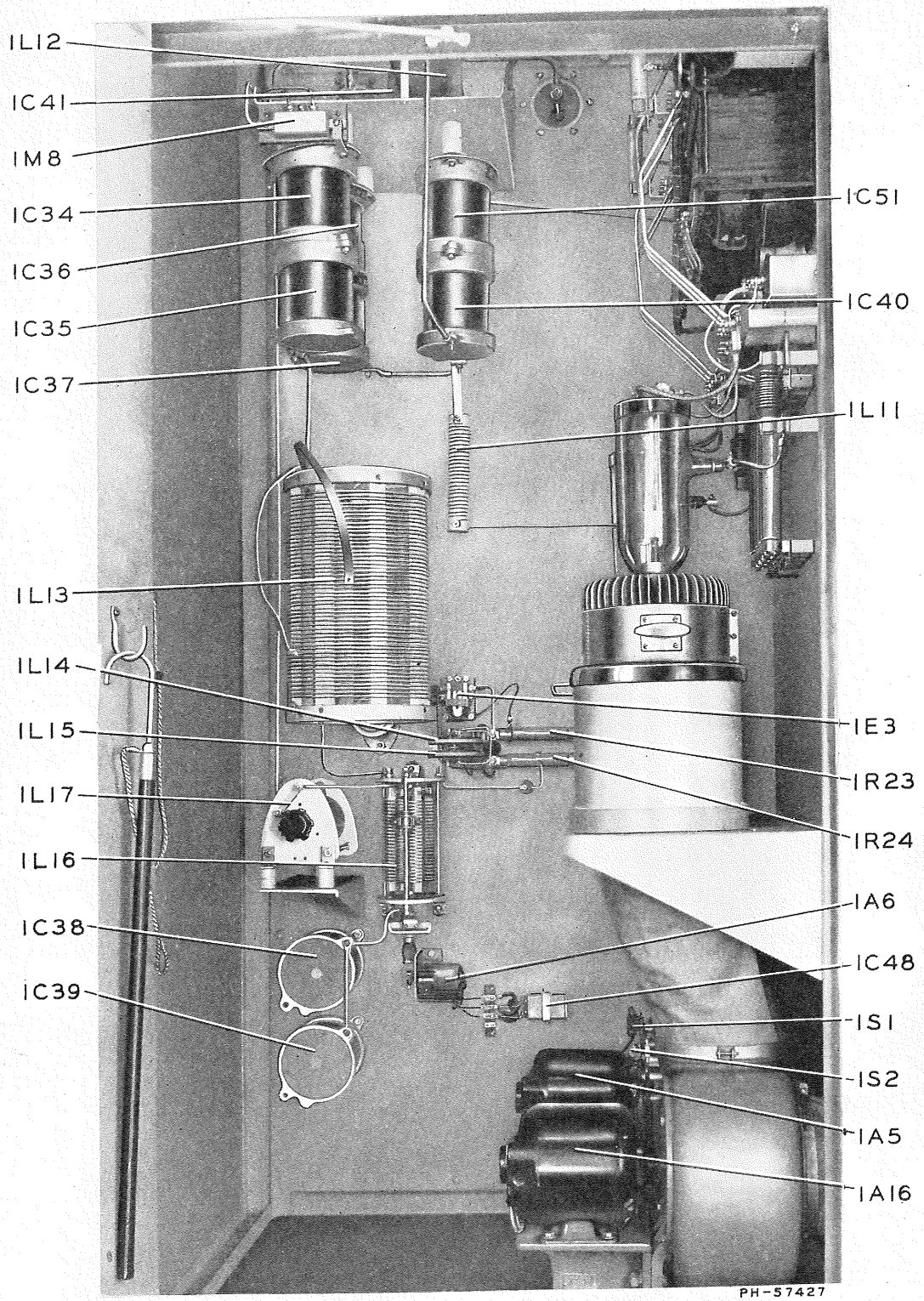


Figure 8—R-F Output Tank Chassis

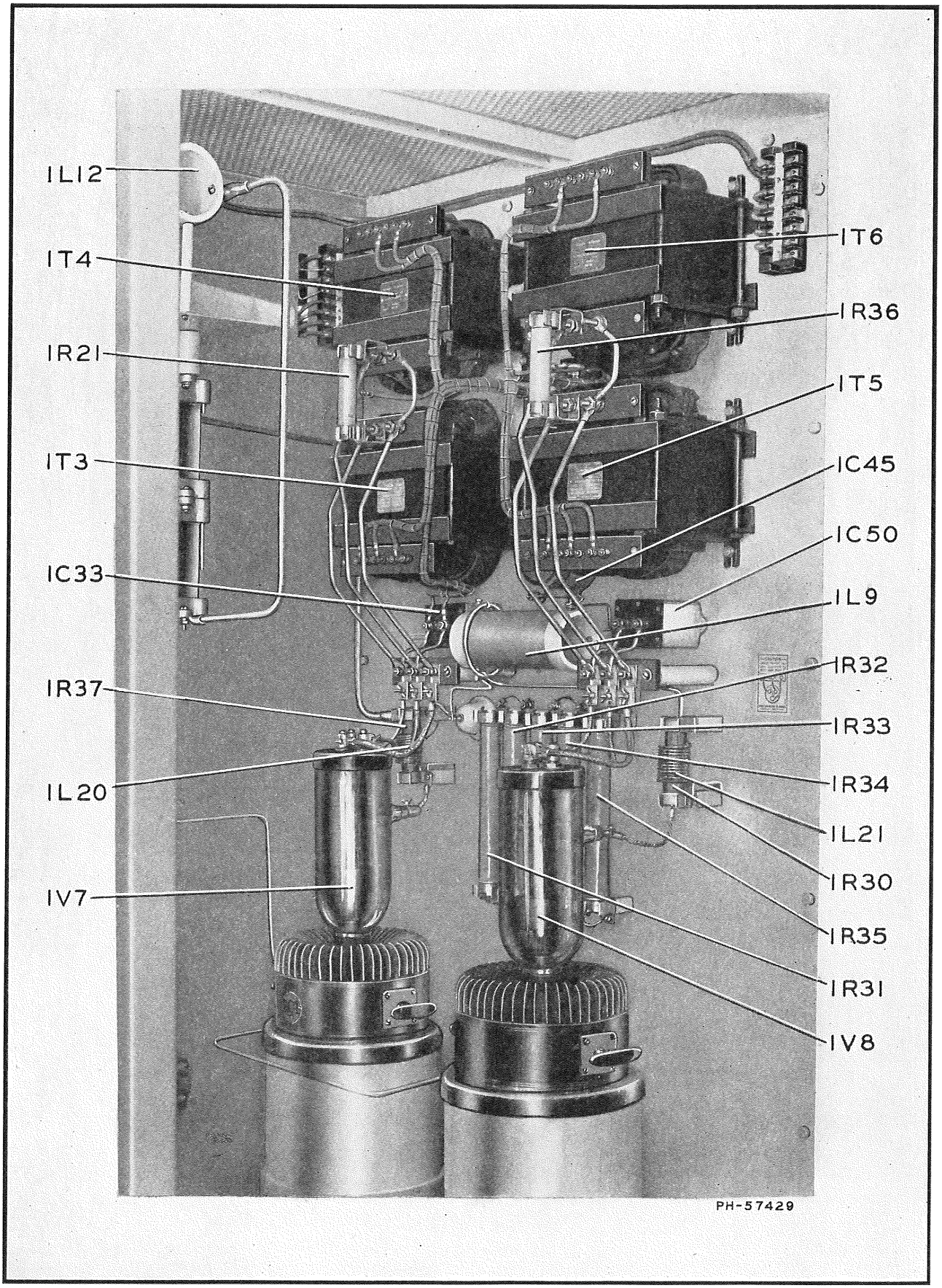


Figure 9—R-F Output Chassis

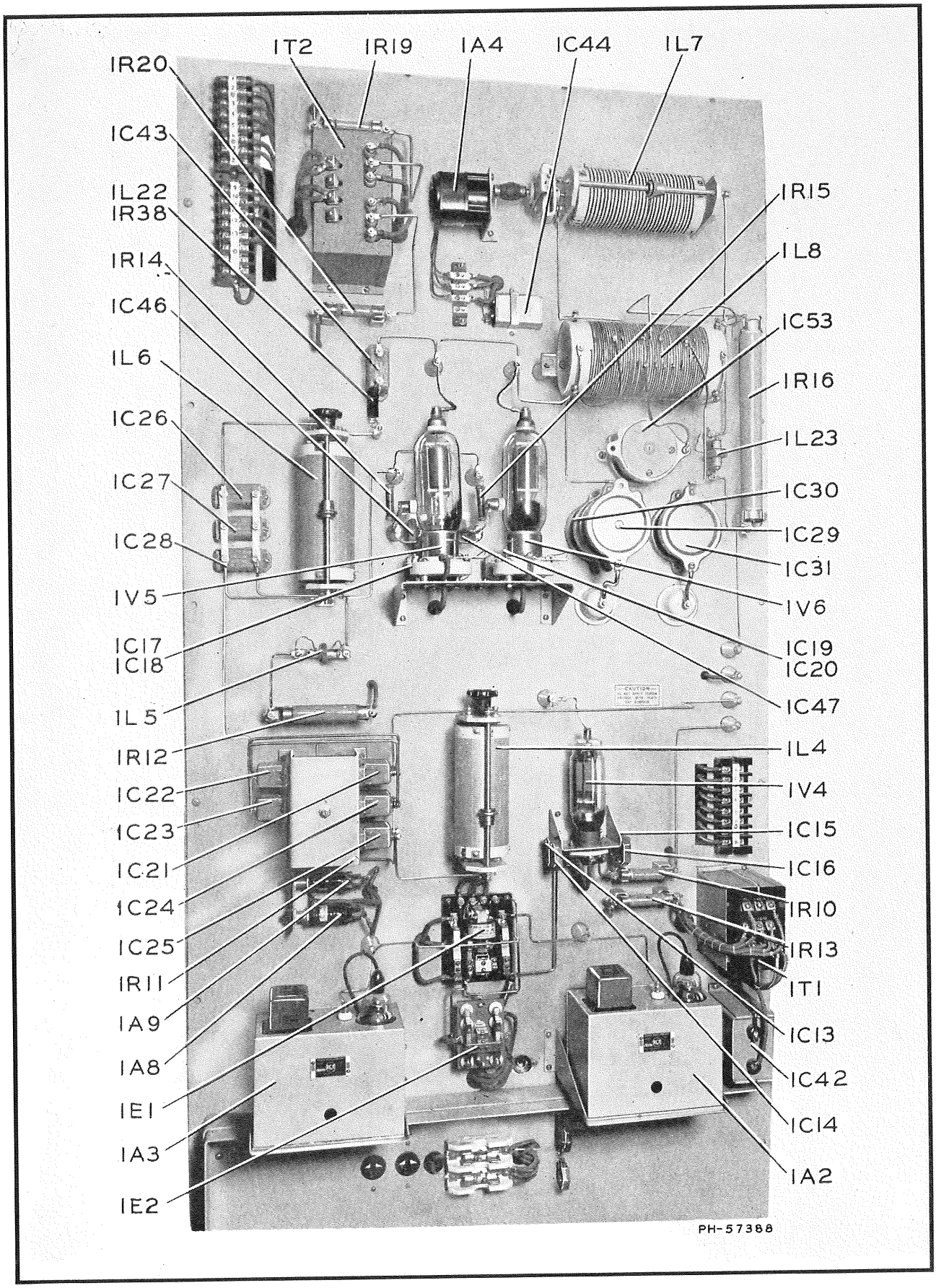


Figure 10—Low-Power R-F Chassis

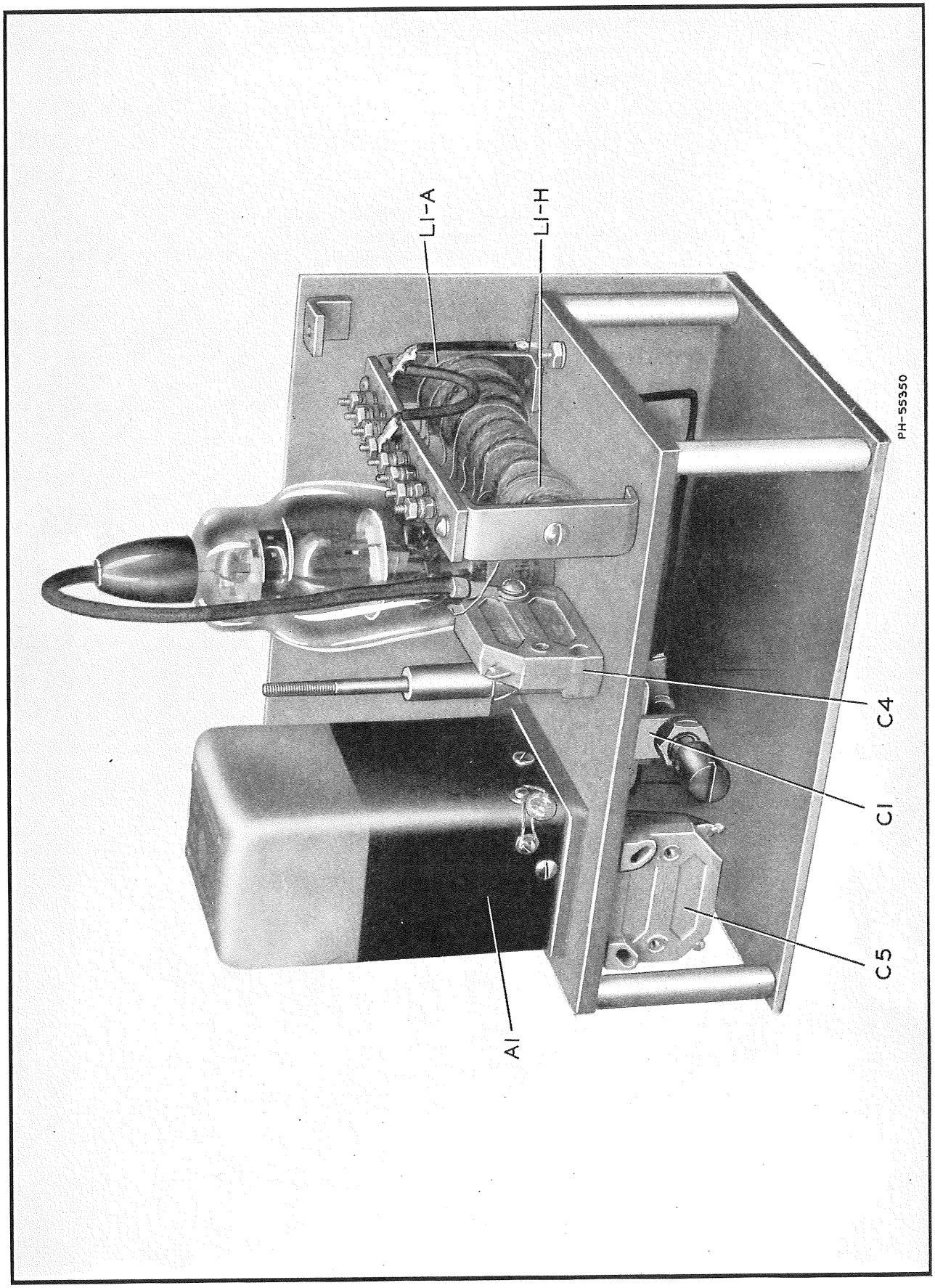


Figure 11—R-F Oscillator Unit (Front Oblique View, Covers Removed)

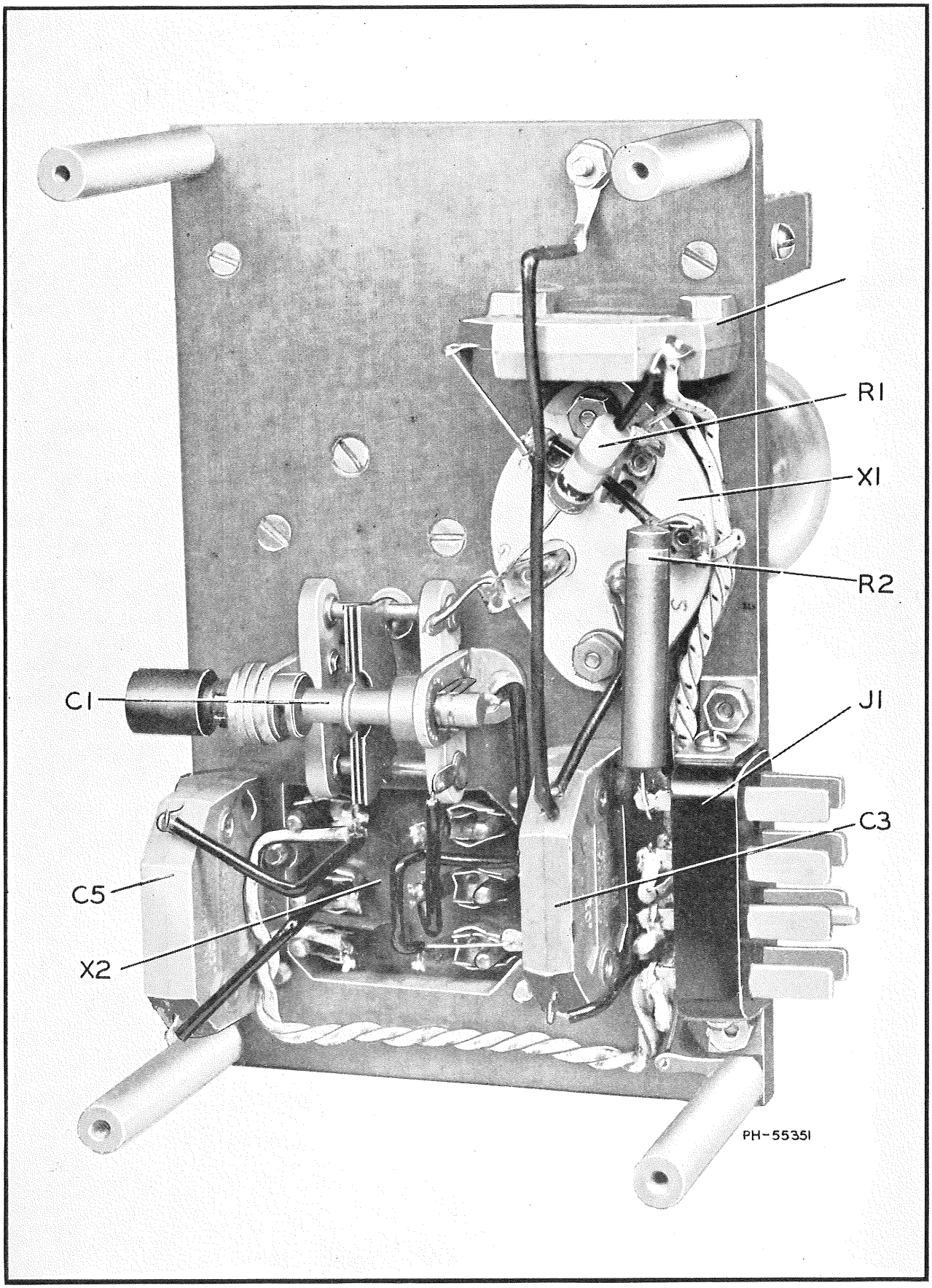


Figure 12—R-F Oscillator Unit (Bottom View, Covers Removed)

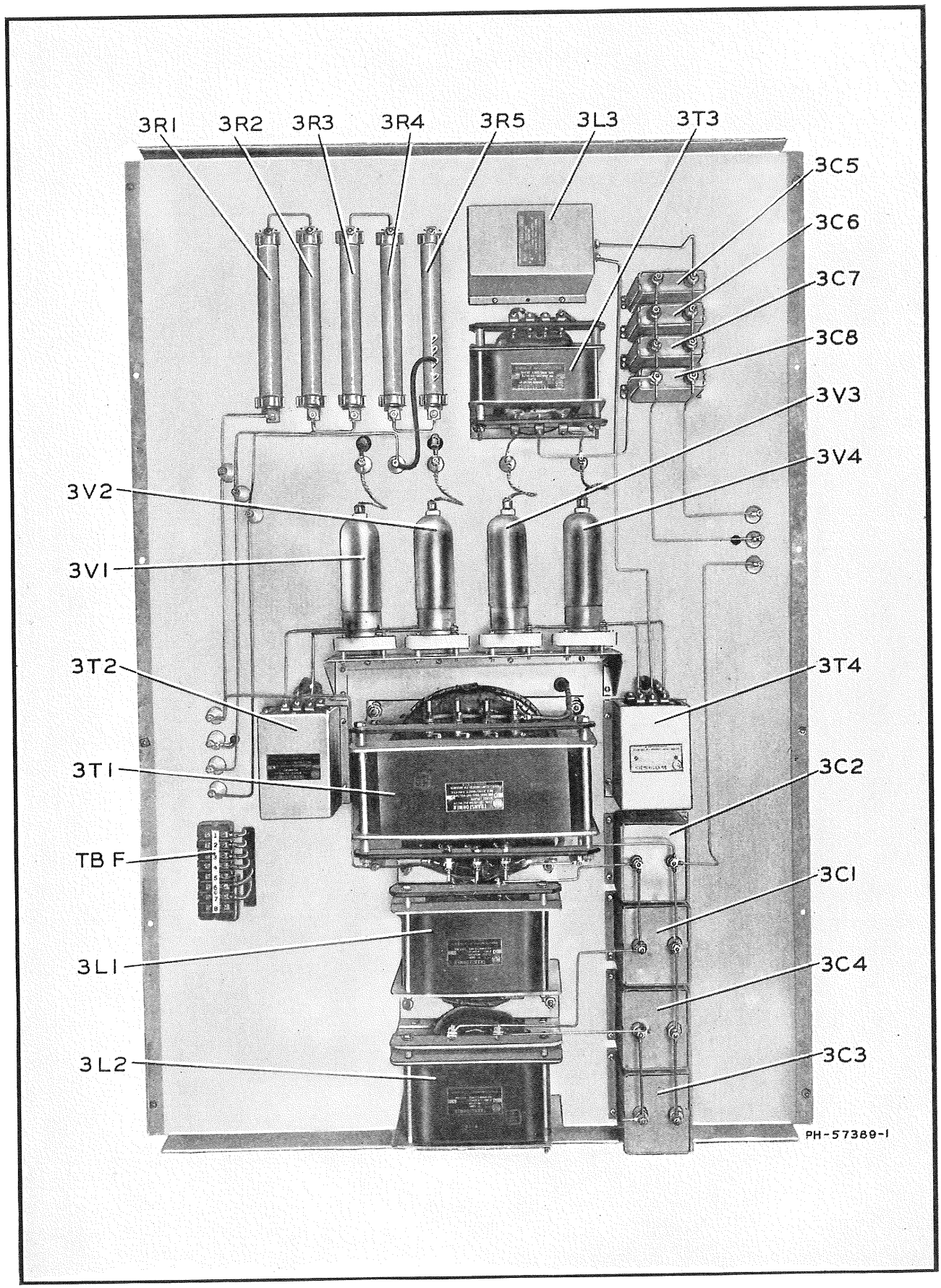


Figure 13—Bias and Auxiliary Rectifier Chassis

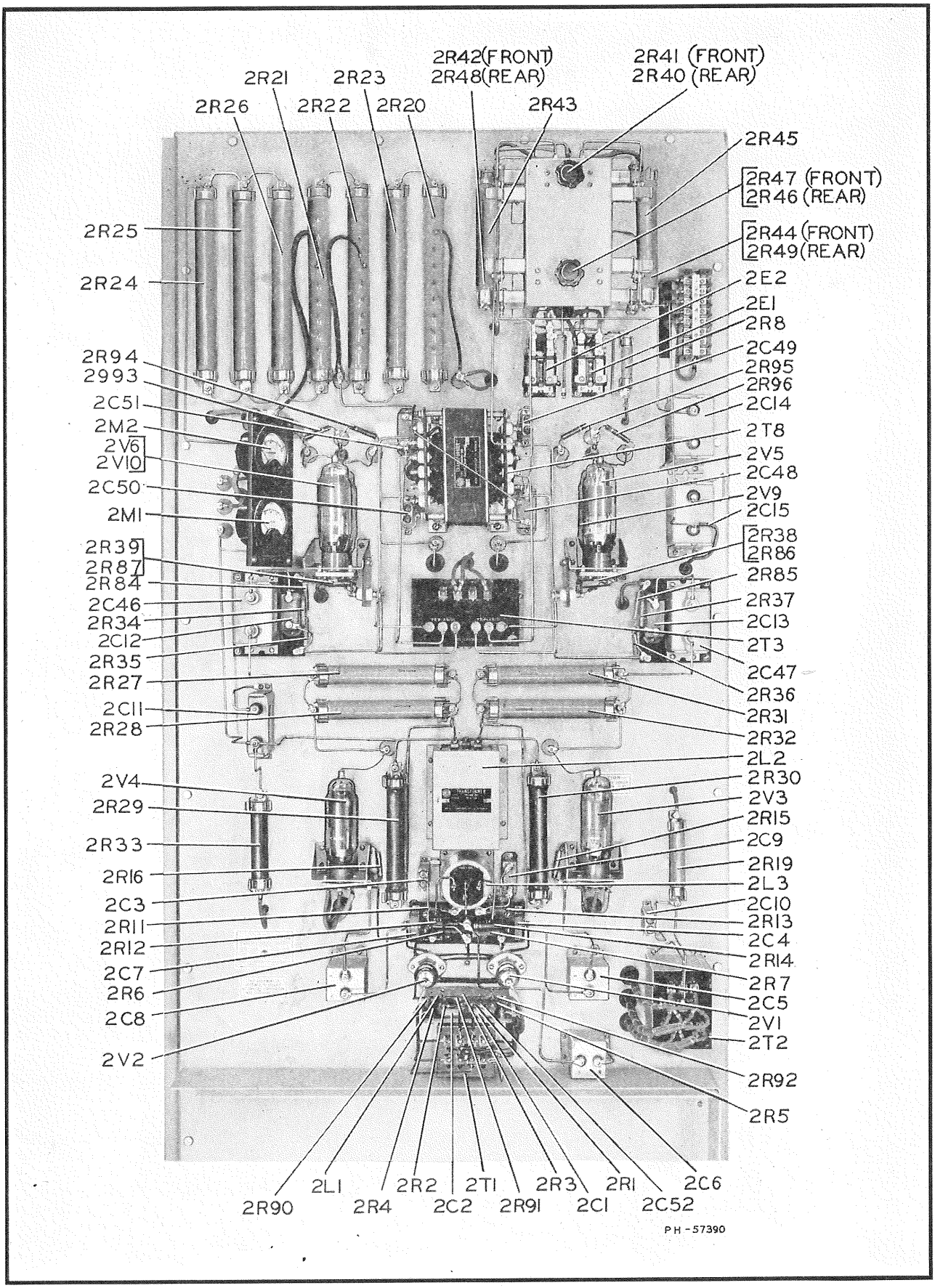


Figure 14—Low-Power A-F Chassis

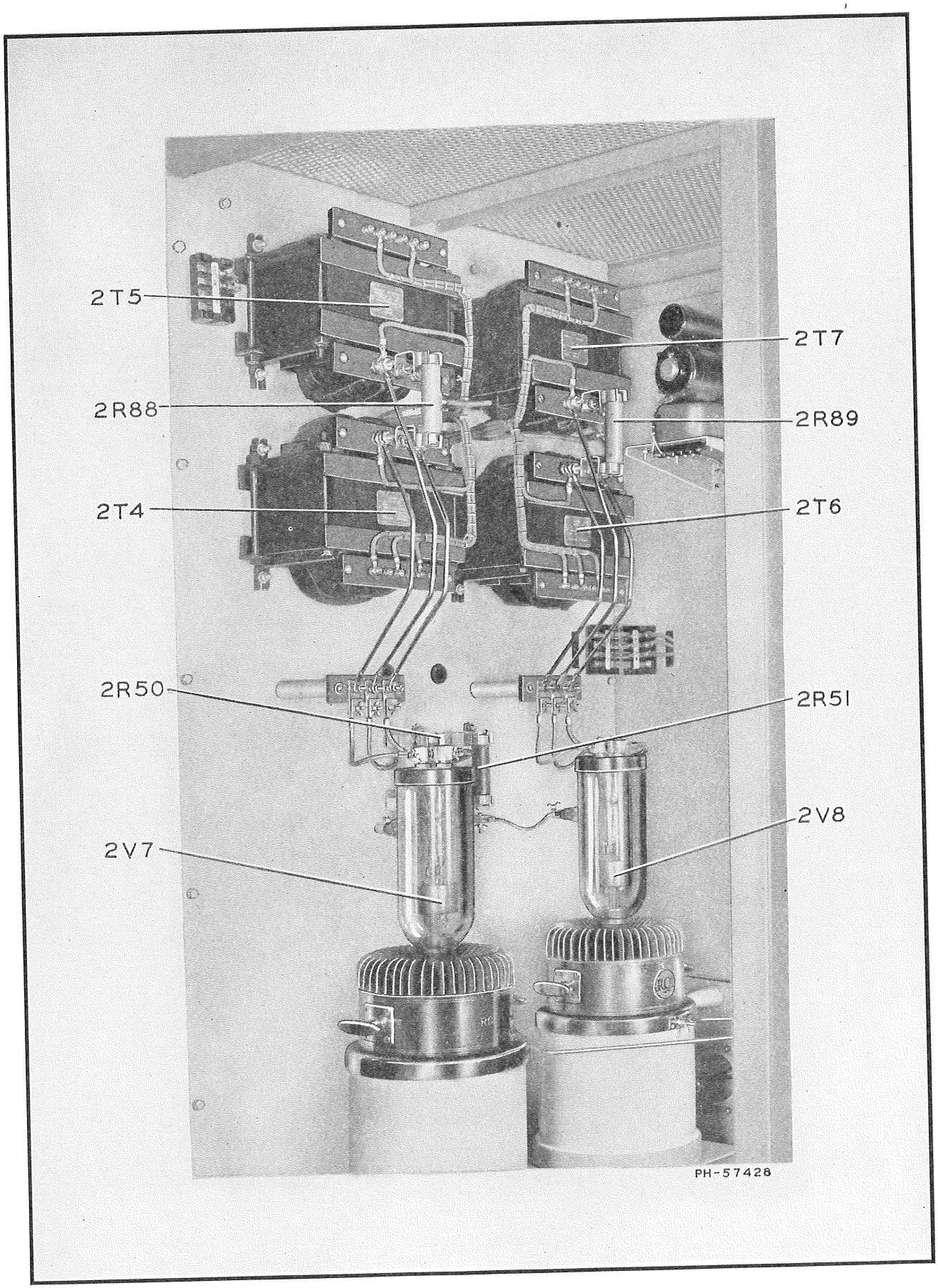


Figure 15—Modulator Chassis

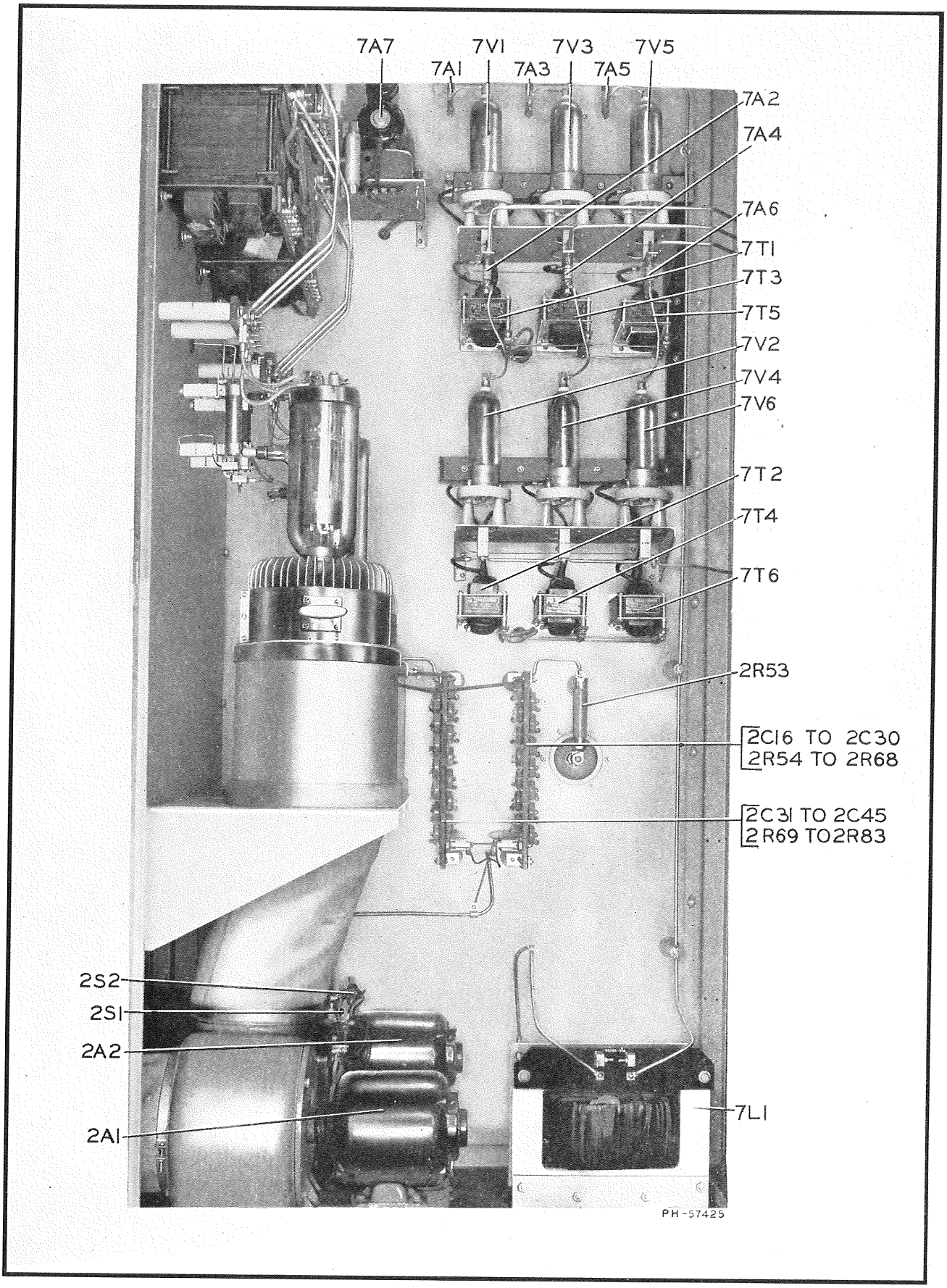


Figure 16—Main Rectifier Chassis

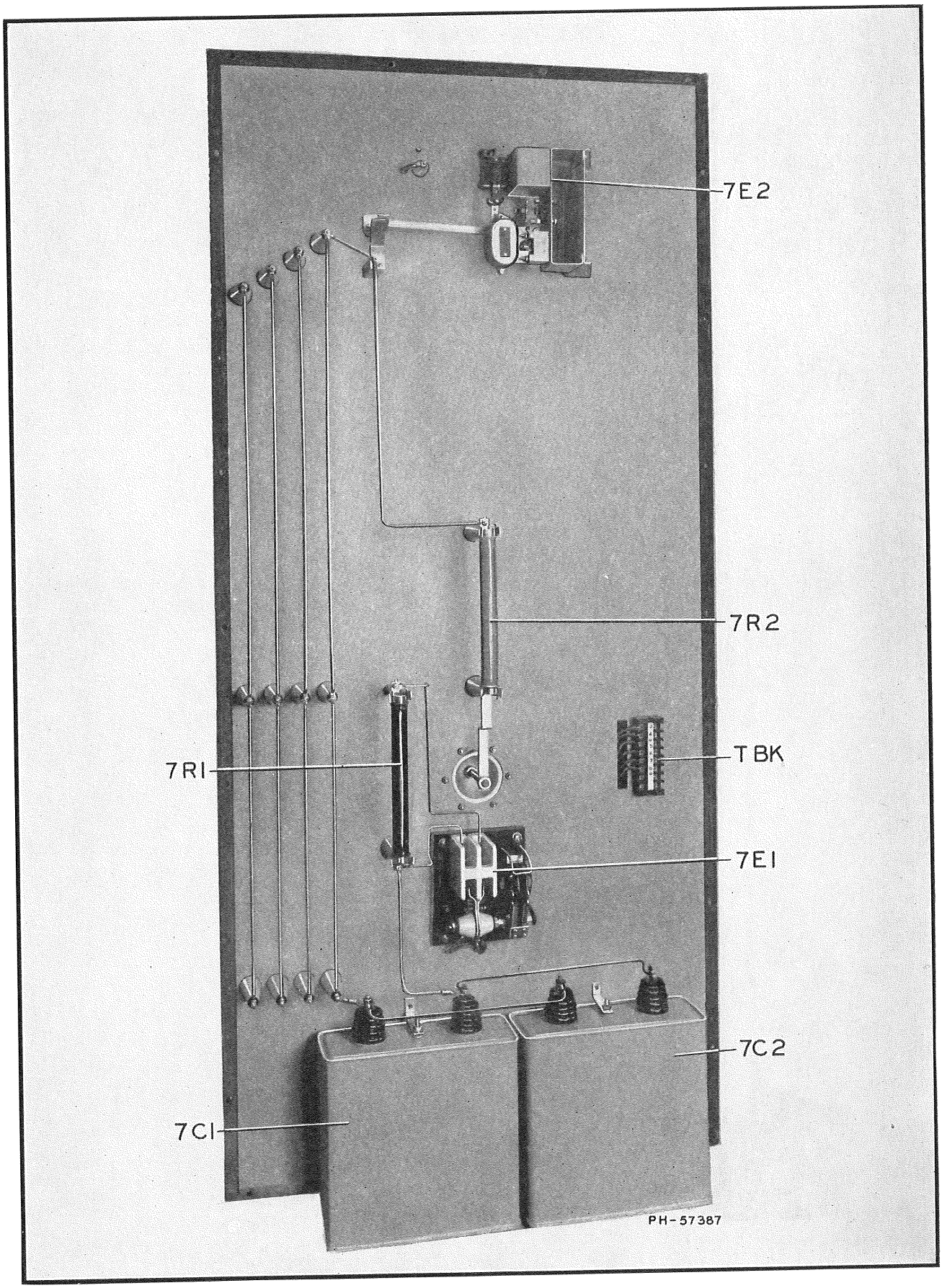


Figure 17—Rectifier Auxiliary Chassis

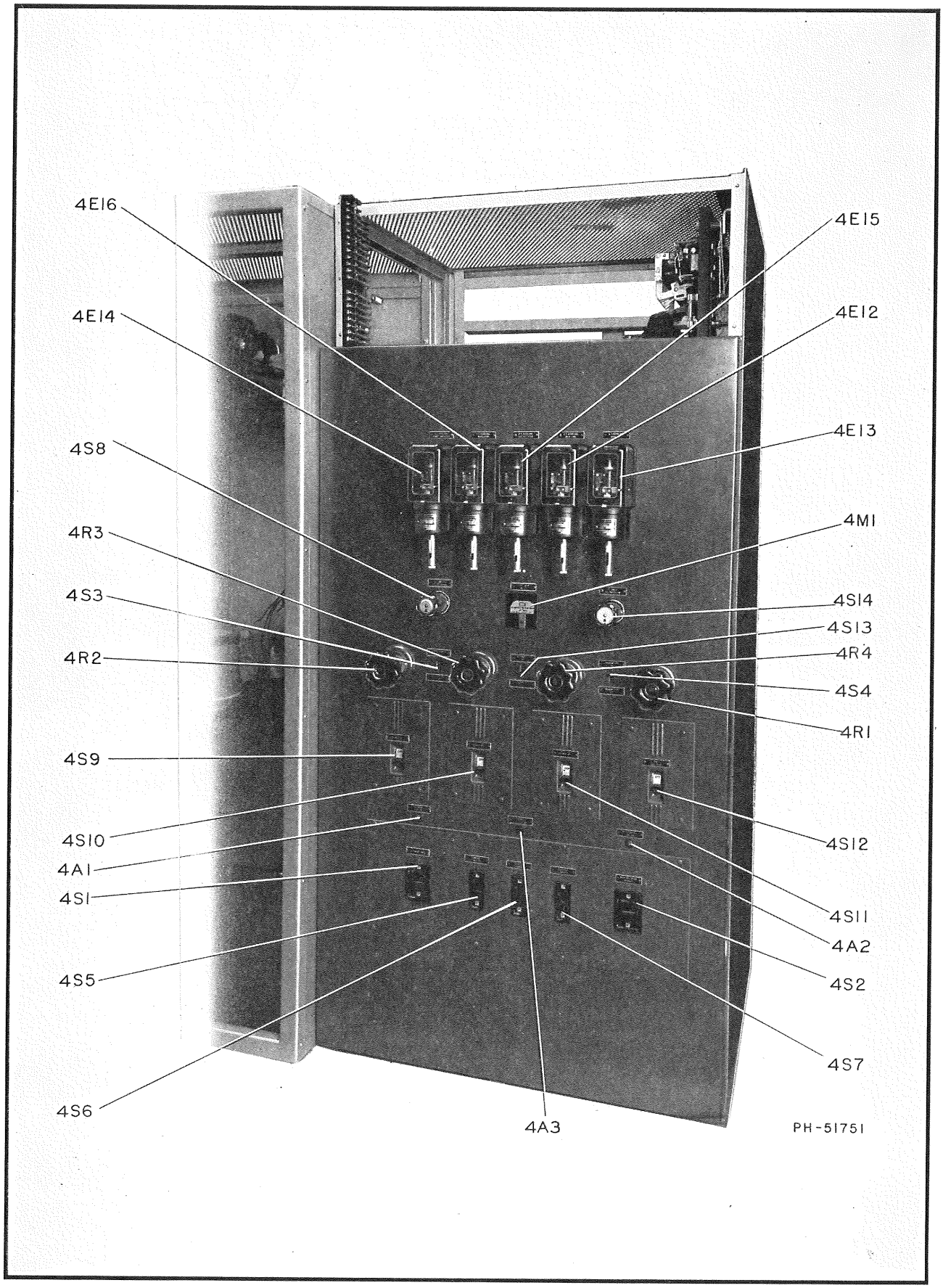


Figure 20—Power Control Panel (Front View)

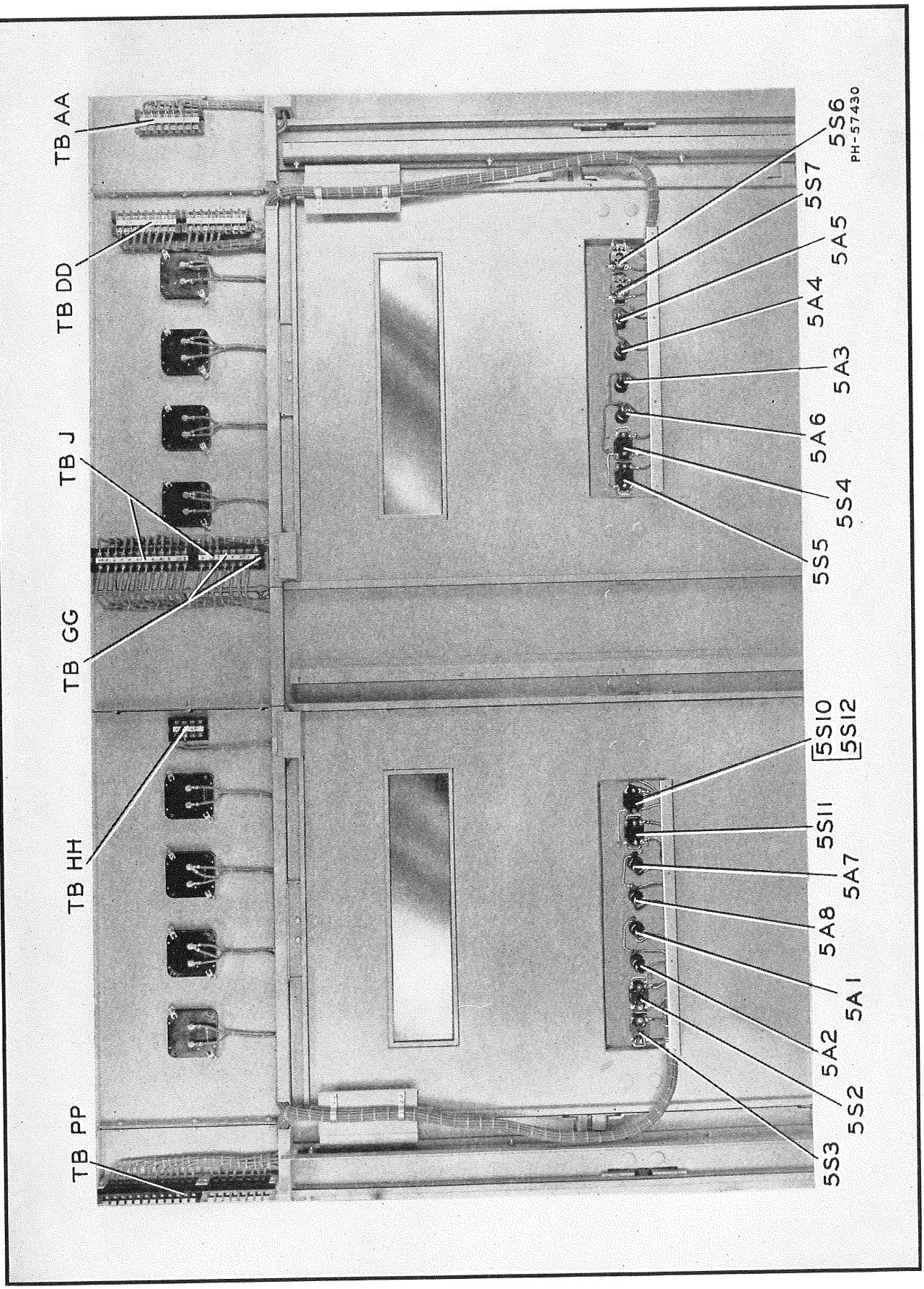


Figure 21—Enclosure (Partial Rear View)

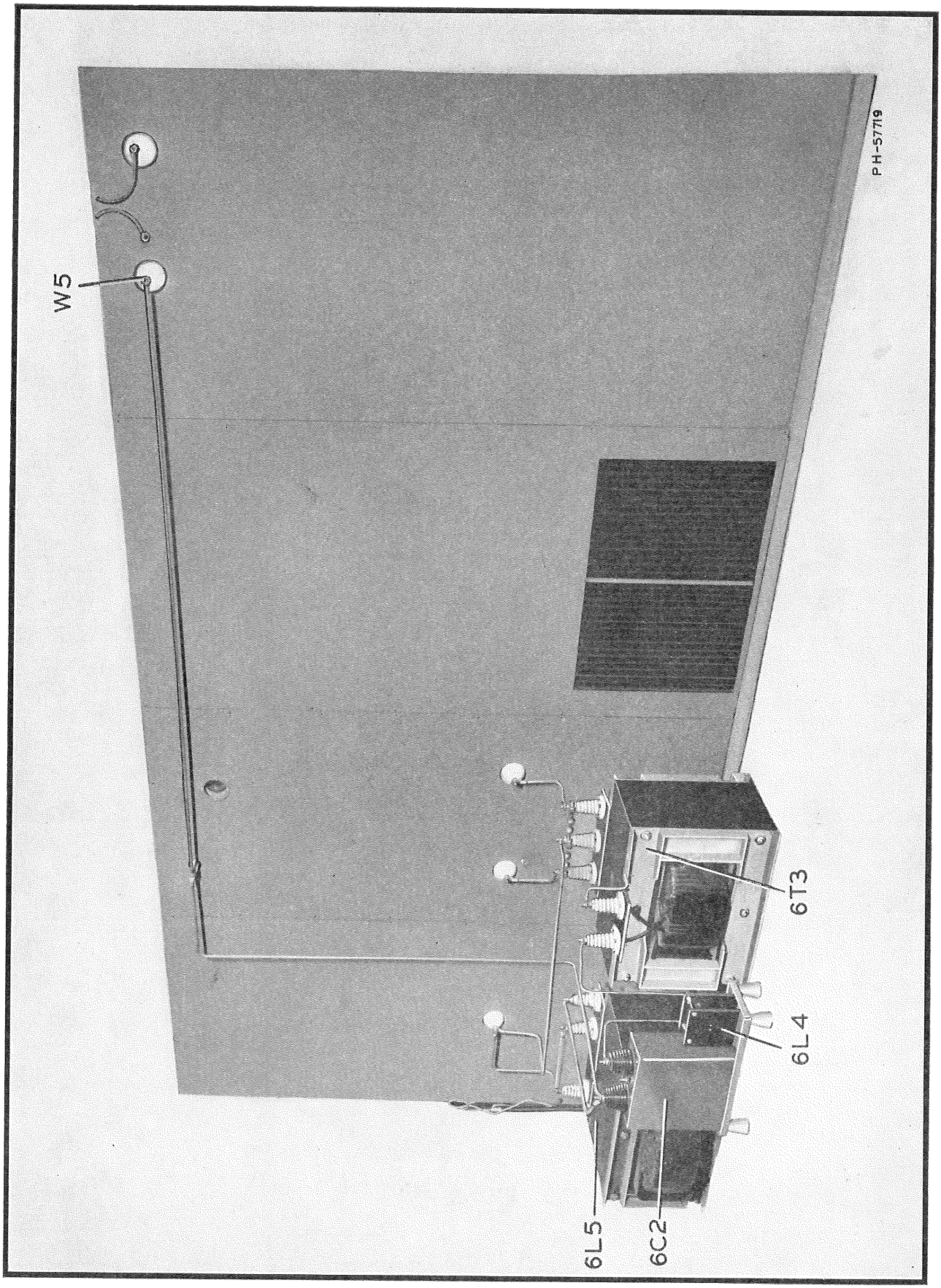


Figure 22—Modulator Output Unit (Rear View of Transmitter)

A2
RCA-807
A3
RCA-807
RCA-828
2-RCA-810
2-RCA-892-R
4-RCA-
BIAS AND L
RECT
PREF
TERMINAL PREFIX "Q"
RADIO FREQUENCY CIRCUITS
PREFIX "1"
115V 50/60 CYC
FRONT PANEL
PREFIX "5"
CRYSTAL HEATERS ON
CRYSTAL OSCILLATOR SELECTOR
CRYSTAL OSCILLATORS OFF
DRIVER RAISE-LOWER
OUTPUT RAISE-LOWER
TO PP7
TO PP8
TO PP17 THRU S8 & S9
TO PP14

2-RCA-892-R

2-RCA-1620

AUDIO FREQUENCY CIRCUITS

2-RCA-828 PREFIX "2"

4-RCA-828

2-RCA-892-R

TERMINAL PREFIX "Q"

4-RCA-800B

BIAS AND LOW POWER RECTIFIER

PREFIX "3"

ALTERNATE TERMINALS

TO A2 ON POWER CONTROL PANEL

TO G8 ON POWER CONTROL PANEL

TO W5 ON MOD. REACTOR

OUTPUT RAISE-LOWER

BIAS

TO PP14

AUDIO FREQUENCY CIRCUITS

2-RCA-828 PREFIX "2"

4RCA-828

2-RCA-892-R

PREFIX "6"

6-RCA8008

MAIN RECT

BL
BR
RE
OR
GR
BL

ALTERNATE TERMINALS

TO W5 ON POWER AMPLIFIER

TO A2 ON POWER CONTROL PANEL

TO G8 ON POWER CONTROL PANEL

TO W5 ON MOD. REACTOR

BIAS

TO PP8
TO PP7
TO PP13
TO PP17
TO PP14

ALL TERMINALS IN THIS GROUP ARE PRECEDED BY "PP" 1 TO 20 INCLUSIVE.

AIR FLOW

PLATE VOLTAGE OFF ON

OVERLOAD RESET

CB"2

CB"1

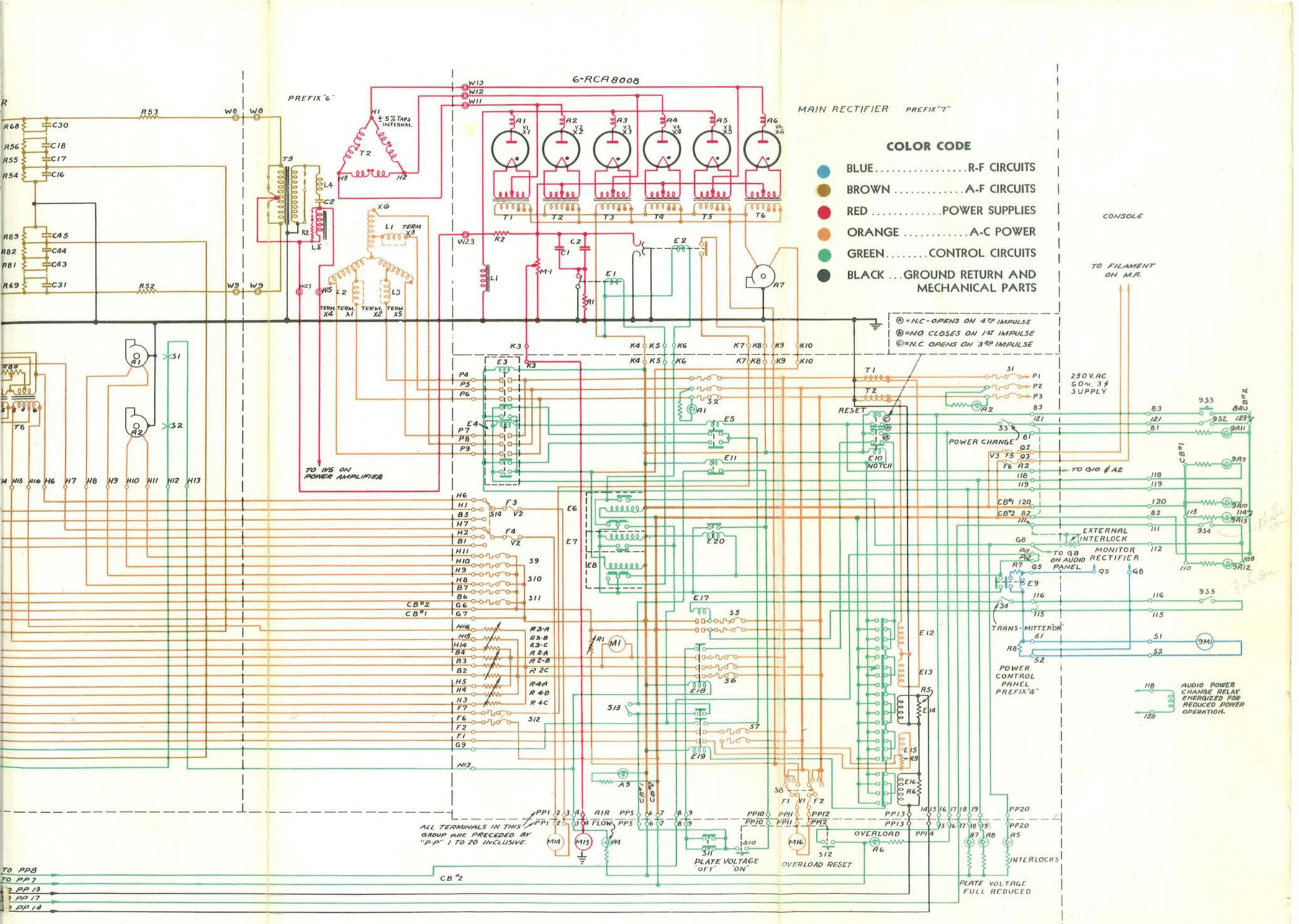
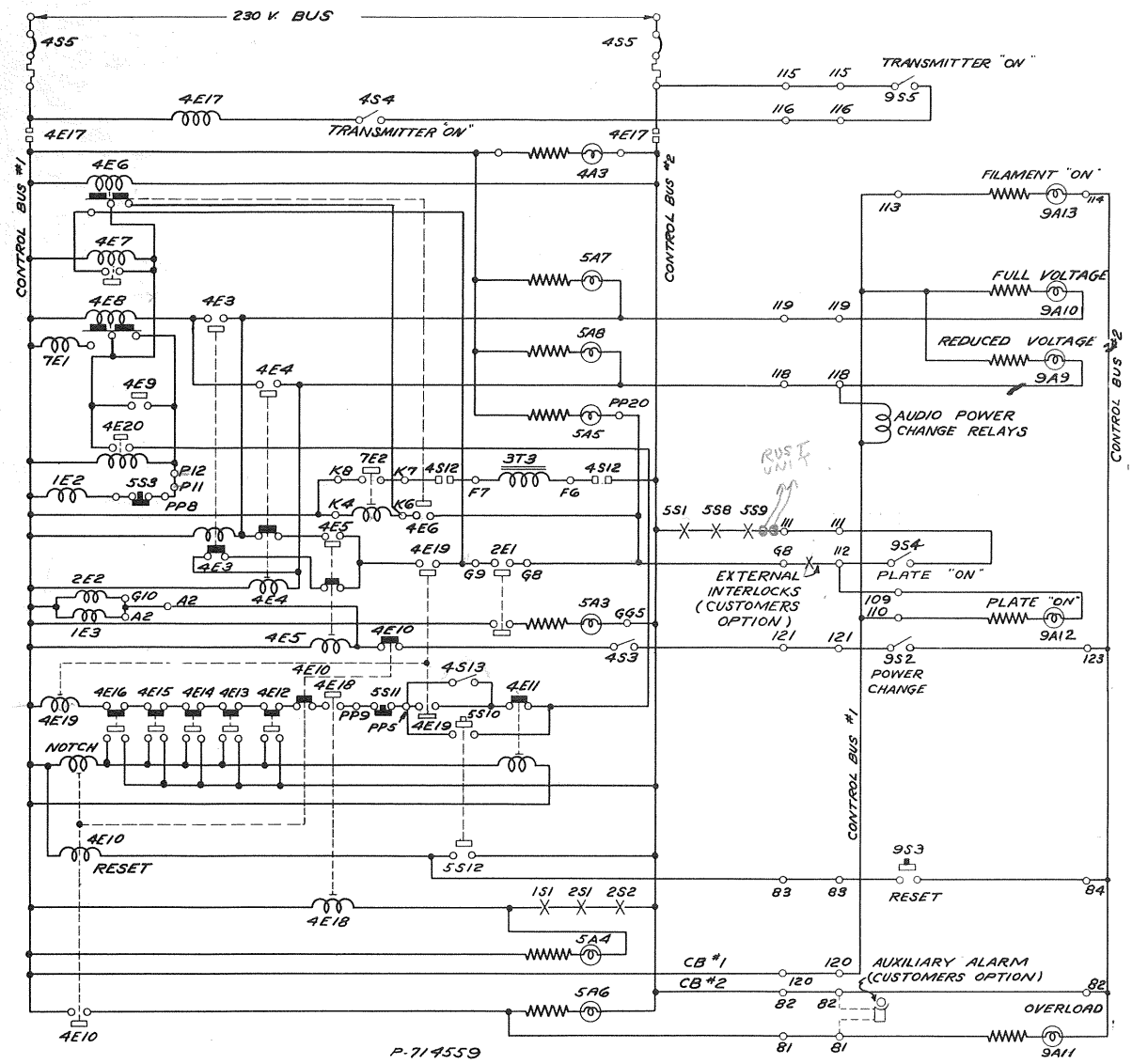


Figure 23—Overall Schematic Diagram (TT-601832, Sub. 9)



R.F.

1E2	CARRIER "BLOCKING" RELAY
1E3	POWER CHANGE COMPENSATING RELAY
1S1	AIR FLOW INTERLOCK

AUDIO

2E1	BIAS PROTECTIVE RELAY
2E2	BIAS CHANGE RELAY
2S1	AIR FLOW INTERLOCK
2S2	AIR FLOW INTERLOCK

BIAS & LOW POWER RECTIFIER

3T3	BIAS RECTIFIER PLATE TRANSFORMER

POWER CONTROL PANEL

4E3	FULL VOLTAGE PLATE CONTACTOR
4E4	REDUCED VOLTAGE PLATE CONTACTOR
4E5	POWER CHANGE AUX. RELAY
4E6	RECTIFIER PLATE DELAY RELAY
4E7	HESITATING RELAY TIMER AUX.
4E8	RECTIFIER SURGE RELAY TIMER
4E9	CARRIER "OFF" RELAY
4E10	OVERLOAD RATCHET RELAY
4E11	HESITATING RELAY, NOTCHING AUX.
4E12	OVERLOAD RELAY, MAIN LINE
4E13	OVERLOAD RELAY, MAIN LINE
4E14	OVERLOAD RELAY, POWER AMPLIFIEIR
4E15	OVERLOAD RELAY, AUX. RECTIFIER
4E16	OVERLOAD RELAY, MODULATOR PLATE.
4E17	FIL. BUS-CONTROL BUS CONTACTOR
4E18	AIR COOLED FILAMENT CONTACTOR
4E19	LOW POWER RECT. PLATE PRI. CONTACTOR
4E20	HESITATING CARRIER "OFF" AUX.
4S3	POWER CHANGE
4S4	TRANSMITTER "ON"
4S5	FIL. BUS-CONTROL BUS BREAKER
4S12	BIAS RECTIFIER PRI. BREAKER
4S13	AUTOMATIC OPERATION
4A3	FIL. "ON" PILOT LIGHT

FRONT PANEL

5A3	INDICATOR LAMP "BIAS ON"
5A4	INDICATOR LAMP "AIR FLOW"
5A5	INDICATOR LAMP "INTERLOCKS"
5A6	INDICATOR LAMP "OVERLOAD"
5A7	INDICATOR LAMP "PLATE VOLTAGE-FULL"
5A8	INDICATOR LAMP "PLATE VOLTAGE-REDUCED"
5S3	PUSH BUTTON "CRYSTAL OSCILLATORS OFF"
5S10	PUSH BUTTON "PLATE VOLTAGE ON"
5S11	PUSH BUTTON "PLATE VOLTAGE OFF"
5S12	PUSH BUTTON "OVERLOAD"

RECTIFIER.

7E1	SURGE RELAY
7E2	CONDENSER GROUNDING SWITCH

CONTROL CONSOLE

9A13	INDICATOR LAMP FIL. "ON"
9A12	INDICATOR LAMP PLATE "ON"
9A9	INDICATOR LAMP "HIGH VOLTAGE REDUCED"
9A10	INDICATOR LAMP "HIGH VOLTAGE FULL"
9A11	INDICATOR LAMP "OVERLOAD"
9S5	TRANSMITTER "ON"
9S2	POWER CHANGE - ENERGIZE FOR FULL POWER
9S4	CARRIER "ON"
9S3	OVERLOAD RESET

Figure 24—Control Circuits Ladder (P-714559, Sub. 2)

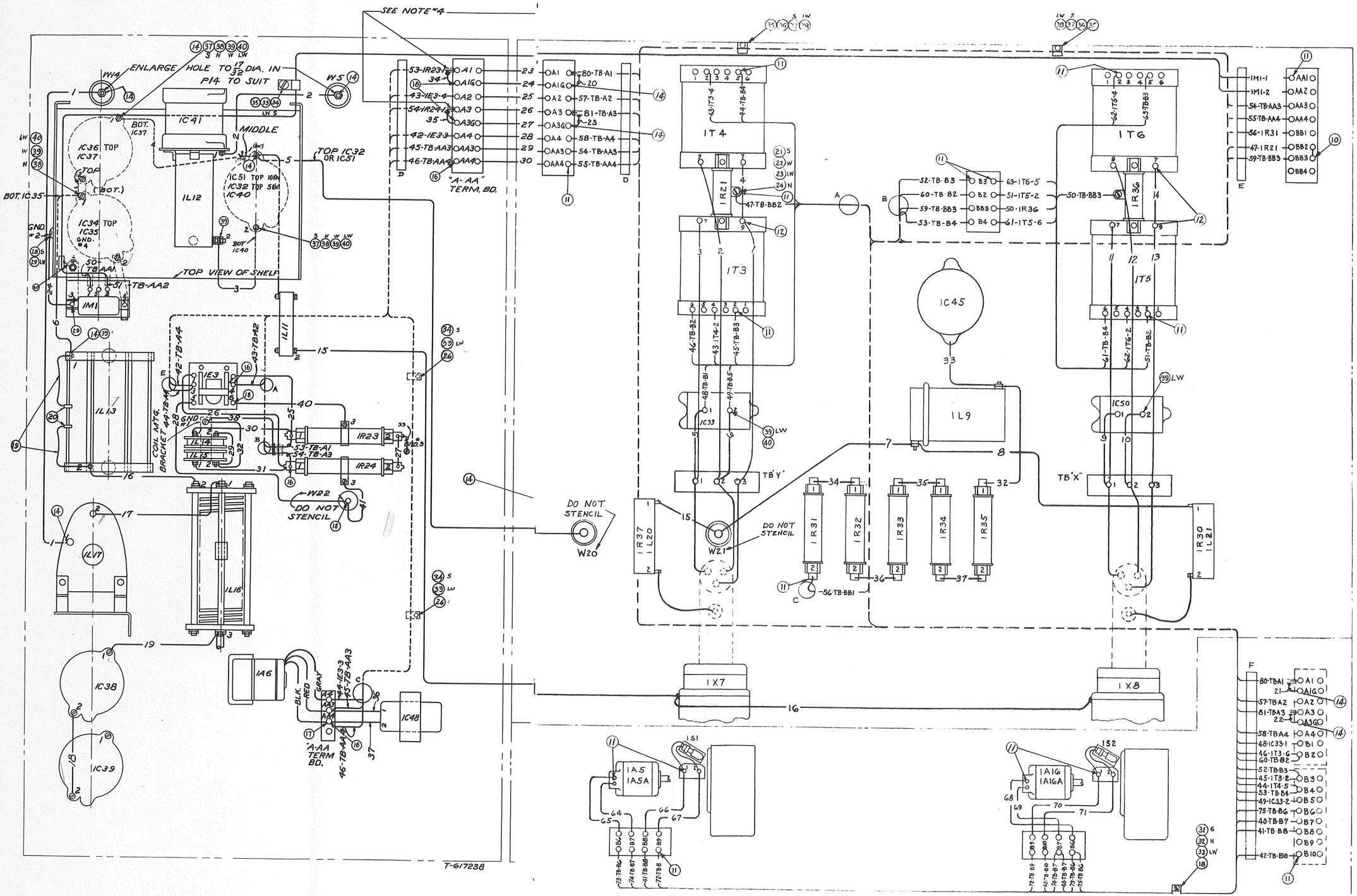
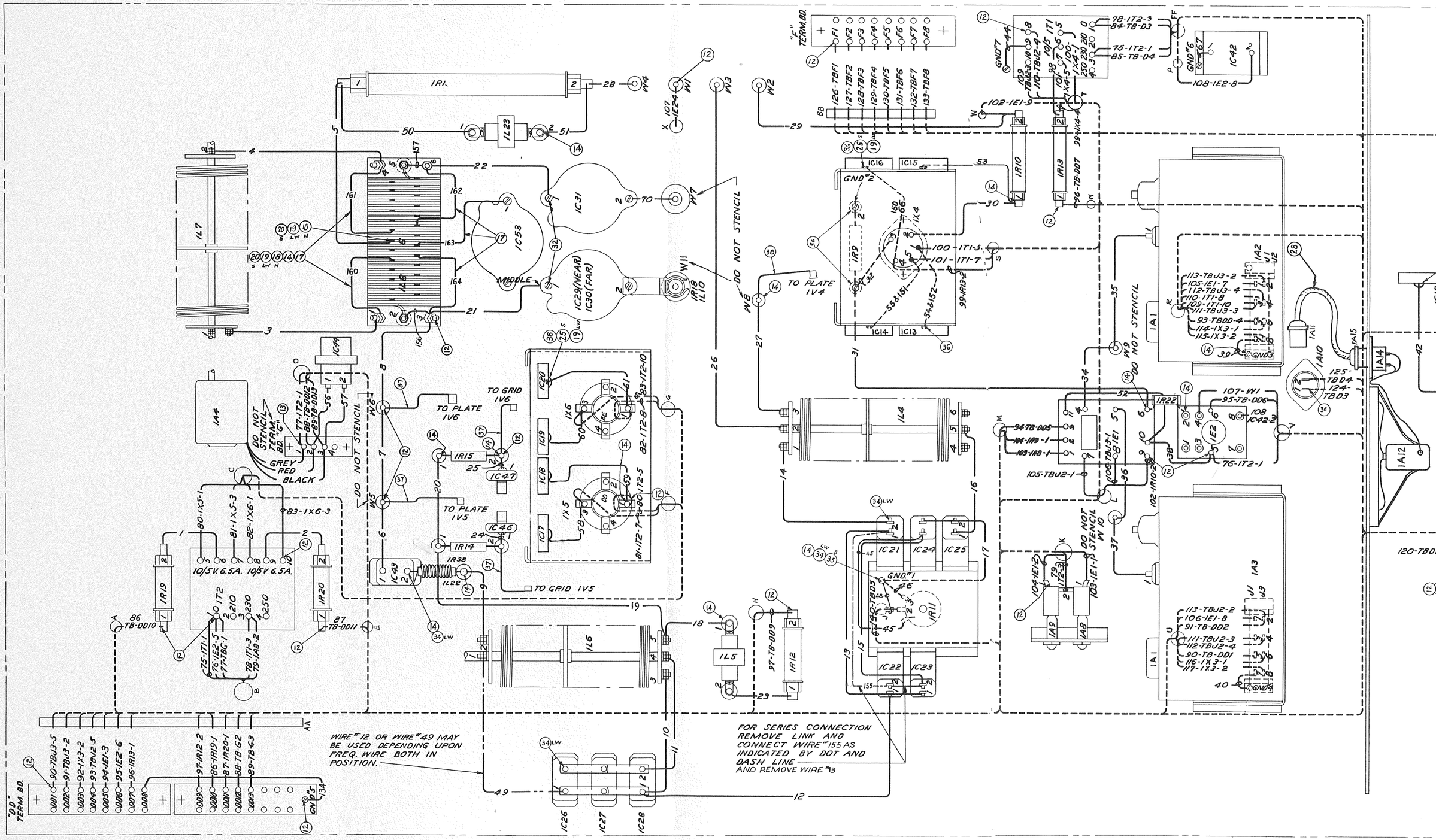


Figure 25—R-F Output Tank and R-F Output Chassis (T-613805, Sub. 1, and T-617238, Sub. 7)


"F" TERM. BD.
F1
F2
F3
F4
F5
F6
F7
F8
126-TBF1
127-TBF2
128-TBF3
129-TBF4
130-TBF5
131-TBF6
132-TBF7
133-TBF8
GND"6
GND"7
IC42
108-IE2-8
78-IT2-3
84-TB-D03
75-IT2-1
85-TB-D04
IR1
IL23
IC31
IC53
IC29(NEAR)
IC30(FAR)
IR18
IL10
IL7
IL8
MIDDLE
DO NOT STENCIL
W1
W2
W3
W4
W7
W8
W11
TO PLATE IV4
IC16
IC15
IC14
IC13
IR9
IR10
IR13
IX4
96-TB-D07
99-IR13-2
100-IT1-3
101-IT1-7
IA1
IA2
IA11
IA12
IA14
IA15
IA10
113-TBU3-2
105-IE1-7
112-TBU3-4
110-IT1-8
109-IT1-10
111-TBU3-3
93-TBD0-4
114-IX3-1
115-IX3-2
125-TBD4
124-TBD3
107-W1
95-TB-D06
108 IC42-2
IR22
IE2
IE1
94-TB-D05
104-IA9-1
103-IA8-1
105-TBU2-1
76-IT2-1
102-IR10-2
IA9
IA8
IA3
113-TBU2-2
106-IE1-8
91-TB-D02
111-TBU2-3
112-TBU2-4
90-TB-DD1
116-IX3-1
117-IX3-2
120-TBD
IC21
IC24
IC25
IC22
IC23
IR11
IL4
IL5
IL6
97-TB-D09
IR12
IC26
IC27
IC28
IC20
IC19
IC18
IC17
IX6
IX5
82-IT2-8
81-IT2-7
80-IT2-5
IC44
IA4
IR15
IC47
IR14
IC46
IR38
IC43
IL22
TO GRID IV6
TO PLATE IV6
TO PLATE IV5
TO GRID IV5
IR19
IR20
10/5V. 6.5A.
10/5V. 6.5A.
IT2
210
230
250
86 TB-DD10
87 TB-DD11
75-IT1-1
76-IE2-5
77-TBC-1
78-IT1-3
79-IA8-2
80-IX5-1
81-IX5-3
82-IX6-1
83-IX6-3
"DD" TERM. BD.
DD1 90-TBU3-5
DD2 91-TB-J3-2
DD3 92-IX3-2
DD4 93-TBU2-5
DD5 94-IE1-3
DD6 95-IE2-6
DD7 96-IR13-1
DD8
DD9 97-IR12-2
DD10 86-IR19-1
DD11 87-IR20-1
DD12 88-TB-G2
DD13 89-TB-G3
GND"5
WIRE #12 OR WIRE #49 MAY BE USED DEPENDING UPON FREQ. WIRE BOTH IN POSITION.
FOR SERIES CONNECTION REMOVE LINK AND CONNECT WIRE #155 AS INDICATED BY DOT AND DASH LINE AND REMOVE WIRE #13
GREY
RED
BLACK

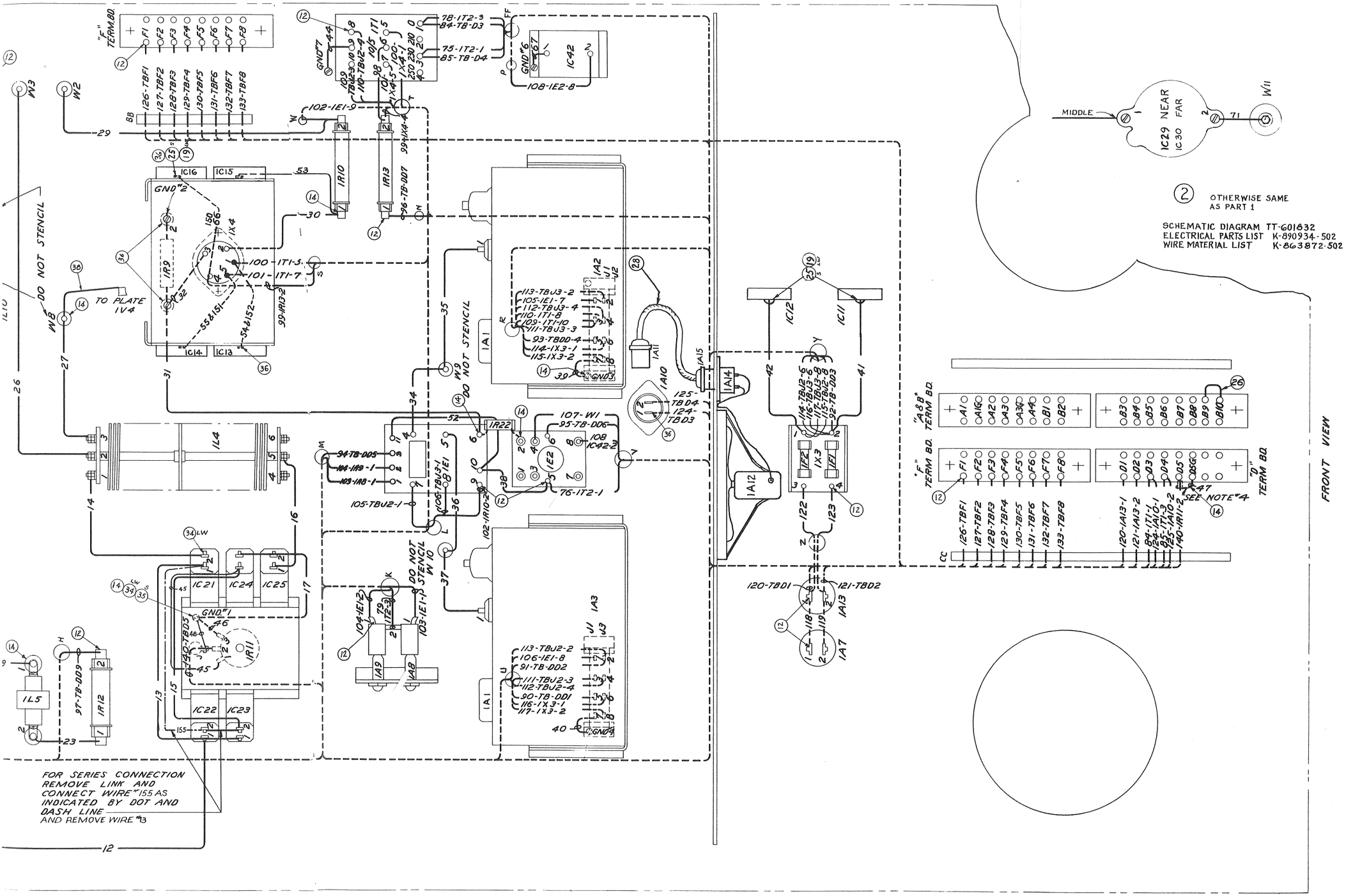


Figure 26—Low-Power R-F Chassis Connections
(TT-617251, Sub. 8)

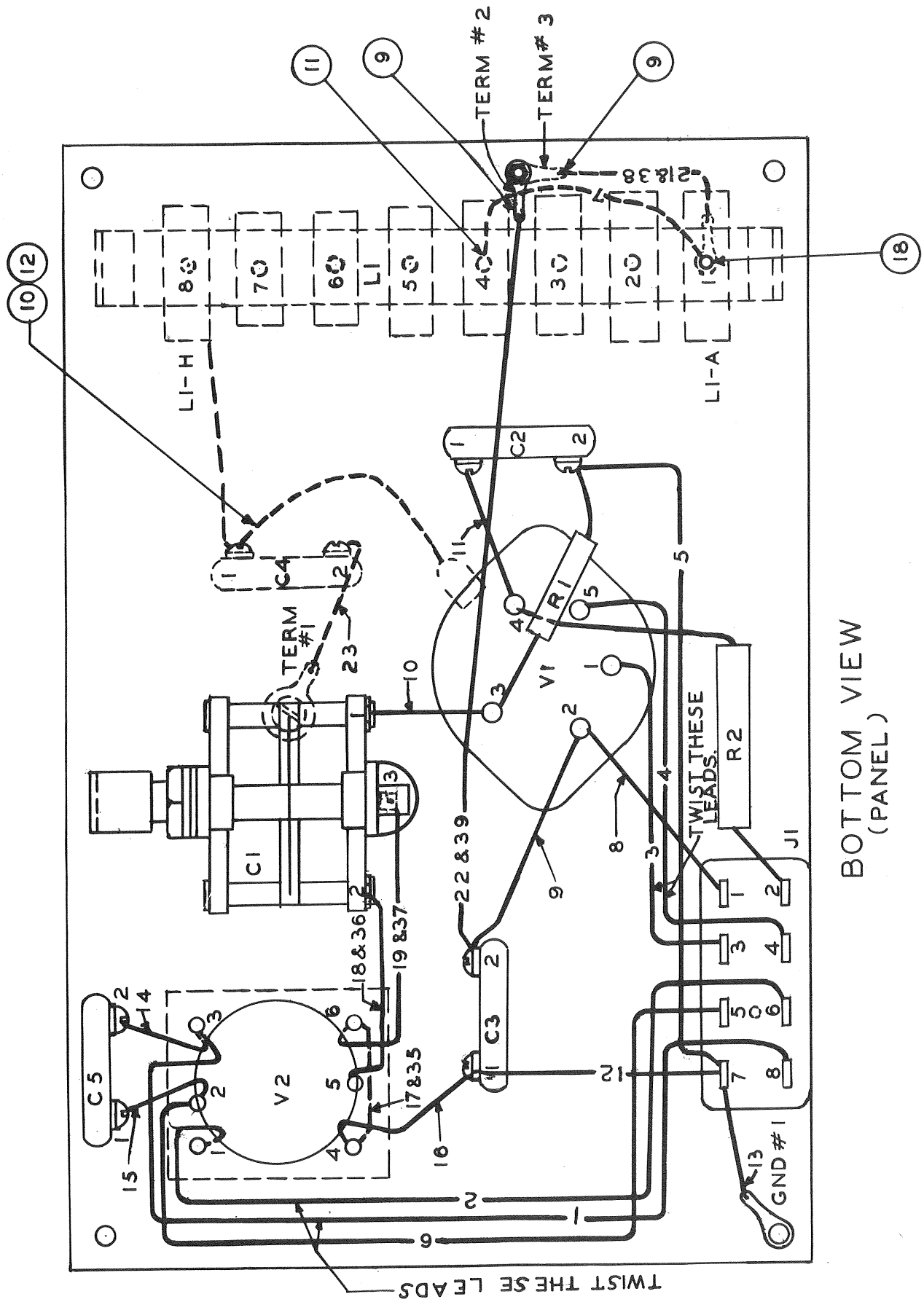
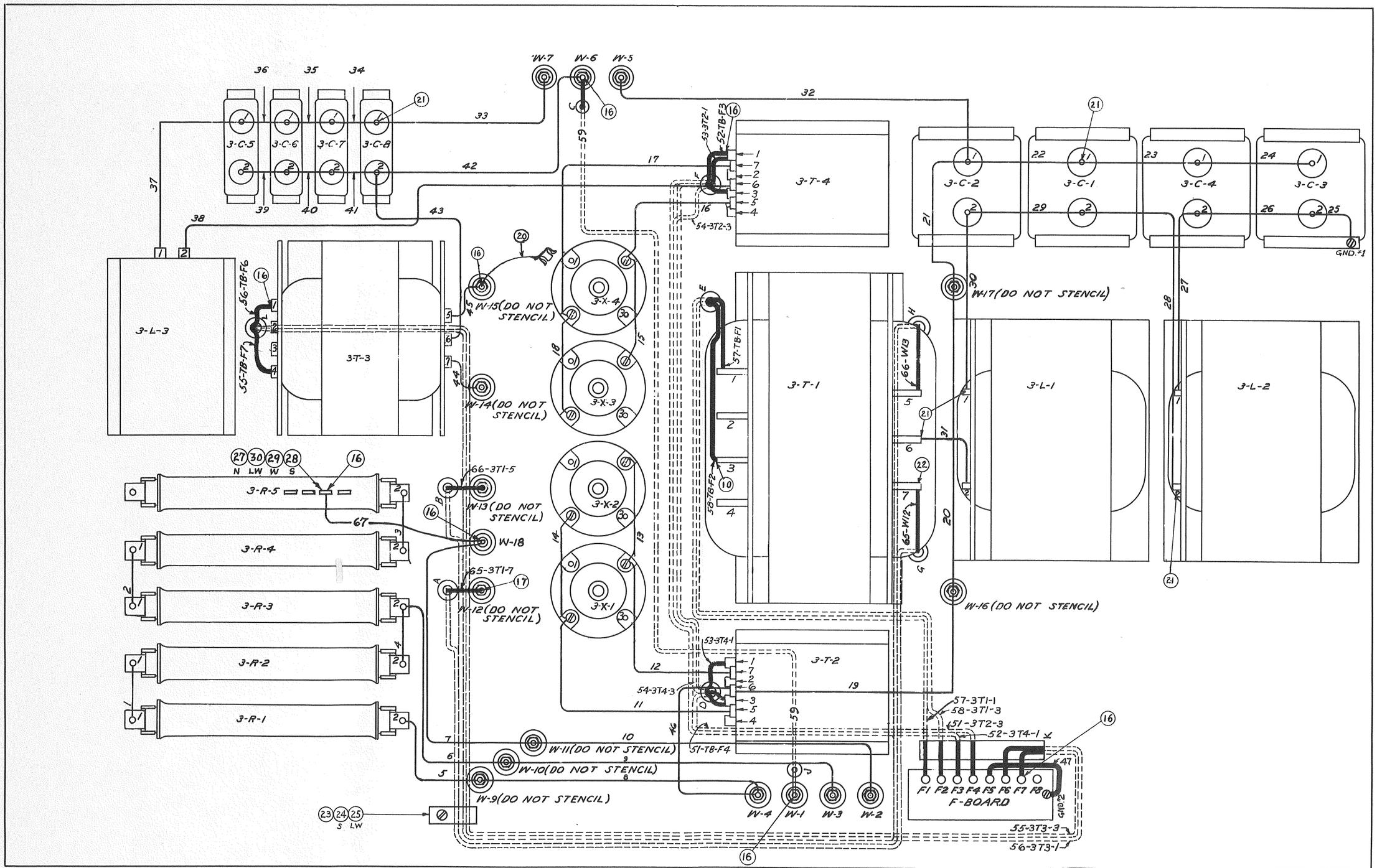
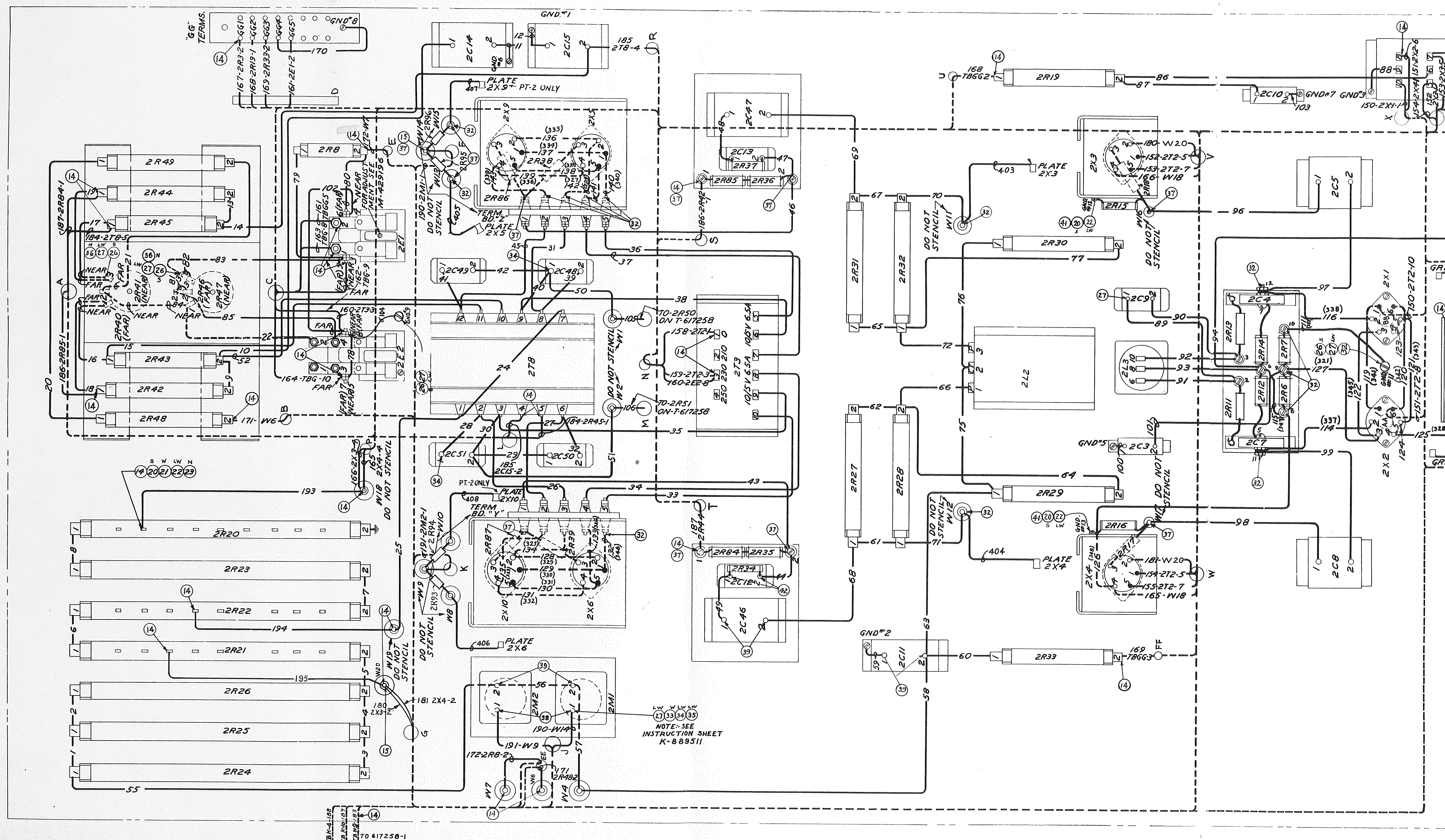


Figure 27—R-F Oscillator Connections (M-429907, Sub. 3)



T-617257

Figure 28—Bias and Auxiliary Rectifier Chassis Connections (T-617257, Sub. 8)



"GG" TERMS.
GND#8
GND#1
2C14
2C15
185 2T8-4
R
PLATE 2X9 PT-2 ONLY
2X9
2X5
2R38
2R86
TERM. BD. "Z"
PLATE 2X5
2R8
FOR ADJUSTMENT SEE M-429196
2E1
2E2
2R49
2R44
2R45
2R43
2R42
2R48
2R40 (FAR)
2R41 (NEAR)
2R46 (FAR)
2R47 (NEAR)
NEAR
FAR
187-2R84-1
186-2R85-1
164-TBG-10
171-W6
2C49
2C48
2T8
TO 2R50 ON T-617258
TO 2R51 ON T-617258
DO NOT STENCIL W1
DO NOT STENCIL W2
2T3
10/5V 6.5A
2C51
2C50
185 2C15-2
184-2R45-1
PT-2 ONLY
PLATE 2X10
TERM. BD. "Y"
2R87
2R39
2X10
2X6
2R93
DO NOT STENCIL
PLATE 2X6
2R20
2R23
2R22
2R21
2R26
2R25
2R24
W18 DO NOT STENCIL
W19 DO NOT STENCIL
181 2X4-2
180 2X3-2
2M2
2M1
190-W14
191-W9
172-2R8-2
171 2R48-2
W7
W4
NOTE:- SEE INSTRUCTION SHEET K-889511
TO 617258-1
2C47
2C13
2R37
2R85
2R36
186-2R42
2R84
2R35
2R34
2C12
2C46
187 2R42
2R31
2R32
2R27
2R28
DO NOT STENCIL W11
DO NOT STENCIL W12
PLATE 2X3
PLATE 2X4
2R30
2R29
2L2
2C9
2L3
GND#5
2C3
GND#2
2C11
2R33
169 TBGG3
FF
168 TBGG2
2R19
2C10
GND#7
GND#3
150-2X1-1
2X3
180-W20
152-2T2-5
153-2T2-7
166-W18
2R15
DO NOT STENCIL
2X4
2R16
2R17
181-W20
154-2T2-5
155-2T2-7
165-W18
2C5
2C8
2C4
2C7
2R13
2R14
2R7
2R11
2R12
2R6
2X1
2X2
150-2T2-10
151-2T2-8

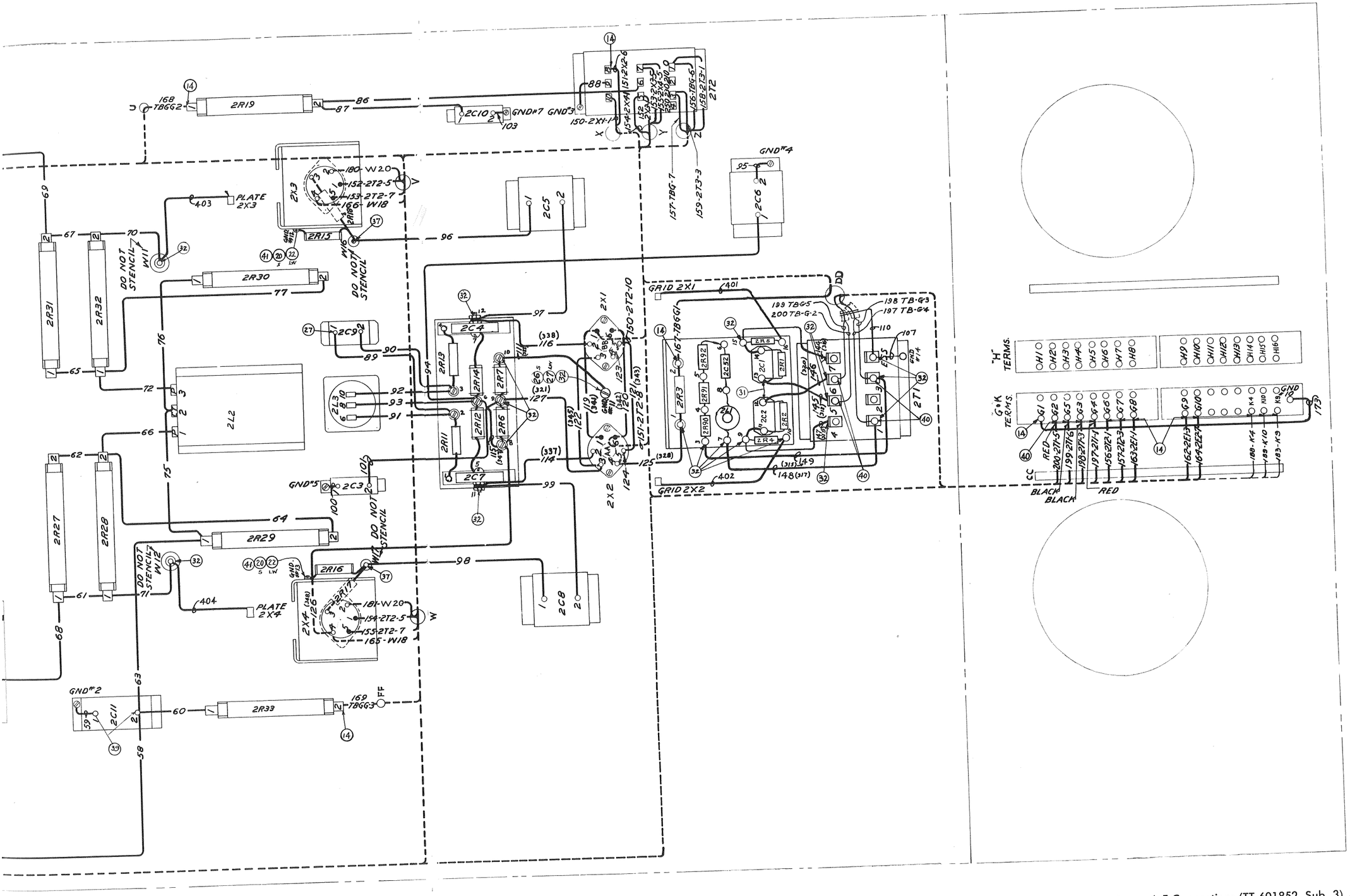


Figure 29—Low-Power A-F Connections (TT-601852, Sub. 3)

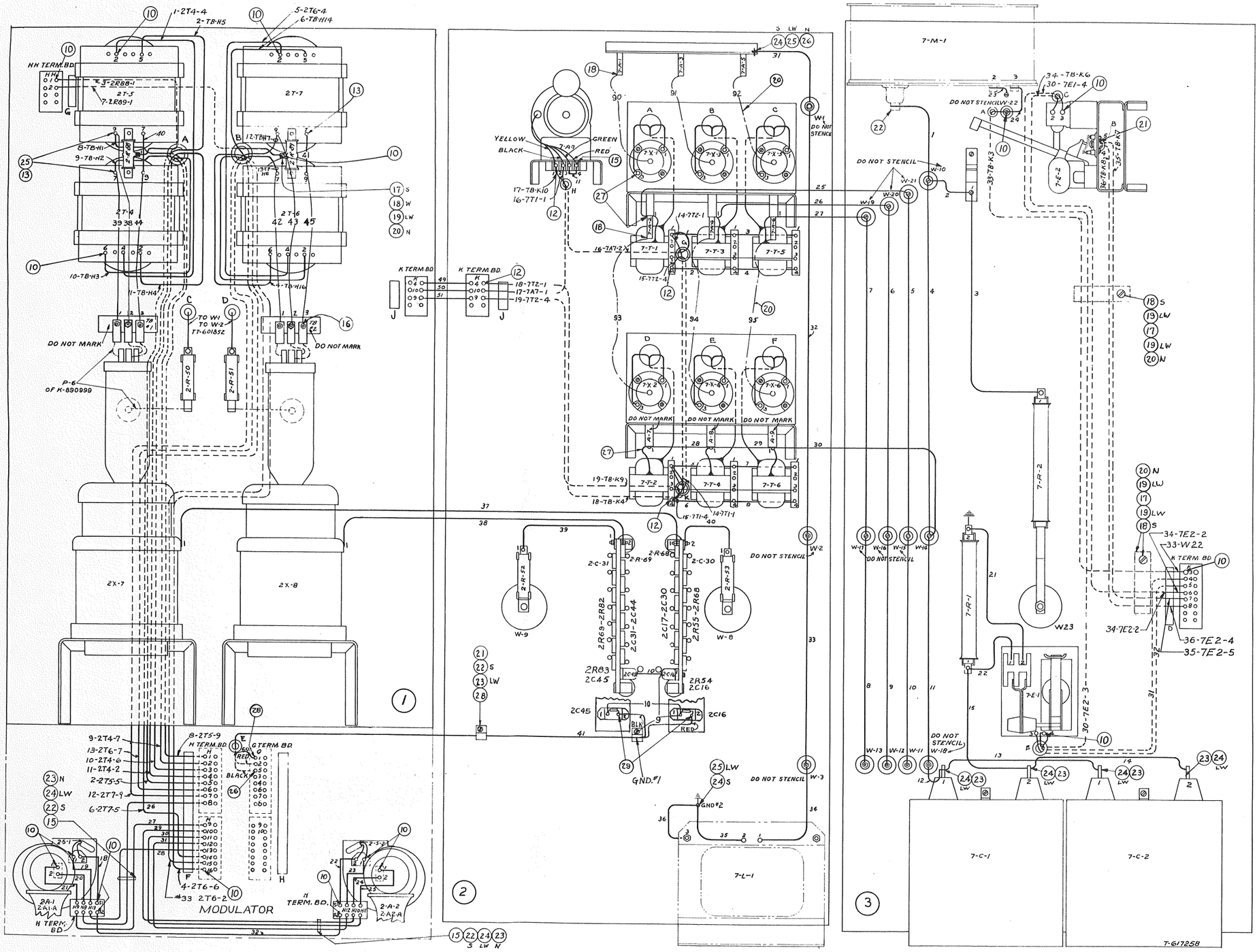
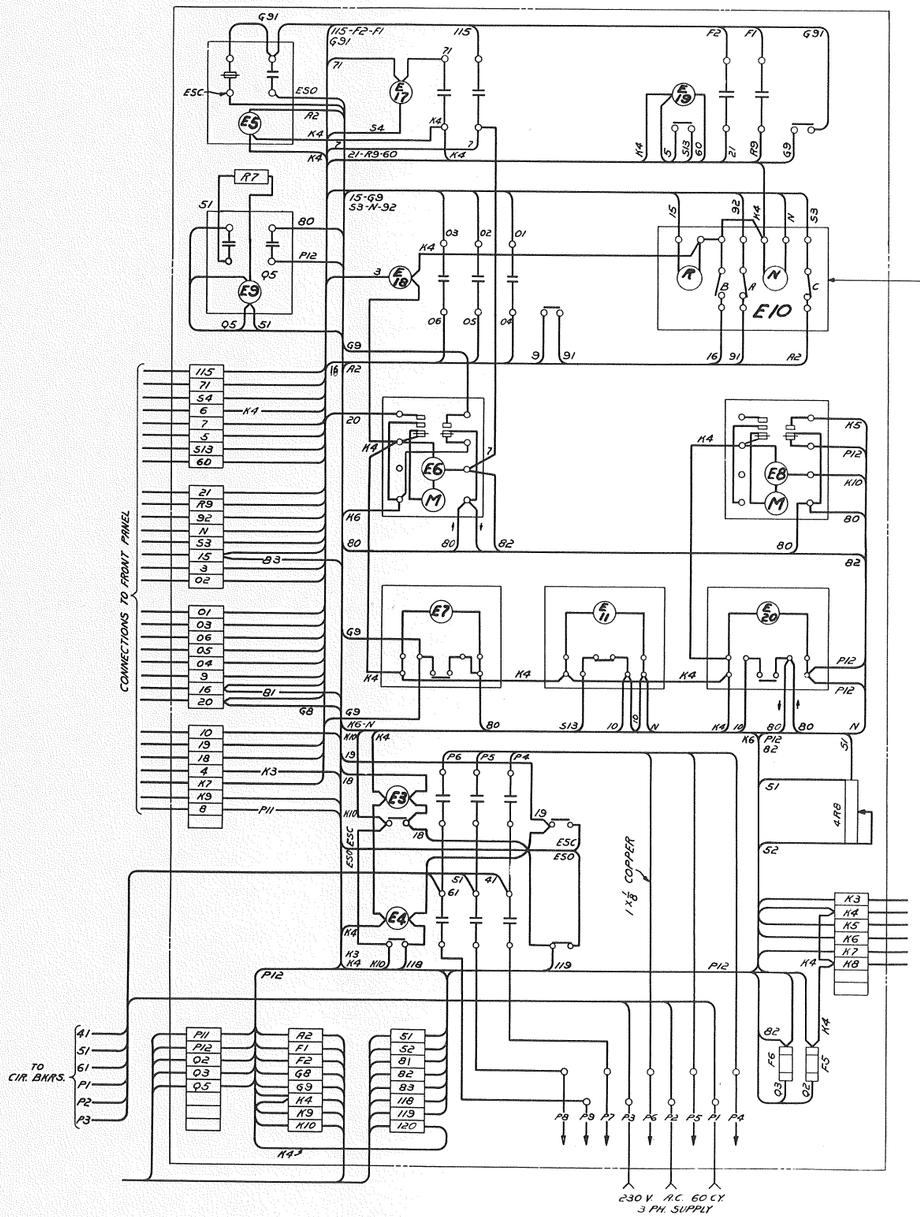
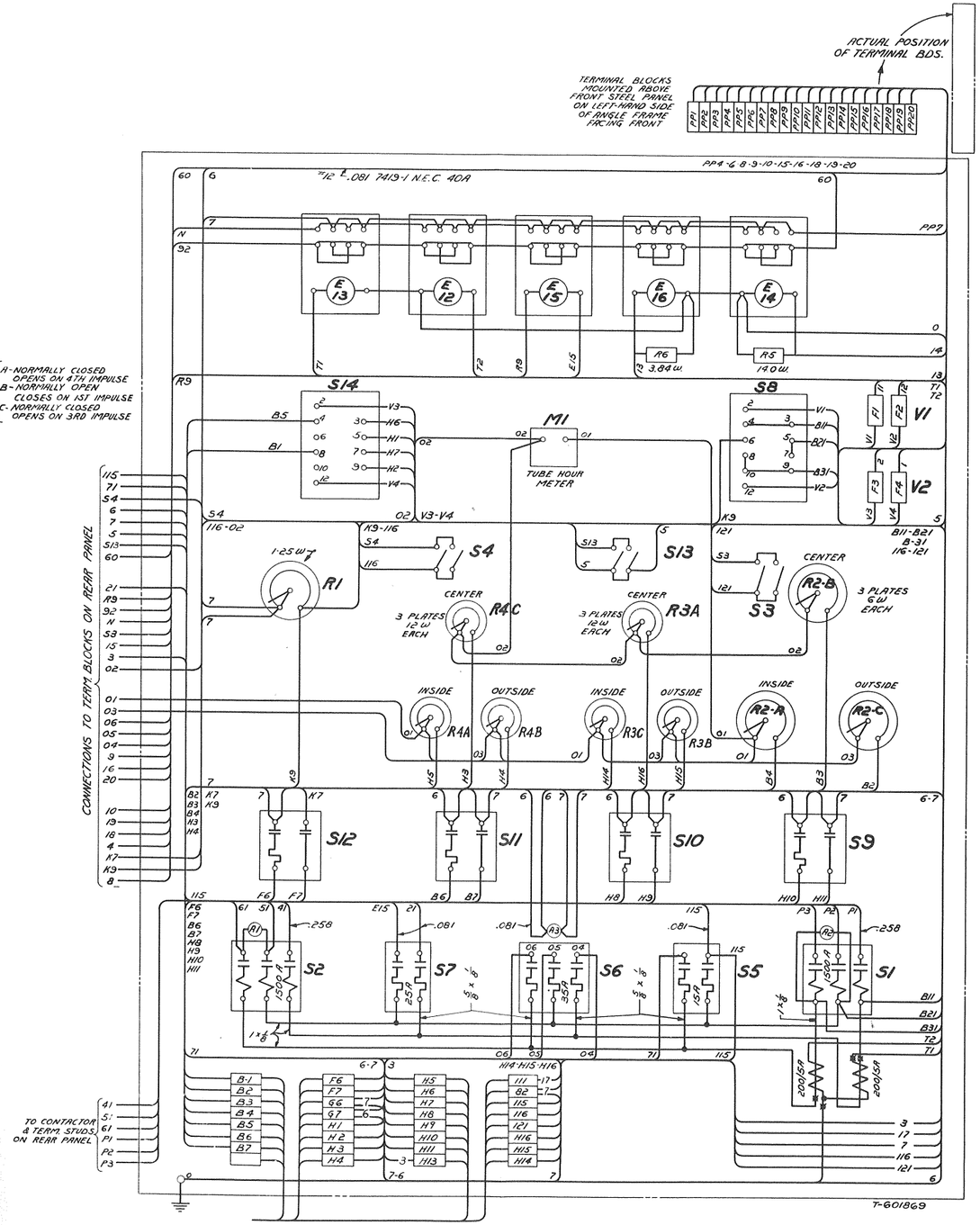


Figure 30—Modulator, Main Rectifier and Rectifier Auxiliary Chassis Connections (T-617258, Sub. 8)



CONTACTOR PANEL CONNECTIONS

A-NORMALLY CLOSED OPENS ON 4TH IMPULSE
B-NORMALLY OPEN CLOSES ON 1ST IMPULSE
C-NORMALLY CLOSED OPENS ON 3RD IMPULSE



POWER CONTROL PANEL CONNECTIONS

Figure 31—Power Control and Contactor Panel Connections (T-601869, Sub. 3)

5M-16 5M-14 5M-13 5M-12 5M11 5M10 5M9 5M5 5M4 5M3 5M2 5M1

5R1 64 20 41 LW 42 S 41 LW

30-TBPP-11 31-TBFP-12 28-TBF P-1 29-TBF P-2 25-TBHH-2 26-5M12-2 24-TBHH-1 26-5M13-2 27-TBFP13

OPP1 28-5M14-1
OPP2 25-5M14-2
OPP3 121-TBJ-2
OPP4 120-TBJ-1
OPP5 106-5S11-7
OPP6 122-TBJ-3
OPP7 126-TBJ-6
OPP8 103-5S2-1
OPP9 102-5S5-2
OPP10 105-5S11-5
OPP11 107-5S10-1
OPP12 30-5R1-2
OPP13 31-5M16-2
OPP14 27-5M12-2
OPP15 127-TBJ-7
OPP16 108-5S12-1
OPP17 126-TBJ-8
OPP18 40-5S9-1
OPP19 88-5A7-1
OPP20 87-5A8-1
124-TBJ-5

20-TBGG-3 22-5M10-2 19-TBGG-2 22-5MII-2 21-5M9-2 18-TBGG-1 21-5M10-2 23-TBGG-4 123-TBJ-4 9-TBJ-15

24-5M12-1 25-5M13-1 HH1 HH2 HH3

120-TB-PP4 121-TB-PP3 122-TB-PP6 123-5M5-1 124-TB-PP20 126-TB-PP7 127-TB-PP14 128-TB-PP16 129-5S9-2 130-5S3-1 131-5S2-3 132-5A2-2 133-5A2-1 134-5A1-1 9-5M5-2 18-5M9-1 19-5M10-1 20-5M11-1 23-5M9-2

J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 GG1 GG2 GG3 GG4 GG5

17-5M15-1 95-5A4-1 97-5A5-2 10-TB-DD-11 96-5A5-1 125-5S1-3 14-5M7-2 94-5A6-1 39-5S8-1 101-TB-DD-6 104-TB-DD-5 86-TB-DD-3 85-TB-DD-4 84-TB-DD-1 150-5M4-2 93-5A3-1

8-TBDD-10 150-TBJ-15 35-5M3-1 5-5M4-2 4-5M2-2 7-TBDD-9 6-TBDD-7 4-5M3-1 2-5M1-2 1-TBDD-2 2-5M2-2 3-TBDD-8

84-TBJ-14 1-5M1-1 86-TBJ-12 85-TBJ-13 104-TBJ-11 101-TBJ-10 6-5M2-1 3-5M1-2 7-5M3-2 8-5M4-1 10-TBJ-4 89-5S4-2 90-5S5-2

DD1 DD2 DD3 DD4 DD5 DD6 DD7 DD8 DD9 DD10 DD11 DD12 DD13

16-5M15-2 GND #1

40-TBPP-17 129-TBJ-9 39-TBJ-9 38-5S1-2

CLAMPS LOCATED ON BRACKET

SEE NOTE #4

CLAMPS LOCATED ON BRACKET

SEE NOTE #4

FAR NEAR 553 552 5A2 5A1 5A8 5A7 5511 5510 5512

102-TBPP-8 130-TBJ-10 131-TBJ-11 103-TBPP-7 109-5S12-2 133-TBJ-13 132-TBJ-12 134-TBJ-14 87-TBPP-19 100-TBPP-6 88-TBFP-18 106-TBPP-5 105-TBPP-9 109-5S2-2 106-TBPP-15 107-TBPP-10

NEAR NEAR 555 554 5A6 5A3 5A4 5A5 557 556

90-TBDD-13 62-5S7-4 88-TBDD-12 94-TBJ-8 93-TBGG-5 95-TBJ-2 97-TBJ-3 96-TBJ-5 62-5S4-3 92-TBAA-4 99-5S1-1 91-TBAA-3

REAR VIEW

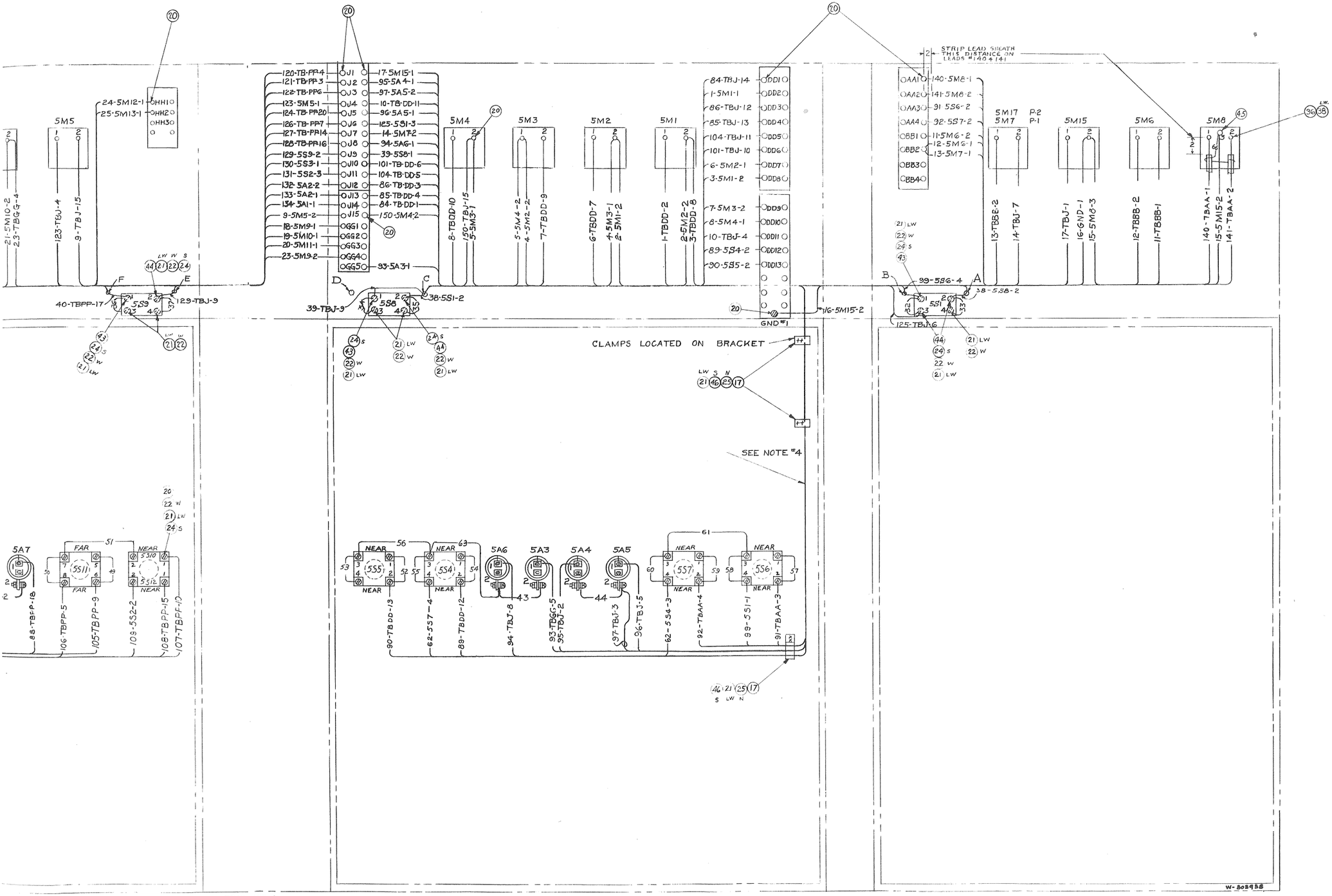


Figure 32—Enclosure Connections (W-303938, Sub. 2)

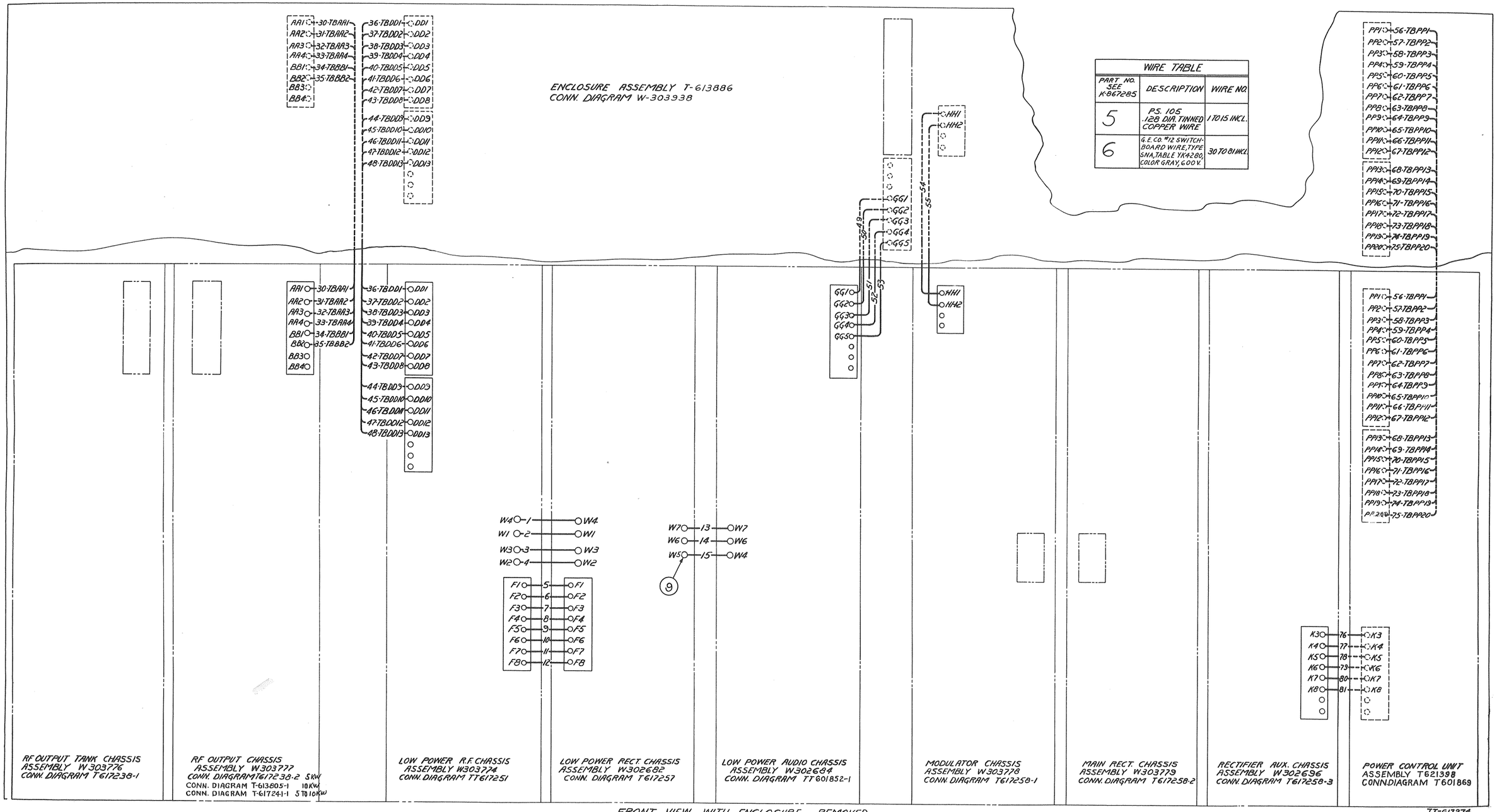


Figure 33—Interconnections (TT-617274, Sub. 5)

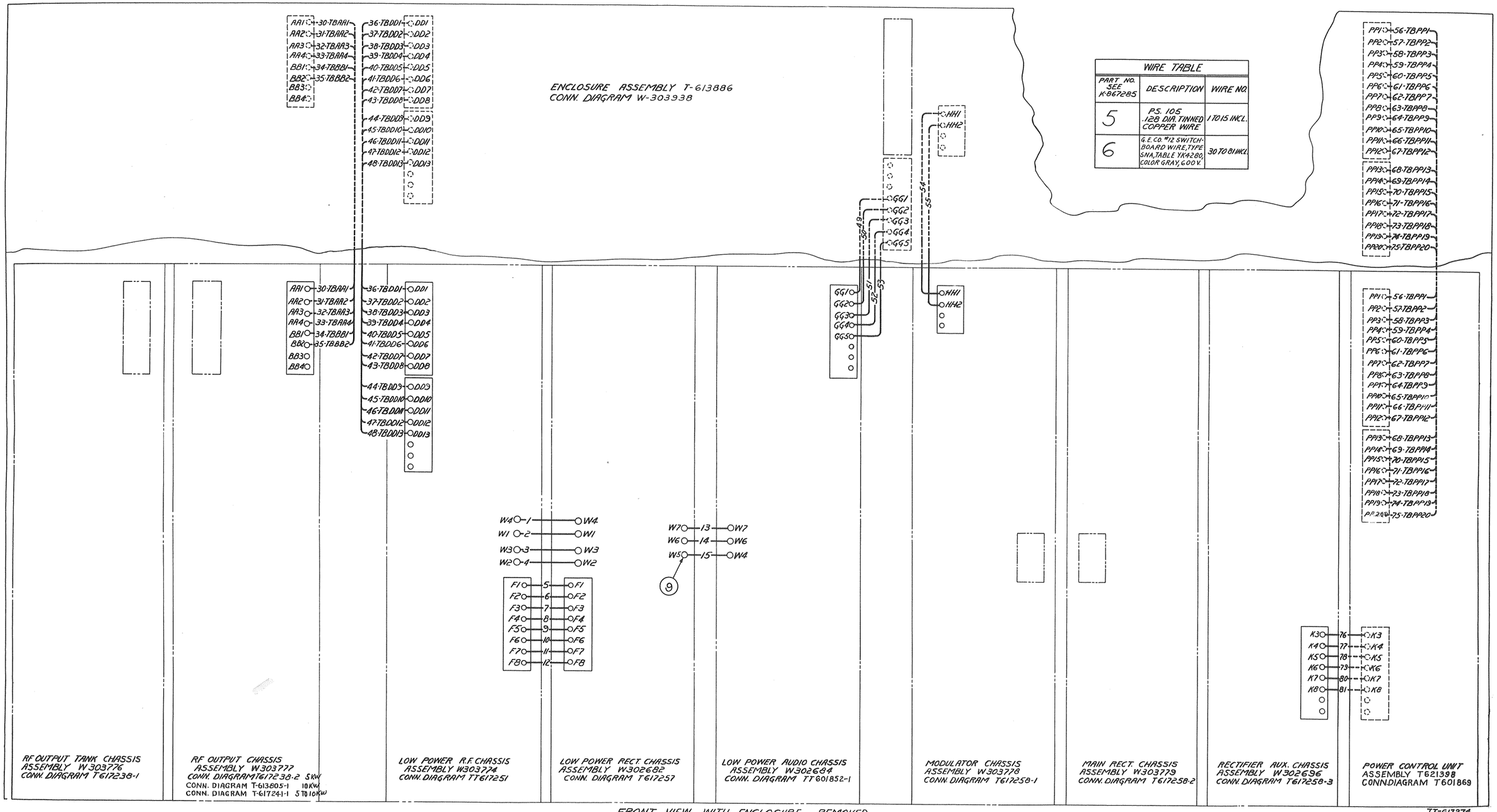
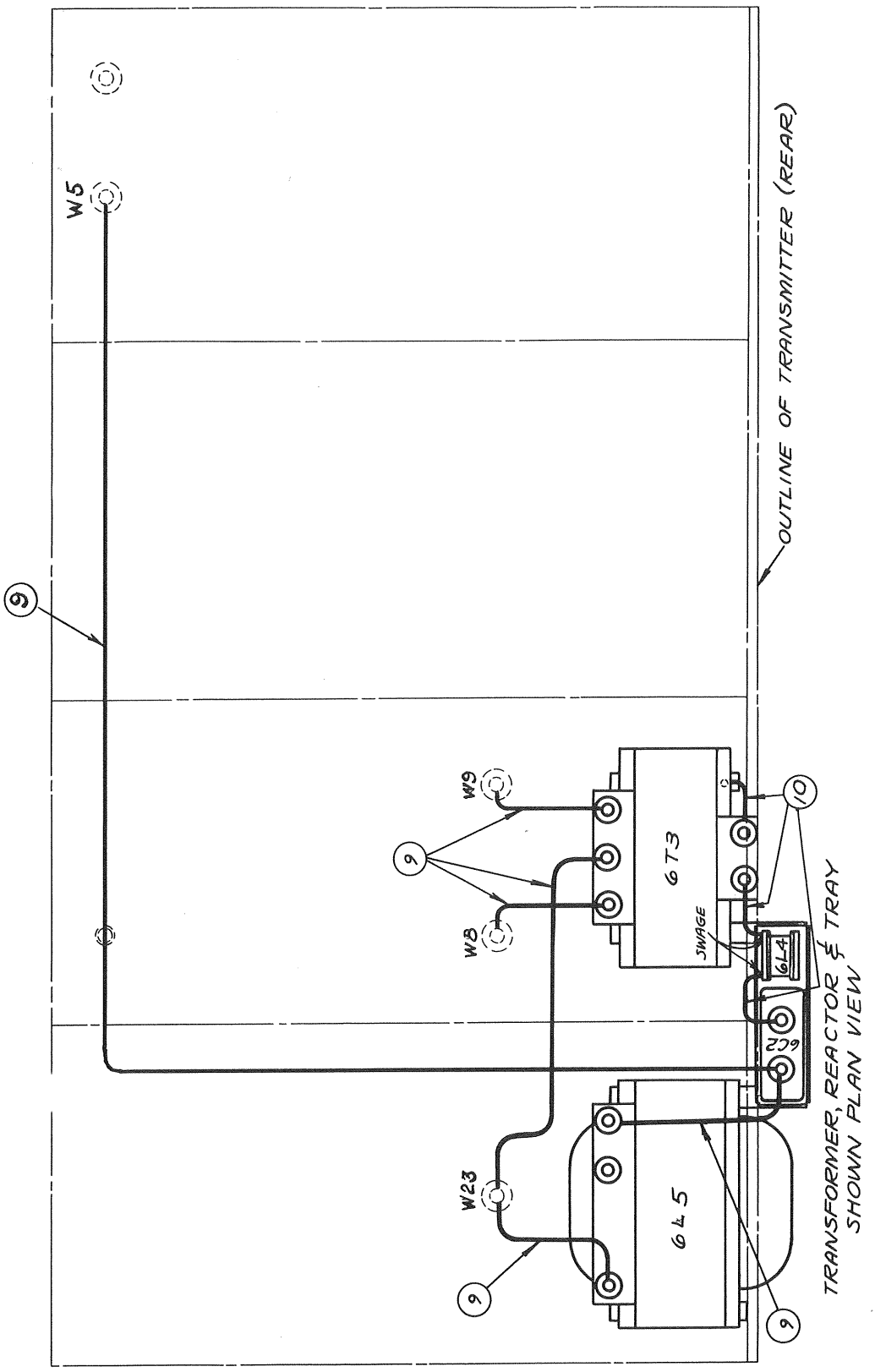


Figure 33—Interconnections (TT-617274, Sub. 5)



(9) ½" O.D. X 0.035 WALL COPPER TUBE
(10) ¼" O.D. X 0.035 WALL COPPER TUBE

Figure 34—Modulator Output Unit Connections (M-422899, Sub. 3)

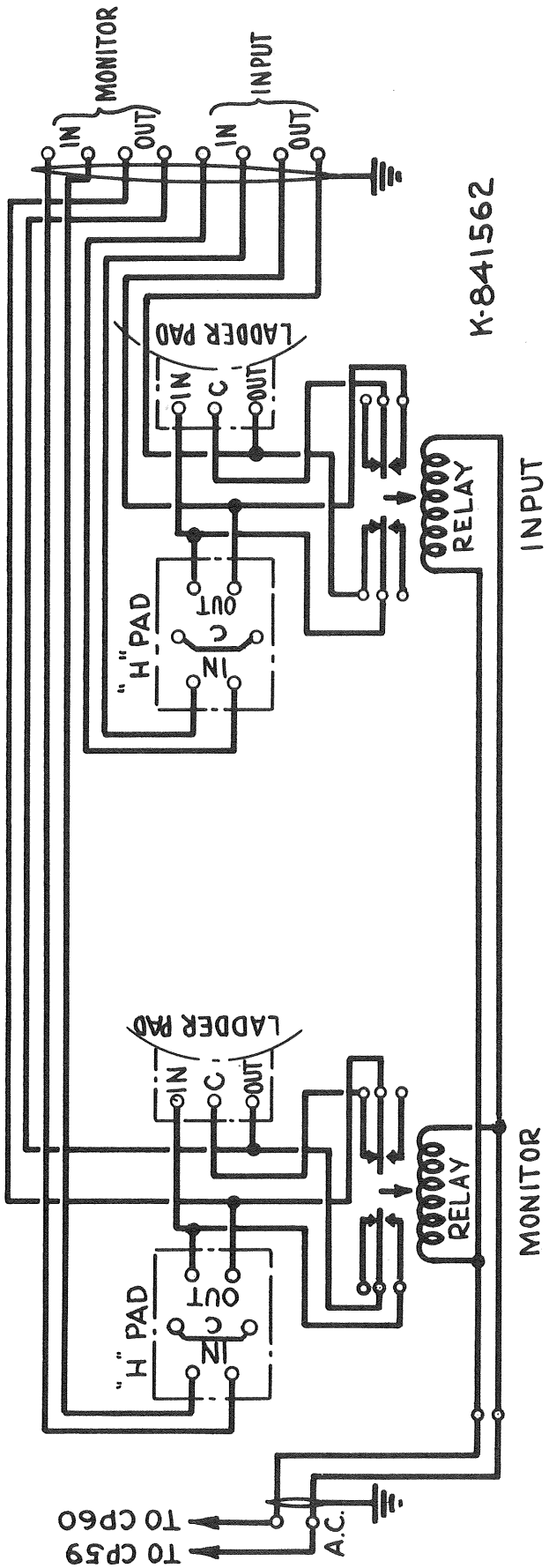


Figure 35—Audio Relay Panel Schematic (K-841562)

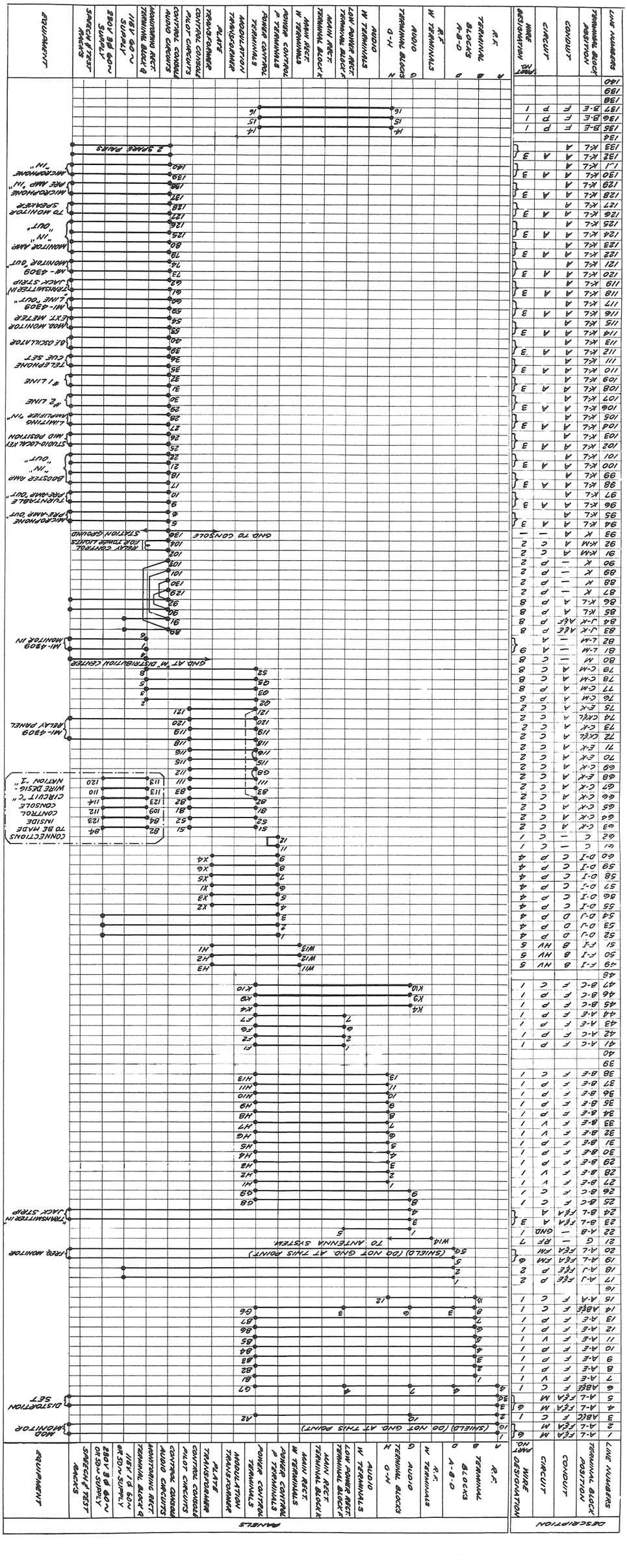


Figure 36—Wire Chart (T-617280, Sub. 4)

85

TERMINAL BLOCK POSITION
A — PLENUM CHAMBER – LEFT GROUP
B — PLENUM CHAMBER – RIGHT GROUP
C — CONTACTOR PANEL- LOWER RIGHT CORNER
D — CONTACTOR PANEL- LOWER LEFT CORNER
E — POWER CONTROL PANEL- BOTTOM REAR
F — RECT. AUX CHASSIS – LOWER LEFT
G — TRANSMITTER-FRAME – EXTREME REAR
H — MODULATION TRANSFORMER
I — PLATE TRANSFORMER
J — POWER DISTRIBUTION CENTER
K — CONTROL DESK
L — EQUIPMENT RACKS
M — ANTENNA CONTROL DISTRIBUTION CENTER

WIRE DESIGNATION	
WT. No.	SIZE OF WIRE
1	#12- 600V GE. FLAMENOL YK 4280
2	#14-600V R.C.C. SINGLE CONDUCTOR
3	#10-200V R.C.C. TWISTED PAIR
4	#0-600V V.C.C.I. SINGLE CONDUCTOR
5	#6-10,000V V.C.C.I. SINGLE CONDUCTOR
6	#16 SHIELDED IGNITION CABLE "MR DUCT"
7	⅜" COPPER TUBING FINISH NICKEL
8	#10 600V. V.C.C.I. SINGLE CONDUCTOR
9	#16 600V V.C.C.I. TWISTED PAIR
*	SEE FULL DESCRIPTION BELOW

CIRCUIT LEGEND	
A	AUDIO
C	CONTROL
M	MODULATION MONITOR
FM	FREQUENCY MONITOR
P	POWER
HV	HIGH POTENTIAL
V	FILAMENT VOLTMETER
RF	RADIO FREQUENCY

CONDUIT	NUMBER OF CHANNELS	EQUIPMENT	SIZE & DESCRIPTION OF CONDUCTORS
A	—	—	FLOOR CHANNEL
B	2	3	PART 3 (#8 – 10,000V)
C	3	6	PART 4 (#0 – 600 V)
D	2	3	PART 4 (#0 – 600 V)
E	1	4	PART 2 (#14–600 V)
F	—	—	TRANSMITTER BASE CHANNEL

NOTE #1:

P-1- #12 AWG G.E. CO. STRANDED SWITCHBOARD WIRE, TYPE SNA, TABLE VK 4280 GRAY.

P-2- #14 AWG. WIRE, 600V SINGLE CONDUCTOR, 3/64 VARNISHED CAMBRIC CLOTH, OVERALL BRAID & HEAVY LEAD SHEATH.

P-3 –#19 AWG. WIRE, 200 V TWISTED PAIR, 32 RUBBER, 32 LEAD SHEATH (1 RED, 1BLACK).

P-4- #0 A.W.G. WIRES, 600V SINGLE CONDUCTOR, STRANDED, 3/64 VARNISHED CAMBRIC, COTTON BRAID & HEAVY LEAD SHEATHING, MAX O.D. .700".

P-5 – #6 A.W.G. WIRE, 10,000 V SINGLE CONDUCTOR, VARNISHED CAMBRIC, COTTON BRAID & HEAVY LEAD SHEATHING, MAX. O.D. .750".

P-6 - #16 A.W.G. WIRE SHIELDED IGNITION CABLE, BELDEN MFG. CO.'S "PRODUCT".

P-7 - ¼" COPPER TUBING, HARD DRAWN. FINISH-DULL NICKEL OR POLISH & CLEAR LACQUER.

P-8- #10 A.W.G. WIRE, 600 V SINGLE CONDUCTOR, 3/64 VARNISHED CAMBRIC, COTTON BRAID & HEAVY LEAD SHEATHING.

P-9 – #16 A.W.G. WIRE, 600 V TWISTED PAIR, 3/64 VARNISHED CAMBRIC, COTTON BRAID & HEAVY LEAD SHEATHING.

NOTE #2: 5KW

USE IN CONJUNCTION WITH DWG. # TT-617215 FOR CONDUITS
DWG # M-4291-73
FOR TERMINAL LOCATION.

10 KW

USE IN CONJUNCTION WITH DWG. # TT-601845 FOR CONDUITS
DWG # M-4291-73
FOR TERMINAL LOCATION.

T-617280

CONTROL CONSOLE AUDIO TERMINAL BLOCK USE P-3	
J1-33	63-65-71
2-34	64-66-72
3-23	67-77
4-24	68-78
7-15	69-31
8-16	70-32
9-13	75-29
10-14	76-30
11-19	
12-20	

ANTENNA
TUNING UNIT

Type BPA-10

INSTALLATION–OPERATION–MAINTENANCE

INSTRUCTIONS

Printed in U. S. A.

IB-30168—3-21-46

TABLE OF CONTENTS

ILLUSTRATIONS

Figure

TECHNICAL SUMMARY

ELECTRICAL CHARACTERISTICS:

Operating Limits:

- Carrier Frequency ..... 540 kc to 1700 kc
- Transmitting Power (maximum) ..... 10 kw

Antenna Resistance:

- Output 5 kw or less ..... 10 ohms to 1100 ohms
- Output 10 kw or less ..... 20 ohms to 1100 ohms

Line Impedance ..... 50 ohms to 350 ohms

Antenna Reactance ..... +j500 to −j500 ohms

Can be extended in a positive direction by the addition of a series capacitor; and in a negative direction if operating from a line of lower impedance than the antenna resistance.

Monitoring Rectifier:

- Output Impedance ..... to operate into 20,000-ohm bridging load
- Output Level (program level—including bridging loss):
  - At 5-10-kw output ..... — 9 vu
  - At 1-kw output ..... —15 vu

Rectified current ..... 75 ma d.c. maximum into a maximum of 1000 ohms

Frequency Characteristic ..... substantially flat to 10,000 cycles

Power Supply ..... 230 volts, 60 cycles

TUBE COMPLEMENT:

Rectifier ..... one RCA-5V4G

MECHANICAL SPECIFICATIONS:

Dimensions:

- Height ..... 44 inches
- Width ..... 34 inches
- Depth ..... 23 inches

Weight (net) ..... 330 pounds

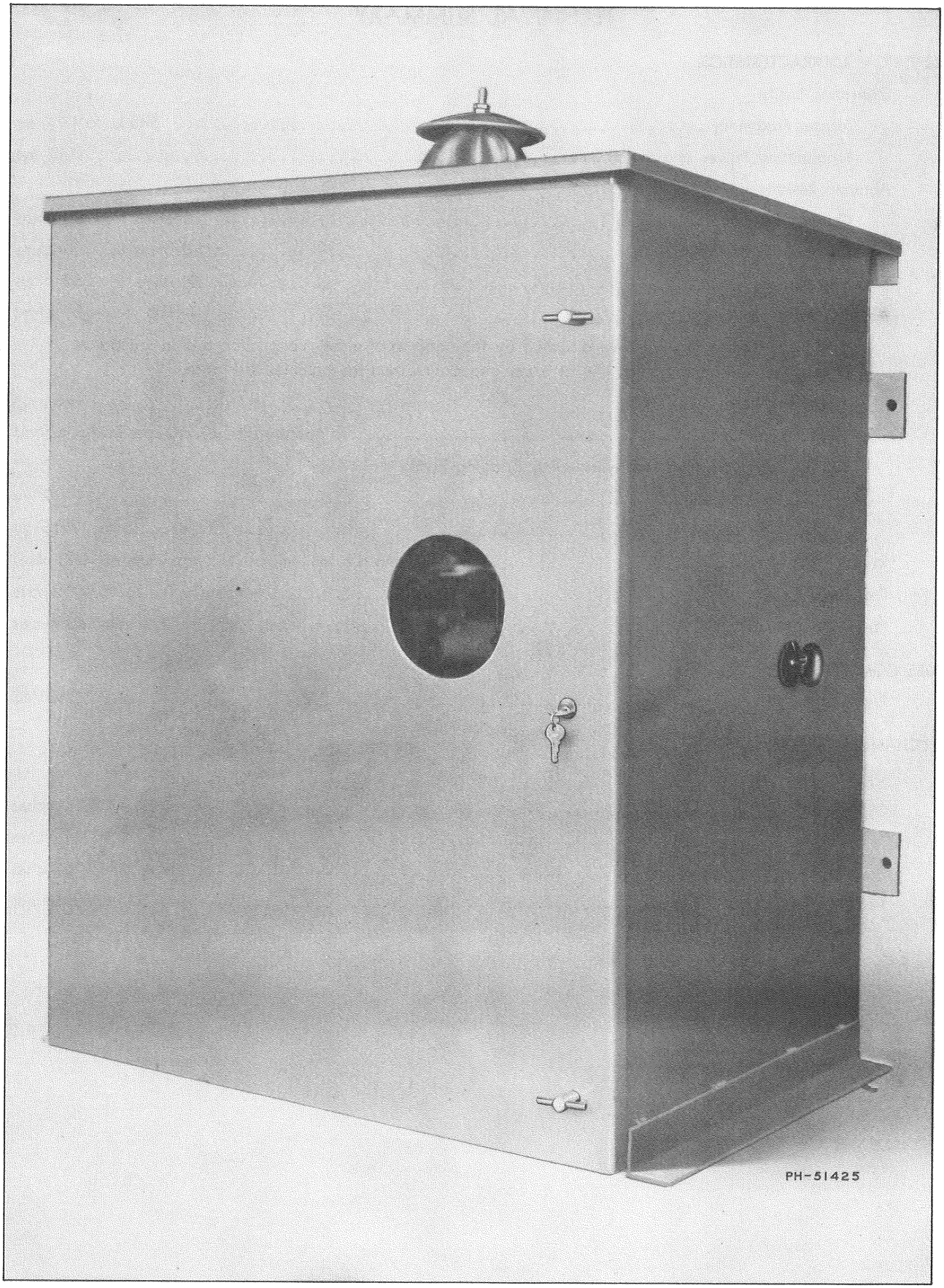


Figure 1—Type BPA-10 Antenna Tuning Unit (Exterior View)

Description

Purpose

The Type BPA-10 Antenna Tuning Equipment serves the double purpose of matching antennas of widely divergent characteristics to either concentric or open-wire transmission lines and of suppressing carrier harmonics on transmitters up to ten kilowatts (kw) output.

Construction

All parts of this equipment are enclosed in a weatherproof metal housing equipped at the front with a door affording ready access to the interior. This door is provided with a lock. The antenna ammeter may be read through a circular window in the door and is protected from lightning surges by a short-circuiting switch, which is operated by means of a knob extending through the side of the housing. A monitoring rectifier unit *(MI-7488-A) is contained within the housing to furnish, if desired, audio-frequency voltage for program monitoring and rectified carrier current for remote antenna current indication.

*MI-28902-B only. MI-28902-A does not contain monitoring rectifier.

Circuit

The circuit of this antenna tuning unit essentially consists of a single T-section low-pass filter which reduces the number of elements to a minimum. Referring to the schematic diagram, Figure 5, there will be observed two series inductors (L1, L2) which are employed to adjust independently the respective terminating impedances of the transmission line and the antenna circuit. The capacitive shunt leg, which is common to the two branches, is fixed at a value determined by the operating frequency of the station.

Signal energy for operation of the monitoring rectifier is obtained from a tuned pickup coil (L3) which is coupled to the antenna loading inductor (L2). This energy is rectified in a full-wave circuit using an 5V4G tube and the output is balanced to ground for excitation of a monitoring amplifier. Terminals also are provided for connection to a remote antenna ammeter and interlock relay located in the transmitter house. A 230-volt, 60-cycle power supply is required for energizing the rectifier filament transformer (T1).

Installation

Mounting

The unit is designed for mounting on a wooden platform or a steel angle cradle by means of the side flanges at the bottom of the housing. Rear mounting strips also are provided to permit mounting the unit on two upright posts. Dimensions are given in the outline drawing, Figure 6.

Care should be taken at installation to select a position where the antenna lead will be as short as possible. It is also important to insure adequate grounding by connecting the housing to the ground system through a heavy conductor or a copper bus.

R-F Connections

The antenna lead-in post is located on the top of the unit, and provision is made for mounting a similar post (MI-19413-1 bowl insulator) on the left-hand side of the housing in case an open-wire line is used. Concentric line when employed should be brought in through a hole in the bottom of the cabinet and connection made to the upper terminal of coil L1. In cases where a remote antenna ammeter is not used, terminals No. 5 and No. 8 should be connected together by means of a jumper.

Remote Metering and Audio Monitoring

An a-c supply of 230 volts, 60 cycles will be required to operate the rectifying equipment for remote metering. The associated filament transformer is tapped for operation at 190, 210, 230 or 250 volts and should be adjusted to the tap nearest the existing line voltage. Terminals No. 2 and No. 3 are used for connection of the power supply.

Static Drain

No provision for static drain is made in this unit. If no conductive path to ground exists elsewhere, a static drain should be mounted across the antenna horn gap, or at some other suitable place.

Tower Lighting

No complication as to tower lighting is introduced as the shunt arm is open circuit to power frequencies.

Tuning

CAUTION — REMOVE THE TRANSMITTER PLATE VOLTAGE PRIOR TO EACH ADJUSTMENT OF THE ANTENNA AND TRANSMISSION-LINE CIRCUITS. FULL POWER SHOULD NOT BE APPLIED TO THE LINE BEFORE PROPER ADJUSTMENTS HAVE BEEN COMPLETED. DANGEROUS VOLTAGES MAY OCCUR THROUGH IMPROPER TERMINATION AND RESULT IN DAMAGE TO THE LINE AND EQUIPMENT.

General Conditions

Although the network used in this unit serves the two functions of impedance matching and antenna tuning concurrently, it is desirable to consider them separately.

For antenna tuning, the coil L2 can be used to series-resonate the reactive component of a capacitive antenna; or, if the antenna is inductive, the reactive com-

ponent can be thought of as being absorbed into the antenna tuning coil. In either case, only the resistive portion of the antenna impedance is left, and the impedance matching function can be regarded as taking place between purely resistive impedances, inasmuch as the characteristic impedance of most lines is resistive.

Under these conditions, the values of reactance employed are determined by the values of the impedances to be matched, with the phase shift through the network as a parameter. Since the circuit is a section of a low-pass filter, the phase shift may be anywhere between zero and −180 degrees, making possible a wide range of reactance values. However, it is not advisable to work too close to the −180 degree (or cut-off) point of the section, or with such low values of phase shift that the second harmonic will not be sufficiently attenuated, hence a value near −90 degrees will usually be found most suitable. These statements will become clearer upon examination of the equations relating to the reactances of the arms of the network and the antenna and line impedances. Referring to Figure 2, which shows a simplified circuit diagram, the reactances are:

$$X_1 = - \frac{\sqrt{R_1 R_2}\left[1 - \frac{\sqrt{R_1}}{\sqrt{R_2}} \cos\beta\right]}{\sin\beta}$$

$$X_2 = - \frac{\sqrt{R_1 R_2}\left[1 - \frac{\sqrt{R_2}}{\sqrt{R_1}} \cos\beta\right]}{\sin\beta}$$

$$X_3 = + \frac{\sqrt{R_1 R_2}}{\sin\beta} \qquad (1)$$

where: R_1 = Line impedance
R_2 = Antenna resistance
β = Phase shift through network

It will be appreciated that choice of β near zero or −180 degrees leads to large values of reactance in all arms since sin β approaches zero for these values. On the other hand, if we take $\beta = -90$ degrees, these equations simplify to:

$$X_1 = + \sqrt{R_1 R_2} \qquad (2)$$

$$X_2 = + \sqrt{R_1 R_2}$$

$$X_3 = - \sqrt{R_1 R_2}$$

If this leads to inconvenient sizes of X_1, X_2, or X_3, a new value of β can be chosen to yield better values for the desired reactance.

Tuning Procedure with R-F Bridge

The use of a radio-frequency bridge is recommended to insure accurate tuning adjustment and the application of this instrument will be assumed during the ensuing treatment of the tuning procedure. In cases where a bridge is not available, measurements can be made by a substitution method, also to be described.

To determine the values of inductance and capacitance to be used for proper line matching and antenna tuning, it is essential to know the impedance of the antenna at the operating frequency. For purposes of comparison, the resistances and reactances for various heights of typical insulated towers of the guyed-mast and self-supporting types are shown in Table I.

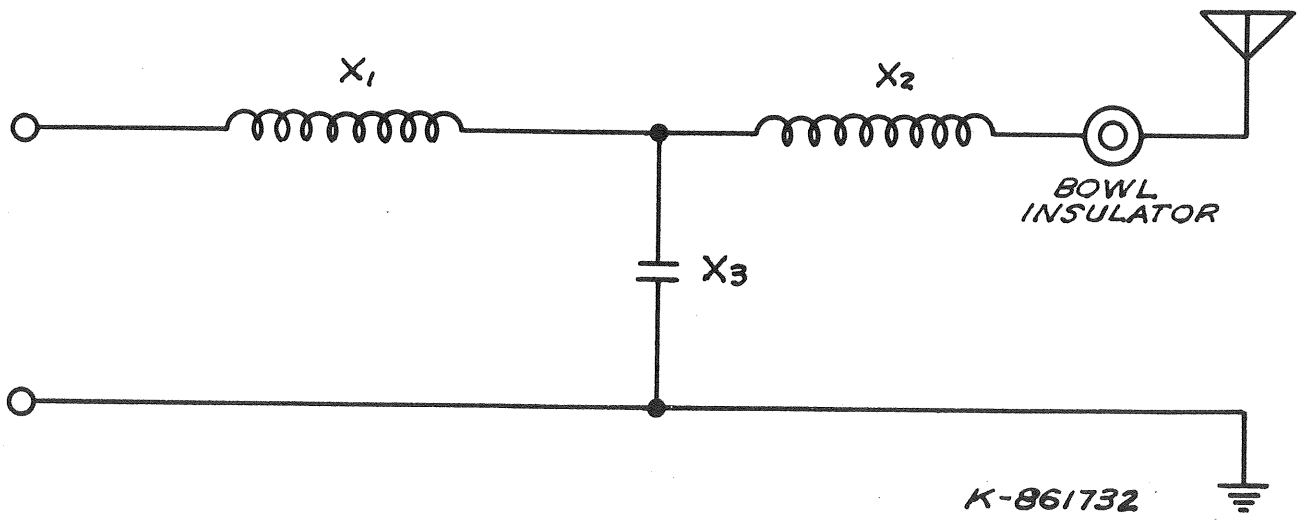


Figure 2—Simplified Circuit Diagram

TABLE I

Antenna Height * in Electrical Degrees	Self-Supporting Type		Guyed-Mast Type	
G	R	jX	R	jX
50	7	−j100	8	−j220
60	9	−j 70	13	−j170
70	14	−j 25	19	−j 75
80	20	+j 11	28	−j 28
90	40	+j 35	36	+j 0
100	60	+j 80	80	+j140
110	90	+j 90	140	+j320
120	175	+j 80	220	+j500
130	190	+j 15	370	+j600
140	165	−j 70	660	+j480
150	130	−j 85	1100	+j 0
160	82	−j 55	550	−j250
170	60	−j 25	280	−j450
180	40	−j 5	180	−j500
190	28	+j 25	120	−j430
200	23	+j 50	80	−j400

* Height in electrical degrees = Height in feet × frequency in kilocycles × 1.016 × 10^{-6} × 360.

Substitution of the resistance components of line and antenna impedances in the equations (1) gives the values of X_1, X_2 and X_3 necessary for the impedance matching function. Examination of the reactive components indicates the reactance necessary for tuning. For example, suppose we have a 60-ohm line and a 120-degree antenna with 175 ohms of resistance and +j80 ohms of reactance. Substitution of the values 60 and 175 ohms in equations (2) gives the value of 102.5 ohms for X_1, X_2 and X_3.

To tune out the antenna reactance in this case, it is only necessary to assume that this reactance is a part of the required value of X_2. Subtracting the 80 ohms of antenna reactance from 102.5 ohms leaves 22.5 ohms to be obtained in the coil L2. When the other arms of the network have been adjusted to the proper value of the 102.5 ohms, there will exist a condition of impedance match between the line and the antenna resistance and the antenna reactance will have been removed as a cause of loss.

In making these adjustments, the line should be disconnected and the impedance bridge connected across the input terminals to determine when the desired value of 60 ohms has been obtained. When measurements show that the input impedance of the tuner with the antenna connected is 60 ohms resistive, the line may be reconnected for a final check before turning on full power.

Calculations of the current in the capacitive branch are made to insure that the rating of the capacitor is not exceeded. Proper capacitors are supplied on the basis of information received with the order.

To enable intelligent estimates to be made of the inductances obtained by tapping down on coils L1 and L2, it should be mentioned that their maximum inductance is 120 microhenries.

Tuning Procedure Without R-F Bridge

If no impedance bridge is available, a simple substitution method may be used to determine when a proper adjustment has been obtained. To do this, it is necessary to arrange to switch the line from the tuner to a resistance equal to the line impedance, noting the change in line current accompanying the switching. When no change occurs, the tuner is in proper adjustment. Because it is not desirable to apply full power to the test resistor, which will usually have a rating of a relatively few watts, connection should be made to a low power stage in the transmitter during this adjustment. To make the adjustment simple, a coupling circuit and a series tuning capacitor can be used, as shown in Figure 3.

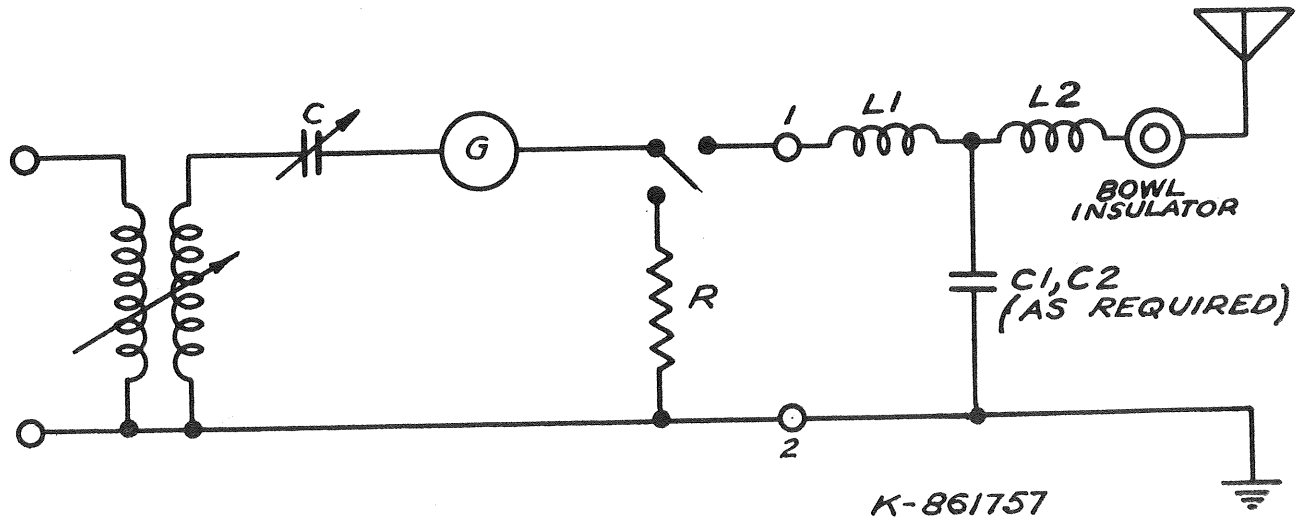


Figure 3—Coupling Circuit and Tuning Unit

With the switch in the resistor position, capacitor C can be tuned for a maximum current reading in meter G. Then, on switching to the tuner input, the direction in which capacitor C must be turned to increase the current again to a maximum indicates the sign of the reactance in the antenna circuit. If the capacitance must be increased, the load is capacitively reactive; if the capacitance must be decreased, the load is inductively reactive; if no change is necessary, the load is resistive. Similarly, if the current reading at resonance is greater than before, the load resistance is less than Z_0; if that reading is less than before, the load resistance is greater than Z_0; if there is no change, the load resistance is equal to Z_0.

CAUTION—Remove unused jumpers.

This method may be used to determine unknown resistances simply by using a calibrated test resistor; likewise, unknown reactance values may be determined by using a calibrated condenser at C.

Final Check

Upon completing the tuning procedure as outlined in the preceding paragraphs, the adjustments should be checked before full power is applied to the line and antenna. The recommended method of check is described in the following paragraph.

With the measuring equipment disconnected from the tuning unit, attach the transmission line and insert a low-range thermal milliammeter in the ungrounded side at each end of the line. Apply sufficient power to provide a readable deflection on each meter and note the current values. These values should agree within 15 per cent when the tuning adjustment has been correctly performed. Under such conditions, full power may be applied to the line after removing the millammeters.

Upon application of full power, the current through each of the tuning capacitors (C1, C2) should be measured under conditions of full modulation. The maximum permissible current values for these capacitors at three nominal frequencies are shown on the nameplates. At intervening frequencies, the maximum values will be approximately proportional to those listed. If such currents are found to be excessive, the capacitors should be rearranged in the circuit.

Remote Metering Equipment

The antenna tuning unit embodies the necessary equipment to enable the installation of a remote meter for measuring antenna current and also furnishes audio-frequency energy for operation of a monitoring amplifier. The method of remote antenna-current indication as outlined herein has been approved by the Federal Communications Commission.

The remote meter should require 25 to 50 ma direct current for full-scale deflection and should have a scale corresponding to that of the antenna ammeter (M1). It should be equipped with a shunt adjusted so that the deflections of both meters are identical. In most cases, a 5-ohm variable shunt will be satisfactory for this purpose.

As shown by the schematic diagram (Figure 5), terminals No. 5 and No. 8 are used for connection to the remote meter and transmitter interlock relay. Sufficient output for proper deflection of the remote meter may be obtained by adjusting the coupling between the antenna loading inductor (L2) and the monitoring pick-up coil (L3) and by tuning the latter to the carrier frequency. A wide tuning range is afforded by the six taps on the pick-up coil and by the use of two capacitors (C4, C5) which may be employed singly, in series, or in parallel. Jumpers are provided to facilitate interconnection of these capacitors.

Maximum output will be secured as the pick-up coil is tuned to resonance. It is not advisable, however, to approach resonance too closely since the increasing selectivity of this circuit will seriously impair the audio-frequency response characteristic. At resonance, the response at 10,000 cycles will be down approximately 4 db. Under no conditions should the current through the series resistors (R1, R4) be allowed to exceed 75 ma d.c.

When an audio monitor is to be used, an output level of approximately +17 dbm is available from this source, the circuit of which is balanced to ground and may be used to feed a 500-ohm load. The load in this case must be capable of handling 25 ma of direct current. It is desirable, therefore, to feed a 20,000-ohm or greater bridging load. If the monitoring amplifier has only a 500-ohm input, a 20,000-ohm carbon resistor may be inserted in series with the 500-ohm transformer. Under this condition, the direct-current flow is negligible and the output level from the rectifier is reduced to −1 dbm at 5-kw operation and to −7 dbm at 1-kw operation.

Maintenance

The antenna ammeter shorting switch (S1) should be kept closed except when readings are being taken.

All connections, especially the coil connector clips, should be inspected regularly to insure tightness and thus avoid undue heating at such points. Screens and ventilation openings should be unobstructed to permit free circulation of air.

PARTS LIST

Symbol No.	Description	Stock No.	Dwg. No.	Symbol No.	Description	Stock No.	Dwg. No.
A1	Rectifier, monitor		K-891875	M1	Meter (frequency determined)	See MI-19465	
C1	Capacitor (frequency determined)	See MI-7444-C		R1	Resistor, 6.4 K, 90 W	17899	K-890162-2
C2	Capacitor (frequency determined)	See MI-7444-C		R2	Resistor, 10 K, 90 W	17900	K-890162-3
C4	Capacitor, 300 mmf	69860	P-32221-532	R3, R5	Resistor, 250 ohms, 10 W	17901	K-891887-2
C5	Capacitor, 200 mmf	69864	P-32220-683	R4	Resistor, 125 ohms, 10 W	17902	K-891887-1
C6	Capacitor, 1000 mmf	42335	P-722009-547	S1	Switch, 250 V., 30 amp.	90038	K-890957-1
L1, L2	Coil		T-611579-501	T1	Transformer	17897	K-900433-501
L3	Coil	17898	M-415903	X1	Socket, vacuum tube, octal	18007	K-844041-501

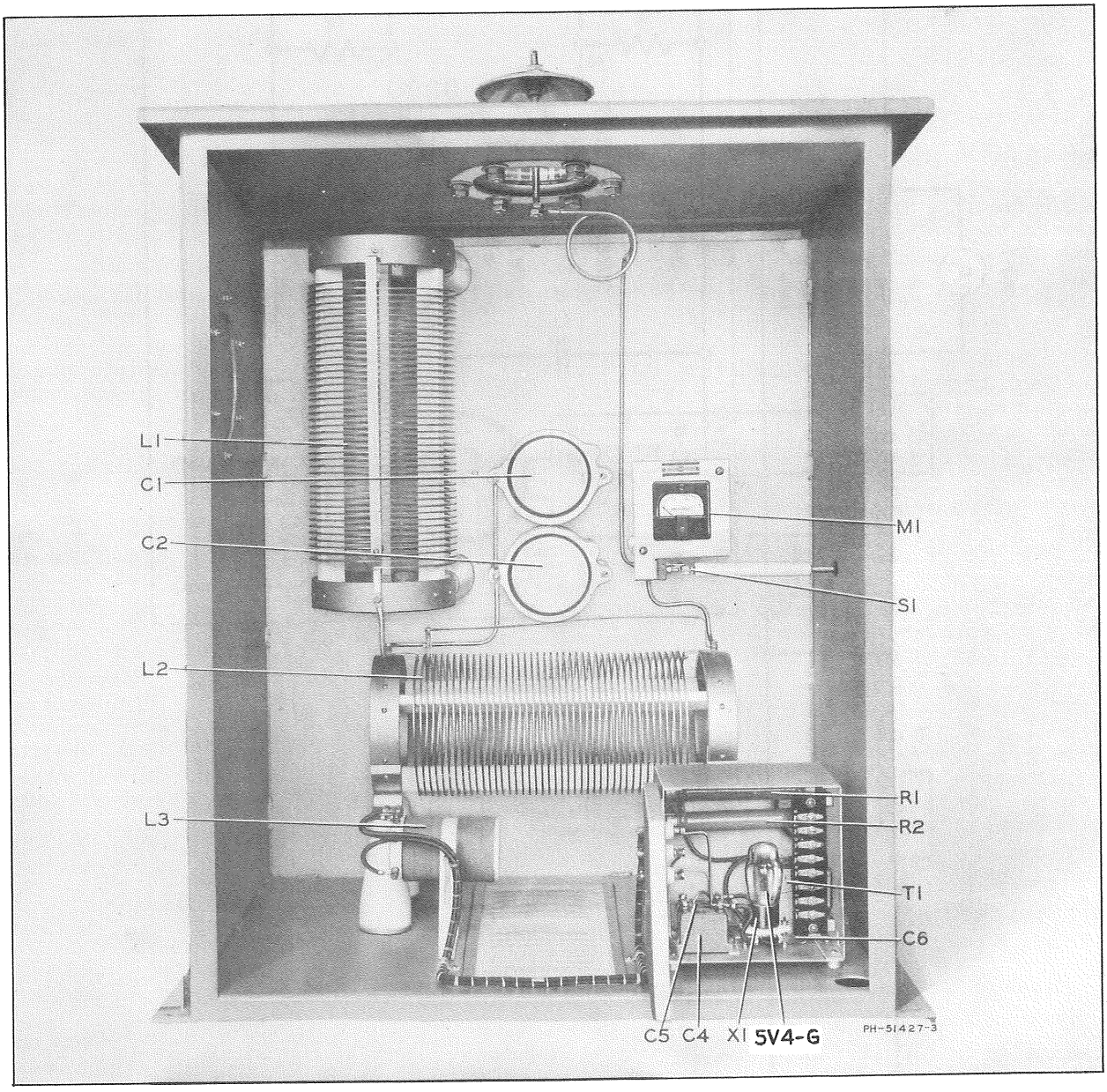


Figure 4—Antenna Tuning Unit (Interior View)

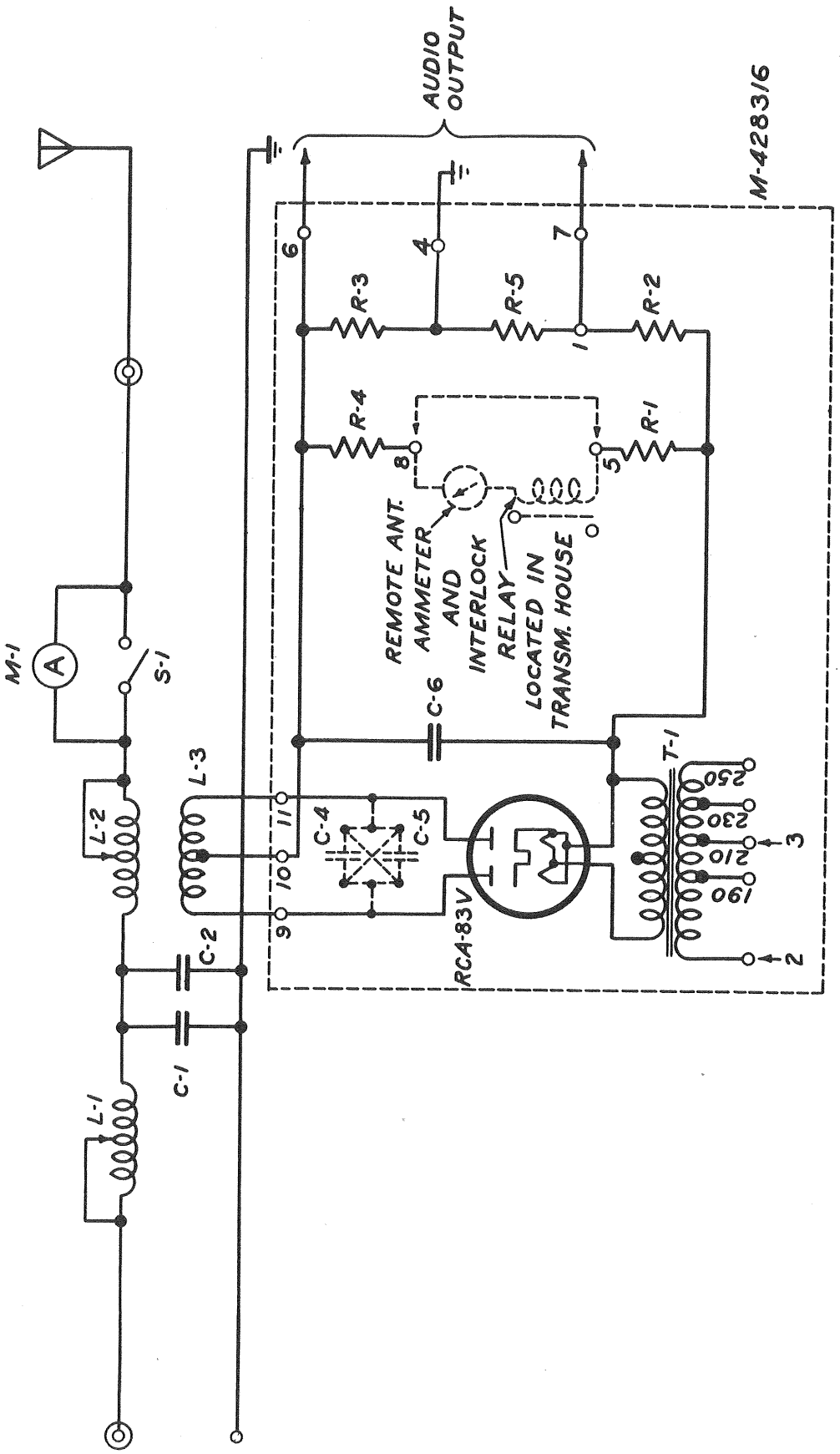


Figure 5—Antenna Tuning Unit Schematic Diagram

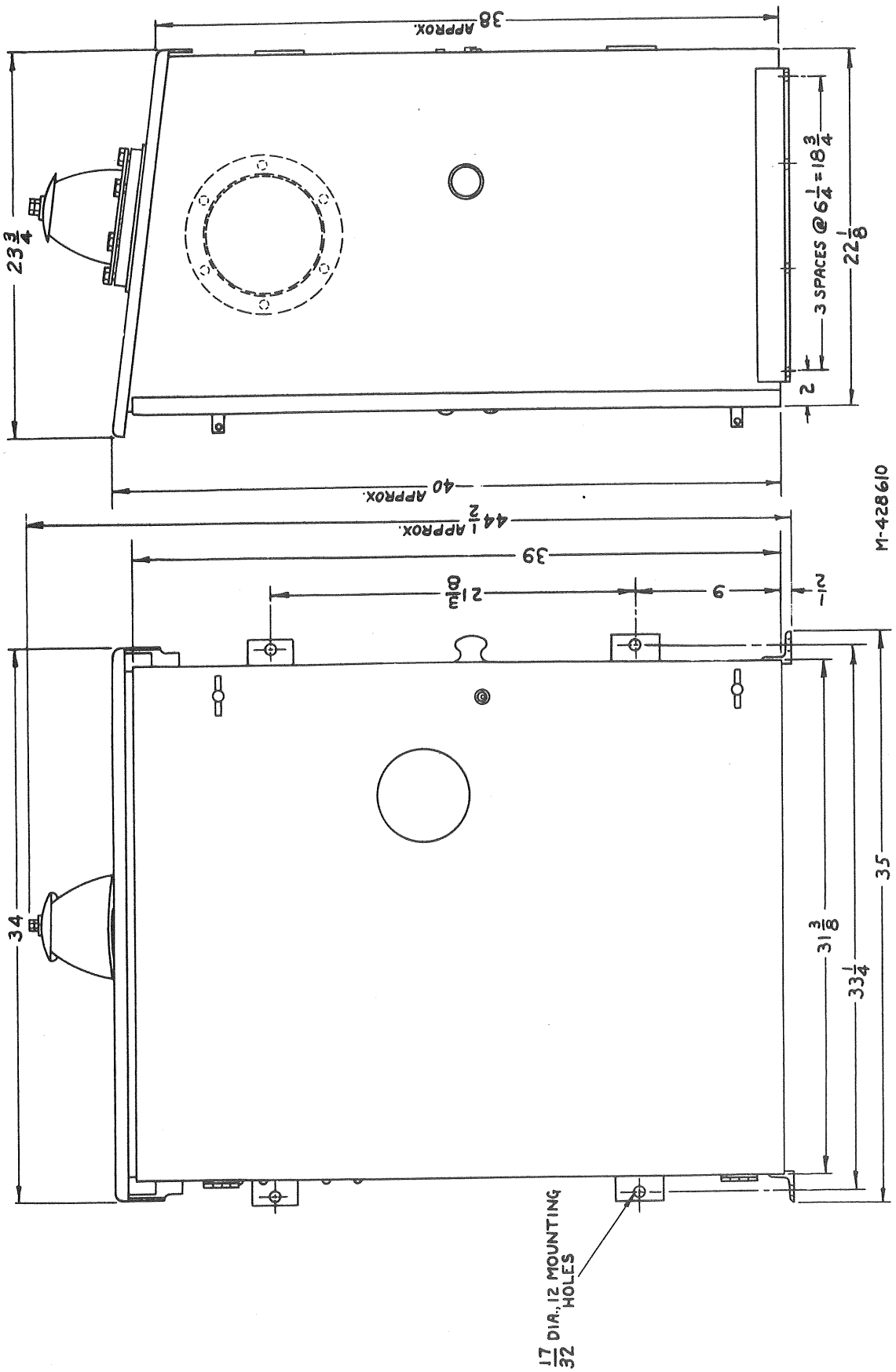


Figure 6—Antenna Tuning Unit Outline

TRANSMITTER CONTROL DESK

MI-11616

INSTRUCTIONS

Printed in U. S. A.

IB-30157

Figure 1—Transmitter Control Desk (Front View)

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ILLUSTRATIONS

TECHNICAL SUMMARY

Electrical Characteristics

Power Required (lamps and relays) ..... 105-125 volts, 50-60 cycles, 25 watts

Input Impedances:

- Lines 1 and 2 ..... 600 ohms, balanced
- Telephone Set ..... 600 ohms
- Studio, Master and Monitor Controls ..... 600 ohms, balanced
- Microphone and Turntable ..... 250 ohms, balanced
- VU Meter ..... 7500 ohms
- Monitor—Transmitter, in and out ..... 10,000 ohms to 20,000 ohms
- Monitor—Lines 1 and 2 ..... 20,000 ohms
- Monitor Speaker Relay ..... 15 ohms

Output Impedances:

- Lines 1 and 2 ..... 600 ohms
- Microphone and Turntable Mixer Circuit ..... 600 ohms, balanced
- Studio, Master and Monitor Controls ..... 600 ohms, balanced
- Microphone and Turntable Controls ..... 250 ohms to 500 ohms

Frequency Response ..... ±0.1 db, 30 to 15,000 cycles

Insertion losses (microphone and turntable mixer circuit) ..... 7 db

Volume Controls:

Studio Control: 600 ohms; 20 steps, 2 db per step, last step infinite, linear; insertion loss 6 db; balanced.

Master Control: 600 ohms to 600 ohms; 20 steps, ½ db per step, last step infinite, linear; insertion loss 6 db; balanced.

Monitor Control: 600 ohms to 600 ohms; 2 db per step, last step infinite, tapered; insertion loss 6 db; balanced.

Microphone and Turntable Controls: 250-500 ohms; 2 db per step, last step infinite, tapered; insertion loss 2 db; balanced.

Volume Indicator Control: 3900-7500 ohms; 2 db per step, linear; insertion loss 0 db.

VU Rheostat: 800 ohms; 10 steps, 0.1 db per step, linear.

Monitor Bridging Controls: 10,000 ohms dual carbon potentiometers, balanced.

Noise Level: Circuits are isolated so that residual noise will not exceed the aggregate noise level of the associated amplifiers.

Relay Power Supply:

- Power Supply ..... 105-125 volts, 50-60 cycles
- A-C Line Fuse ..... 0.5 ampere
- Power Output (d-c) ..... 12 volts at 1 ampere
- Ripple Voltage ..... 0.75 volt maximum

Mechanical Specifications

Dimensions:

Width	60 inches
Depth	34½ inches
Height (Turret extends approximately 11 inches above desk top)	30½ inches
Weight	393 pounds

EQUIPMENT

The equipment supplied with this Transmitter Control Desk is as follows:

Quantity	Item	
1	Transmitter Control Desk	MI-11616

The following equipment is recommended and may be obtained on separate order:

1 Transmitter Monitor and Amplifier Rack (for 60 c.p.s., MI-11620-E, for 50 c.p.s., MI-11620-G). including:

- 1 Type 9AX Cabinet Rack
- 1 Type 66-D Modulation Monitor (including tubes)
- 1 Type 86-A1 Limiting Amplifier (including tubes), MI-11216-C
- 1 Type BA-4A, MI-11223, or Type BA-4B, MI-11223A, Monitoring Amplifier
- 2 Type 33-A Jack Strips with Mat, MI-11501-A
- 4 Type 36-B Panel and Shelf Assemblies
- 3 Type BA-1A Pre-Amplifiers, MI-11218-A
- 1 Type BX-1A, MI-11305, or Type BX-1B, MI-11305-A Power Supply
- 2 Type 56-C Line Equalizers
- 3 Line Coils, MI-4900-A
- 1 Type 57-C Switch and Fuse Panel
- 2 "J" Strips, MI-4537-D
- 1 Sola Regulator
  (60 c.p.s. unit supplied with MI-11620-E), MI-11280
  (50 c.p.s. unit supplied with MI-11620-G), MI-11280-G.

NOTE: If two-power operation is required, one Audio Relay Panel, MI-4309-B must be obtained.

DESCRIPTION

GENERAL

The Transmitter Control Desk, MI-11616 has been designed for use with a broadcast transmitter to provide a complete and flexible system of control in one console. It contains all of the mixing and switching facilities required at the transmitter station, and is equipped with a standard VU meter, an extension modulation monitor meter, and an extension antenna current meter.

It consists of a turret-type assembly mounted on top of a metal desk. All controls, switches, and meters are mounted on three panels which are hinged at the bottom so that they may be opened forward for convenient servicing. These panels are mounted in the turret top. The entire rear cover of the turret may be removed to facilitate installation or basic changes.

The desk and turret are of metal construction. The left-hand pedestal contains a typewriter shelf, and the right-hand pedestal contains two convenient drawers. A third drawer is located between the two pedestals. Metal skirts have been provided below the pedestals to conceal the wiring conduits. All wiring is carried inside the desk.

All a-c power switches and associated indicator lamps are mounted on the left-hand panel. The three meters and six attenuator controls are mounted on the middle panel. The monitor and VU meter, push-button switches, together with the audio lever switches, and the associated indicator lamps are mounted on the right-hand panel. Chromium plated guards prevent accidental operation of the most important lever switches ("LINES-IN," "TRANSMITTER ON," and "STUDIO-LOCAL").

Power is supplied to the monitor loudspeaker relay and audio indicator lamps from a 12 volt d-c power supply which is contained in the control desk. It is designed to operate from a power supply of 105-125 volts at from 50 to 60 cycles.

CIRCUIT FUNCTIONS

The electrical circuits of the Control Desk are detailed in Figure 6. For purposes of description Figure 6 may be considered as six separate groups of interrelated circuits: (a) metering circuits, (b) monitoring circuits, (c) "LINES-IN" circuits, (d) local transcription—turntable circuit, (e) local microphone circuit, and (f) power switching circuits. A description of the function of each of these circuits and of the component parts as well as the inter-relationships of the different circuits to each other follows:

METERING CIRCUITS

The Control Desk is equipped with a standardized VU meter, 9M2. Mechanically interlocked push-button switches 9S4 permit instantaneous selection of the circuit into which it is desired to insert the VU meter. Jacks "A" and "B" may be connected to any desired circuit by means of switches. The "TRANS.-IN" push button is connected so as to read the level of the audio current being fed to the modulator unit of the transmitter.

A step-by-step control marked "VI" (9A6) is connected in the volume indicator circuit making it possible to read levels of +4 db to +40 db at a reference level of 1 milliwatt. A step marked 1 mw is included for reference purposes.

A vernier control, 9R35, is mounted beneath the VU meter. This control may be adjusted so as to vary the meter indication ±0.5 db so as to compensate for small differences in pointer indications when this meter is used in conjunction with one or more VU meters in any one network.

The antenna current indicator 9M3 is connected directly to terminals 51 and 52 of the terminal board behind the Attenuator and Meter Panel. These terminals should be connected to the rectified carrier circuit of the transmitter. The meter consists of a 0-50 ma, d-c movement with a scale of 50 divisions calibrated linearly from 0 to 10 amperes (r-f). It is calibrated especially for use on a steel panel one-eighth inch thick.

The modulation meter 9M1 is connected directly to terminals 53 and 54 of the terminal board behind the Attenuator and Meter Panel. This meter is intended to operate as an extension meter from the station modulation monitor.

Two spare meter positions are wired to terminals 49 and 50, and 55 and 56. An extension db gain reduction meter and an extension frequency monitor may be used in these positions if desired.

MONITORING CIRCUITS

The Control Desk contains equipment designed to bridge and monitor the following circuits: line 1 or line 2; transcription turntable; transmitter input; and transmitter output. Any one of these circuits may be selected instantly by means of the mechanically interlocking switches of the push-button switch assembly 9S15.

Incoming line 1 (L1) is connected through terminals 69 and 70 and the "LINE 1" push-button switch to the monitoring circuit. Line 2 (L2) is connected through terminals 75 and 76 and the "LINE 2" push-button switch to the monitoring circuit. Connections between the four line terminals (69 and 70, and 75 and 76) are made to the program lines at the jack strip of the station patching panel.

When either one of the two line push buttons are depressed the signal from the selected line will be connected through a bridging transformer (9T2) and the "TT-CUE" switch to the "MONITOR" volume control (9A7) and thence to terminals 79 and 80. The latter terminals should be connected through the jack strip of the station patching panel to the monitor amplifier input. The monitor amplifier output should be connected through the station patching panel to terminals 125 and 126. From these terminals the signal

is fed through the speaker relay (9E1) to terminals 127 and 128 which should be connected to the monitor speaker voice coil.

The "TT-CUE" push-button switch is connected through a bridging potentiometer, 9R32, to terminals 13 and 14. These terminals may be connected across the turntable line terminals 9 and 10. When the "TT-CUE" push button is depressed the signal from the turntable line is connected through the bridging potentiometer to the "TT-CUE" push-button switch and from here to the monitor speaker as described in the preceding paragraph.

The transmitter input is connected to the monitoring circuit by connecting terminals 63 and 64 to terminals 71 and 72. The "TRANS.-IN" push-button switch is connected through a bridging potentiometer, 9R33, to terminals 71 and 72. When this push button is depressed the transmitter input will be connected to the monitor speaker in the manner previously described.

The transmitter output is connected to the monitoring circuit by connecting the output of the antenna monitor rectifier to terminals 73 and 74. The "TRANS.-OUT" push-button switch is connected through a bridging potentiometer, 9R34. When the push button is depressed the transmitter output will be connected to the monitor speaker as described previously.

The bridging potentiometers may be adjusted so that the transmitter input may be compared to the transmitter output at the same audio level. A 600-ohm loading resistor should be connected across the "TRANS.-OUT" line if it has been designed to work into a 600-ohm load. The bridging potentiometers have input impedances of 10,000 ohms each.

The "OFF" push-button switch simply disconnects the monitor circuit from all lines.

INCOMING LINES CIRCUITS

Under normal conditions line 1 (L1) will be connected through the jack strip of the station patching panel to a repeating coil and from there to terminals 31 and 32 of the Control Desk. Likewise line 2 (L2) would be connected at the Control Desk to terminals 29 and 30. If line equalizers are used they should be connected across the jack strip ahead of the repeater coils. The patching panel, repeater coils, and line equalizers are all part of the accessory equipment recommended in the Equipment Table.

The incoming lines are connected to the "LINES-IN" switch 9S13 in such a way that when it is in the middle position both lines are disconnected and the red pilot lamp indicates "OFF." When the switch is in the "1" position, line 1 is connected through the "STUDIO" mixer control 9A5, while line 2 is connected to a telephone jack. From the "STUDIO" mixer control, line 1 passes through the "STUDIO-LOCAL" switch 9S9. If the latter is set in the "S" position, line 1 passes through the limiting amplifier (optional) to the "MASTER" volume control 9A2 and the "TRANS.-ON" switch 9S11 to the input of the transmitter. When the "LINES-IN" lever switch is set to position "2," the functioning of the lines is reversed.

With the "TRANS.-ON" lever switch in the "ON" position, a green pilot lamp (marked "ON") should light. When the switch is in the "OFF" position, a red pilot lamp should be illuminated.

LOCAL TRANSCRIPTION—TURNTABLE CIRCUITS

A transcription turntable (TT) may be connected through a pre-amplifier (accessory equipment) to the Control Desk at terminals 9 and 10. From this point the turntable line passes through the "TT" mixer control 9A3 to the "TT-OSC." lever switch 9S10. When this switch is in the "TT" position the line is connected through various items of accessory equipment consisting of an impedance matching transformer, a booster amplifier, and a matching pad to the "STUDIO-LOCAL" switch 9S9. When this switch is in the "LOCAL" position the turntable line is connected through the limiting amplifier (accessory equipment), master control and "TRANS.-ON" switch to the transmitter.

The transcription turntable should be connected to the type BA-1A pre-amplifier as indicated in Figure 2.

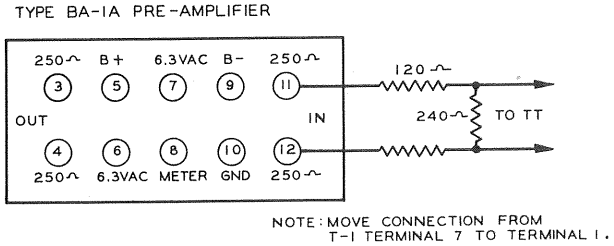


Figure 2—TT to Type BA-1A Pre-Amplifier Interconnections (K-893495)

In the "S" position of the "STUDIO-LOCAL" switch a green pilot lamp (marked "S") should light. In the "L" position of this switch the red pilot lamp (marked "L") should be illuminated.

If desired, an audio oscillator (accessory equipment) may be connected through the station patching panel to terminals 39 and 40, which are wired to the "TT-OSC." switch. With this switch in the "OSC." position the audio oscillator is connected through to the transmitter input the same as described for the turntable except that the "TT" mixer control is not in the circuit.

When the "TT-OSC." switch is in either position the yellow pilot lamp should be illuminated.

LOCAL MICROPHONE CIRCUIT

Microphones (1 or 2) may be connected through to the input of the transmitter in exactly the same way as described for the turntable, except that the microphone switch "MIC." (9S12) should be used instead of the "TT-OSC." switch.

A red pilot light located above the "MIC." switch indicates when the switch is thrown to either position 1 or 2.

The speaker relay coil (accessory equipment) is interlocked with the "MIC." lever switch, and is energized when the switch is in the center position. With the switch in either position 1 or 2 the relay coil is de-energized, the speaker is disconnected, and a 15-ohm resistor load is connected across the output of the amplifier. This arrangement prevents feedback howl which would occur if the microphone and speaker were on simultaneously.

POWER SWITCH CIRCUITS

All power switches are wired directly to the terminal board behind the left-hand panel. They should be connected into their respective circuits and used as follows:

The "AUDIO POWER" switch (9S8) is wired to terminals 89, 90, 91 and 92 and controls the 115-volt, 60-cycle supply to the auxiliary equipment in the speech rack, making it possible to control that equipment from the Control Desk as desired. A red pilot light (125 volts) operates in conjunction with this switch.

A "SPARE" switch (9S7) is wired to terminals 95, 96, 97 and 98 and is provided to be used as desired, depending upon the particular installation. A white pilot light (125 volts) wired to terminals 93 and 94 is provided to operate in conjunction with this switch.

The "TOWER LIGHTS" switch (9S6) wired to terminals 101, 102, 103 and 104, is included for convenience in controlling the tower lights. A yellow pilot light (230 volts) operates in conjunction with this switch. If a multi-element antenna array is used it may be desirable to use this switch to control a small contactor rather than run the full power for all the towers through the Control Desk. Since the conditions in each station may vary considerably it is preferable to locate the conduit from the floor channels to the tower lighting circuit in accordance with the particular station layout plans.

The "FILAMENT ON" switch (9S5) wired to terminals 115 and 116, should be connected in series with the filament switch of the exciter. Both switches must then be closed to operate the equipment, and the transmitter may be started or stopped at the Control Desk by means of this switch. The "FILAMENT" pilot light (red, 230 volts), wired to terminals 113 and 114, may be connected to indicate when power is applied to the filaments.

The "PLATE ON" switch (9S4) wired to terminals 111 and 112, should be connected in series with the rectifier switch on the power amplifier panel. Thus the plate supply may be turned on or off at the Control Desk. A red pilot light (230 volts) wired to terminals 109 and 110, should be connected to work in conjunction with this switch, and indicates when plate power is on.

The "OVERLOAD" switch (9S3) wired to terminals 83 and 84, is of the momentary contact type and normally is used in conjunction with a notching relay. If the notching relay has operated it may be reset by throwing the "OVERLOAD" switch to the "RESET" position. A yellow pilot light (230 volts) wired to terminals 81 and 82, should be connected to indicate when the relay operates.

The "POWER CHANGE" switch (9S2) wired to terminals 117, 118, 119, 121, 122, and 123, should normally be connected to the power control panel to control the plate voltage supply through relays. The common lead from a green pilot light ("LOW") and a red pilot light ("HIGH") is wired to terminal 120.

CAUTION — The "POWER-CHANGE" switch should always be in the "LOW" position for the first application of power.

INSTALLATION

LOCATION

Since no two installations of this equipment will be exactly alike, the location of the Control Desk will depend mainly upon local conditions. The Control Desk will usually be mounted in front of the transmitter so that the operator, when seated at the desk, faces the transmitter meter panels. The rack of auxiliary equipment will usually be located off to the side. If a measuring equipment rack is used it will normally be placed alongside the rack of auxiliary equipment. The exact layout of equipment will depend upon the transmitter layout, architectural arrangement of the station, and other conditions surrounding the specific installation.

WIRING

All external wiring should be connected to the Control Desk through the three terminal blocks which are located inside the turret top assembly. The audio terminal board (solder type) is located behind the meter panel assembly. Four power terminal boards are located behind the power switching panel and one behind the monitor switching panel assembly. Audio and power leads should be kept as far apart as possible at all times.

The control desk is designed so that the wiring may be brought up through the left rear side of the desk from a conduit junction box in the floor below. The metal skirt (or false base) around the bottom of the pedestal may be removed for wiring without lifting the desk from the floor. When installing the equipment the back rear cover of the turret assembly should be removed to facilitate wiring.

Connections to the terminal boards behind the two end panels may be made from the front, and connections to the audio terminal board should be soldered to terminals from the back. However, all circuits may be tested from the front.

The following table can be used as a reference when connecting the Control Desk, MI-11616 to external equipment. When a recommended equipment is to be connected, the instruction book accompanying that equipment should be consulted for wiring to the respective terminal boards.

Terminal No.	Internal Connection	External Connection Recommended
1	Studio Attenuator Input	To terminals 33 and 34 through matching pad* if desired.
2	Studio Attenuator Input	
3	Studio Attenuator Output	To terminals 23 or 24.
4	Studio Attenuator Output	To terminals 24 or 23.
5	Microphone Attenuator Input	To station patching panel jack strip* and pre-amplifier.*
6	Microphone Attenuator Input	
7	Microphone Attenuator Output	To terminals 15 or 16.
8	Microphone Attenuator Output	To terminals 16 or 15.
9	Turntable Attenuator Input	To terminals 13 and 14; station patching panel and pre-amplifier.*
10	Turntable Attenuator Input	
11	Turntable Attenuator Output	To terminals 19 or 20.
12	Turntable Attenuator Output	To terminals 20 or 19.
13	Turntable Bridging Potentiometer	To terminals 9 or 10.
14	Turntable Bridging Potentiometer	To terminals 10 or 9.
15	Microphone Switch (MIC. 1)	To terminals 7 or 8.
16	Microphone Switch (MIC. 1)	To terminals 8 or 7.
17	Mixer Circuit Output	To station patching panel; impedance matching transformer*; booster amplifier.*
18	Mixer Circuit Output	
19	Turntable "IN" Switch	To terminals 11 or 12.
20	Turntable "IN" Switch	To terminals 12 or 11.
21	Studio-Local Switch ("L")	To matching pad* and station patching panel jack strip.*
22	Studio-Local Switch ("L")	
23	Studio-Local Switch ("S")	To terminals 3 or 4.
24	Studio-Local Switch ("S")	To terminals 4 or 3.
25	Studio-Local Switch (Local)	To station patching panel jack strip.*
26	Studio-Local Switch (Local)	
27	Studio-Local Switch (Common)	To station patching panel jack strip.*
28	Studio-Local Switch (Common)	
29	Line Switch (L2)	To station patching panel jack strip.*
30	Line Switch (L2)	
31	Line Switch (L1)	To station patching panel jack strip.*
32	Line Switch (L1)	
33	Line Switch (Common Output)	To terminals 1 and 2 through matching pad* if desired.
34	Line Switch (Common Output)	
35	Line Switch (Common Input)	To station patching panel jack strip* and telephone set.*
36	Line Switch (Common Input)	
37	Microphone Switch (MIC. 2)	Optional.
38	Microphone Switch (MIC. 2)	
39	TT-Osc. Switch (Osc.)	To station patching panel jack strip* and audio amplifier.*
40	TT-Osc. Switch (Osc.)	
41	Jack Switch "A"	To station patching panel jack strip.*
42	Jack Switch "A"	
43	Jack Switch "B"	
44	Jack Switch "B"	
45	Monitor Attenuator Common	To station patching panel jack strip.*
46	Studio Attenuator Common	
47	Mic.—TT Attenuator Common	
48	Master Attenuator Common	
49	Spare Meter	To limiting amplifier (optional). *DB gain reduction meter to be mounted in panel.
50	Spare Meter	

Terminal No.	Internal Connection	External Connection Recommended
51	Antenna Current Meter	
52	Antenna Current Meter	To rectified carrier circuit of transmitter.
53	Modulation Meter	
54	Modulation Meter	To station modulation monitor.
55	Spare Meter	To frequency monitor.* Frequency meter to be
56	Spare Meter	installed in panel (optional).
57	Volume Indicator Meter	
58	Volume Indicator Meter	To volume indicator switching circuits.
59	Master Attenuator Input	
60	Master Attenuator Input	To station patching panel jack strip.*
61	Trans.-ON Switch (contact)	To transmitter modulator unit through jack
62	Trans.-ON Switch (contact)	strip* of station patching panel.
63	Trans.-ON Switch (arm)	To terminals 71 or 72, and 65 or 66.
64	Trans.-ON Switch (arm)	To terminals 72 or 71, and 66 or 65.
65	Master Attenuator Output	To terminals 63 or 64, and 71 or 72.
66	Master Attenuator Output	To terminals 64 or 63, and 72 or 71.
67	Turntable Cue Switch (Common)	To terminals 77 or 78.
68	Turntable Cue Switch (Common)	To terminals 78 or 77.
69	Monitor Switch (Line 1)	
70	Monitor Switch (Line 1)	To station patching panel jack strip.*
71	Trans.-IN—Bridging potentiometer	To terminals 63 or 64.
72	Trans.-IN—Bridging potentiometer	To terminals 64 or 63.
73	Trans.-OUT—Bridging potentiometer	
74	Trans.-OUT—Bridging potentiometer	To antenna monitor rectifier circuit.
75	Monitor Switch (Line 2)	
76	Monitor Switch (Line 2)	To station patching panel jack strip.*
77	Monitor Attenuator Input	To terminals 67 or 68.
78	Monitor Attenuator Input	To terminals 68 or 67.
79	Monitor Attenuator Output	Through station patching panel to monitor am-
80	Monitor Attenuator Output	plifier input.
81	Overload Pilot Lamp	
82	Overload Pilot Lamp	To overload circuit of transmitter.
83	Overload Switch	
84	Overload Switch	To overload circuit of transmitter.
85	No Connection	
86	No Connection	
87	No Connection	
88	No Connection	
89	Audio Switch	
90	Audio Switch and Pilot Lamp	
91	Audio Switch	To audio circuits to be controlled.
92	Audio Switch and Pilot Lamp	
93	Spare Pilot Lamp	
94	Spare Pilot Lamp	Any circuit.
95	Spare Switch	Optional.
96	Spare Switch	Optional.
97	Spare Switch	Optional.
98	Spare Switch	Optional.
99	No Connection	
100	No Connection	
101	Tower Light Switch	To tower light electrical circuit.
102	Tower Light Switch and Pilot Lamp	To tower light electrical circuit.

Terminal No.	Internal Connection	External Connection Recommended
103	Tower Light Switch	To tower light electrical circuit.
104	Tower Light Switch and Pilot Lamp	To tower light electrical circuit.
105	No Connection	
106	No Connection	
107	No Connection	
108	No Connection	
109	Plate Pilot Lamp	To plate supply circuit of transmitter.
110	Plate Pilot Lamp	
111	Plate Voltage Switch	To plate voltage circuit of transmitter.
112	Plate Voltage Switch	
113	Filament Pilot Lamp	To filament supply circuit of transmitter.
114	Filament Pilot Lamp	
115	Filament Voltage Switch	To filament supply voltage of transmitter.
116	Filament Voltage Switch	
117	Hi-Low Power Switch (Common)	To high voltage power control circuits of transmitter.
118	Hi-Low Power Switch and Low Lamp	
119	Hi-Low Power Switch and High Lamp	
120	Pilot Lamp Common	
121	Hi-Low Power Switch (Common)	
122	Hi-Low Power Switch (Low)	
123	Hi-Low Power Switch (High)	
124	No Connection	
125	Monitor Speaker Relay	To station patching panel jack strip* and output of monitor amplifier.*
126	Monitor Speaker Relay	
127	Monitor Speaker Relay	To monitor speaker voice coil.*
128	(Contacts)	
129	A-C and D-C Voltage	A-C Power Source.
130	Terminal Board (A-C)	
131	MIC. 1 or 2 Pilot Lamp	+12 volts d-c.
132	Audio Switches Pilot Lamps (Com.)	—12 volts d-c.
133	Volume Indicator Pilot Lamps	+12 volts d-c.
134	Volume Indicator Pilot Lamps	—12 volts d-c.
135	MIC. 1 or 2 Pilot Lamp	+12 volts d-c.
136	Desk Ground	Station Ground.
137	Jack (9J1)	To pre-amplifier input.*
138	Jack (9J2)	To pre-amplifier input.*
139	Jack (9J1)	Optional.
140	Jack (9J2)	Optional.

NOTE: Items marked with an asterisk (*) are accessory equipment recommended in the Equipment Table.

Figure 5 shows the connections for a typical installation. As stated, care should be exercised that audio and power leads are not previously included in any one conduit running to, or from, the Control Desk.

AUDIO CONNECTIONS

The impedances of the various circuits are listed in the "Technical Summary." In order to match these circuits it is necessary that the auxiliary equipment be connected as follows:

The turntable microphone pre-amplifiers should each be connected for an output impedance of 250 ohms, balanced. Pre-amplifier inputs must match the turntable and microphone output impedances respectively.

The booster amplifier must be connected for an input and output impedance of 500-600 ohms, balanced. When a Type BA-1A amplifier is used (as recommended) an MI-4900-A matching transformer should be connected into the input circuit.

The limiting amplifier must be connected to an input and output impedance of 500-600 ohms, balanced.

The monitor amplifier must be connected for an input impedance of 500-600 ohms, balanced, and an output impedance to match the voice coil impedance of the monitor speaker.

If an audio oscillator is used it must have an output impedance of 500-600 ohms.

If auxiliary equipment is used in which it is impossible to obtain the proper impedances, impedance matching pads or transformers should be used.

RELAY POWER SUPPLY

The line voltage should first be determined so that the proper tap on the primary of the transformer may be used. There are three taps provided, one each for 105-, 115- and 125-volt operation. The tap to be used should be soldered to the fuse panel and the two wires not used should have their ends taped or otherwise insulated. The transformer should be connected for line voltages as follows:

Line Voltage	Transformer Tap	Primary Wire To Be Connected
Less than 110 volts.....	105	Blue
110-120 volts.....	115	Black-Red
More than 120 volts....	125	Red

A voltage control switch located on top of the chassis may be adjusted by means of a screwdriver. This will permit a regulation of the d-c terminal voltage over a range of 2 volts.

OPERATION

Switches found on the left-hand panel control the filament and plate power supplied to the transmitter making it possible to start and stop the transmitter at the Control Desk by closing or opening the "FILAMENT ON" and "PLATE ON" switches. When making adjustments to the transmitter the "POWER" switch should be set in the "LOW" position. To reset the notching relay which operates after an overload, the "OVERLOAD" switch should be thrown to the "RESET" position.

By means of the lever switches located on the center of the right-hand panel, the incoming lines, local microphone, transcription turntable or audio oscillator may be selectively connected to the input of the transmitter. In a similar manner the transmitter input may be connected to the local control room or to the studio.

By means of the push-button switches which are located on the right-hand panel, the input or the output of the transmitter, line 1 or 2, or the transcription turntable may be connected to the monitoring circuit.

The volume indicator meter may be switched to jacks "A" or "B" or to the input of the transmitter by the "VI METER" switches located on the right-hand panel.

MAINTENANCE

This Control Desk has been designed to provide maximum ease of servicing and accessibility of component parts. Switches, meters and controls are mounted on the three front panels. These panels may be tilted forward on hinges, thus making all parts and terminal boards accessible from the front.

For any piece of equipment that is subject to continuous use, as is most broadcast equipment, a regular routine of inspection should be set up and followed in order to avoid time off the air resulting from noisy circuits caused by the accumulation of dirt on terminals, volume controls and switches, corroded plugs, etc.

Auxiliary equipment should be inspected and serviced regularly in accordance with the separate instructions supplied for that equipment.

Attenuator control contacts should be cleaned by applying "Davenoil" to the contacts, rotating the knob and, if any dark streaks appear, wiping off the contacts. Repeat this procedure until absolutely clean, then lubricate with a thin film of Davenoil included as part of this equipment. IMPORTANT — The Davenoil is provided for cleaning and lubricating the contacts of the attenuator controls, and no other cleaning agent such as carbon tetrachloride should be used.

As shipped from the factory the various key switch contacts have been properly adjusted to give the proper sequence of circuit connections when they are operated, so that, for instance, a local microphone and monitor speaker will not be on at the same time and because of this cause acoustic feedback when the "MIC." lever key is operated.

In case the "MIC." key switch is replaced, or if feedback trouble is encountered, the contacts should be adjusted, using a standard key switch or relay contact bending tool. When adjusting the switch the following desired sequence of operations should be kept in mind. The RELAY CONTACTS MUST OPERATE FIRST AND THE AUDIO CIRCUITS TRANSFER LAST. This is accomplished by relieving the tension of the center spring of the form D contacts controlling the relay and increasing the tension of the center spring of the form D contacts carrying audio. Care should be taken that the spring shape is not altered or the contact pressure reduced so much as to cause poor contact or short circuits.

Before replacing the 0.5 ampere line fuse which is located in the relay power supply, disconnect the source of power.

REPLACEMENT PARTS LIST

When ordering replacement parts, please give Symbol, Description, and Stock Number of each item ordered.

The part which will be supplied against an order for a replacement item may not be an exact duplicate of the original part, however, it will be a satisfactory replacement, differing only in minor mechanical or electrical characteristics. Such differences will in no way impair the operation of the equipment.

MAIN ASSEMBLY

Symbol No.	Description	Stock No.
9C3	Capacitor, 0.5 mfd., 200 volts	70619
9E1	Relay, 12-volt (monitor speaker)	16998
9R22	Resistor, 15 ohms, 10 watts	18236
9R32, 9R33, 9R34	Control, dual, 10,000 ohms, bridging potentiometer	44102
9T2	Transformer, bridging	MI-4901
	Spring, panel fastener, with mounting screws, nuts and lockwashers	44217

RELAY POWER SUPPLY

9A1	Rectifier unit	44104
9C1, 9C2	Capacitor, 1000 mfd., 25 volts	18374
9F1	Fuse, 0.5 ampere, line	3748
9R1	Resistor, 120 ohms, 10 watts	44106
9S1	Switch, voltage regulator	44105
9T1	Transformer, 105-115-125 volts, 50/60 cycle, power	45965
	Holder, fuse	32059
	Plate, capacitor mounting	18469

POWER PANEL ASSEMBLY

9A9	Pilot light, green, 250 volts	
9A10, 9A12, 9A13	Pilot light, red, 250 volts	
9A11, 9A14	Pilot light, yellow, 250 volts	
9A15	Pilot light, white, 125 volts	
9A16	Pilot light, red,125 volts	
	Parts for Above	
	Cap, green	44136
	Cap, red	19897
	Cap, white	44135
	Cap, yellow	44137
	Lamp, 24 volts	16154
	Resistor, 125 volts	44131
	Resistor, 250 volts	44570
	Receptacle, less lamp, cap, and resistor	44997
9S2	Switch, "High-Low" power	21802
9S3	Switch, "Over-Load" reset	44107
9S4, 9S5	Switch, "Filament" or "Plate" control	44109
9S6	Switch, "Tower Lights" control	44108
9S7, 9S8	Switch, "Audio Power" or "Spare" control	25040

CONTROL PANEL ASSEMBLY

9A2	Control, 600-600 ohm "Master" attenuator	44101
9A3, 9A4	Control, 250-500 ohm "Mic." or "TT" attenuator	44100
9A5	Control, 600-600 ohm "Studio" attenuator	44099

REPLACEMENT PARTS LIST (Continued)

Symbol No.	Description	Stock No.
9A6	Control, "Meter" attenuator	44092
9A7	Control, 600-600 ohm "Monitor" attenuator	44097
9M1	Meter, modulation	44110
9M2	Meter, V. U.	43186
9M3	Meter, 0-10 ampere, antenna	19889
9R35	Control, meter rheostat	44098
	Knob, control	17369
	LINE SWITCH PANEL ASSEMBLY	
9A17, 9A21, 9A24	Pilot light, green	
9A18, 9A20, 9A22, 9A25	Pilot light, red	
9A19, 9A23	Pilot light, yellow	
	Parts for Above	
	Cap, green	44136
	Cap, red	19897
	Cap, yellow	44137
	Lamp, 12 volt	21332
	Receptacle, less cap and lamp	44997
9J1	Jack, closed circuit, less mounting strip	51576
9R2 to 9R16	Resistor, 560 ohms, ½ watt	5164
9R17, 9R18, 9R19, 9R20	Resistor, 56 ohms, ½ watt, wire-wound	44095
9R21	Resistor, 600 ohms, 1 watt	44274
9R23, 9R24, 9R25	Resistor, 8200 ohms, ½ watt	14250
9R26, 9R27, 9R28, 9R29	Resistor, 22,000 ohms, ½ watt	30492
9R30, 9R31	Resistor, 125 ohms, ½ watt, wire-wound	44096
9S9, 9S13	Switch, key (used for "LINES" and "STUDIO-LOCAL" switching)	18291
9S10, 9S11, 9S12	Switch, key (used for "MIC," "TRANS," and "TT-OSC" switching)	17015
9S14	Switch, 4-button, push	44094
9S15	Switch, 6-button, push	44093
	Support, fall (for panel)	44216

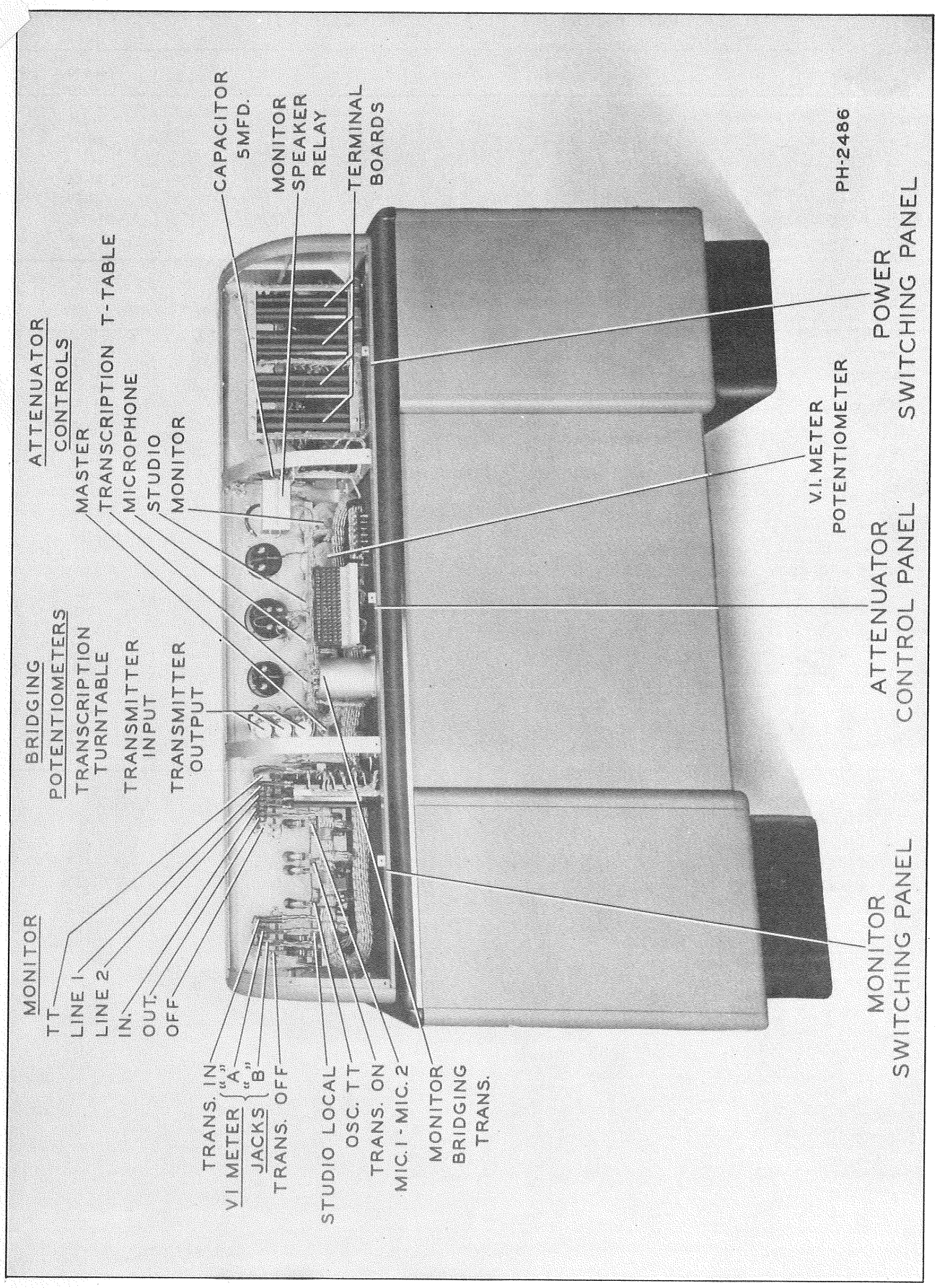


Figure 3—Transmitter Control Desk (Rear View, Turret Cover Removed)

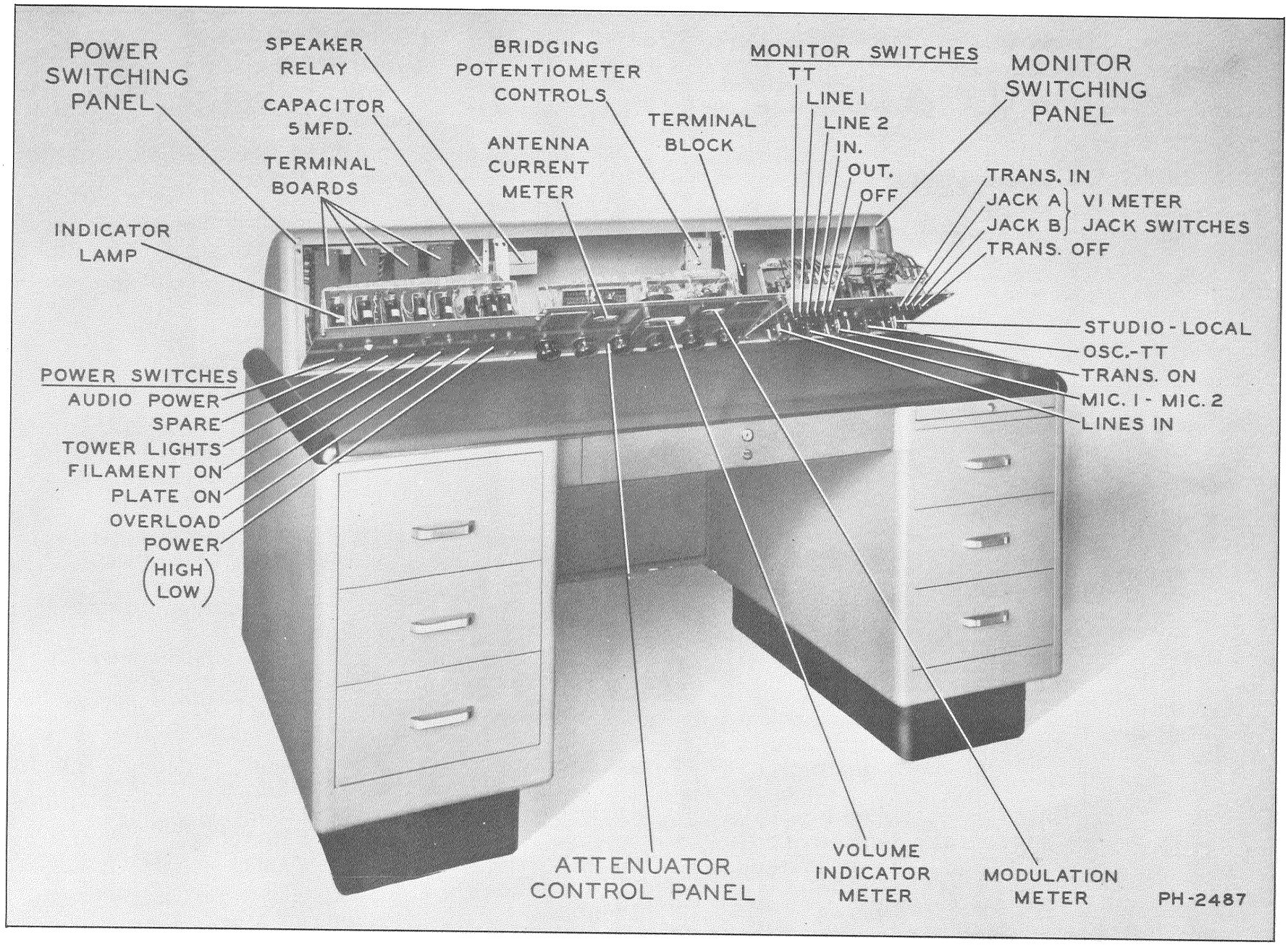


Figure 4—Transmitter Control Desk (Front View, Panels Tilted Open)

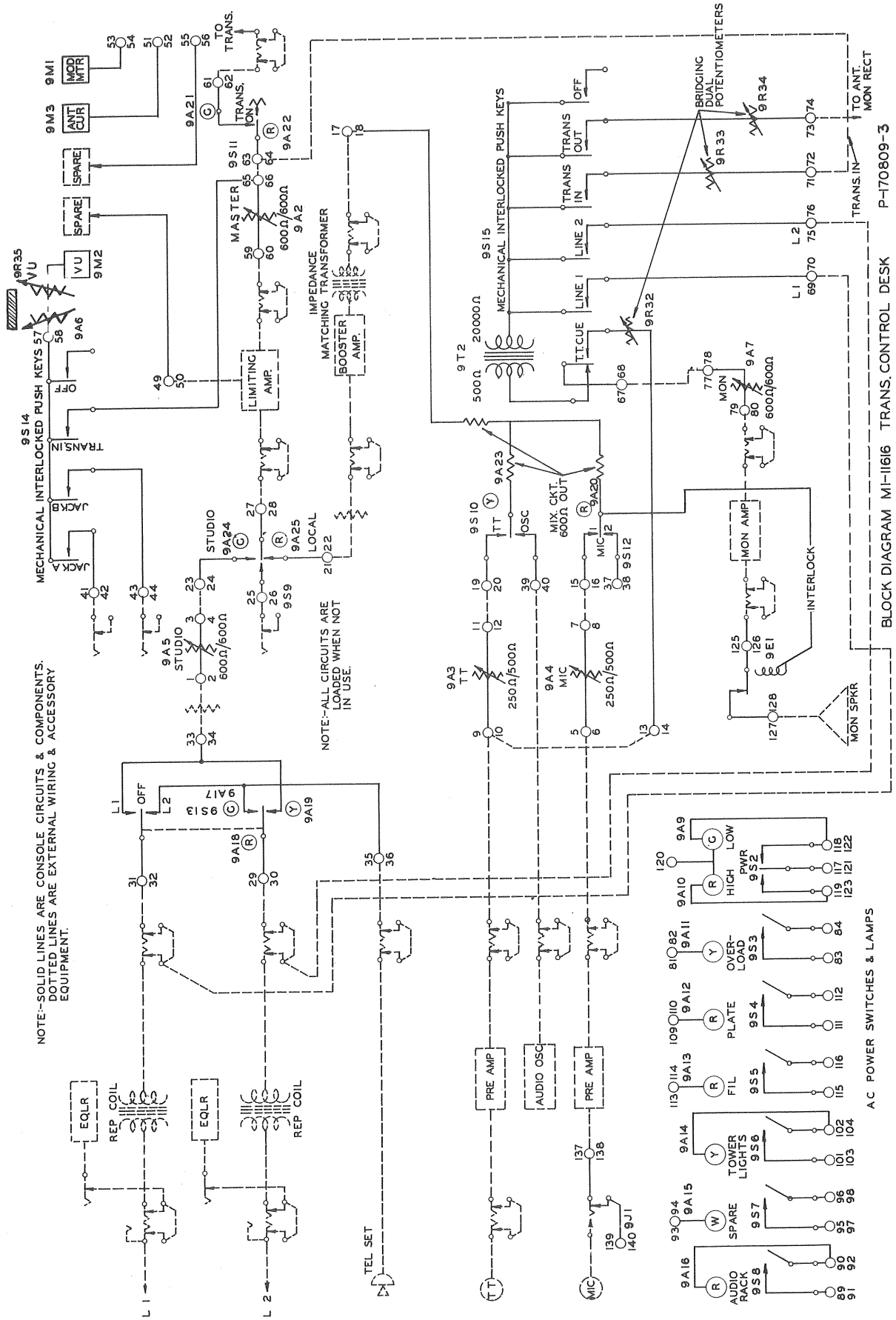


Figure 5—Transmitter Control Desk, Simplified Schematic (P-170809)

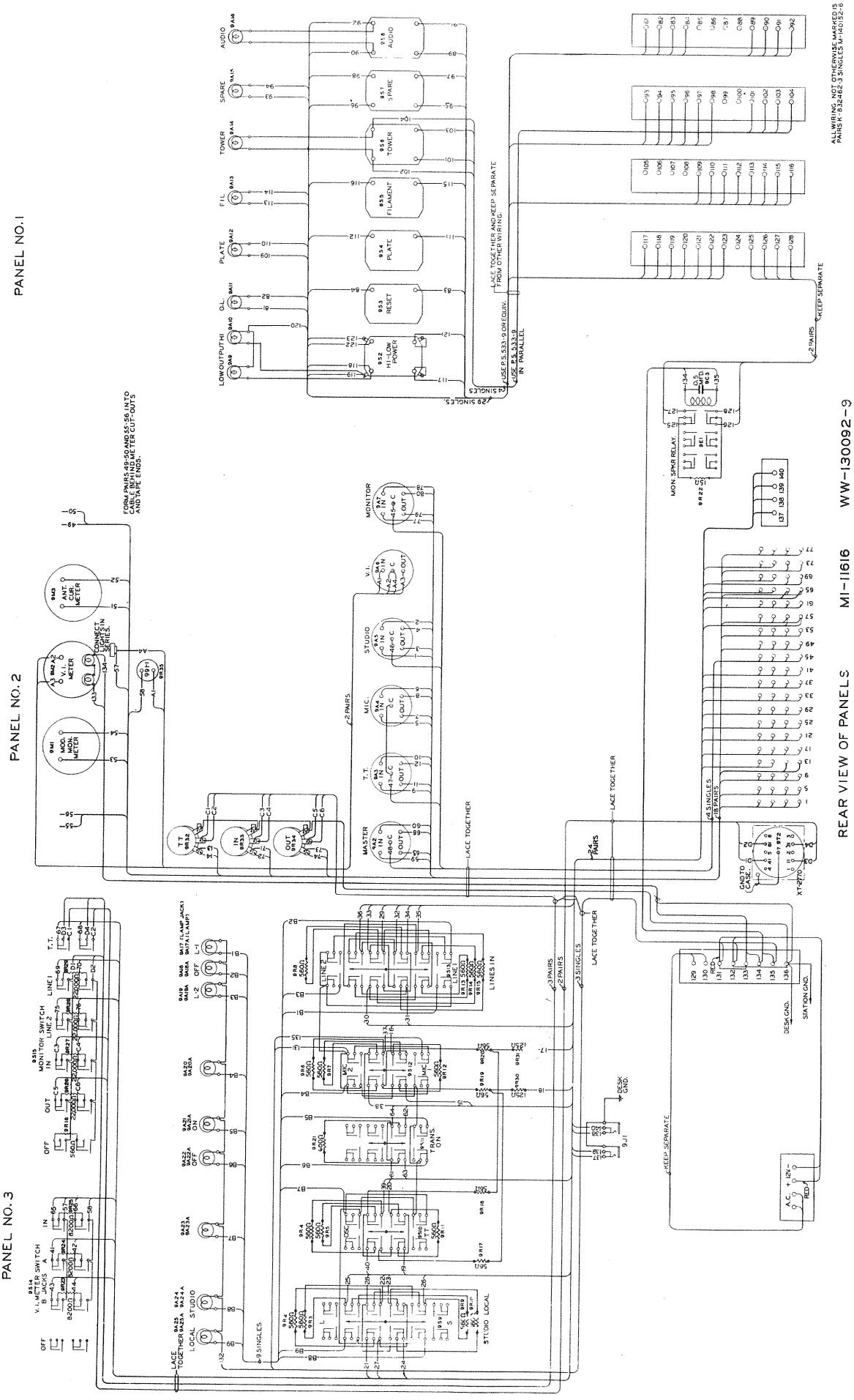


Figure 6—Transmitter Control Desk Connections (WW-130092)

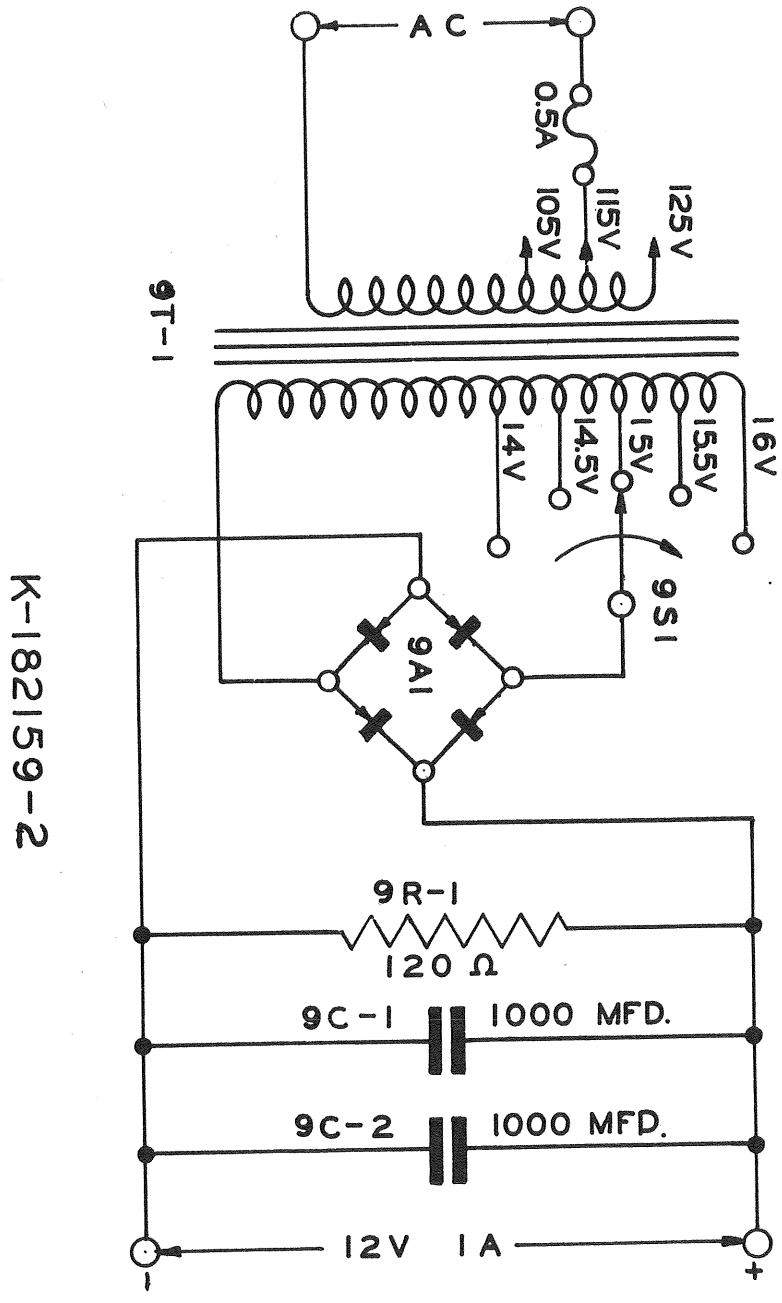


Figure 7—Relay Power Supply, Schematic (K-182159)

INSTRUCTIONS GEH-954A

PLUNGER RELAYS

TYPES PAA, PAC, PAV, PBA, PBC, AND PCV

GENERAL ELECTRIC
SCHENECTADY, N.Y.

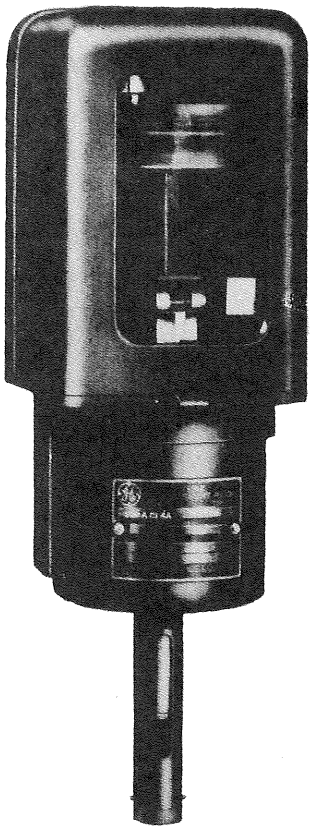


Fig. 1. Time Relay

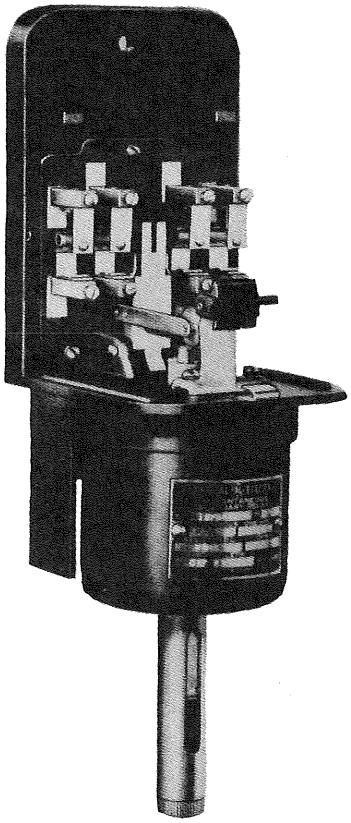


Fig. 2. Instantaneous Relay

PLUNGER RELAYS

TYPES PAA, PAC, PAV, PBA, PBC, and PCV

The above nomenclature embraces a line of relays designed to protect against overcurrent and undervoltage and also for use as auxiliary devices. The same principle of operation is common to all of them and 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.

Three distinct varieties of the general construction are available. These are differentiated by the second letter of the nomenclature; thus the letter "A" denotes the standard construction, "B" indicates the sensitive form (hand or electrical reset only), while "C" distinguishes a shaded-pole construction designed to insure quiet operation on alternating voltage. The three types are not interchangeable in service and the outstanding features of each are listed on page 4.

INSTALLATION

When received, 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 (see below) before mounting the relay than afterward.

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.

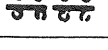
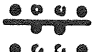
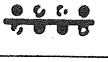
Lifting the plunger and operating the contact bar solely by hand, see that all the back contacts make simultaneously and all the front contacts make simultaneously. Adjust for this condition, if necessary, by loosening the set screws and moving the contact piece forward or backward as required.

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.

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 projecting through the front of the cover. This rotation is accomplished by removing the clamping spring at the top of the rod

APPLICATIONS AND CHARACTERISTICS

Type of Relay	Application	Time	*Contacts	RATINGS Volts	Amp.	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 dropout.
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	25 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 dropout. It has no provision for calibration, but will pickup at approximately 80 per cent of rated voltage and dropout at 30 per cent.
PCV12A		Time			.....	25 and 60	Self	No	
PCV13A		Inst.			.....	25 and 60	Self	No	
PCV14A		Time			.....	25 and 60	Self	No	
PCV11B		Inst.			.....	25 and 60	Self	No	
PCV12B		Time			.....	25 and 60	Self	No	
PCV13B		Inst.			.....	25 and 60	Self	No	
PCV14B		Time			.....	25 and 60	Self	No	
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			.....	25 and 60		Yes	
PAA13A		Inst.			.....	25 and 60		Yes	
PAA14A		Time			.....	25 and 60		Yes	
PAA11B		Inst.			.....	25 and 60		Yes	
PAA12B		Time			.....	25 and 60		Yes	
PAA13B		Inst.		9 to 600 D-c.	.....	25 and 60		Yes	
PAA14B		Time			.....	25 and 60		Yes	
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	

* { ●Positions of contacts.
{ ○Alternative positions of contacts.

† One-minute rating of d-c. coil in amperes: 1.5, 2.8, 6, 12, 25, 30, and 80.

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.

TIME DELAY

This feature 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 unaffected, 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 disc 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 disc rotates. This disc is arbitrarily marked from 1 to 10 and the valve mechanism is so arranged that when the numeral 1 lies over the valve opening the time delay of the relay is at its minimum value: as the disc 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 10. (See Fig. 3.)

The setting of the left-hand disc, 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 disc 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 disc 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.

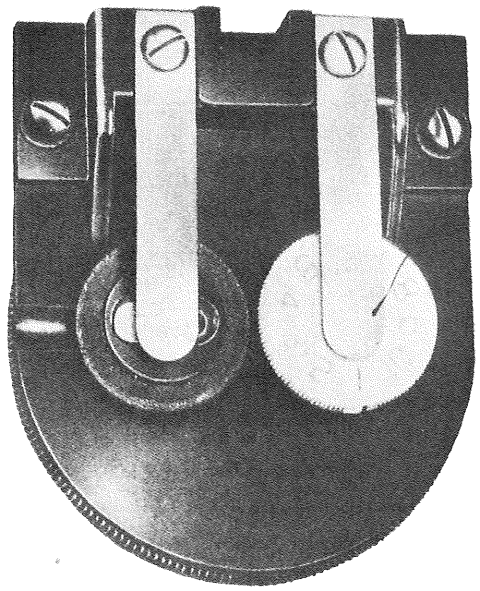


Fig. 3. Discs for Adjustment of Time Delay

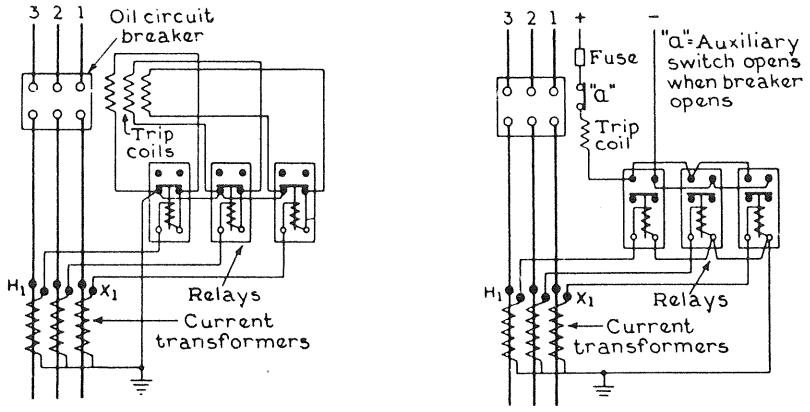
In making the any of above adjustments care should be taken to see that the leather washer under the disc is properly seated when the latter is replaced.

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 valve 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 several varieties 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.



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

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 means of a push-rod extending through the front of the cover.

Contact Rating

By choosing the proper contacts the overcurrent 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 20 amperes for one minute. 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 not in excess of those given in the following table:

Volts	UPSTROKE	Amperes		DOWN-STROKE
	D-c.	A-c.	D-c.	A-c.
12	5.0	10.0	2.5	5.0
30	3.0	10.0	1.5	5.0
125	1.0	10.0	0.5	2.5
250	0.4	7.0	0.2	1.0
600	0.1	3.0	0.0	0.0

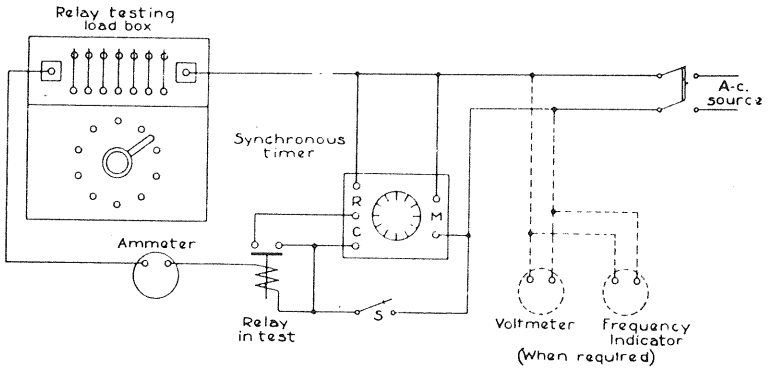


Fig. 5. Connections for Testing a Circuit-closing Relay Operated from Same Supply as Type MF-2 Synchronous Timer

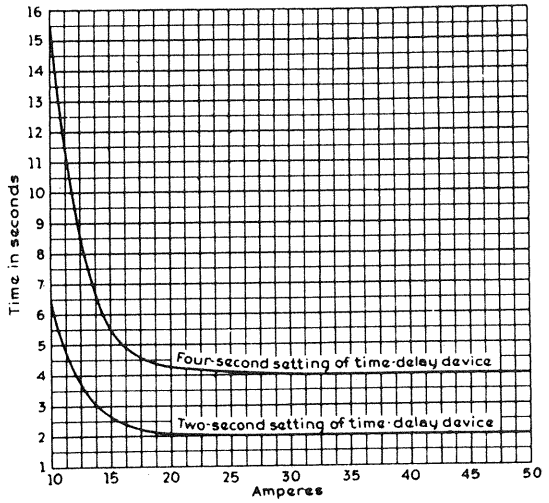


Fig. 6. Characteristic Time-current Curves of Type PAC Overcurrent Relays with 5-amp. Coil; Plunger Setting at 8 Amperes with Two Different Settings of Time-delay Device

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 overcurrent relay are given in this book, while the various methods of adjustment have already been described.

Renewal Parts

Order renewal parts by Cat. No. from the nearest Office of the General Electric Company. If the Cat. No. is not available, give a complete description of the part required, together with the complete rating and all other information that may appear on the relay nameplate.

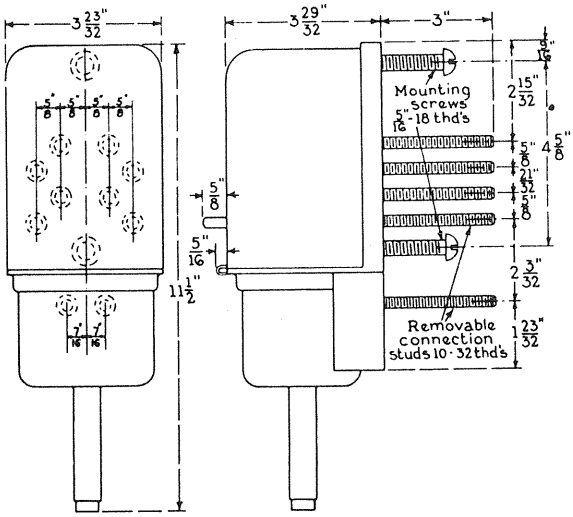


Fig. 7. Outline and Dimensions of Types PAA, PAC, PAV, PBA, and PBC Relays (Number of Studs Varies with Different Types)

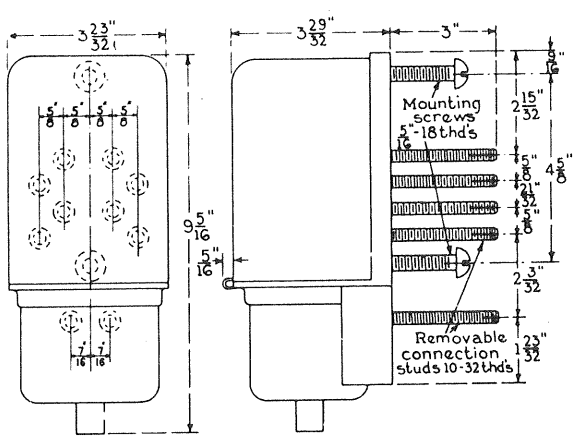


Fig. 8. Outline and Dimensions of Type PCV Relays (Number of Studs Varies with Different Types)

WHEN SERVICE IS REQUIRED

THE facilities of our engineering departments and factories are available to purchasers of G-E apparatus, through G-E Service Shops and Sales Offices. Any additional information or advice can be obtained on application to the nearest Sales Office. When it is necessary to renovate, repair, or change apparatus to meet a new operating condition or application, the facilities of the nearest Service Shop should be employed. Each Service Shop is equipped to maintain the same standard of workmanship and excellence of materials as that employed in the factory. When the required work must be performed on the purchaser's premises, the Service Shop is prepared to send capable and dependable men into the field to make the changes or repairs promptly and efficiently. G-E Service Shops and Sales Offices are located at the points listed below.

SERVICE SHOPS

Atlanta, Ga.	496 Glenn Street, Southwest
Buffalo, N. Y.	318 Urban Street
Chicago, Ill.	509 East Illinois Street
Cincinnati, Ohio	215 West Third Street
Cleveland, Ohio	4966 Woodland Avenue
Dallas, Texas.	1801 North Lamar Street
Detroit, Mich.	5950 Third Avenue
Houston, Texas.	1312 Live Oak Street
Kansas City, Mo.	819 East Nineteenth Street
Los Angeles, Calif.	5203 Santa Fe Avenue
Milwaukee, Wis.	940 West St. Paul Avenue
Minneapolis, Minn.	410 Third Avenue, North
New York, N. Y.	416 West Thirteenth Street
Philadelphia, Pa.	429 North Seventh Street
Pittsburgh, Pa.	16 Terminal Way, South Side
St. Louis, Mo.	1110 Delmar Boulevard
Salt Lake City, Utah	360 West Second South Street
San Francisco, Calif.	361 Bryant Street
Seattle, Wash.	1508 Fourth Avenue, South

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. (River Works and West Lynn Works).

SALES OFFICES (Address nearest office)

Akron, Ohio	335 South Main Street
Atlanta, Ga.	187 Spring Street, Northwest
Baltimore, Md.	39 West Lexington Street
Bangor, Me.	600 Main Street
Binghamton, N. Y.	19 Chenango Street
Birmingham, Ala.	600 North Eighteenth Street
Boston, Mass.	140 Federal Street
Buffalo, N. Y.	1 West Genesee Street
Butte, Mont.	20 West Granite Street
Cedar Rapids, Iowa	203 Second Street, Southeast
Charleston, W. Va.	304 Capitol Street
Charlotte, N. C.	200 South Tryon Street
Chattanooga, Tenn.	536 Market Street
Chicago, Ill.	230 South Clark Street
Cincinnati, Ohio	215 West Third Street
Cleveland, Ohio	4966 Woodland Avenue
Columbus, Ohio	40 South Third Street
Dallas, Texas.	1801 North Lamar Street
Davenport, Iowa	511 Pershing Avenue
Dayton, Ohio	25 North Main Street
Dayton, Colo.	650 Seventeenth Street
Des Moines, Iowa	418 West Sixth Avenue
Detroit, Mich.	700 Antoinette Street
Duluth, Minn.	14 West Superior Street
El Paso, Texas	109 North Oregon Street
Erie, Pa.	10 East Twelfth Street
Evansville, Ind.	123 Northwest Fourth Street
Fort Wayne, Ind.	1635 Broadway
Fort Worth, Texas	408 West Seventh Street
Grand Rapids, Mich.	148 Monroe Avenue, Northwest
Hartford, Conn.	338 Ann Street
Houston, Texas	1312 Live Oak Street
Indianapolis, Ind.	110 North Illinois Street
Jackson, Mich.	212 Michigan Avenue, West
Jacksonville, Fla.	237 West Forsyth Street
Kansas City, Mo.	106 West Fourteenth Street
Knoxville, Tenn.	602 South Gay Street
Los Angeles, Calif.	212 North Vignes Street
Louisville, Ky.	455 South Fourth Street
Memphis, Tenn.	8 North Third Street
Milwaukee, Wis.	940 West St. Paul Avenue
Minneapolis, Minn.	107 South Fifth Street
Nashville, Tenn.	234 Third Avenue, North
Newark, N. J.	744 Broad Street
New Haven, Conn.	129 Church Street
New Orleans, La.	837 Gravier Street
New York, N. Y.	570 Lexington Avenue
Niagara Falls, N. Y.	201 Falls Street
Oklahoma City, Okla.	119 North Robinson Street
Omaha, Nebr.	409 South Seventeenth Street
Philadelphia, Pa.	1405 Locust Street
Phoenix, Ariz.	435 West Madison Street
Pine Bluff, Ark.	501 Main Street
Pittsburgh, Pa.	436 Seventh Avenue
Portland, Me.	25 Bedford Street
Portland, Ore.	621 Southwest Alder Street
Providence, R. I.	111 Westminster Street
Richmond, Va.	700 East Franklin Street
Rochester, N. Y.	89 East Avenue
St. Louis, Mo.	112 North Fourth Street
Salt Lake City, Utah.	200 South Main Street
San Antonio, Texas.	201 Villita Street
San Francisco, Calif.	235 Montgomery Street
Schenectady, N. Y.	1 River Road
Seattle, Wash.	821 Second Avenue
Spokane, Wash.	421 Riverside Avenue
Springfield, Ill.	607 East Adams Street
Springfield, Mass.	95 State Street
Syracuse, N. Y.	113 South Salina Street
Tacoma, Wash.	1019 Pacific Avenue
Toledo, Ohio	420 Madison Avenue
Tulsa, Okla.	409 South Boston Street
Utica, N. Y.	258 Genesee Street
Washington, D. C.	806 Fifteenth Street, Northwest
Waterbury, Conn.	72 West Liberty Street
Wichita, Kan.	116 South Main Street
Worcester, Mass.	165 Commercial Street
Youngstown, Ohio	25 East Boardman Street

Canada: Canadian General Electric Company, Ltd., Toronto

Hawaii: W. A. Ramsay, Ltd., Honolulu

Motor Dealers and Lamp Agencies in all large cities and towns

GENERAL ELECTRIC

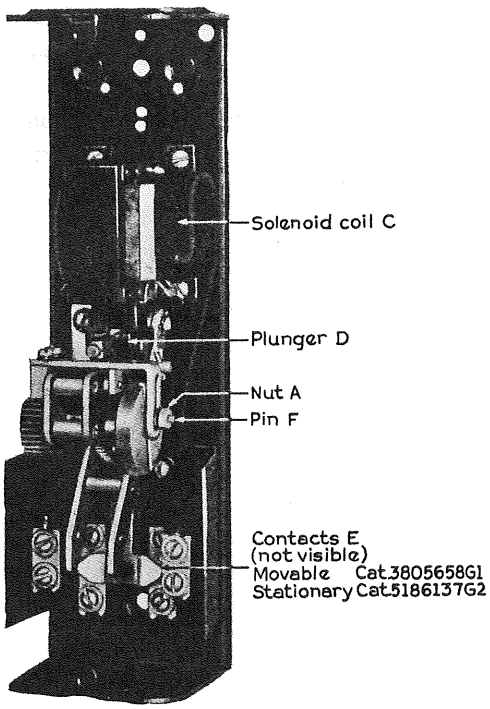
November, 1937 (5500)
Filing No. B7600

INSTRUCTIONS GEH-1016A

TIME DELAY RELAY

CR2820-1731A AND 1731B

Also for Form.....Switch



Movable	Stationary
Cat. 4929723G6 for CR2820-1731A	Cat. 5186137G2 for CR2820-1731A
Cat. 5346421G1 for CR2820-1731B	Cat. 5346423G1 for CR2820-1731B

Fig. 1. CR2820-1731A Time-delay Relay (Cover Removed)

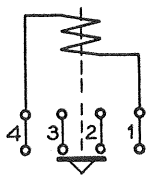


Fig. 2. Internal Connections (CR2820-1731A)

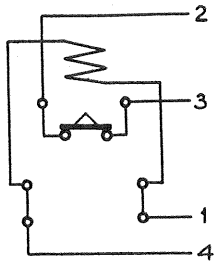


Fig. 3. Internal Connections (CR2820-1731B)

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.

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 re-energized.

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. If prominent copper beads form on the surfaces of the copper contacts, or if the tips turn a dark color due to overheating, the contact surfaces should be dressed with a fine file. 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.

TYPE SG AUXILIARY RELAYS

Closed and Open Types for A-C. or D-C. Use;

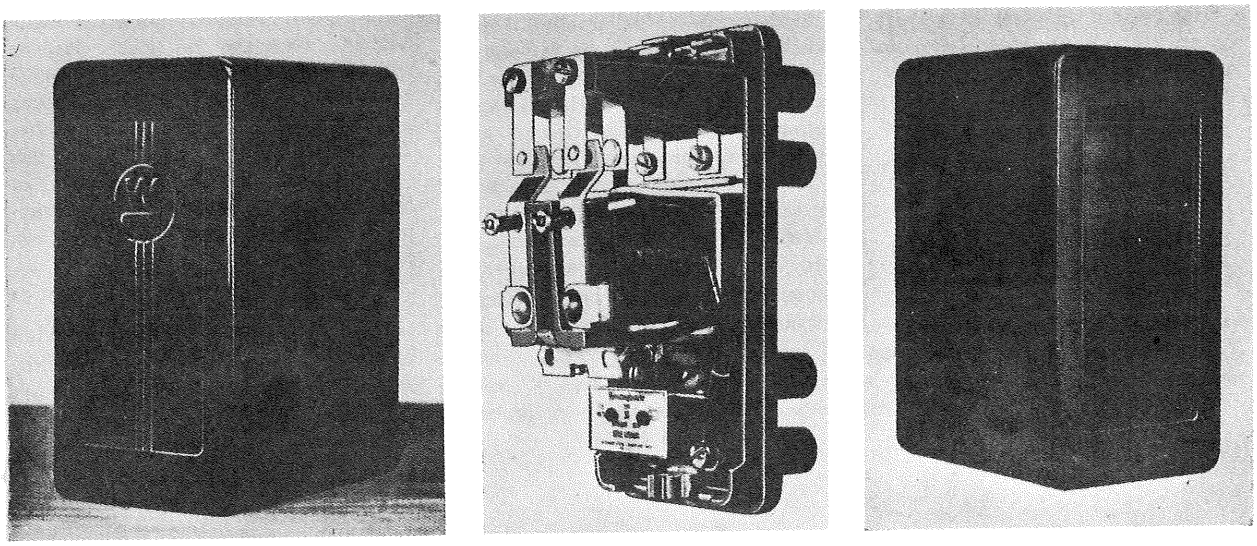


FIG. 1—CLOSED TYPE SG RELAY SHOWING SOLID MOLDED COVER, RELAY WITH COVER OFF, AND MOLDED COVER WITH GLASS WINDOW. THIS RELAY HAS TWO-MAKE AND TWO-BREAK CONTACTS.

Application

The SG relay is made small and sturdy for auxiliary service. It is obtainable in two types; closed type with molded cover or molded cover with glass front, and front connected open type without cover. The open type is used widely for mounting in individual sheet metal cabinets or in larger cabinets with other apparatus.

The standard closed type relay is supplied with two-make and two-break contacts with each moving contact being common to its corresponding front and back stationary contacts. The standard open type relay is supplied with two independent contact circuits, and the contacts can readily be adjusted to provide either two-make, two-break, or one-make and one-break. The open relay also can be supplied with two-make and two-break contacts similar to the standard closed type SG.

Designed for continuous duty at rated voltage, the SG relay is obtainable for circuits up to 575 volts a-c. or 600 d-c. Ranges up to 250 volts can be used for intermittent duty up to approximately three times their continuous value.

Fig. 7 gives the method of connection when the SG relay is used to control circuits where the circuits required cannot be incorporated in the primary relay.

Distinctive Features

1. Design is simple, construction is sturdy, and price is low.

2. The complete relay can be dismantled in a few minutes.

3. The stationary contacts of the open-type relay are reversible to provide for either two-make, one-make and one-break, or two-break contact service.

4. Relay is adapted for any thickness of panel material from $\frac{1}{8}$" (steel) to 2" (slate). The molded terminals are $1\frac{1}{8}$" long, being ample for steel-panel mounting. For thicker panels, extension terminal studs are furnished.

5. Molded cover is held securely by a bracket and a spring clip, yet can be easily removed. A glass window is optional.

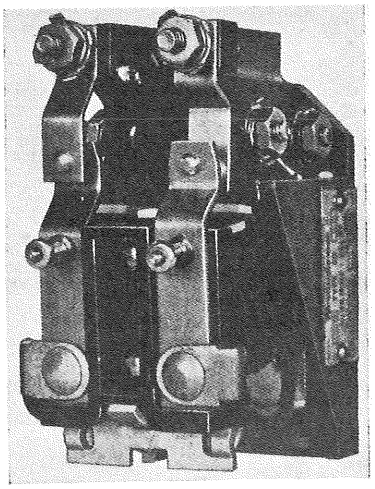


FIG. 2—OPEN TYPE SG AUXILIARY RELAY WITH ONE-MAKE AND ONE-BREAK CONTACT. THIS RELAY CAN BE SUPPLIED WITH TWO-MAKE AND TWO-BREAK CONTACTS.

Construction

The SG relay, closed type, is shown in Fig. 1. The magnetic circuit is fastened to the molded base by two screws, while the coil and core are held securely in place by one screw. The armature is held in the de-energized position by gravity and a spring.

The moving contact fingers have a contact surface on both sides, and is so mounted on the armature block that motion in either direction compresses a spring. This permits sufficient contact follow to be obtained for both the make and the break contacts.

The standard relay is supplied with a molded cover which can be equipped with a glass front if desired.

The SG open type, shown in Fig. 2, has the same operating characteristics as the closed type. The coil, magnetic circuit, contacts and connecting screws are mounted on a molded base. The entire assembly is arranged so it can be mounted on any flat surface by means of 3 screws or bolts.

Contact Rating for Each Contact

Non-Inductive

Each contact will carry 12 amperes continuous and 30 amperes for one minute.

Volts	Interrupting Rating Amperes D-C. 1 Gap	Interrupting Rating Amperes D-C. 2 Gaps in Series	Interrupting Rating Amperes A-C. 1 Gap
24	15	50	60
48	8	35	45
115	2.4	20	30
230	.75	2.5	20
550	.25	.5	10

The SG relay operating time is approximately 1 to 2 cycles (60 cycle basis) and for most applications this characteristic is required. However, in certain relay applications it is desirable to have a D-C. relay which provides a short time lag between the opening of the circuit to the relay coil and the dropping out of the relay armature. A time delay of approximately 0.1 second can be obtained with the SG relay by providing it with a heavy copper ring on the core. Because of the consequent reduction of coil space, this relay can be used only for intermittent service.

A longer time delay can be obtained by using a condenser, with or without a series resistor, connected across the relay coil. In this case the copper ring is omitted and the coil can be energized continuously. A maximum time delay of approximately 0.5 second can be obtained by using a condenser of approximately 30 mfd. capacity. A similar arrangement, with the resistor in series with the coil, will delay the pick-up time to approximately .07 second.

Operation

The armature to which the moving contacts are fastened closes the make contacts when the coil is energized at the proper voltage or current which should not be less than 80% of the maximum rating marked on the name-plate. The armature will open at 30% or less (on d-c.) and 60% or less (on a-c.) of the relay rating. The relay can be supplied for voltage circuits up to 575 a-c. or 600 d-c.

Volt-Ampere Burden

The volt-ampere burden at rated voltage (60 cycles) is 10, power factor, 50%. The watt consumption at rated d-c. voltage is 3.5.

Application Table No. 1

Relay Coils

Volts	Amperes	D-C. Resistance: Coil Style No.	D-C. Resistance: 25°C. Ohms.	D-C. Resistance: Impedance Closed Gap*	External Resistance When Used: Style No.	External Resistance When Used: Resistance Ohms.
Direct-Current Coil Ratings						
...	1.0	1 059 282	2.5	.....	None	None
...	3.0	1 059 284	0.33	.....	None	None
...	5.0	1 059 286	0.1	.....	None	None
24	0.130	1 008 517	185	.....	None	None
48	0.066	1 008 520	725	.....	None	None
125	0.028	1 008 524	4430	.....	None	None
250	0.028	1 008 524	4430	.....	1 009 014†	5000
50 to 60 Cycle Coil Ratings						
115	0.087	1 008 517	185	1320	None	None
230	0.044	1 008 520	725	5300	None	None
460	0.022	1 008 523	2770	21000	None	None
25 Cycle Coil Ratings						
15	0.057	1 008 519	460	2000	None	None
30	0.029	1 008 522	1780	8020	None	None
60	0.019	1 008 524	4430	19800	1 009 014†	5000

*Impedance open gap approximately ½ closed gap value.
Impedance given includes external resistor if used.
† External resistor Style No. 1009014 is a 3⅝-inch tube type with screw terminals and is supplied with an insulated mounting stud.

Application Table No. 2

Operation Indicators

Use this table to determine if an additional resistor is required with an SG relay in order to draw enough current to operate a 0.2 ampere indicator. The resistor is not supplied with the relay and should be ordered separately.

Control Volts D-C.	Indicator Rating Amperes	SG Relay Coil Resistance and Resistor if Required	Rating	Current in Indicator at Normal Voltage
24	0.2	Relay Coil 185 ohms plus 150 ohm resistor (3.8 watts) style #879976 in parallel with relay coil	Continuous	0.29
48	0.2	Relay Coil 725 ohms plus 200 ohm resistor (12 watts) style #879977 in parallel with relay coil	Continuous	0.31
125	0.2	Relay Coil 4430 ohms plus 400 ohm resistor (39 watts) style #281407 in parallel with relay coil	Continuous	0.34
250	0.2	Relay Coil 4430 ohms with 5000 ohm resistor (furnished with relay) in series with relay coil plus 970 ohm resistor (64 watts) style #286266 in parallel with relay coil and series resistor	Continuous	0.28

NOTE—The 400 ohm and 970 ohm resistors are 8" tube type with screw terminals and require mounting detail style #454921. The other resistors are 2½" tube type with flexible leads and require mounting detail style #877339.

LIST PRICES

Volts	Amperes	Cycles*	Ohms. Resistance Relay Coil	Amperes	Coil Style No.	Relay Style No.	Relay List Price Discount Symbol FC
CLOSED TYPE							
2 make—2 break contacts, moving contact common							
...	1	D-C.	2.5	.....	1 059 282	1 157 848	$7 50
...	3	D-C.	0.33	.....	1 059 284	1 157 849	7 50
...	5	D-C.	0.1	.....	1 059 286	1 157 850	7 50
24	...	D-C.	185	0.130	1 008 517	1 155 687	7 50
48	...	D-C.	725	0.066	1 008 520	1 155 688	7 50
125	...	D-C.	4430	0.028	1 008 524	1 155 689	7 50
250	...	D-C.	4430	0.028	1 008 524	1 155 690	7 50
115	...	50 & 60	185	0.087	1 008 517	1 155 693	7 50
230	...	50 & 60	725	0.044	1 008 520	1 155 694	7 50
460	...	50 & 60	2770	0.022	1 008 523	1 155 695	7 50
OPEN TYPE †							
2 contact with stationary reversible contacts							
...	1	D-C.	2.5	.....	1 059 282	1 157 852	5 00
...	3	D-C.	0.33	.....	1 059 284	1 157 853	5 00
...	5	D-C.	0.1	.....	1 059 286	1 157 854	5 00
24	...	D-C.	185	0.130	1 008 517	1 059 231	5 00
48	...	D-C.	725	0.066	1 008 520	1 008 534	5 00
125	...	D-C.	4430	0.028	1 008 524	1 008 535	5 00
250	...	D-C.	4430	0.028	1 008 524	1 008 536	5 00
115	...	50 & 60	185	0.087	1 008 517	1 008 539	5 00
230	...	50 & 60	725	0.044	1 008 520	1 008 540	5 00
460	...	50 & 60	2770	0.022	1 008 523	1 008 541	5 00

* 25 cycle relays can be supplied. Specify, "similar to style number ..... (give 60 cycle style) except 25 cycle." Add 10% to price of 60 cycle relay SG relays can be supplied for other A-C. voltages up to 575 A-C. or 600 D-C. and with D-C. current coils not over 5 amperes. Refer to nearest Westinghouse Sales Office for prices.

For SG relays having glass front add $0.25 to the list price of the standard style. When ordering, give "similar to style number..... except with molded cover having glass front." The nameplate furnished with this relay will have the standard style number.

† Open type relays can be obtained at no additional price with 2 make and 2 break contacts having moving contact common. When ordering, give "similar to style number.....except with 2 make, 2 break contacts."

SG RELAYS CAN BE FURNISHED FOR VOLTAGES OTHER THAN THOSE LISTED ABOVE AT AN ADDITIONAL PRICE.

SHEET METAL CABINETS

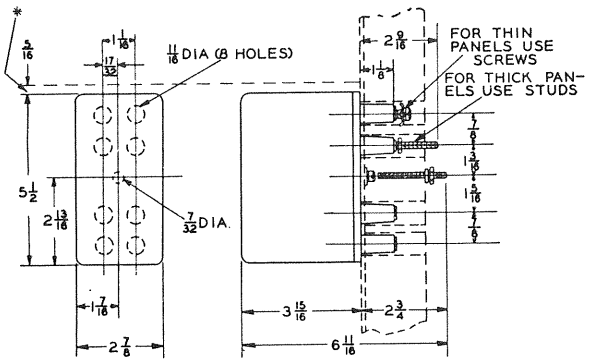
Two sizes of sheet metal cabinets for mounting the open-type SG relays can be supplied for industrial applications, etc. where it is desired to enclose one or two relays for conduit wiring or where it is desired to mount the relays near the machine. Both cabinets have knockouts for conduit connections.

LIST PRICES

No. of Relays to be Mounted in One Cabinet	Dimensions in Inches Width	Height	Depth	Style No.	List Price Discount Symbol FC
1	4⅛	5⅞	4⅛	1 095 760	$0 90
2	8⅛	5⅞	4⅛	1 095 759	1 35

Order by Style Number

OUTLINE DIMENSIONS IN INCHES



* If relay is mounted under another device extending approximately same distance from panel, allow 5/16" minimum spacing to permit removal of cover.

FIG. 3—OUTLINE AND DRILLING PLAN FOR THE CLOSED TYPE SG AUXILIARY RELAY.

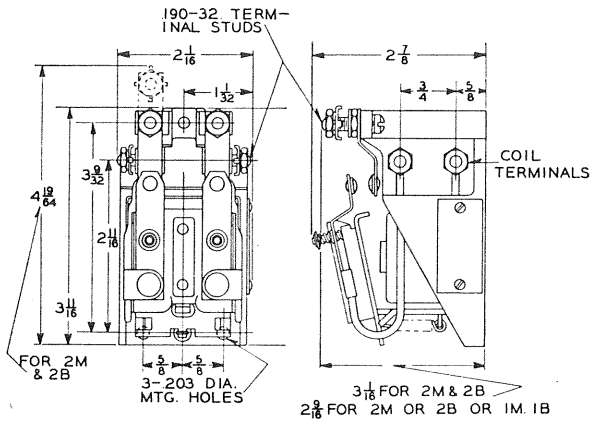


FIG. 4—OUTLINE AND DRILLING PLAN FOR THE OPEN TYPE SG AUXILIARY RELAY

WIRING DIAGRAMS

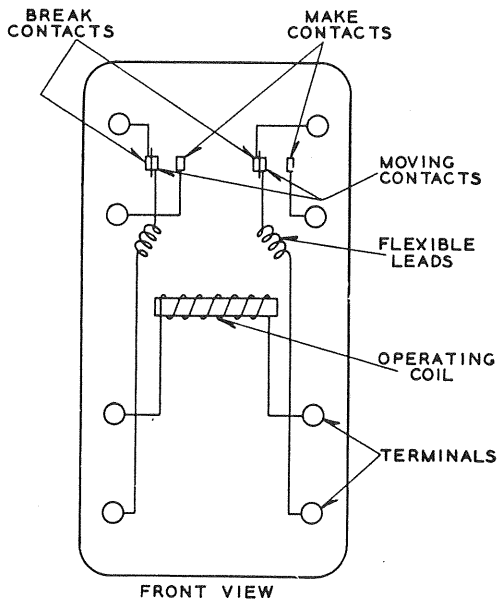


FIG. 5—INTERNAL CONNECTIONS FOR CLOSED TYPE SG RELAY.

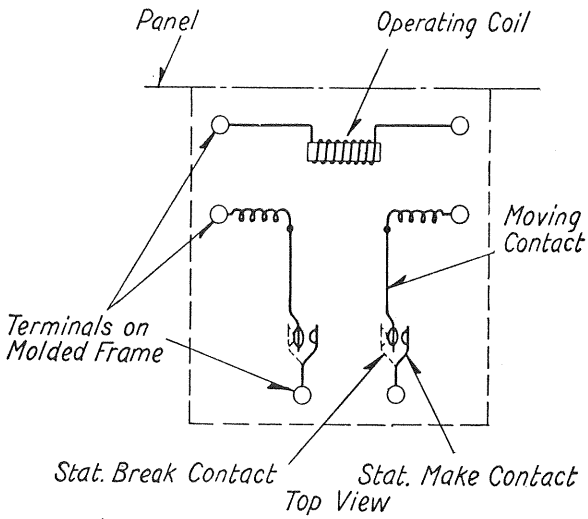


FIG. 6—INTERNAL CONNECTIONS FOR OPEN TYPE SG RELAY

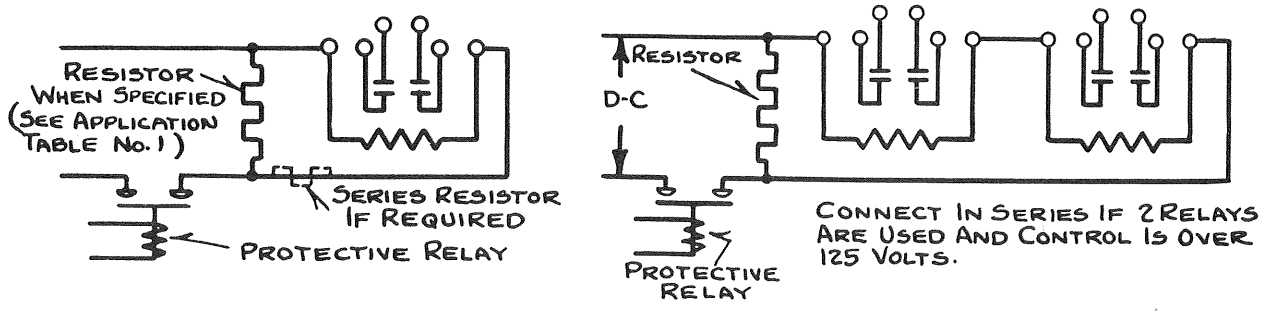


FIG. 7—EXTERNAL CONNECTIONS FOR THE OPEN TYPE SG RELAYS. THE CONNECTIONS WOULD BE SIMILAR FOR THE CLOSED TYPE RELAY EXCEPT THAT FOUR EXTERNAL CIRCUITS CAN BE CONTROLLED.

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TYPE SG AUXILIARY RELAYS

Non-Reversible Contact Relays

Volts	Cycles	Switchboard Mounting			Panel Mounting		
		2 Make Contact Relay	1 Make 1 Break Contact Relay	2 Break Contact Relay	2 Make Contact Relay	1 Make 1 Break Contact Relay	2 Break Contact Relay
		Style Number	Style Number	Style Number	Style Number	Style Number	Style Number
48	DC	837 257	877 717	930 432	837 264	877 724	930 439
125	DC	837 255	877 715	930 430	837 262	877 722	930 437
250	DC	877 034	930 444	930 446	837 035	930 445	930 447
115	25	837 256	877 716	930 431	837 263	877 723	930 438
230	25	837 259	877 719	930 434	837 266	877 726	930 441
115	50 & 60	837 258	877 718	930 433	837 265	877 725	930 440
230	50 & 60	837 261	877 721	930 436	837 268	877 728	930 443
460	50 & 60	837 260	877 720	930 435	837 267	877 727	930 442

NOTE: Switchboard mounting relays may be supplied with or without glass cover. If glass cover is desired it should be clearly specified on the order. Otherwise all new relays will be supplied with solid moulded covers.

When desired, the 2-make contact switchboard type can be changed to 1 make-1 break. The set of parts for the 1-break contact, switchboard type only, is covered by S#930448.

When desired, the 2-make contact panel type can be changed to 1 make-1 break. The set of parts for the 1-break contact, panel type only is covered by S#930449.

When desired, the panel type only can be changed to single pole, double throw or double pole, double throw contacts. The set of parts for single pole, double throw combination of contacts, panel type only, is covered by S#930450.

Reversible Contact Relays

Volts	Cycles	Switchboard Mounting	Panel Mounting
		Style Number	Style Number
48	DC	1 008 526	1 008 534
125	DC	1 008 527	1 008 535
250	DC	1 008 528	1 008 536
115	25	1 008 529	1 008 537
230	25	1 008 530	1 008 538
115	50 & 60	1 008 531	1 008 539
230	50 & 60	1 008 532	1 008 540
460	50 & 60	1 008 533	1 008 541

NOTE: Switchboard mounting relays may be supplied with or without glass cover. If glass cover is desired, it should be clearly specified on the order. Otherwise all new relays will be supplied with solid moulded covers.

For Prices refer to Price List 120

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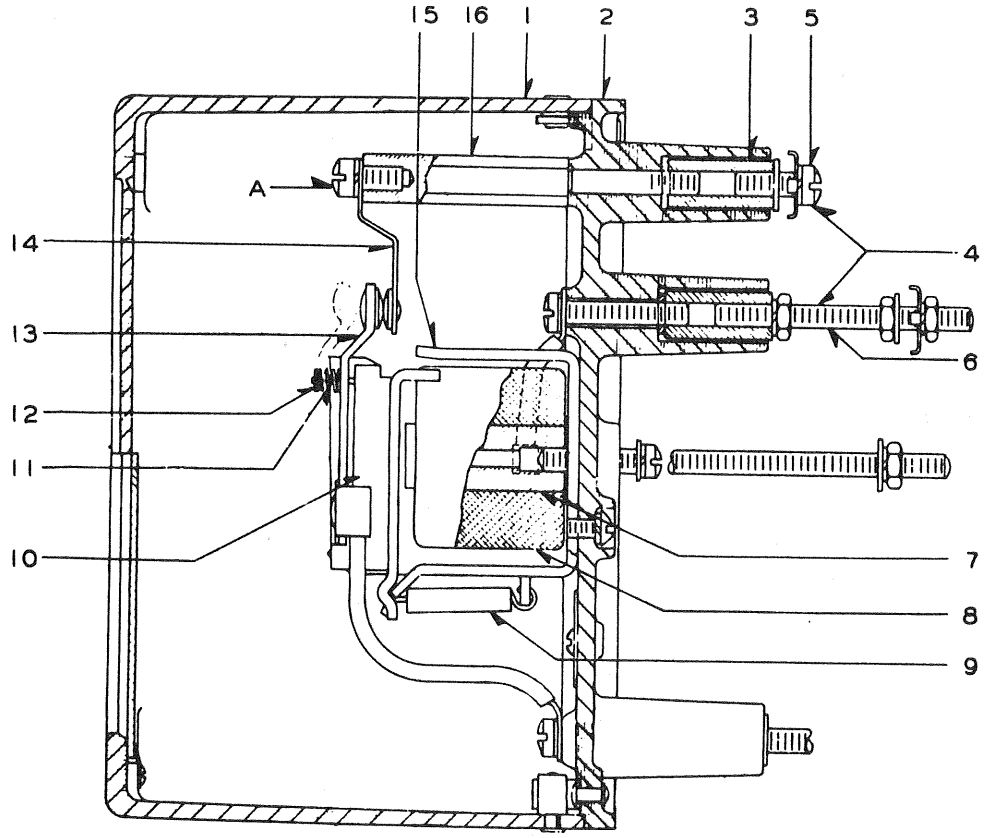
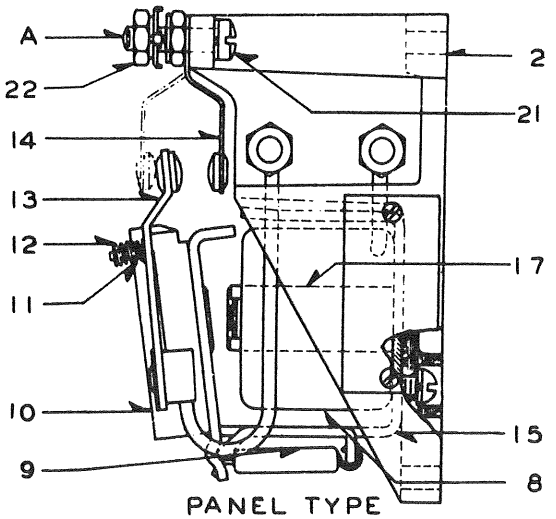
TYPE SG AUXILIARY RELAYS

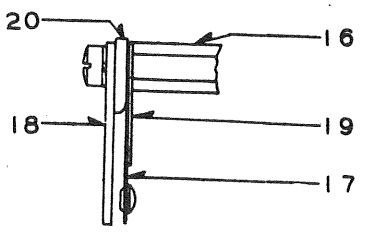
Non-Reversible Contact Relays



SWITCHBOARD TYPE



PANEL TYPE



VIEW-A

TWO BREAK CONTACTS

TYPE SG AUXILIARY RELAYS

Non-Reversible Contact Relays

Ref No.	DESCRIPTION OF PART	Style Number	No. Req
1	Cover, moulded solid, switchboard	876 718	1
1	Cover, moulded with glass front, switchboard.	876 270	1
2	Base, moulded, switchboard type	878 637	1
2	Base, moulded, panel type	821 999	1
3	Terminal nut, switchboard type	821 998	6
4	Mounting details, switchboard type	839 114	1
5	Terminal stud.	797 078	6
6	Mounting stud.	837 330	2
7	Core complete, a-c. only.	762 981	1
7	Core complete, d-c. only.	838 286	1
8	Coil, 48 volt, d-c., 115 volt, 25 cycle.	837 270	1
8	Coil, 125 and 250 volts, d-c., 460 volts, 50 and 60 cycle	837 269	1
8	Coil, 230 volts, 25 cycle	837 273	1
8	Coil, 115 volt, 50 and 60 cycle.	837 272	1
8	Coil, 230 volt, 50 and 60 cycle.	837 275	1
9	Spring for armature, 2 make.	837 967	1
9	Spring for armature, 1 make, 1 break, 2 break.	876 778	1
10	Armature block complete	837 931	1
11	Spring for contact finger	837 968	2
12	Spring cap	975 418	1
13	Contact finger and lead, left hand.	838 253	1
13	Contact finger and lead, right hand	838 255	1
14	Stationary contact support and contact, 2 make	836 175	2
14	Stationary contact support and contact, 1 make, 1 break	836 175	1
15	Yoke	668 593	1
*	Washer under yoke, a-c. only	935 765	1
16	Post, switchboard type, 2 make	836 176	2
16	Post, switchboard type, 1 make, 1 break	836 176	1
16	Post, switchboard type, 1 make, 1 break	837 991	1
16	Post, switchboard type, 2 break	837 991	2
17	Stationary contact spring and contact, 1 make, 1 break	930 303	1
17	Stationary contact spring and contact, 2 break.	930 303	2
18	Stop, 1 make 1 break.	837 989	1
18	Stop, 2 break	837 989	2
19	Stationary contact support, 1 make, 1 break	838 632	1
19	Stationary contact support, 2 break	838 632	2
20	Back plate, 1 make, 1 break	837 990	1
20	Back plate, 2 break	837 990	2
21†	Fillister head brass machine screw, ".190-32 x 7/8", for mounting stationary contact, panel type only	Std Hdw	2
22†	Hexagon brass machine screw nut for above screw	Std Hdw	2
*	External resistor, 250 volt, d-c. only	879 978	1
*	Resistor mounting details, 250 volt, d-c. only	877 339	1

* Not Illustrated

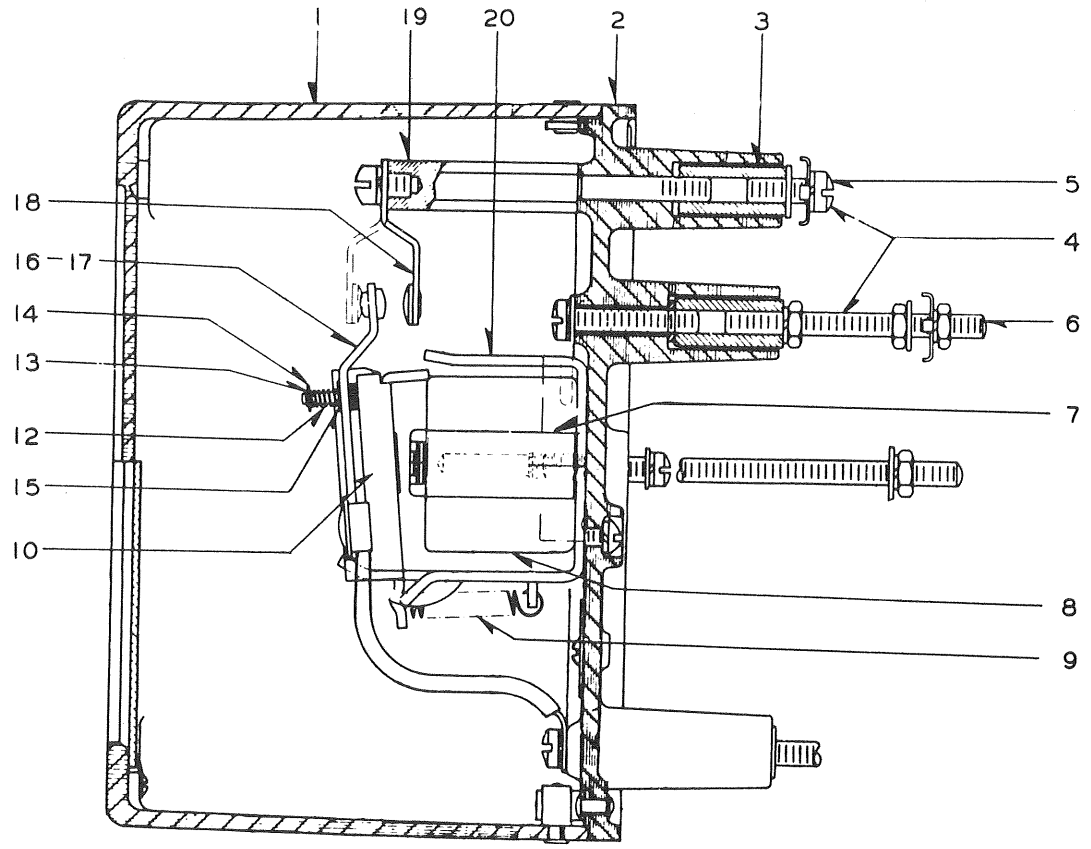
Order Parts by Style Number and Description

† When ordering, specify "Plus nickel finish"

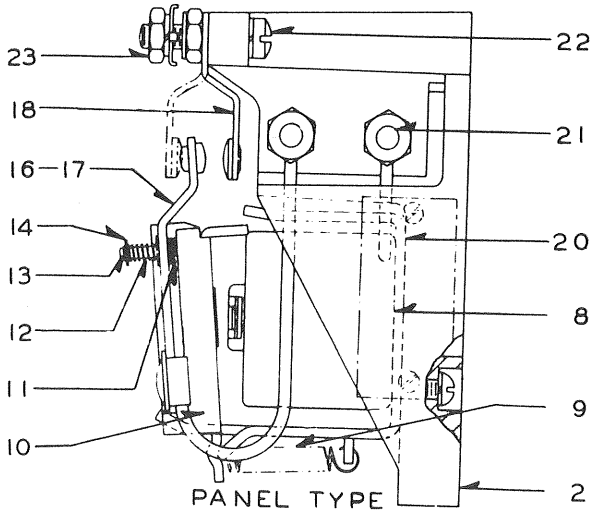
Parts indented are included in the Part under which they are indented

TYPE SG AUXILIARY RELAYS

Reversible Contact Relays



SWITCHBOARD TYPE



PANEL TYPE

TYPE SG AUXILIARY RELAYS

Reversible Contact Relays

Ref No.	DESCRIPTION OF PART	Style Number	No. Req
1	Cover, moulded solid, switchboard	876 718	1
1	Cover, moulded with glass front, switchboard.	876 270	1
2	Base, moulded, switchboard type	878 637	1
2	Base, moulded, panel type	821 999	1
3	Nut, for terminal screw, switchboard type	821 998	6
4	Mounting details, panel type	1 008 226	1
4	Mounting details, switchboard type	839 114	1
5	Terminal stud.	797 078	6
6	Mounting stud.	837 330	2
7	Core, d-c.	1 008 224	1
7	Core, a-c.	1 008 225	1
*	Washer, under core, a-c. only.	935 765	1
8	Coil, 48 volts, d-c., 230 volts, 50 and 60 cycles	1 008 520	1
8	Coil, 125 and 250 volts d-c.	1 008 524	1
8	Coil, 115 volt, 25 cycle.	1 008 519	1
8	Coil, 230 volt, 25 cycle.	1 008 522	1
8	Coil, 115 volt, 50 and 60 cycle.	1 008 517	1
8	Coil, 460 volt, 50 and 60 cycle.	1 008 523	1
9	Spring for armature	1 000 998	1
10	Armature block complete.	1 008 712	1
11	Lower contact spring.	1 001 025	2
12	Upper contact spring.	1 000 826	2
13	Washer for upper contact spring.	1 001 009	2
14	Cup washer for upper contact spring.	1 000 824	2
15	Bushing under upper contact spring.	1 008 223	2
16	Lead and contact, left hand	1 008 709	1
17	Lead and contact, right hand	1 008 710	1
18	Stationary contact complete	1 008 711	2
19	Post for mounting stationary contact, switchboard type	836 176	2
20	Yoke	668 593	1
21	Terminal screw, panel type.	837 321	4
22†	Fillister head brass machine screw, ".190-32 x 7/8" for mounting stationary contact, panel type only	Std Hdw	2
23†	Hexagon brass machine screw nut for above screw	Std Hdw	2
*	External resistor, 250 volts, d-c. only.	1 008 714	1
*	Resistor mounting details, 250 volt, d-c. only	877 339	1

* Not Illustrated

Order Parts by Style Number and Description

† When ordering, specify "Plus nickel finish"

Parts indented are included in the Part under which they are indented

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°PEORIA, ILL., 104 E. State St.
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°ROANOKE, VA., 726 First St., S.E.
°ROCHESTER, N. Y., 1048 University Ave.
°ROCKFORD, ILL., 130 South Second St.
°SACRAMENTO, CALIF., Twentieth & "R" Sts.
°ST. LOUIS, MO., 411 North Seventh St.
†ǂST. LOUIS, MO., 717 South Twelfth St.
§°SALT LAKE CITY, UTAH, 10 West First South St.
†ǂSALT LAKE CITY, UTAH, 346 A Pierpont Ave.
°SAN ANTONIO, TEXAS, 115 W. Travis St.
°SAN DIEGO, CALIF., 861 6th Ave.
§SAN FRANCISCO, CALIF., 1355 Market St.
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°SEATTLE, WASH., 603 Stewart St.
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§SEATTLE, WASH., 1041 First Ave., South
xSHARON, PA., 469 Sharpsville Ave.
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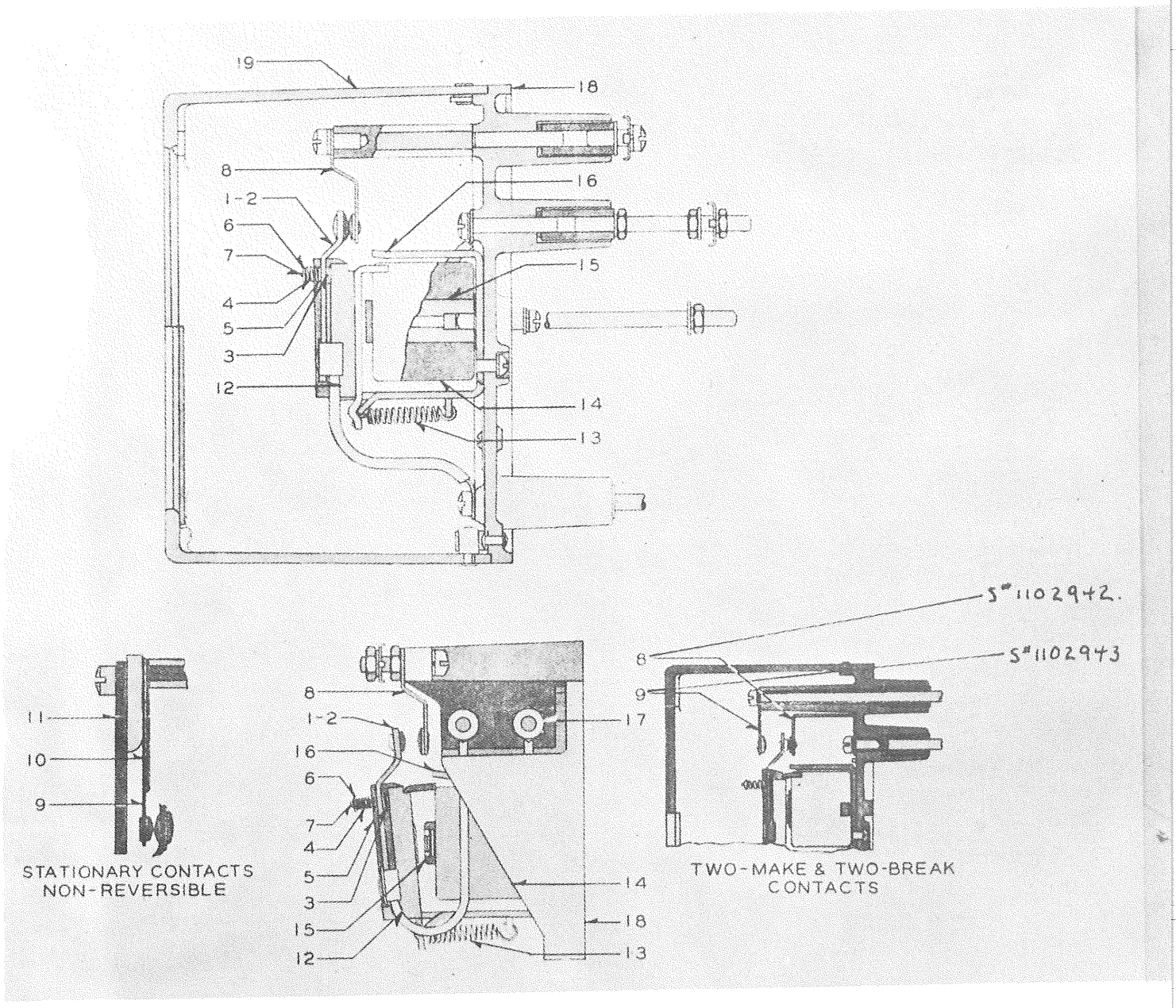
October, 1940

TYPE SG AUXILIARY RELAY

Closed or Open



Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

Westinghouse Press
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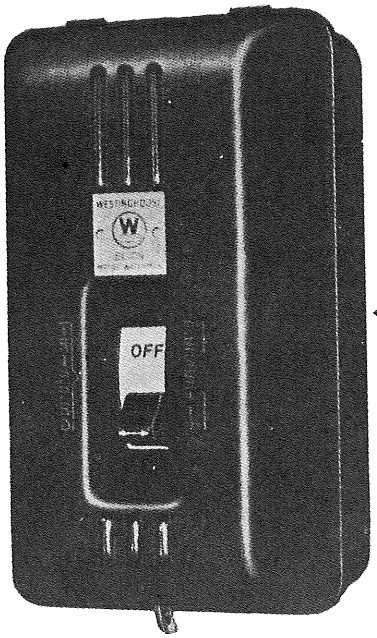
EVERY HOUSE NEEDS WESTINGHOUSE

NEW

TYPE DnW "DE-ION" MOTOR WATCHMAN

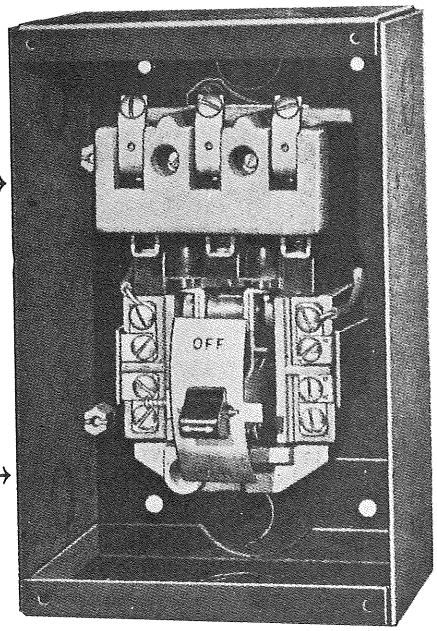
Manual Motor Starter for A-C. Motors

1 and 3 Phase — 1/6 to 7½ Hp. — 110 to 600 Volts



Indicating Handle

FIG. 1—TYPE DnW "DE-ION" MOTOR WATCHMAN IN STANDARD SURFACE ENCLOSURE



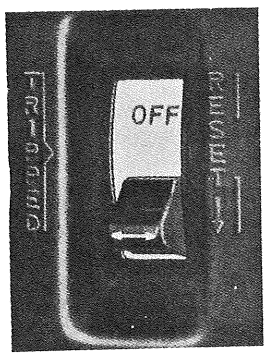
"De-Ion" Arc Quenchers

Bi-metallic Dixc Overload

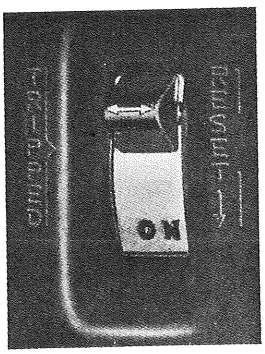
FIG. 2—SIZE 1 TYPE DnW "DE-ION" MOTOR WATCHMAN IN FLUSH ENCLOSURE WITH COVER REMOVED

DISTINCTIVE FEATURES

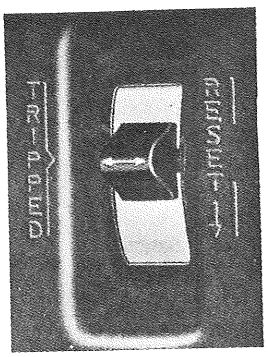
- "DE-ION" ARC QUENCHERS most effectively open circuit and save contacts from burning.
- QUICK-MAKE AND QUICK-BREAK TRIP-FREE toggle operating mechanism.
- POSITIVE INDICATION of all switch positions (On, Off, Tripped).
- BI-METALLIC DISC TYPE overload relay provides inverse time limit motor protection.
- NON-CARBONIZING, NON-WARPING, moisture-proof arc boxes and relays.
- SAFETY INTERLOCK prevents contact with live parts.
- DOUBLE BREAK silver to silver contacts eliminate necessity for flexible shunts.
- STRAIGHT THROUGH WIRING and easily accessible terminals.



OFF



ON



TRIPPED

FIG. 3—THE HANDLE INDICATES

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TYPE DnW "DE-ION" MOTOR WATCHMAN—Continued

DISTINCTIVE FEATURES

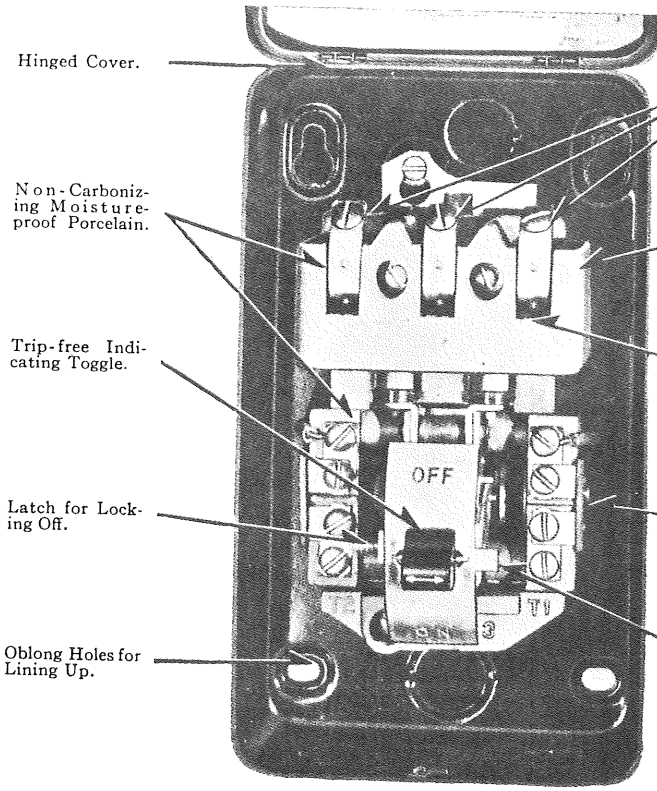
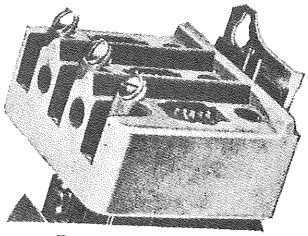
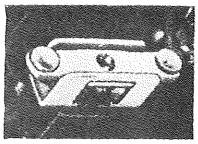


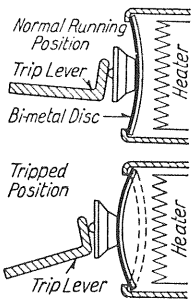
FIG. 4—"DE-ION" MOTOR WATCHMAN CLASS 10-100-SOA WITH HEATERS IN PLACE; SHOWING GENEROUS WIRING SPACE



"DE-ION" ARC QUENCHER



SIZE O MOVING CONTACT



HOW BI-METAL DISC RELAY WORKS

APPLICATION

The "De-ion" Motor Watchman is a manually operated motor starter, designed for starting, stopping and protecting small single phase and polyphase A-C. motors driving looms, fans, pumps, machine tools, food machinery and many other industrial applications. It may also be used for small D-C. motors which may be started directly across the line.

110 to 600 Volts — Ratings and Nomenclature. — 25 to 60 Cycles

MAXIMUM HORSEPOWER					CLASS NUMBER				
3 PHASE			1 PHASE						
110 Volts	208-220 Volts	440-600 Volts	110 Volts	208-220 Volts	Standard Sheet Steel Enclosure NEMA Type I	Flush Type Steel Enclosure NEMA Type Ib	Water-Tight Dust-Tight Cast Iron Enclosure NEMA Types III IV, V	For Hazardous Locations Class I Group D, Class II Group G NEMA Types VIII, IX	Switch Unit Without Enclosure
1½	2	2	1	1½	10-100-SO	10-100-PO	10-100-WO	10-100-UO	10-100.O
1½	2	2	1	1½	*10-100-SOA	.....	.....	.....	.....
3	5	7½	1½	3	10-100-S1	10-100-P1	10-100-W1	10-100-U1	10-100.1

* Especially designed for loom motor service, a Size O switch in a Size 1 box.

TYPE DnW "DE-ION" MOTOR WATCHMAN—Continued

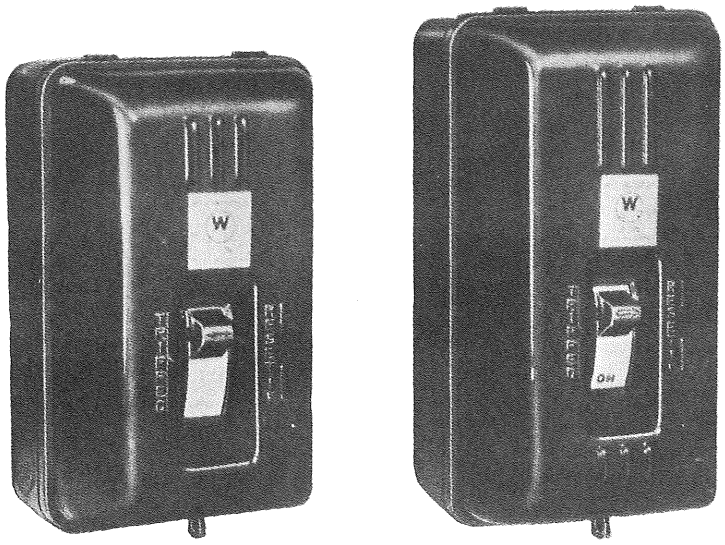


FIG. 5—SIZES 0 AND 1 "DE-ION" MOTOR WATCHMAN STARTERS IN STANDARD SURFACE ENCLOSURES

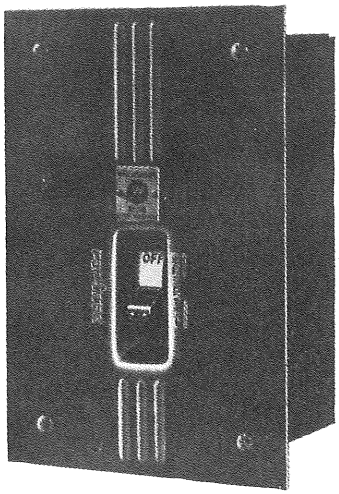


FIG. 6—FLUSH TYPE ENCLOSURE

● OPERATION

These starters are operated by means of a positive toggle mechanism that is:

1. Quick-make and quick-break.
2. Trip free on overload.
3. Indicating of all switch positions (on, off, tripped).
4. Capable of rapid and accurate inching operation.

● CONSTRUCTION

The switch unit is assembled on a rigid steel base. The toggle mechanism operates the moving contact assembly vertically, and is so easy yet positive in operation that rapid inching and accurate control of the machine is possible. The stationary contacts and the "De-ion" grids of the arc quencher are mounted in porcelain arc boxes. All contacts are steel-backed silver buttons. Double break silver contacts—plus the "De-ion" arc quenchers—assure minimum contact burning, and eliminate the necessity for flexible shunts. Size 0 and Size 1 starters are similar except that the moving contact assembly of Size 1 starters has a magnetic loop (like Class 11-200-S1 **LINESTARTERS**) to accelerate the movement of the arc into the "De-ion" grids. This also requires a different arc box.

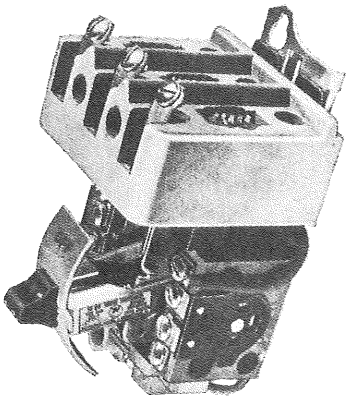


FIG. 7—SWITCH UNIT REMOVED FROM ENCLOSURE; HEATER IN PLACE

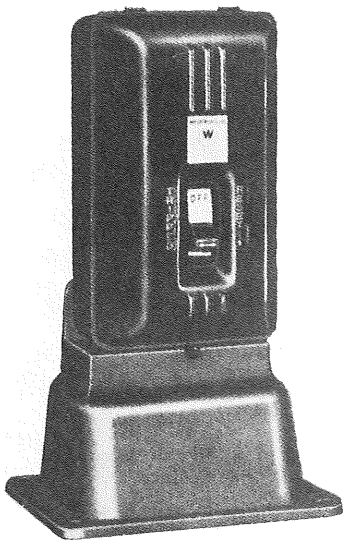


FIG. 8—"DE-ION" MOTOR WATCHMAN ON PEDESTAL

Overload protection is provided by two pre-formed **bi-metallic** disc relays, which operate independently with inverse time limit characteristics. These relays allow ample time in starting and for short peak loads, yet accurately protect the motor. The discs are heated by heaters in the motor circuit. When an overload causes the disc to reach tripping temperature, it snaps from concave to convex form and trips a latch on the toggle mechanism, opening the switch.

The discs reset themselves when cooled, but the switch mechanism must be "reset" by moving the handle to the extreme "off" position, before the switch may be closed again. The handle cannot be held closed on overload.

The heaters are the same as those used on Size 0 and Size 1 magnetic **LINESTARTERS**; a great convenience when stocking or changing heaters.

Arc boxes and relays are moulded of grey porcelain which will neither absorb moisture, warp nor carbonize. All metal parts are cadmium plated or tinned to resist corrosion.

The switch unit mounts in any enclosure by only one screw at the top of the base. The lower end of the base is hooked into place over a projection in the back of the cabinet.

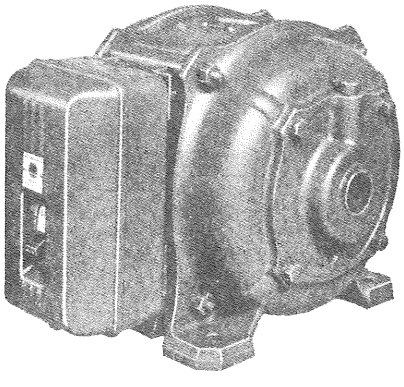


FIG. 9—"DE-ION" MOTOR WATCHMAN MOUNTED ON LOOM MOTOR

TYPE DnW "DE-ION" MOTOR WATCHMAN—Continued

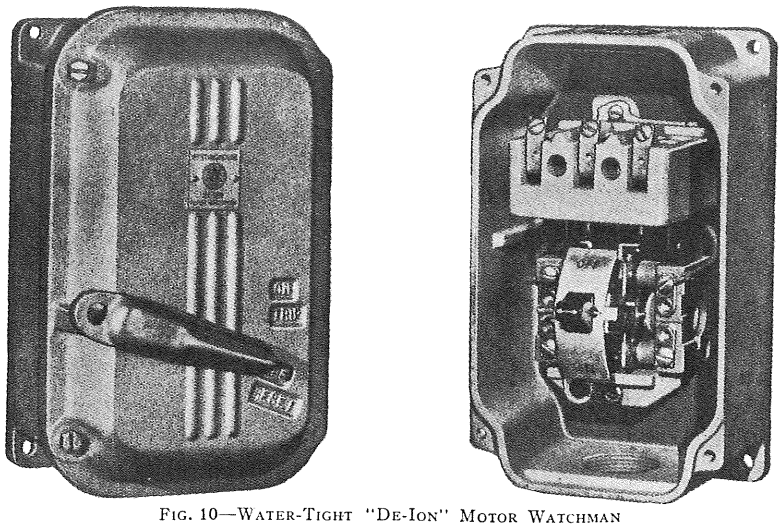


FIG. 10—WATER-TIGHT "DE-ION" MOTOR WATCHMAN

●ENCLOSURES

Standard steel enclosures (Type S, Fig. 5) have deep drawn covers, hinged at the top. The operating handle is recessed in the front of the cover, eliminating projecting pieces, and permitting close mounting in group installations. Keyhole mounting holes at the top and oblong holes at bottom of cabinet make mounting and lining up easy. Ample knockouts for conduit are provided in top, bottom and both sides; and in addition the Size OA and Size 1 switches have two knockouts in the back.

The cover is interlocked for safety so that it cannot be opened unless the switch is in the "off" position. A spring latch holds the cover closed, and only one padlock is needed to lock both the switch off and the cover closed. A small latch on the switch unit may be swung into position and then the cover locked shut. Finish is baked black enamel.

Flush enclosures (Type P, Fig. 6) for mounting in a plastered wall, or in a recess in a machine casting, consist of a wide flanged flush plate and a folded steel box with an adjustable mounting plate for accurately lining up the switch unit. The box has knockouts in all four sides and is finished baked black enamel. The flush cover is finished in gray lacquer.

Water-tight and dust-tight (Type W, Fig. 10) enclosures are cast iron with tapped conduit holes and with a rubber gasket between cover and box. The switch is operated by a handle on the front which is arranged for padlocking in the "off" position. Finish is weather-resisting aluminum paint and all hardware is corrosion resisting copper-alloy.

Explosion-protecting (Type U, Fig. 13) enclosures are cast-iron designed in accordance with the specifications of the Underwriters' Laboratories for Class I, Group D; Class II, Group G; or Class III or IV Hazardous Locations. Finish is weather-resisting aluminum paint, and all hardware is corrosion-resisting copper alloy.

For Textile Loom service special mountings are available either on the side or top of the special loom motor (Fig. 9) or on pedestals (Fig. 8) which are designed for floor mounting over a junction box.

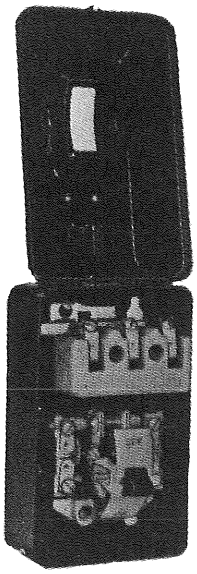


FIG. 11—SIZE O "DE-ION" MOTOR WATCHMAN

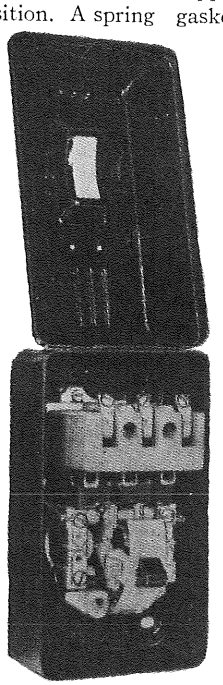
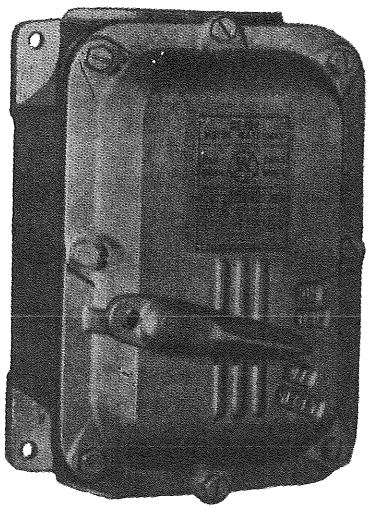


FIG. 12—SIZE 1 "DE-ION" MOTOR WATCHMAN



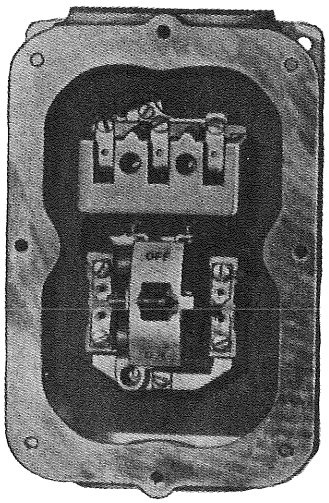


FIG. 13—"DE-ION" WATCHMAN FOR CLASS I GROUP D AND CLASS II GROUP G HAZARDOUS LOCATIONS

TYPE MW MOTOR WATCHMAN THERMAL OVERLOAD RELAY INSTRUCTIONS

Application

The type MW Thermal Overload Relay employs an electrically heated bimetallic disc to open a pair of contacts in the coil circuit of a contactor for the disconnection of power on the occurrence of an overload. Heating of the disc is accomplished by a heating element connected directly in the circuit to be protected. With a proper choice of heaters, the relay may be used on a-c. or d-c. circuits of from .49 to 40 amperes at not more than 600 volts. The contacts will carry and break coil currents up to 1 ampere in an a-c. circuit and 50 volt-amperes at a maximum of 1 ampere in a d-c. circuit.

The relay will provide protection against abnormal load conditions to current values exceeding locked rotor current. In accordance with the National Electric Code the relay should be protected against short circuits by fuses rated at not more than four times the rated motor current, by a time limit circuit breaker set at not more than four times the rated motor current or by an instantaneous trip circuit breaker.

Construction and Operation

The thermostatic element is a bi-metallic disc which suddenly reverses its convexity when it is heated to a given temperature. This acts to separate the double-break silver-plated contacts, and initiates the movement of a reset rod which latches the relay contacts in this position until manually reset. After the disc has cooled sufficiently to resume its normal convexity, resetting may be accomplished by depressing the reset rod.

Under normal operating conditions the reset rod may be used as a spring-returned stop button, separating the relay contacts when fully depressed.

In case automatic resetting of the relay is desired it is necessary only to remove the reset rod. This is accomplished by deflecting the contact spring until clearance is provided for withdrawing the rod.

The time required for the relay to trip depends upon the size of the overload, the greater the overload the shorter being the time to trip. This is indicated in the Time Characteristic Curve, Fig. 3, of a relay operating in a 40°C. ambient temperature. The curve applies in general when the relay is operated in any ambient temperature as long as the currents are expressed in percentages of the heater rating at that ambient temperature.

The performance of the relay is such that it will allow motor starting currents to flow during the starting period, but will trip when subjected to smaller but long-continued overloads. A short time must elapse before the relay can be reset.

Installation and Maintenance

The Heater, with its mounting screws, is supplied separately, and is to be mounted as indicated in Fig. 1. Con-

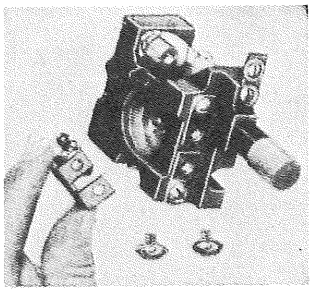


FIG. 1—THERMAL OVERLOAD RELAY SHOWING HOW HEATER IS INSTALLED

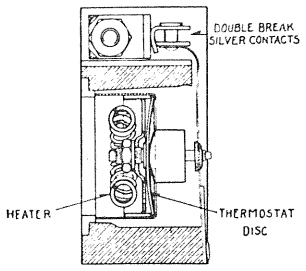


FIG. 2—SECTIONAL VIEW TYPE MW OVERLOAD RELAY WITH RESET ROD REMOVED

tact surfaces must be clean and all connections tight. Periodic inspection is recommended.

No oiling of relay parts is required.

Heaters

Each heater is identified by a code marking stamped on one terminal near the mounting hole. The Heater Application Table indicates the range of full load motor current to which a given heater may be applied. This range is so selected that the current to produce ultimate tripping of the relay will be approximately 115% to 125% of the rated motor current.

The current rating of the relay (see Table No. 1) is based on an ambient temperature of 40°C. Standard motor ratings are also based on an ambient temperature of 40°C. For protection of the motor when it and the relay are operated in a common ambient temperature, heaters should be applied according to Heater Table No. 1 for average applications.

Confining the relay in a small space, such as a starter cabinet, with other apparatus which dissipates heat will raise its ambient temperature, affecting thereby its tripping value. Heater Table No. 2 is for use when the temperature of the air within the cabinet and immediately surrounding the relay is 15°C. above the ambient temperature in which the motor is applied. Heater Table No. 3 is to be used when this temperature difference is 30°C.

Renewal Parts

Type MW Overload Relay Complete S# 972879
Reset push rod ..... S# 899862
Push rod coil spring ..... S# 899855

HEATER APPLICATION TABLE

Heater* Style Number	Heater Code Marking	Full Load Current of Motor — Table No. 1 Relay Ambient Same as Motor Ambient	Table No. 2 Relay Ambient 15° C. Above Motor Ambient	Table No. 3 Relay Ambient 30° C. Above Motor Ambient
1 129 372	X .49	0.50 to 0.54	0.44 to 0.49	0.39 to 0.43
1 129 373	Y .55	0.55 to 0.62	0.50 to 0.54	0.44 to 0.49
1 129 374	Z .63	0.63 to 0.71	0.55 to 0.62	0.50 to 0.54
966 465-B	AA .71	0.72 to 0.79	0.63 to 0.71	0.55 to 0.62
966 466-B	AB .82	0.80 to 0.89	0.72 to 0.79	0.63 to 0.71
966 467-B	AC .93	0.90 to 0.99	0.80 to 0.89	0.72 to 0.79
966 468-B	AD 1.0	1.00 to 1.04	0.90 to 0.99	0.80 to 0.89
966 469-B	AE 1.1	1.05 to 1.18	1.00 to 1.04	0.90 to 0.99
966 470-B	AF 1.2	1.19 to 1.32	1.05 to 1.18	1.00 to 1.04
966 471-B	AG 1.4	1.33 to 1.49	1.19 to 1.32	1.05 to 1.18
966 472-B	AH 1.5	1.50 to 1.71	1.33 to 1.49	1.19 to 1.32
966 473-B	AI 1.7	1.72 to 1.89	1.50 to 1.71	1.33 to 1.49
966 474-B	AK 1.9	1.90 to 2.09	1.72 to 1.89	1.50 to 1.71
966 475-B	AL 2.1	2.10 to 2.35	1.90 to 2.09	1.72 to 1.89
966 476-B	AM 2.5	2.36 to 2.65	2.10 to 2.35	1.90 to 2.09
966 477-B	AN 2.7	2.66 to 2.98	2.36 to 2.65	2.10 to 2.35
966 478-C	AO 3.0	2.99 to 3.35	2.66 to 2.98	2.36 to 2.65
966 479-C	AP 3.4	3.36 to 3.75	2.99 to 3.35	2.66 to 2.98
966 480-C	AR 3.8	3.76 to 4.21	3.36 to 3.75	2.99 to 3.35
966 481-B	AS 4.3	4.22 to 4.71	3.76 to 4.21	3.36 to 3.75
966 482-C	AT 4.8	4.72 to 5.33	4.22 to 4.71	3.76 to 4.21
966 483-C	AU 5.4	5.34 to 5.94	4.72 to 5.33	4.22 to 4.71
966 484-C	AW 6.1	5.95 to 6.63	5.34 to 5.94	4.72 to 5.33
966 485-C	AX 6.8	6.64 to 7.52	5.95 to 6.63	5.34 to 5.94
966 486-C	AY 7.7	7.53 to 8.51	6.64 to 7.52	5.95 to 6.63
966 487-B	AZ 8.5	8.52 to 9.31	7.53 to 8.51	6.64 to 7.52
966 488-C	BA 9.6	9.32 to 10.5	8.52 to 9.31	7.53 to 8.51
966 489-B	BB 11.	10.6 to 11.5	9.32 to 10.5	8.52 to 9.31
966 490-B	BC 12.	11.6 to 12.4	10.6 to 11.5	9.32 to 10.5
966 491-B	BD 13.	12.5 to 13.4	11.6 to 12.4	10.6 to 11.5
966 492-C	BE 14.	13.5 to 14.9	12.5 to 13.4	11.6 to 12.4
966 493-D	BF 16.	15.0 to 17.5	13.5 to 14.9	12.5 to 13.4
966 494-C	BG 18.	17.6 to 18.2	15.0 to 17.5	13.5 to 14.9
966 495-C	BH 19.	18.3 to 19.0	17.6 to 18.2	15.0 to 17.5
966 496-C	BI 21.	19.1 to 20.5	18.3 to 19.0	17.6 to 18.2
966 497-D	BK 23.	20.6 to 22.6	19.1 to 20.5	18.3 to 19.0
966 498-D	BL 25.	22.7 to 24.9	20.6 to 22.6	19.1 to 20.5
966 499-C	BM 27.	25.0 to 28.4	22.7 to 24.9	20.6 to 22.6
1 040 588	BN 29.	28.5 to 32.2	25.0 to 28.4	22.7 to 25.0
974 084-A	BO 31.	32.3 to 35.0	28.5 to 32.2	25.0 to 28.4
1 040 589	BR 36.	.....	32.3 to 35.0	28.5 to 32.2
1 040 590	BS 40.	.....	.....	32.3 to 35.0

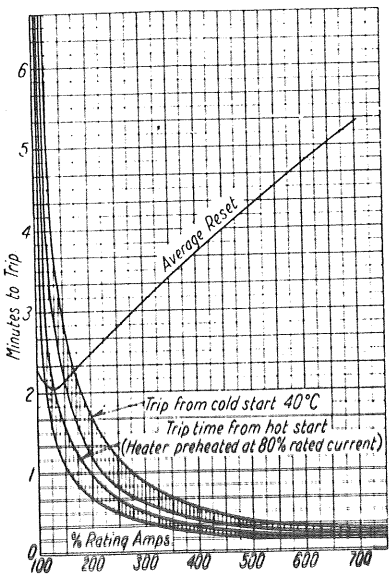


FIG. 3—AVERAGE TIME CURRENT CURVE

* For totally enclosed, splash-proof, drip-proof and all other continuous rated 50° and 55°-motors, use one size smaller Heaters.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

Printed in U.S.A. (Rep. 11-41)

TYPE TK UNIVERSAL TIMING RELAY AND D-C. TO A-C. INVERTER

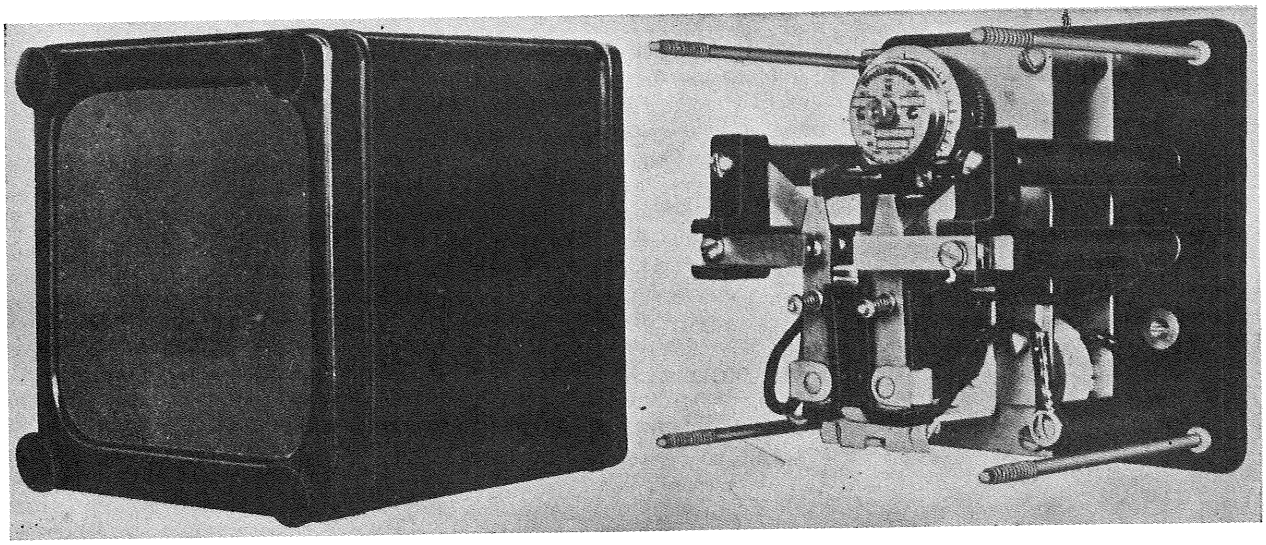


FIG. 1—TYPE TK RELAY WITH COVER REMOVED

Application

The TK relay can be used on a-c. circuits which require a definite time delay between the closing of an a-c. circuit and the closing or opening of other circuits (either a-c. or d-c.) through the relay contacts. Accurate time settings from a few seconds to fifty minutes can be obtained in a single relay. The relay will reset practically instantaneously even with the longest time setting. Two sets of main contacts, one single pole double throw and the other single pole single throw are provided, and these contacts can be adjusted to operate either simultaneously or sequentially.

An unusually wide variation of applications can be handled with the TK relay. The wide time range, quick reset and number of contacts provided will allow a single relay to be applied without modification. Some typical applications are found in automatic control circuits for generators and motors, in connection with the operation of large rectifiers and other thermionic tubes, as a part of the control for voltage regulators, tap-changing transformers, and various forms of industrial control.

Distinctive Features

1. Synchronous motor that will stay "in step" over a very wide fluctuation of voltage. (20% plus or minus motor rating).
2. Quick reset (less than 1 second at the maximum time setting).
3. Large silver contacts capable of carrying 12 amperes continuously. They will open 20 amperes 115 volts a-c. or 15 amperes at 230 volts a-c. non inductive or a circuit carrying 3 amperes at 125 volts d-c.
4. The motor is energized only during the timing interval and since the bearing has sealed-in lubrication, no attention is required and wear is negligible.
5. A new design relay consisting of standard well-known design parts.
6. Time settings from approximately 2 seconds to 50 minutes.

Construction and Operation

The TK relay consists essentially of (1) a synchronous motor (2) a gear train which provides three different ratios (3) a clutch to permit quick resetting when the relay is de-energized (4) tripping mechanism adjustable for time delay and (5) a contactor which carries the main contacts and operates the clutch.

The motor and gear train are mounted between two plates supported by four posts which are in turn fastened to the relay base.

(1) The motor is the same standard design used in some of our other products (relays, meters, etc). It runs at a speed of 600 rpm. and its coil has a low temperature rise. Sleeve bearings, in which a permanent supply of lubrication is placed, are used. The motor pinion is permanently in mesh with the gear train.

(2) The gear train is mounted between the upper portion of the two plates which act as supports for the motor and gear train. The plates are drilled and reamed for the polished gear shafts. These shafts run at low speeds and require no lubrication. The location of a sliding gear assembly on its shaft can be varied to allow it to mesh with different gears or pinions to obtain any one of three speeds. This sliding gear assembly consists of two gears and hub which are free to slide on a shaft but can be locked in any desired position by a set screw. To assist in determining which speed is to be obtained, arrows are placed on the index plate. The sliding gear assembly can be moved to the position where its larger gear is opposite the index plate arrow corresponding to the desired time scale.

The 30 second scale is graduated in sub-divisions to 1 second, and the smallest sub-division on the 5 minute and 50 minute scales is .1 and 1 minute respectively.

(3) The clutch consists of two aluminum discs with serrated faces (resembling crown gears) which are normally separated. The clutch is mounted on the same shaft as the sliding gear assembly. The rear aluminum disc is mounted on this shaft; the front disc has a loose fit on the shaft and has fastened to it the pinion that drives the tripping mechanism. When the relay is energized, the two discs are pressed together by a spring, the serrations on

TYPE TK UNIVERSAL TIMING RELAY—Continued

their faces mesh, and power is transmitted from the motor through the gear train to the tripping mechanism.

(4) The tripping mechanism is fastened to the front plate of the gear train assembly. The armature and clutch spring move in (that is toward the rear of the relay) when energized, but the two moving contacts that the armature carries are prevented from moving by the micarta latch arms. Therefore, the back contact on the left hand side (from the front of the relay) will remain closed until the arms are tripped and the moving fingers released. This same statement also applies to the side of the motor circuit which uses the back contact on the right-hand side of the relay. The tripping is accomplished by a pin on each of the tripping discs pushing down the latch arm levers.

Each of the tripping discs has an index mark on its edge. These marks are located so as to coincide with the zero on the scale plate when the trip pins have reached a point where they will just trip the micarta latch arms and release the contact fingers. Before setting for a predetermined tripping time the gear on the sliding gear assembly should be shifted to the ratio desired. The tripping discs can be rotated so the index is on the desired scale marking by loosening the thumb nut. If sequential operation of the contact fingers is required the left hand contact must trip first as the motor is in series with the back contacts on the right-hand side. When the latter contact is tripped the motor supply becomes open circuited. The minimum setting obtainable without partially raising the latch arm is approximately one small division on the 30 second scale. When the relay is de-energized the clutch is released at once and therefore the tripping mechanism does not have to operate through the gear train. The tripping discs will reset from the maximum travel position in less than one second.

(5) The contactor is of the clapper type. The spring arm, which presses against the front half of the clutch and pushes it into mesh, is fastened to the top of the armature. The sealing-in contact, when used, is operated by an insulating button attached to the same spring arm. The motor and contactor coil are connected together so that as soon as the clutch is operated the motor is also energized. The armature carries the two moving contacts. The moving and stationary contacts are made of chemically pure silver which will carry 12 amperes continuously and 20 amperes for 1 minute. The contacts will interrupt a non-inductive a-c. circuit carrying 20 amperes at 115 volts or 15 amperes at 230 volts. On 230 volts or higher voltages (60 cycles) the contactor coil has a tap brought out at the proper place to act as an auto-transformer to supply 115 volts to the motor.

The TK Relay can be provided with a sealing-in contact which closes when the relay is energized. By properly connecting this contact the relay can be energized and kept energized by momentary closure of an external contact or switch, such as a push button. The supply circuit must then be opened through some other contact or switch in order to de-energize the relay.

Burden at 125 Volts, 60 Cycles

Contactor Burden = 18 Volt-amperes
Motor Burden = 2.6 Volt-amperes

TK RELAY LIST PRICES

Volts	Frequency	Style No. of Relay Without Sealing Contact	List Price Discount Symbol FC	Style No. of Relay With Sealing Contact	List Price Discount Symbol FC
115	25	1 008 930	$40 00	1 008 933	$40 00
230	25	1 008 931	40 00	1 008 934	40 00
460	25	1 008 932	40 00	1 008 935	40 00
115	50	1 008 924	40 00	1 008 927	40 00
230	50	1 008 925	40 00	1 008 928	40 00
460	50	1 008 926	40 00	1 008 929	40 00
115	60	936 926	40 00	1 008 552	40 00
230	60	1 008 550	40 00	1 008 553	40 00
460	60	1 008 551	40 00	1 008 554	40 00

Order by Style Number

TYPE TK UNIVERSAL TIMING RELAY—Continued

WIRING DIAGRAMS

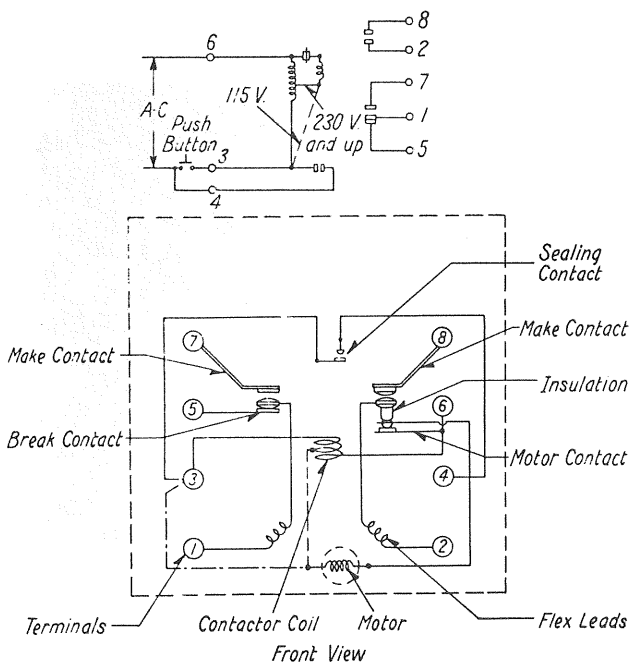


FIG. 2—TK RELAY WITH SEALING CONTACT

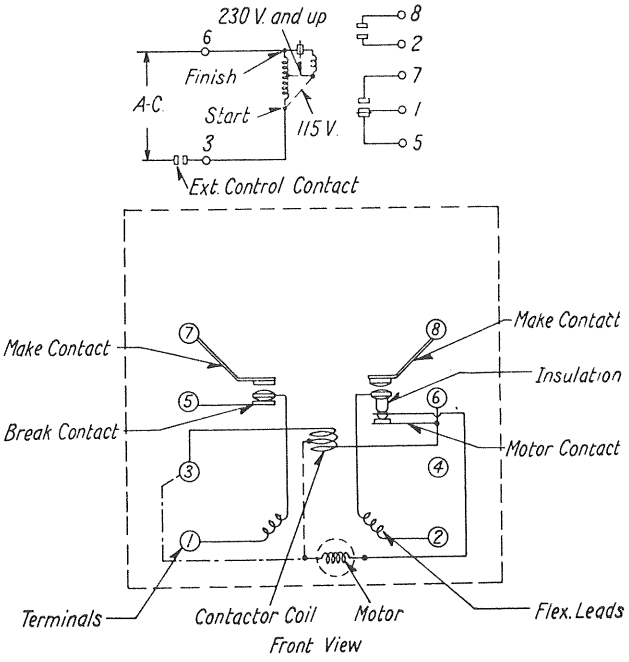
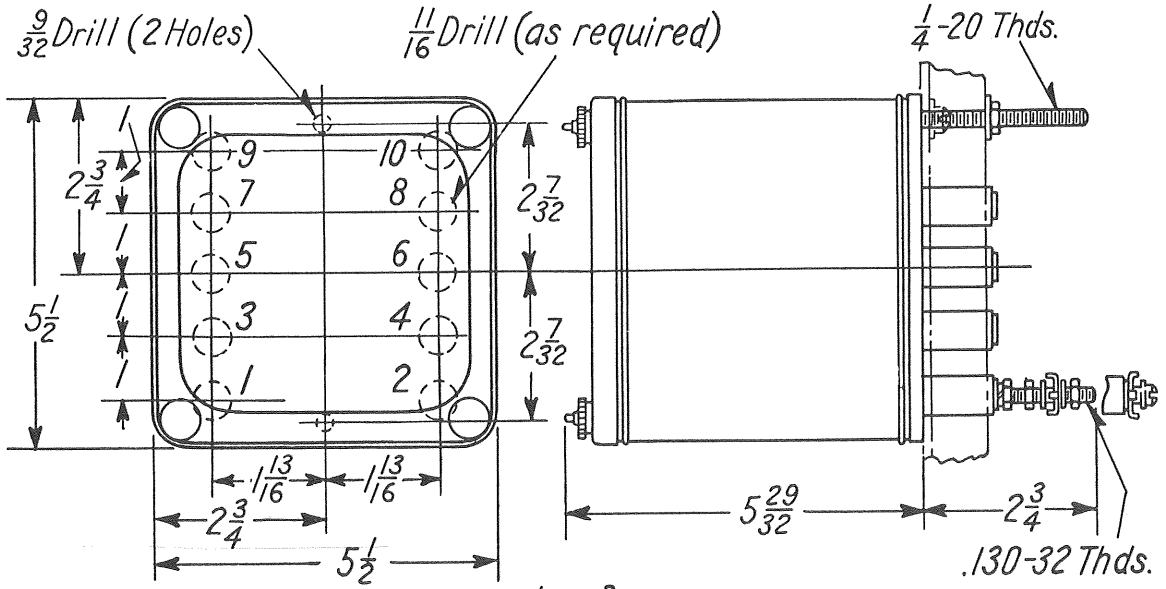


FIG. 3—TK RELAY WITHOUT SEALING CONTACT

OUTLINE DIMENSIONS IN INCHES

Dimensions are for reference only. For official dimensions refer to nearest Westinghouse Sales Office



No. of Terms.	Drill Holes
8 or less	1 to 8
9	1 to 9
10	1 to 10

Note - For 1/8 or 3/16 metal swbds. use screws For mtg. relay and for terminal conns. For 1/4 to 1 IN swbds. use studs for mtg. relay and screws for terminal connections For all other swbds. use studs for both purposes.

FIG. 4—TK RELAY OUTLINE AND DRILLING PLAN

TYPE TK UNIVERSAL TIMING RELAY—Continued

D-C. TO A-C. INVERTER

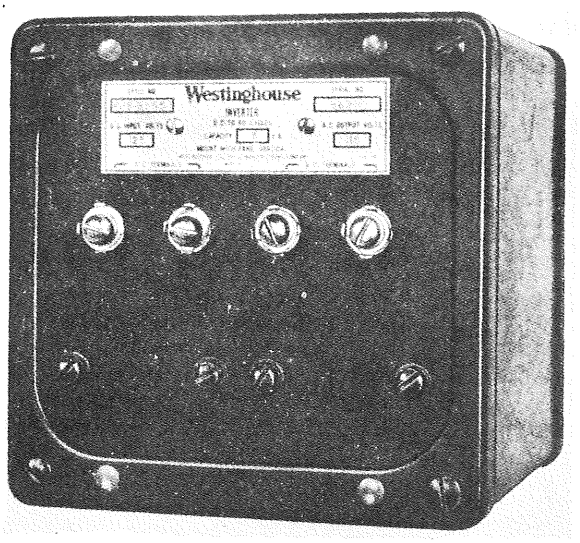


FIG. 5—D-C. TO A-C. INVERTER

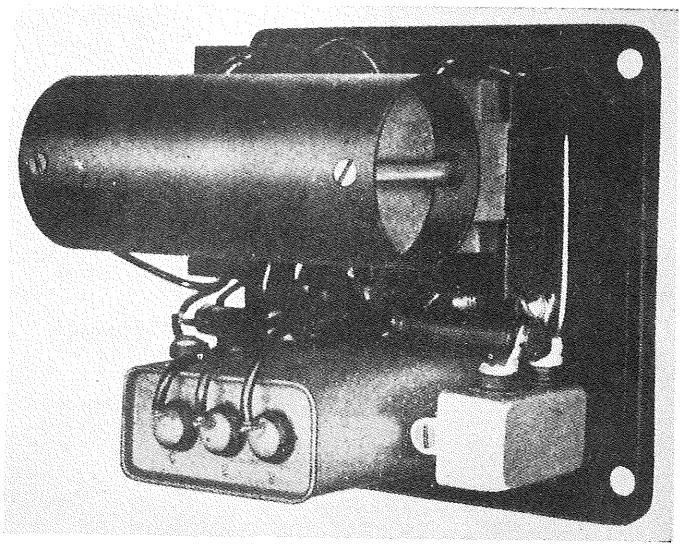


FIG. 6—D-C. TO A-C. INVERTER—COVER REMOVED

D-C.—A-C. INVERTER

To provide a means of converting d-c. power to a-c. for operating 60 cycle devices of low power consumption the inverter was developed; and as there are a number of installations where it will be desirable to operate a TK relay from a d-c. source, the information on the inverter is included in this section.

Application

It is well-known that very small d-c. motors generally are not as satisfactory or accurate as small a-c. motors. Consequently most motor-driven relays are a-c. operated to obtain the most reliable results.

In many installations it is essential to obtain the operating energy from an unfailing source of power. In these installations a battery is used.

The d-c. to a-c. inverter enables both of these advantages to be employed. It is an intermediate device used to convert battery power into 115 volts 60 cycles so that standard a-c. apparatus within its capacity can have a positive source of power at all times. It, therefore, is sometimes desirable to convert available d-c. to a-c. to operate timing relays such as the Westinghouse TK relay and other small synchronous motor-driven devices.

It will not convert a-c. to d-c.

Distinctive Features

1. Simple and reliable.
2. Provides a reliable sinusoidal wave form.
3. No chemical action or thermonic tubes required.
4. Small burden (does not exceed 20 Watts).
5. Contained in 5½" square case for back of switchboard mounting.

Construction and Operation

The d-c. to a-c. inverter includes a magnetically operated double contact vibrator that charges a tank circuit through a series reactor. When the contacts make on either side the tank circuit is given impulses which furnishes the power to keep it oscillating.

The vibrator mechanism is mounted in a sulphur free sponge rubber sleeve with end pads to absorb the contact noise, so that the operation of the d-c. to a-c. inverter is practically noiseless. The mounting serves as a resilient support as well as for sound absorption.

The vibrator has special silver-alloy contact material which has high conductivity, resists oxidation and will give long wear. There is a magnetic weight with a cross-wire on the end of the moving contact spring. The combined weight of these parts together with the spring strength determines the oscillating period of the vibrator.

The tank circuit is composed of a center tap reactor that has a center-tapped capacitor connected to it. The oscillatory circuit is designed to maintain a sinusoidal wave form from no load to full load. The reactor is tapped to obtain the proper operating voltage.

The series reactor is the same size as the tank reactor and has the proper characteristics to reduce the instantaneous tank circuit charging current, reduce the contact duty and aid in obtaining the excellent wave form secured for a device of this kind.

There is a condenser and resistor combination used to absorb the voltage of the series reactor when the vibrator contacts open.

A second resistor and condenser is connected to the vibrator coil. This gives frequency stabilization with varying loads. It reduces the a-c. in the vibrator coil, which in turn reduces the amplitude of vibration, and by permitting the d-c. in the coil to be increased it permits low-starting voltage.

There is a resistor connected across the a-c. output terminals which should be disconnected if the device supplied from the inverter requires more than 3 VA. The maximum output of the inverter is 7.5 VA.

The inverter is intended for intermittent use only, which is the type of service ordinarily required of timing relays and apparatus of that nature.

Burden

20 watts on the d-c. side.

TYPE TK UNIVERSAL TIMING RELAY—Continued

D-C. TO A-C. INVERTER—Continued

INVERTER LIST PRICE

VOLTS		Style No.	List Price Discount Symbol FC
D-C. Input	A-C. 60 Cycle		
125	115	1 008 561	$25 00

WIRING DIAGRAM

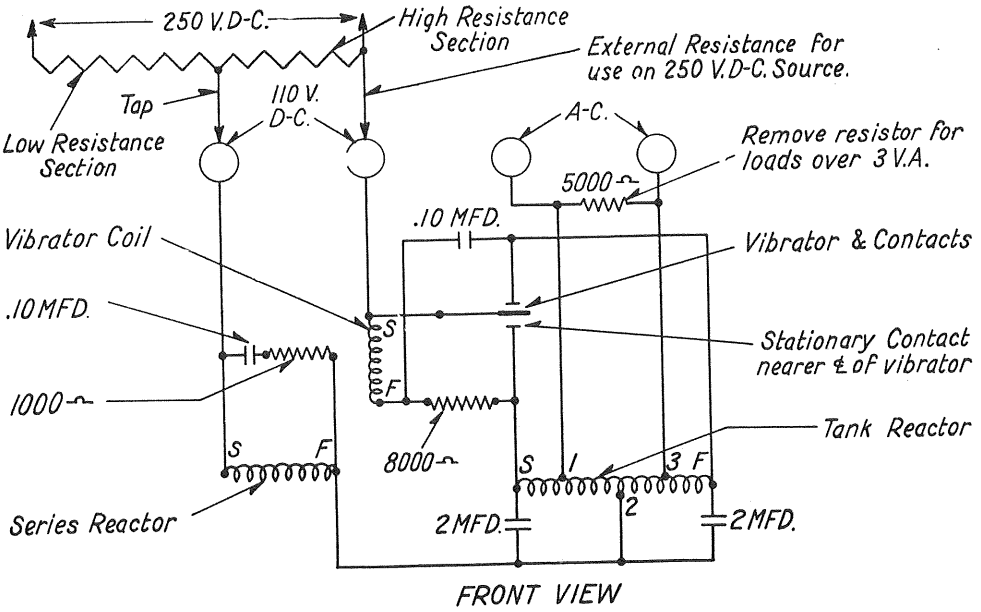


FIG. 7—WIRING DIAGRAM FOR INVERTER STYLE NO. 1008561

OUTLINE DIMENSIONS IN INCHES

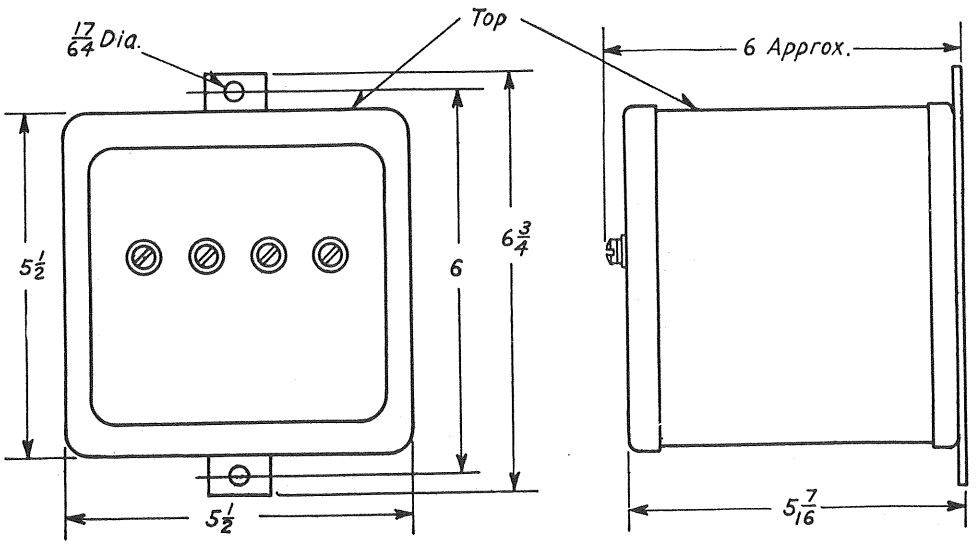
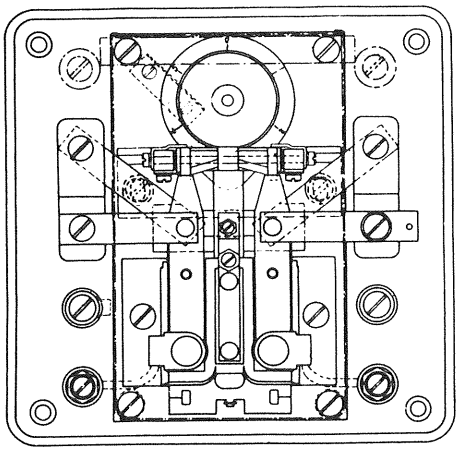
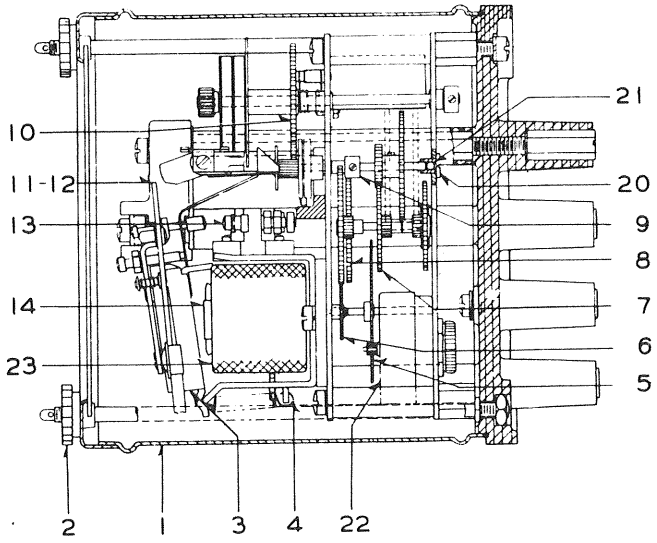
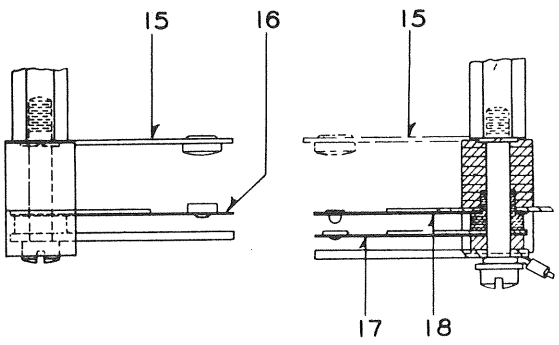


FIG. 8—OUTLINE DIMENSIONS FOR INVERTER STYLE NO. 1008561

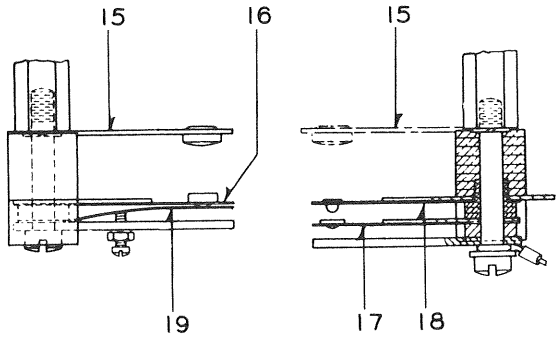
TYPE TK UNIVERSAL TIMING RELAY







STATIONARY CONTACT
ASSEMBLY OLD DESIGN



STATIONARY CONTACT
ASSEMBLY IMPROVED DESIGN

Westinghouse Electric & Manufacturing Company
Newark Works, Newark, N. J.

Printed in U.S.A.

EVERY HOUSE NEEDS WESTINGHOUSE

TYPE TK UNIVERSAL TIMING RELAY

5½" Square Case

Relay Complete		Volts	Cycles	Ref. No. 5	Ref. No. 22	Ref. No. 23
Without Sealing Contact	With Sealing Contact			Shaft Assembly No.1	Synchronous Motor	Operating Coil
Style Number	Style Number			Style Number	Style Number	Style Number
936 926	1 008 552	115	60	1 009 266	1 009 265	937 021
1 008 550	1 008 553	230	60	1 009 266	1 009 265	1 008 563
1 008 551	1 008 554	460	60	1 009 266	1 009 265	1 008 564
1 008 924	1 008 927	115	50	1 059 221	1 059 219	1 002 324
1 008 925	1 008 928	230	50	1 059 221	1 059 219	1 002 325
1 008 926	1 008 929	460	50	1 059 221	1 059 219	1 002 326
1 008 930	1 008 933	115	25	1 059 222	1 059 220	1 002 462
1 008 931	1 008 934	230	25	1 059 222	1 059 220	1 002 463
1 008 932	1 008 935	460	25	1 059 222	1 059 220	1 002 464

Ref No.	DESCRIPTION OF PART	Style Number	No. Req
1	Case	1 009 305	1
2	Cover Nut	1 001 015	4
3	Armature Block Complete for relays with sealing contact	1 099 578	1
3	Armature Block Complete for relays without sealing contact	1 009 564	1
4	Armature Spring	837 967	1
5	Shaft Assembly #1, meshes with motor	Per Table	1
6	Shaft Assembly #2	1 009 267	1
7	Shaft Assembly #3	1 009 268	1
8	Shaft Assembly #4	1 009 269	1
9	Shaft Assembly #5 with clutch	1 009 270	1
10	Shaft Assembly #6 with tripping discs, 50 and 60 cycles	1 009 456	1
10	Shaft Assembly #6 with tripping discs, 25 cycle	1 059 181	1
11	Lead and Contact Arm Complete, left hand	1 099 580	1
12	Lead and Contact Arm Complete, right hand	1 099 581	1
13	Sealing Contact , when used	1 055 830	1
14	Core Complete	1 096 714	1
15	Stationary Contact and Support, make contact	1 096 860	2
16	Stationary Contact and Spring, break contact	1 009 291	1
17	Stationary Contact and Spring, front break contact, motor circuit	1 009 290	1
18	Stationary Contact and Spring, rear break contact, motor circuit	1 009 289	1
19	Not Used	... ...	.
20	Bearing Screw, for shaft #5	1 009 272	1
21	Steel Ball, 3/32" Dia.	... ...	1
22	Motor	Per Table	1
23	Operating Coil	Per Table	1
*	Mounting Details for relays with sealing contact	839 131	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	8
*	Mounting Details for relays without sealing contact	839 130	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	7

* Not Illustrated
Order Parts by Style Number and Description
Parts indented are included in the Part under which they are indented

TYPE TK UNIVERSAL TIMING RELAY

5½" Square Case—Improved Design

Relay Complete		Volts	Cycles	Ref. No. 5	Ref. No. 22	Ref. No. 23
Without Sealing Contact	With Sealing Contact			Shaft Assembly No.1	Synchronous Motor	Operating Coil
Style Number	Style Number			Style Number	Style Number	Style Number
1 059 953	1 059 962	115	60	1 009 266	1 009 265	937 021
1 059 954	1 059 963	230	60	1 009 266	1 009 265	1 008 563
1 059 955	1 059 964	460	60	1 009 266	1 009 265	1 008 564
1 096 870	1 096 817	575	60	1 009 266	1 009 265	1 008 565
1 059 950	1 059 959	115	50	1 059 221	1 059 219	1 002 324
1 059 951	1 059 960	230	50	1 059 221	1 059 219	1 002 325
1 059 952	1 059 961	460	50	1 059 221	1 059 219	1 002 326
1 096 869	1 096 872	575	50	1 059 221	1 059 219	1 003 383
1 059 947	1 059 956	115	25	1 059 222	1 059 220	1 002 462
1 059 948	1 059 957	230	25	1 059 222	1 059 220	1 002 463
1 059 949	1 059 958	460	25	1 059 222	1 059 220	1 002 464
¢1 096 868	¢1 096 871	575	25	1 059 222	1 059 220	¢1 002 464

¢ For 575 Volt, 25 Cycles only, one external resistor S# 1009014 is required in series with 460 Volt, 25 Cycle Coil S# 1002464.

Ref No.	DESCRIPTION OF PART	Style Number	No. Req
1	Case	1 009 305	1
2	Cover Nut	1 001 015	4
3	Armature Block Complete for relays with sealing contact	1 099 579	1
3	Armature Block Complete for relays without sealing contact	1 096 713	1
4	Armature Spring	1 000 998	1
5	Shaft Assembly #1, meshes with motor	Per Table	1
6	Shaft Assembly #2	1 009 267	1
7	Shaft Assembly #3	1 009 268	1
8	Shaft Assembly #4	1 009 269	1
9	Shaft Assembly #5 with clutch	1 096 695	1
10	Shaft Assembly #6 with tripping discs, 50 and 60 cycles	1 009 456	1
10	Shaft Assembly #6 with tripping discs, 25 cycles	1 059 181	1
11	Lead and Contact Arm Complete, left hand	1 099 580	1
12	Lead and Contact Arm Complete, right hand	1 099 581	1
13	Sealing Contact, when used	1 099 582	1
14	Core Complete	1 096 714	1
15	Stationary Contact and Support, make contact	1 096 860	2
16	Stationary Contact and Spring, break contact	1 096 710	1
17	Stationary Contact and Spring, front break contact, motor circuit	1 096 709	1
18	Stationary Contact and Spring, rear break contact, motor circuit	1 096 708	1
19	Spring	1 094 807	1
20	Bearing Screw for Shaft #5	1 009 272	1
21	Steel Ball 3/32" Dia.	... ...	1
22	Motor	Per Table	1
23	Operating Coil	Per Table	1
*	Mounting Details for relays with sealing contacts	839 131	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	8
*	Mounting Details for relays without sealing contacts	839 130	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	7

* Not Illustrated
Order Parts by Style Number and Description
Parts indented are included in the Part under which they are indented

TYPE TK UNIVERSAL TIMING RELAY

Standard Rectangular Case—Improved Design

Relay Complete				Volts	Cycles	Ref. No. 5	Ref. No. 22	Ref. No. 23
Without Sealing Contacts		With Sealing Contacts						
Projection Mounting	Flush Mounting	Projection Mounting	Flush Mounting			Shaft Assembly No.1	Synchronous Motor	Operating Coil
Style Number	Style Number	Style Number	Style Number			Style Number	Style Number	Style Number
1 056 824-A	1 056 924-A	1 056 833-A	1 056 933-A	115	60	1 009 266	1 009 265	937 021
1 056 825-A	1 056 925-A	1 056 834-A	1 056 934-A	230	60	1 009 266	1 009 265	1 008 563
1 056 826-A	1 056 926-A	1 056 835-A	1 056 935-A	460	60	1 009 266	1 009 265	1 008 564
1 096 875-A	1 096 881-A	1 096 878-A	1 096 884-A	575	60	1 009 266	1 009 265	1 008 565
1 056 821-A	1 056 921-A	1 056 830-A	1 056 930-A	115	50	1 059 221	1 059 219	1 002 324
1 056 822-A	1 056 922-A	1 056 831-A	1 056 931-A	230	50	1 059 221	1 059 219	1 002 325
1 056 823-A	1 056 923-A	1 056 832-A	1 056 932-A	460	50	1 059 221	1 059 219	1 002 326
1 096 874-A	1 096 880-A	1 096 877-A	1 096 883-A	575	50	1 059 221	1 059 219	1 003 383
1 056 818-A	1 056 918-A	1 056 827-A	1 056 927-A	115	25	1 059 222	1 059 220	1 002 462
1 056 819-A	1 056 919-A	1 056 828-A	1 056 928-A	230	25	1 059 222	1 059 220	1 002 463
1 056 820-A	1 056 920-A	1 056 829-A	1 056 929-A	460	25	1 059 222	1 059 220	1 002 464
¢1 096 873-A	¢1 096 879-A	¢1 096 876-A	¢1 096 882-A	575	25	1 059 222	1 059 220	¢1 002 464

¢ For 575 Volt, 25 Cycles only, one external resistor S# 1009014 is required in series with 460 Volt, 25 Cycle Coil S# 1002464.

Ref No.	DESCRIPTION OF PART	Style Number	No. Req
*	Glass Cover, projection type	1 001 582	1
*	Glass Cover, flush type	1 001 581	1
*	Case, flush type	939 034	1
2	Cover Nut	704 110	2
3	Armature Block Complete for relays with sealing contact	1 099 579	1
3	Armature Block Complete for relays without sealing contact	1 096 713	1
4	Armature Spring	1 000 998	1
5	Shaft Assembly #1, meshes with motor	Per Table	1
6	Shaft Assembly #2	1 009 267	1
7	Shaft Assembly #3	1 009 268	1
8	Shaft Assembly #4	1 009 269	1
9	Shaft Assembly #5 with clutch	1 096 695	1
10	Shaft Assembly #6 with tripping discs, 50 and 60 cycles	1 009 456	1
10	Shaft Assembly #6 with tripping discs, 25 cycles	1 059 181	1
11	Lead and Contact Arm Complete, left hand	1 099 580	1
12	Lead and Contact Arm Complete, right hand	1 099 581	1
13	Sealing Contact, when used	1 099 582	1
14	Core Complete	1 096 714	1
15	Stationary Contact and Support, make contact	1 096 860	2
16	Stationary Contact and Spring, break contact	1 096 710	1
17	Stationary Contact and Spring, front break contact, motor circuit	1 096 709	1
18	Stationary Contact and Spring, rear break contact, motor circuit	1 096 708	1
19	Spring	1 094 807	1
20	Bearing Screw for shaft #5	1 009 272	1
21	Steel Ball, 3/32" Dia.	... ...	1
22	Motor	Per Table	1
23	Operating Coil	Per Table	1
*	Mounting Details for relays with sealing contacts	839 131	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	8
*	Mounting Details for relays without sealing contacts	839 130	1
*	Mounting Stud	837 331	2
*	Terminal Stud	839 582	7

* Not Illustrated
Order Parts by Style Number and Description
Parts indented are included in the Part under which they are indented

Westinghouse

TYPE TK TIMING RELAY

INSTRUCTIONS

APPLICATION

The type TK relay is an a-c. relay suitable for applications which require a definite time-delay between closing an a-c. circuit and closing or opening other a-c. or d-c. circuits, through contacts on the relay. Accurate time-settings from a few seconds to fifty minutes can be obtained in the same relay, with a maximum reset time of less than one second for any setting. Two sets of main contacts--one single-pole double-throw and one single-pole single-throw--are provided, and these contacts can be adjusted to operate either simultaneously or sequentially. A seal-in auxiliary contact can also be provided for applications where it is desired to start a timing operation by the monentary closure of an external switch.

INSTALLATION

Inspect relay for any damage that might have occurred in shipment. When removing the blocking from the contactor armature, make sure that the armature has not shifted off its bearings. Rotate the tripping disc mechanism counter-clockwise and allow to reset to make sure that it returns to zero positively. Remove the cover strip at the top of the gear case. This can be readily done by pulling aside one end of the strip which covers the sides and bottom. This strip is held against the top corner posts by a spring. When the bent-over end is clear of the top strip, the strip can be lifted off, exposing the sliding gear assembly and the gear position index plate. With the large gear on clutch shaft set opposite the 30-second mark on index plate, rotate this gear slowly in order to check for apparent friction in gear train.

The tripping disc mechanism is at the top of the relay and the synchronous motor at the bottom. The relay should be mounted in an approximately level position, as viewed from both front and side. Any appreciable variation from a level position will affect the operating characteristics of the relay.

Mounting studs and terminal details are contained in a small cloth bag packed with the relay.

CONSTRUCTION AND OPERATION

The type TK relay consists of a synchronous motor, a gear train to provide three different ratios, a clutch interposed in the gear train to permit quick resetting when the relay is de-energized, a contactor which carries the main contacts and operates the clutch, and a tripping mechanism adjustable for time-delay.

The motor for driving the gear train is located on the back plate of the gear train assembly in the lower right-hand corner. It runs at a synchronous speed of 600, 500 or 250 R.P.M. for 60, 50 or 25 cycle relays respectively, its bearing is self-sealed and self-lubricated and does not require special attention. On relays rated at 230 volts or higher, the contactor coil has a tap brought out at the proper place to act as an auto-transformer to supply 115 volts for the motor.

The gear train is assembled as a separate unit and consists of two brass bearing plates fastened together at the corners by brass posts. The gear shafts run at low speeds and require no lubrication. The three different speeds are obtained by changing the location of a sliding gear assembly. This assembly consists of two gears on a hub that is free to slide on the clutch shaft and can be locked in any desired position with a set screw. The hub is moved to the position where the larger gear is opposite the arrow on the index plate corresponding to the desired time scale. The mesh of the gear teeth should be inspected and the hub shifted slightly if necessary to secure a full mesh, and then the set-screw should be tightened securely.

In 50 and 60 cycle TK relays the maximum time settings available for the three gear positions are: 30 seconds, 5 minutes and 50 minutes. The smallest sub-division is 1 second on the 30 second scale, 0.1 minute on the 5 minute scale and 1 minute on the 50 minute scale. In 25 cycle TK relays the three time scales are 1, 10 and 100 minutes and the smallest sub-divisions are twice the time value for the 50 and 60 cycle relays.

The motor may require one or two seconds to reach synchronous speed after the relay is energized and its average speed during this accelerating period will be something less than synchronous speed. The time scales on the dial make no provision for the effect the accelerating period has upon the total operating time, as this is not noticeable on the intermediate or slow speed settings. When the gears are in the high speed position, it will be more accurate to use a scale setting approximately one second less than the desired time setting.

The clutch is two aluminum discs with serrated faces, arranged so that they are positively engaged and disengaged by a spring on the contactor armature when the latter is in its closed and open positions respectively. The rear disc is fastened on its shaft and the front disc is a running fit on the end of the same shaft. The latter disc has fastened to it the pinion which drives the tripping mechanism. When the relay is energized, the clutch discs engage and power is transmitted from the motor, through the gear train, to the tripping mechanism. When the relay is de-energized, the clutch discs are separated by the opening of the contactor armature, and the reset spring for the tripping mechanism is required to rotate only the trip discs and the front clutch disc. Because of the low inertia and low friction of these parts, the trip discs will reset from the position of maximum travel in much less than one second. The position of the sliding gear assembly has no effect upon the resetting time.

The contactor is of the clapper type. At the top of the armature is fastened a spring arm which presses against the front half of the clutch when the relay is energized, causing the clutch to mesh. The position of the clutch-operating spring can be controlled by an adjusting screw on a bracket fastened to the front of the armature. The seal-in contact is operated by an insulating button on the end of an adjusting screw on the upper end of the same bracket. The motor and contactor coil are connected together so that as soon as the clutch is operated the motor also is energized. The armature carries the two moving contacts, which, as well as the stationary contacts, are silver. The "make" contacts will carry 12 amperes continuously and 20 amperes for 1 minute. The "break" contact has somewhat less pressure and will carry about two-thirds of this rating. The contacts will interrupt a non-inductive a-c. circuit carrying 20 amperes at 115 volts or 15 amperes at 230 volts.

The trip mechanism is fastened to the front plate of the gear train assembly. Although the armature and clutch-operating spring move in when energized, the two moving contact fingers on the armature are prevented from operating by the two Micarta latch arms. Consequently, the back contact on the left-hand side, and the motor circuit which is the back contact on the right-hand side, will remain closed until the Micarta arms are tripped up and the moving fingers released. This is accomplished by the heads of the trip screws on the two discs, which push down the latch arm levers. Repeated tests have shown that the relay will make more than one million operations before the striking and rubbing action of the contact fingers on the ends of the latch arms wears them sufficiently to require replacement.

Each disc has a small bronze index pin projecting approximately 1/32" from its edge. The relay is adjusted so that these pins are opposite the zero on the scale plate when the trip screws in the discs have reached a point where they will just trip the Micarta latch arms and release the contact fingers. To set for a predetermined trip time, first shift gears to the scale wanted. Then loosen the thumb nut locking the trip discs and rotate them so each index is on the desired scale marking, and tighten the thumb nut. The disc nearest the scale plate will trip the left finger only; the disc that is nearest the front will trip both contact fingers. To set the contact fingers for sequential operation the left finger must trip first, as the motor is in series with the back contacts on the right-hand side. When this finger is tripped, it opens the motor circuit.

In making these settings the trip disc should not be rotated so that the trip pins are holding the Micarta arms part way up. Under this condition it is possible for the moving contacts to bounce under these arms and close the front contacts instantaneously when the relay is energized. The minimum settings obtainable without partially raising the latch arm are approximately 1-1/2 division on the 30 second scale, and corresponding points on the other scales.

In some applications it may be desired to have the left-hand contact operate instantaneously, as soon as the relay is energized, and have the time-delay on the right-hand contact only. This can be done by setting the disc nearest the scale plate so that the left-hand latch arm is raised above the end of the contact finger when the trip discs are reset. If any time-delay is desired, however, the minimum setting obtainable without the possibility of erratic operation is the point at which the trip disc begins to raise the latch arm.

Some styles of the TK relay are provided with a seal-in contact, which closes the moment the relay is energized. When connected according to the wiring diagram, this contact energizes the relay, and keeps it energized, when an external contact or switch (such as a push button) is momentarily closed. The relay can be de-energized then only by interrupting the supply circuit by means of some other contact or switch.

ADJUSTMENTS AND MAINTENANCE

The adjustments described in the following paragraphs ordinarily need be made only when reassembling the relay after it has been dismantled for repairs. However, it will be advisable to check the adjustment at the regular maintenance periods and correct them, if necessary.

The die-cast bracket which supports the latch arm assembly is secured to the front gear plate by means of screws passing through slotted holes. To adjust the position of this bracket, loosen both the mounting screws and the screw which holds the stop bracket for the right hand latch arm. Move the sliding gear assembly out of mesh, so that the trip discs will not rotate, and energize the relay. The latch arms should be down so that the contact fingers are held out. Shift the die-cast bracket so that with the latch arms touching the aluminum trip discs (not the trip screws), the projection of the end of the latch arm above the top of its adjacent contact finger will be .075" for the left-hand finger and .070" for the right-hand finger. The dimensions given apply to relays in which the trip discs are 1-1/8" in diameter Earlier relays used discs with a diameter of 1-3/16", and on these the dimension should be .110" for the left-hand finger and .120" for the right-hand finger. A small strip of metal with the ends filed to these dimensions will be convenient to use as a gauge. It can be rested on the ends of the contact fingers and the bracket shifted until the upper front corners of the fingers are even with the ends of the gauge. The mounting screws for the bracket should then be tightened securely. The screw for the right-hand latch arm stop bracket should also be tightened, and the end of the bracket should be bent up or down until the latch arms just clear the small bronze index pins projecting from the trip discs.

Raise the right-hand latch with the fingers and move the armature in by hand until the tips of the contact fingers are opposite the lowest portions of the latch arms. When the left-hand latch arm is just touching its contact finger, there should be a gap of about .010" to .015" between the right-hand arm and its contact finger. (This relation between the latches and the contact fingers prevents any possibility of the left-hand finger tripping first when the trip discs are set for simultaneous tripping.)

Loosen the thumb nut locking the two trip discs and energize the relay with the gears still out of mesh. Hold the final gear firmly against its back stop, and rotate each trip disc by hand until it depresses its latch arm far

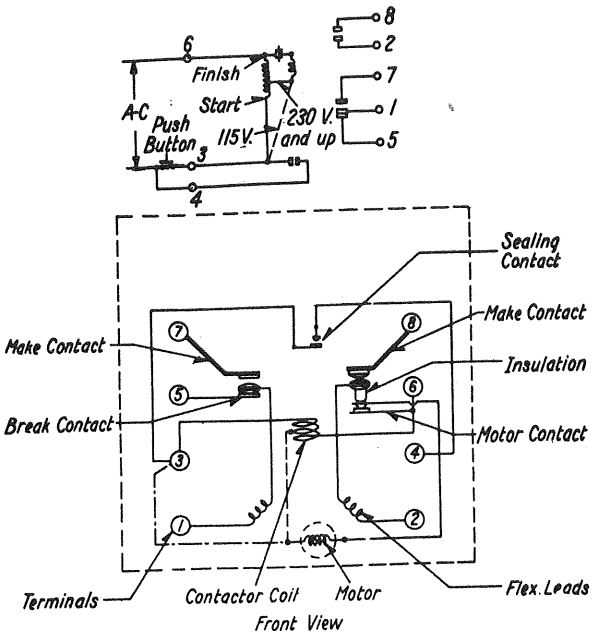


Figure 1
Internal wiring diagram of the Type TK relay with Seal-in cont acts. (Outline & drilling see Fig. 5)

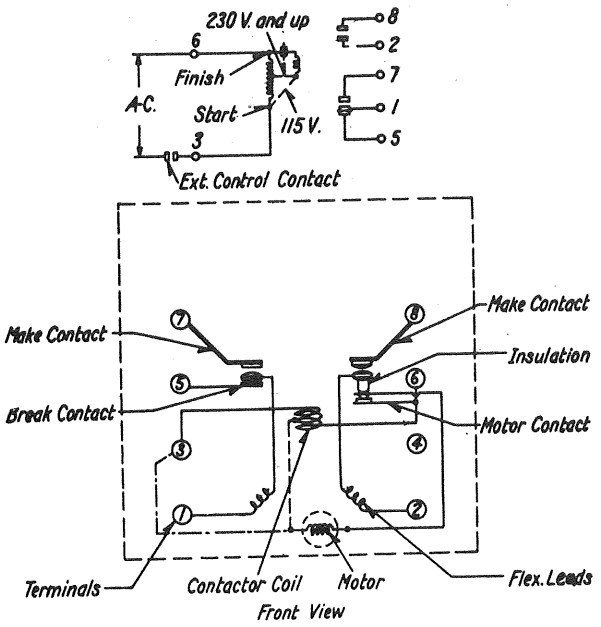


Figure 2
Internal wiring diagram of the Type TK relay without seal-in cont acts. (Outline & drilling see Fig. 5)

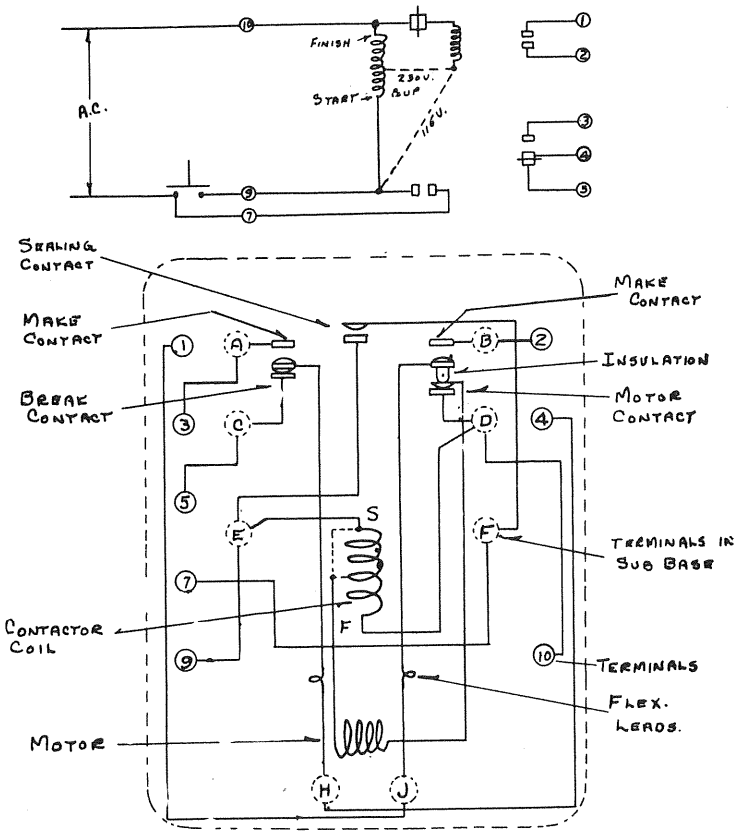


Figure 3
Internal wiring diagrams of the Type TK relay with Seal-in cont acts. (Outline & drilling see Fig. 6 & 7)

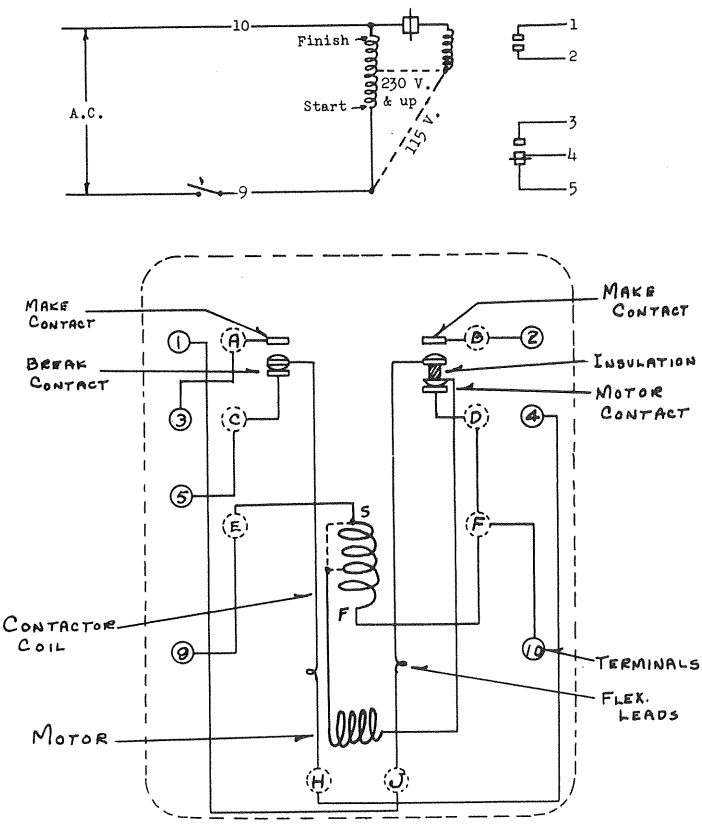


Figure 4
Internal wiring diagram of the Type TK relay without Seal-in cont acts. (Outline & drilling see Fig. 6 & 7)

enough to just trip the contact finger. The bronze pin projecting from each trip disc serves as its zero index, and should be opposite the zero on the dial when the contact finger trips. The trip screws are prevented from turning by a locking wire spring which passes through a slot in the inner end of the trip screw and is accessible from the rear of the trip disc. It should be moved out of the slot and the trip screw should be screwed in or out until the index pin is opposite the zero on the dial when the contact finger is released. Then the locking spring should be placed in the slot of its trip screw to prevent any accidental change in adjustment. The trip discs should release the contact fingers when the trip screws are one-scale division or more from the center or lowest position.

When the armature is held closed, the clutch teeth should have a full mesh and there should be approximately 1/32" follow on the clutch spring. Any necessary adjustment should be made by means of the lower screw in the bracket at the front of the armature, and the lock nut should be securely tightened. One-quarter turn of the adjusting screw, after the clutch is closed and with the operating spring just touching the clutch pinion without deflection, will give about 1/32" follow on the spring. When the armature is released, the clutch teeth should have sufficient separation to prevent any interference with resetting of the trip discs. Too much follow on the clutch spring will prevent the clutch from being held open positively when the relay is de-energized.

The stationary contacts should be adjusted by bending so that both moving contacts make simultaneously when they move in with the armature with about 1/16" follow. With the relay de-energized, adjust the position of the left hand back contact spring, by means of the adjusting screw, so that there will be a gap of 1/64" or slightly more, between the ends of the latch arms and the contact fingers. Tighten the lock nut securely. The gaps between the contact fingers and the ends of the latch arms should be approximately equal. If the gaps are unequal, the contact fingers probably have been bent. When the relay is de-energized and the front clutch member is at the limit of its outward travel, there should be a slight clearance between the clutch spring and the washer at the front of the clutch pinion. There should also be clearance between the clutch spring and the dial plate.

The motor circuit contact should have 1/16" to 3/32" follow when the right-hand contact finger is against the latch arm. When the motor circuit is open, there should be no gap between the rear contact spring (in which the flat contact is assembled) and its stop plate.

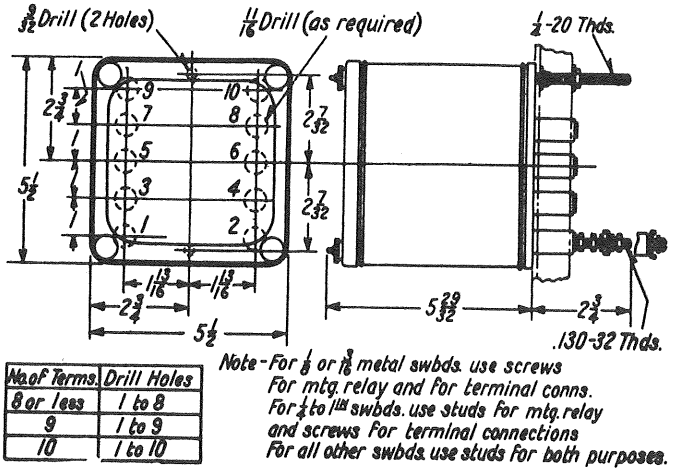
On relays provided with a seal-in contact, adjust the upper screw in the bracket at the front of the armature so that there will be 1/32" to 3/64" follow on the seal-in contact after it has closed. Tighten the lock nut securely. When the relay is de-energized, the seal-in contact should have 1/32" to 3/64" gap.

The motor bearing is of the self-sealed, self-lubricated type and requires no special attention. Due to the close tolerances held in manufacture, no attempt should be made to repair the motor in case of damage. It should be returned to the factory for repair or a complete new motor ordered as a replacement.

If the relay operates very frequently, a small drop of special oil should be applied to the clutch pinion bearing at intervals of six months to one year. This oil is obtainable in small bottles under style #1101752. It will not congeal at low temperatures, and it contains an anti-oxident to retard the formation of gum at high temperatures. It can be applied by dipping a small wire into the oil and touching this to the clutch shaft between the two clutch discs. A very small amount of oil is sufficient. A drop of oil may be applied to the teeth of the clutch pinion at the same time.

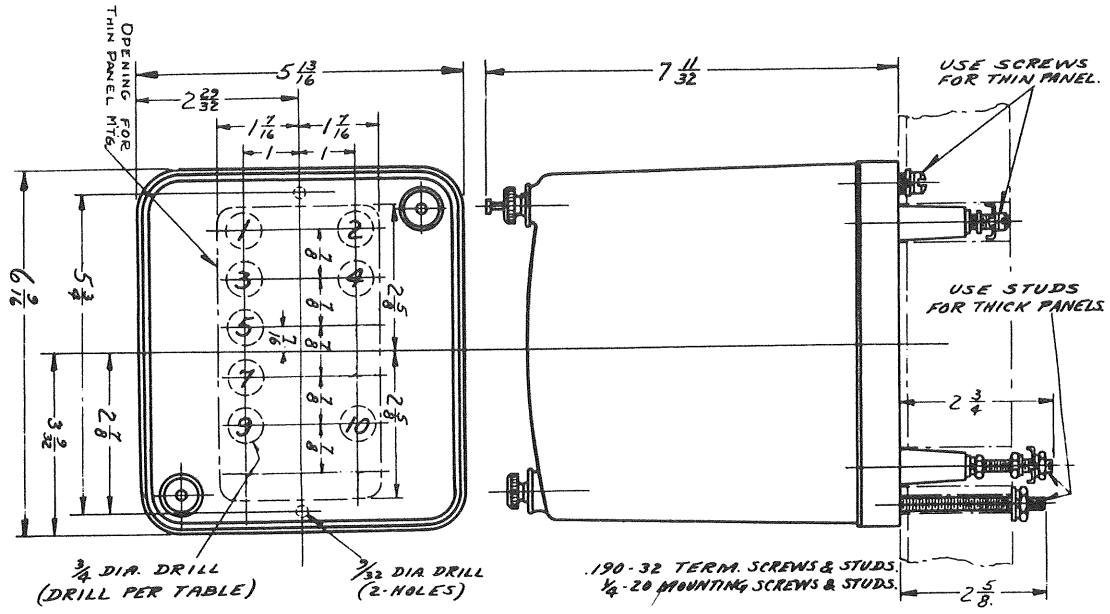
The silver contacts are large enough to permit dressing with a fine file if they should become tarnished or pitted due to breaking heavy currents. Contact file S#1002110 is recommended for this purpose. Any other part that may be damaged can be replaced by advising the factory of the style number of the relay and giving a description of the part. However, if very extensive repairs are required, it is most satisfactory to return the complete relay to the factory unless the customer is well equipped for repair work of this nature and carries a stock of renewal parts on hand.

The burden of the TK relay at rated voltage, 60 cycles, is approximately 18 volt-amperes for the contactor and 2.6 volt-amperes for the motor.



No. of Terms.	Drill Holes
8 or less	1 to 8
9	1 to 9
10	1 to 10

Figure 5
Outline and drilling plan for the metal case with a glass front. (Figures 1 and 2)



Omit Term. No. 7 for Fig. 4.

Figure 6
Outline and drilling plan for the glass cover case - projection type mounting (Figures 3 and 4)

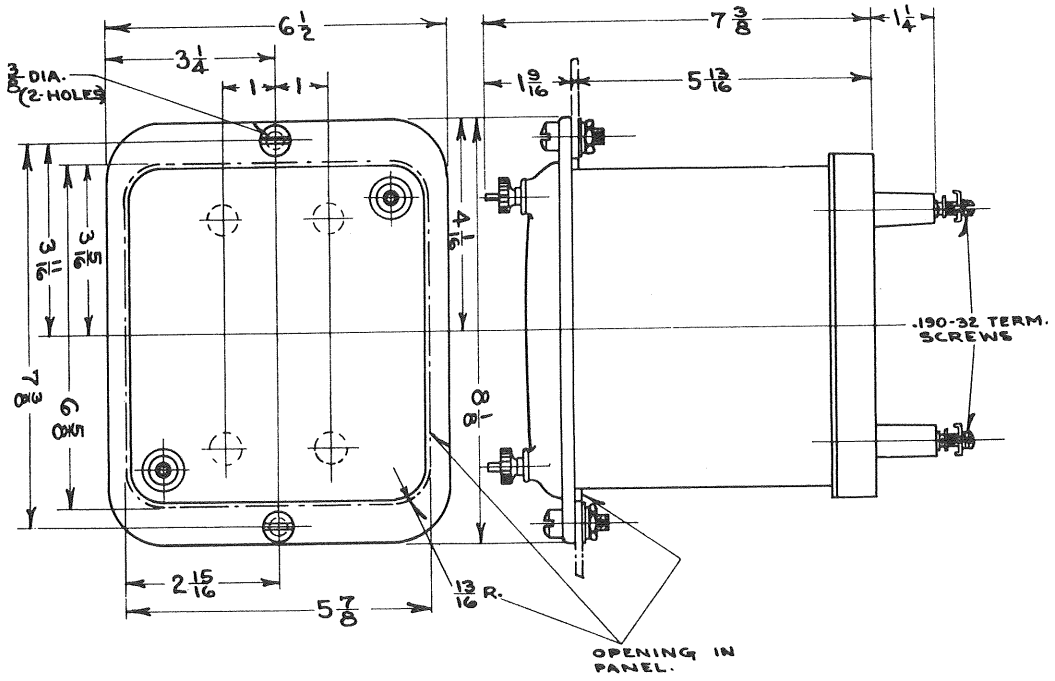
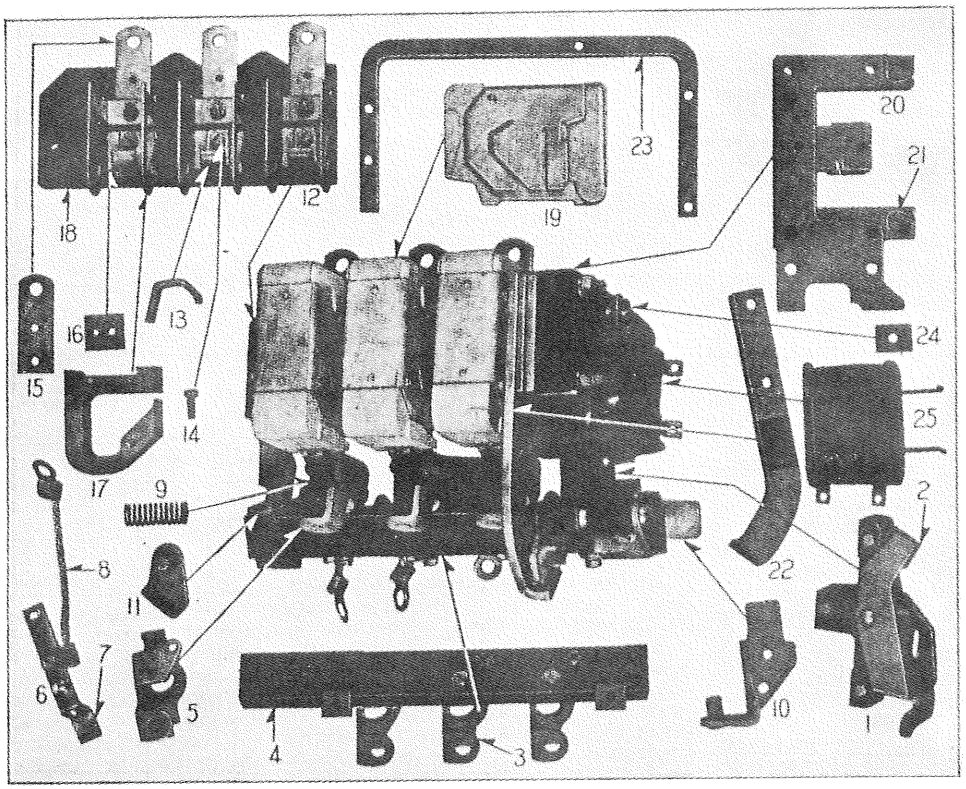


Figure 7
Outline and drilling plan for the glass cover case - flush type mounting (Figures 3 and 4)

TYPE Dn CONTACTORS

Size 3, Frame No. 330 (3 Pole)—Size 4, Frame No. 430 (3 Pole)



Frame Size	330-P	430-P	No. Per Contactor	Contactors in Use	
Ampere Rating	100	150		1	5
Style Number of Contactor	1 039 891	1 039 892		Recommended for Stock	

Ref. No.	Description of Part	Style Number of Part				
1	Armature Iron with Mounting Bracket	884 580	884 581	1	0	0
2	Non-Magnetic Shim	884 574	884 574	1	0	1
3	Cross Bar with Moving Contact Bracket	1 039 878	1 039 878	1	0	0
4	Cross Bar	1 039 860	1 039 860	1	0	1
5	Moving Contact Bracket	884 594	884 594	3	0	0
6	Moving Contact with Shunt	884 567	884 568	3	0	1
7	Moving Contact	884 595	884 595	3	2	4
8	Shunt	884 613	884 614	3	2	4
9	Contact Spring	884 590	884 591	3	0	1
10	Bearing Bracket—Magnet End	884 575	884 575	1	0	0
11	Bearing Bracket—Left Hand End	884 576	884 576	1	0	0
12	Stationary Contact Base Complete	1 039 877	1 039 877	1	0	0
13	Stationary Contact	884 596	884 596	3	2	4
14	Stationary Contact Screw	186 529	186 529	3	2	4
15	Stationary Contact Connector	884 597	884 597	3	0	0
16	Stationary Contact Spacer	884 598	884 598	3	0	0
17	Blowout Coil	884 583	884 583	3	0	1
18	Base	1 039 859	1 039 859	1	0	0
19	Arc Quencher	884 589	884 589	3	1	2
†	Stationary Contact Stud	178 553	178 553	3	0	1
†	Shunt Stud	361 718	361 718	3	0	1
20	Stationary Core	884 560	884 562	1	0	0
21	Shading Coil	884 558	884 559	2	0	1
22	Stop	1 041 907	1 041 907	1	0	0
23	Frame	1 039 874	1 039 874	1	0	0
24	Coil Retaining Washer	882 191	882 191	2	0	0
25	Operating Coil	‡	‡	1	1	1

† Not illustrated.
‡ When ordering, specify identification number shown on Coil. See Table for Style Number of commonly used Coils.
Parts indented are included in the part under which they are indented.

This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration, additional insurance against shutdowns is desirable. Under such conditions more renewal parts should be carried, the amount depending upon the severity of the service and the time required to secure renewals.

ORDERING INSTRUCTIONS

Name the part and give its style number. Give the complete nameplate reading. State wheather shipment is desired by express, freight or parcel post. Send all orders or correspondence to nearest Sales Office of the Company. Small orders should be combined so as to amount to a value of at least $1.00 net. Where the total of the sale is less than this, the material will be invoiced at $1.00.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

Printed in U.S.A. (Rep. 6-39)

R

TYPE Dn CONTACTORS
Size 3, Frame No. 330 (3 Pole)—Size 4, Frame No. 430 (3 Pole)

Instructions

Description—Type Dn Contactors are alternating current contactors which can be supplied either with or without De-ion arc quenchers. The contactors are designed for mounting on steel plate or insulating panels up to 2 inches thick.

When a contactor is mounted on a steel plate, insulation of the shunts is provided by an insulating plate interposed between the contactor and steel plate.

Ratings—The 8 hour open ratings are 100 amperes for the Size 3 Dn Contactor and 150 amperes for the Size 4 Dn Contactor. Insulation is for a maximum of 600 volts.

Unit Assembly—Type Dn Contactors are of unit assembly, with the crossbar pivoted in bearings integral with the frame, which supports the magnet and stationary contacts. This insures accurate and permanent alignment of parts before leaving the factory.

Interchangeability of parts among Sizes 3 Dn and 4 Dn Contactors is an advantageous feature enabling the user to carry a smaller stock of renewal parts.

Mounting of the contactor to a vertical panel is accomplished by means of three bolts inserted from the front of the frame. These may be held by nuts at the back of the panel or may be threaded into tapped spacers previously secured to the panel. The latter arrangement permits of removing the contactor from the panel for servicing or other attention without necessitating the operator's going to the rear of the panel.

Magnet—The magnet consists of an E-shaped stator and a T-shaped armature. In addition to other advantages, the T-shaped armature is of sufficiently low inertia to accelerate rapidly on opening, affording a quick break of the contacts and consequently less arcing. Movement of the armature is almost vertical, rendering less likely the chance of accidental closing due to shock or impact.

Operating Coil—The coil is designed for continuous duty at 100% of its rating. It will operate the contactor satisfactorily at from 85% to 110% of its rated voltage.

TABLE OF OPERATING COILS

Volts	Cycles	DN 330-P Style No.	DN 430-P Style No.
110	60	897 905	1 014 611
208	60	944 740	1 040 139
220	60	874 111	1 040 140
440	60	919 996	966 752
550	60	943 156	966 746
110	50	966 738	1 040 141
220	50	966 739	1 040 142
440	50	966 740	1 040 143
550	50	966 741	1 040 144
110	25	874 111	1 040 140
220	25	919 996	966 752
440	25	966 742	1 040 145
550	25	895 655	1 040 159

Contacts—The contact tips are of heavy copper, designed for easy removal and replacement. Movement of the tips on opening and closing produces a slight wiping action which insures a clean contact surface but which is not sufficient to produce undue wear. A "hammer blow" dealt the contacts at the moment of opening increases the speed of separation, thereby decreasing the arcing.

Following the moment at which the contacts meet, the armature and crossbar have an unusually long overtravel before the magnet seals. This insures that ample contact pressures exist, even when the contacts are worn so far as to require replacement.

The contact springs are unusually long, insuring almost constant pressure as the contacts wear.

The current-carrying contact shunts of flexible copper cable give complete freedom to the cross-bar and have ample capacity to carry the maximum current for which the contactors are rated. The shunts are suspended about the center of rotation of the crossbar, minimizing their flexure and increasing their life to such an extent that their renewal is practically never required.

De-ion Arc Quenchers—The De-ion arc quenchers are of exclusive design functioning to confine, divide and extinguish the arc almost instantaneously, greatly prolonging the contact life. Confinement of the arc is a feature which admits of close spacing of the contactor poles, while at the same time the superior performance of the De-ion principle enables the contactor to maintain a high interrupting capacity.

The arc quenchers are easily removed for inspection of the contacts.

Connections—The contactors may be connected from the front or from the back. See the Renewal Parts List for studs for back-connecting.

Provision for Interlock—Provision is made in two places, on the cross-bar of the contactor for mounting moving contact assemblies of Type L-41 Electrical Interlocks. The stationary members of the interlocks are to be secured to the panel on which the contactor is mounted. For more complete information concerning the Type L-41 Electrical Interlock refer to Instruction Leaflet 2406.

Maintenance

The contactor should be inspected frequently to see that no impairment of electrical or mechanical functioning occurs in service. Accumulations of dust may be removed with a dry cloth or a compressed air jet. Except only when cleaning the magnet sealing surfaces avoid oily cloths, as an oil film quickly attracts dust.

Bearings—Bearing pins are of wear-resistant nitrided alloy steel. They should not be lubricated as oil collects dust, hindering free operation of the contactor.

Magnet—Before shipment, the magnet sealing surfaces are covered with grease to prevent rusting. This should be removed before the contactor is placed in service. The surfaces should be cleaned occasionally with a cloth moistened with a light oil to remove deposits of dirt and prevent rusting.

The magnet armature and the bracket supporting it may be easily removed as a unit by removing the two screws securing the bracket to the cross-bar.

Contacts—The contact tips should not be lubricated, as the slight wear of dry contacts produces a self-cleaning action. Should excessive roughening or burning occur the tips may be dressed with a fine file. Do not use emery cloth, as abrasive granules left imbedded in the contact surfaces may raise the contact resistance and produce a tendency of the contacts to weld.

Chiefly for reasons of mechanical strength it is advisable to replace the contact tips before they have become worn to one-third their original thickness.

Correct contact pressures should be maintained as follows:

Contactor Size No.	Initial Pressure	Final Pressure
3	2.8 pounds	6 pounds
4	4 pounds	9 pounds

The contact gap, measured at the heels of the contacts in their fully-open position, is $\frac{5}{8}$ inch for both the Size 3 Dn and Size 4 Dn contactors.

Operating Coil—To remove the coil, first remove the armature by taking out the two bolts securing its supporting bracket to the cross-bar. Then loosen the bolt which holds the coil to the magnet and separate the rectangular washers until it is possible to lower the coil entirely free of the magnet.

De-ion Arc Quenchers—To remove a De-ion arc quencher, grasp it at its lower end and swing it upward (it will pivot about point P, see Fig. 2), striking its lower corner upward with the palm of the hand to overcome any initial resistance to movement. The arc quencher is then free to be lifted entirely clear of the contactor.

To restore the De-ion arc quencher to its location on the contactor, slide it into the position indicated in Fig. 2, and by striking the upper corner in a direction indicated by the arrow force the arc quencher into the final location shown by the dotted lines.

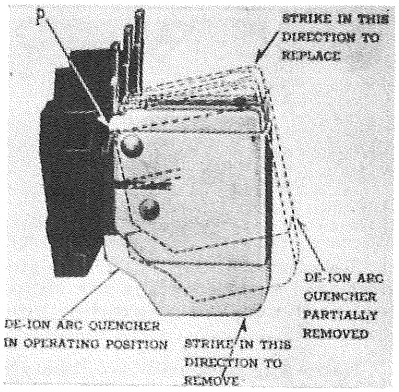
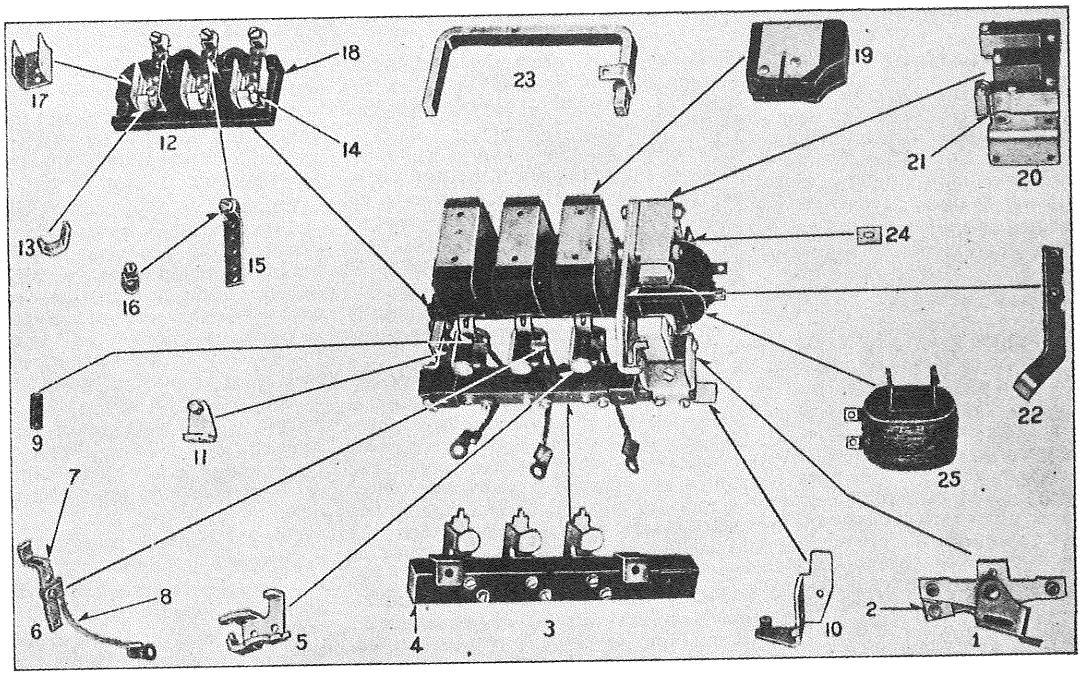


FIG. 2—DETAIL OF ARC QUENCHER AND ITS SUPPORTING BRACKET, SHOWING EASE OF REMOVAL AND REPLACEMENT.

TYPE Dn CONTACTOR—SIZE 2, Frame Numbers 220, 230, 230-P, 240



Ref. No.	Description of Part	220	230	230-P	240	No. Per Contactor	Contactors in Use: 1	Contactors in Use: 5
	Frame Size	220	230	230-P	240			
	Style Number of Contactor — With Arc Quencher	972 863	972 866	1 039 961	972 869			
	Style Number of Contactor — Without Arc Quencher	972 864	972 867	....	972 870			
		Style Number of Part					Recommended For Stock	
1	Armature Iron With Mounting Bracket	972 858	972 858	972 858	972 859	1		0
2	Non-Magnetic Shim	972 734	972 734	972 734	972 734	1	0	1
3	Cross Bar With Moving Contact Bracket	972 779	972 855	1 039 958	972 856	1	0	0
4	Cross Bar	972 747	972 748	1 039 862	972 749	1	0	1
5	Moving Contact Bracket	972 738 (2)	972 738 (3)	972 738 (3)	972 738 (4)	( )	0	0
6	Moving Contact With Shunt	972 778 (2)	972 778 (3)	972 778 (3)	972 778 (4)	( )	0	1
7	Moving Contact	972 739 (2)	972 739 (3)	972 739 (3)	972 739 (4)	( )	0	4
8	Shunt	972 773 (2)	972 773 (3)	972 773 (3)	972 773 (4)	( )	2	4
9	Contact Spring	972 774 (2)	972 774 (3)	972 774 (3)	972 774 (4)	( )	2	1
10	Bearing Bracket—Magnet End	972 735	972 735	972 735	972 735	1	0	0
11	Bearing Bracket—Left Hand End	972 736	972 736	972 736	972 736	1	0	0
12°	Stationary Contact Base Complete	972 860	972 861	1 039 957	972 862	1	0	0
12x	Stationary Contact Base Complete	972 775	972 776	....	972 777	1	0	0
13	Stationary Contact	972 740 (2)	972 740 (3)	972 740 (3)	972 740 (4)	( )	0	4
14	Stationary Con. Screw, 190"-32 x 3/8" Fil. Hd. I. M. Sc.	Std. Hdw. (2)	Std. Hdw. (3)	Std. Hdw. (3)	Std. Hdw. (4)	( )	2	4
15	Stationary Contact Connector	972 743 (2)	972 743 (3)	1 039 956 (3)	972 743 (4)	( )	2	0
15	Connection Lug—Solderless	974 131 (2)	974 131 (3)	....	974 131 (4)	( )	0	1
†x	Stationary Contact Spacer	972 742 (2)	972 742 (3)	....	972 742 (4)	( )	0	0
17°	Arc Quencher Support	972 766 (2)	972 766 (3)	972 765 (3)	972 766 (4)	( )	0	0
18	Base	972 746	972 744	1 039 861	972 745	1	0	0
19	Arc Quencher	972 771 (2)	972 771 (3)	972 771 (3)	972 771 (4)	( )	0	2
†	Shunt Stud	559 187 (2)	559 187 (3)	559 187 (3)	559 187 (4)	( )	1	0
20	Stationary Core	972 658	972 658	972 658	972 660	1	0	0
21	Shading Coil	972 654	972 654	972 654	972 657	2	0	1
22	Stop	972 687	972 687	1 041 906	972 687	1	0	0
23	Frame	972 683	997 939	1 039 920	972 685	1	0	0
24	Coil Retaining Washer	972 754	972 754	972 754	972 754	2	0	0
25	Operating Coil	‡	‡	‡	‡	1	0	0

† Not illustrated. ° Used Only on Contactor With Arc Quencher. x Used Only on Contactor Without Arc Quencher.
( ) Figures in Parentheses indicate the number per Contactor. ‡ When ordering, specify identification number stamped on coil.
See table for style number of commonly used coils. Parts indented are included in the part under which they are indented.

This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration, additional insurance against shutdowns is desirable. Under such conditions more renewal parts should be carried, the amount depending upon the severity of the service and the time required to secure renewals.

ORDERING INSTRUCTIONS

Name the part and give its style number. Give the complete nameplate reading. State whether shipment is desired by express, freight or parcel post. Send all orders or correspondence to nearest Sales Office of the Company. Small orders should be combined so as to amount to a value of at least $1.00 net. Where the total of the sale is less than this, the material will be invoiced at $1.00.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

Printed in U.S.A.

R

TYPE Dn CONTACTORS

Size 2—Frame Nos. 220 (2 poles), 230 and 230-P (3 poles), 240 (4 poles)

Instructions

Description — Type Dn Contactors are alternating current contactors which can be supplied either with or without De-ion arc quenchers. The contactors are designed for mounting on steel plate or insulating panels up to 2 inches thick.

When a contactor is mounted on a steel plate, insulation of the shunts is provided by an insulating plate interposed between the contactor and steel plate.

Ratings — The 8 hour open rating of the size 2 Dn contactors is 50 amperes. Insulation is for a maximum of 600 volts.

Unit Assembly—Type Dn Contactors are of unit assembly, with the crossbar pivoted in bearings integral with the frame which supports the magnet and stationary contacts. This insures accurate and permanent alignment of parts before leaving the factory.

Mounting of the contactor to a vertical panel is accomplished by means of three bolts inserted from the front of the frame. These may be held by nuts at the back of the panel or may be threaded into tapped spacers previously secured to the panel. The latter arrangement permits of removing the contactor from the panel for servicing or other attention without necessitating the operator's going to the rear of the panel.

Magnet—The magnet consists of an E-shaped stator and a T-shaped armature. In addition to other advantages, the T-shaped armature is of sufficiently low inertia to accelerate rapidly on opening, affording a quick break of the contacts and consequently less arcing. Movement of the armature is almost vertical, rendering less likely the chance of accidental closing due to shock or impact.

Operating Coil—The coil is designed for continuous duty at 100% of its rating. It will operate the contactor satisfactorily at from 85% to 110% of its rated voltage.

TABLE OF OPERATING COILS

Volts	Cycles	Dn-220 Dn-230 Dn-230-P Style No.	Dn-240 Style No.
110	60	974 133	1 014 618
220	60	974 135	1 014 620
440	60	974 136	1 014 621
550	60	974 138	1 014 623
110	50	974 140	1 014 625
220	50	974 141	1 014 626
440	50	974 142	1 014 627
550	50	974 143	1 014 628
110	25	974 135	1 014 620
220	25	974 136	1 014 621
440	25	974 144	1 014 629
550	25	974 145	1 014 630

Contacts—The contact tips are of heavy copper, designed for easy removal and replacement. Movement of the tips on opening and closing produces a slight wiping action which insures a clean contact surface but which is not sufficient to produce undue wear. A "hammer blow" dealt the contacts at the moment of opening increases the speed of separation, thereby decreasing the arcing.

Following the movement at which the contacts meet, the armature and crossbar have an unusually long overtravel before the magnet seals. This insures that ample contact pressures exist, even when the contacts are worn so far as to require replacement.

The contact springs are unusually long, insuring almost constant pressures as the contacts wear.

The current-carrying contact shunts of flexible copper cable give complete freedom to the cross-bar and have ample capacity to carry the maximum current for which the contactors are rated. The shunts are suspended about the center of rotation of the crossbar, minimizing their flexure and increasing their life to such an extent that their renewal is practically never required.

De-ion Arc Quenchers—The De-ion arc quenchers are of exclusive design functioning to confine, divide and extinguish the arc almost instantaneously, greatly prolonging the contact life. Confinement of the arc is a feature which admits of close spacing of the contactor poles, while at the same time the superior performance of the De-ion principle enables the contactor to maintain a high interrupting capacity.

The arc quenchers are easily removed for inspection of the contacts.

Connections—The contactors may be connected from the front or from the back. See the Renewal Parts List for studs for back-connecting.

Provision for Interlock—Provision is made in two places, on the cross-bar of the contactor for mounting moving contact assemblies of Type L-41 Electrical Interlocks. The stationary members of the interlocks are to be secured to the panel on which the contactor is mounted. For more complete information concerning the Type L-41 Electrical Interlock refer to Instruction Leaflet 2406.

Maintenance

The contactor should be inspected frequently to see that no impairment of electrical or mechanical functioning occurs in service. Accumulations of dust may be removed with a dry cloth or a compressed air jet. Except only when cleaning the magnet sealing surfaces avoid oily cloths, as an oil film quickly attracts dust.

Bearings—Bearing pins are of wear-resistant nitrided alloy steel. They should not be lubricated as oil collects dust, hindering free operation of the contactor.

Magnet—Before shipment, the magnet sealing surfaces are covered with grease to prevent rusting. This should be removed before the contactor is placed in service. The surfaces should be cleaned occasionally with a cloth moistened with a light oil to remove deposits of dirt and prevent rusting.

The magnet armature and the bracket supporting it may be easily removed as a unit by removing the two screws securing the bracket to the cross-bar.

Contacts — The contact tips should not be lubricated, as the slight wear of dry contacts produces a self-cleaning action. Should excessive roughening or burning occur the tips may be dressed with a fine file. Do not use emery cloth, as abrasive granules left imbedded in the contact surfaces may raise the contact resistance and produce a tendency of the contacts to weld.

Chiefly for reasons of mechanical strength it is advisable to replace the contact tips before they have become worn to one-third their original thickness.

Correct contact pressures should be maintained as follows:

Initial pressure—1 lb. 2 oz.
Final pressure—2 lb. 14 oz.

The contact gap, measured at the heels of the contacts in their fully-open position, is $\frac{7}{16}$ inch.

Operating Coil—To remove the coil, first remove the armature by taking out the two bolts securing its supporting bracket to the cross-bar. Then loosen the bolt which holds the coil to the magnet and separate the rectangular washers until it is possible to lower the coil entirely free of the magnet.

De-ion Arc Quenchers — To remove a De-ion arc quencher, grasp it at its lower end and swing it upward (it will pivot about point P, see Fig. 1), striking its lower corner upward with the palm of the hand to overcome any initial resistance to movement. The arc quencher is then free to be lifted entirely clear of the contactor.

To restore the De-ion arc quencher to its location on the contactor, slide it into the position indicated by the dashed rules in Fig. 1, and by striking the upper corner in a direction indicated by the arrow force the arc quencher into its final location

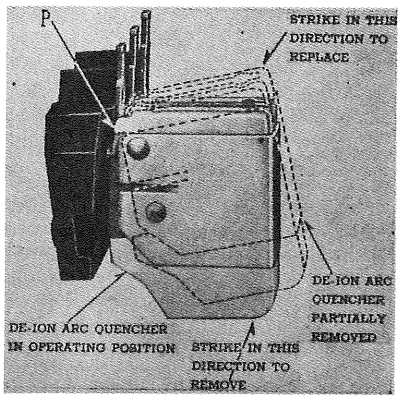


FIG. 1 — DETAIL OF ARC QUENCHER AND ITS SUPPORTING BRACKET, SHOWING EASE OF REMOVAL AND REPLACEMENT.

TYPE L-41 ELECTRICAL INTERLOCK

INSTRUCTIONS

APPLICATION

The Type L-41 electrical interlock is an auxiliary contacting device to be mounted on Sizes 2, 3 and 4 Dn contactors.

Rating

The interlock will carry 6 amperes continuously in control circuits up to 600 volts A-C.

DESCRIPTION

Sizes

The Type L-41 electrical interlock is produced in two sizes: Size 2 for Size 2 Dn contactors, and Size 3 for Sizes 3 and 4 Dn contactors. The only difference between the two exists in the insulating base, which is slightly smaller in the Size 2 interlock.

"Make" and "Break"

The interlock is shipped for "make" or "break" service, as ordered. Any Type L-41 "make" interlock may readily be converted to a "break" interlock by substituting stationary break contacts 11 (Fig. 1) for the make contacts 10; and rotating the moving contact assembly 3 one-half turn about the mounting screw 21, loosening and retightening screw 21 to accomplish this. A "break" interlock may be converted to a "make" interlock in an inverse manner.

Contact Tips

Both the moving and stationary contacts of the Type L-41 interlock are equipped with silver buttons securely welded in place.

INSTALLATION

Location

The Type L-41 electrical interlock may be mounted on a 2, 3 or 4 pole contactor in any or all of three locations, depending upon the limitations of space imposed by the presence of other equipment.

On a **LINESTARTER** one of these interlock locations is occupied by the overload relay, leaving but two locations available. These two locations are indicated by B and C in Fig. 1. Location C (mounting holes shown dotted in Fig. 1) is generally available in addition to B and C on panel mounting applications.

On a reversing **LINESTARTER**, the upper contactor affords only locations A and B, location C being obstructed by the mechanical interlock. The lower contactor, being accompanied by the overload relay, has available for the interlock only positions B and C.

Since interlocks are more accessible in locations A and B, these locations are to be preferred to location C.

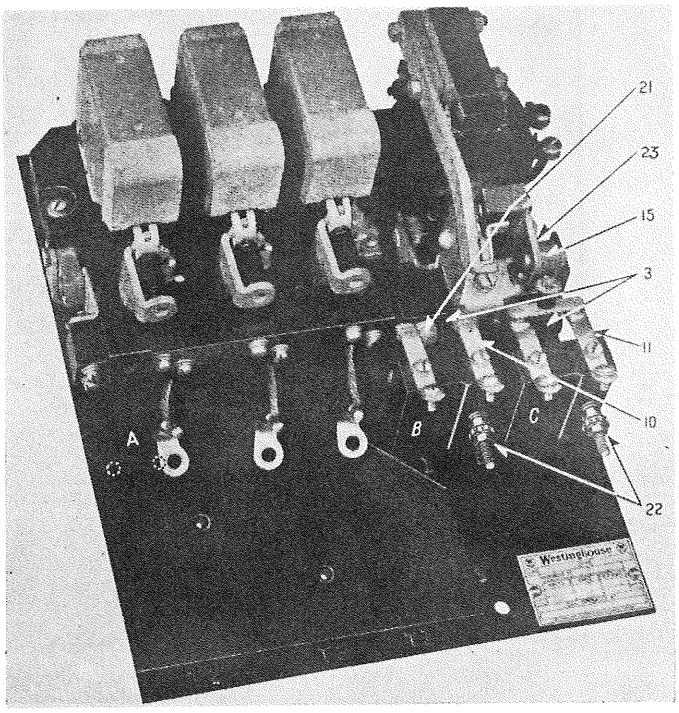


FIG. 1—SIZE 2 TYPE L-41 INTERLOCKS APPLIED TO A SIZE 2, 3 POLE **LINESTARTER** (OVERLOAD RELAY REMOVED, LEAVING CONTACTOR SHUNTS UNATTACHED)

Mounting

In locations A and B, the moving contact assembly 3 of the interlock is held to a projecting surface of the insulation cross-bar of the contactor by the mounting screw 21 (a $\frac{1}{4}$-20 fillister head iron machine screw $\frac{5}{8}$ of an inch long). In position C, an adaptor 15 is required, by means of which the moving contact assembly 3 is secured to the armature bracket 23 of the contactor. The adaptor used with the Size 2 interlock differs from that used with the Size 3 interlock. When ordering, see Renewal Parts List.

The interlock base is secured directly to the contactor panel or mounting plate, employing studs for insulation panel mounting or machine screws inserted from the rear for **LINESTARTER** on steel plate mounting. The threaded holes provided in the interlock base to receive the mounting screws or studs are completely insulated from current-carrying parts. Mounting hardware is included in the interlock styles in the Renewal Parts List.

Contact Pressure

The contacts should have long life without much attention. They should be replaced, however, before the contact buttons have become reduced to one-third their original thickness.

The normal overtravel of the contact support after the contacts touch is approximately $\frac{3}{32}$ of an inch.

Extra Terminals

For the convenience of the user, the interlock base is provided with holes to receive extra terminals (22, Fig. 1), insulated from current-carrying parts and from ground. These will be found especially useful when it is desired to operate the contactor coil from a separate control circuit, or when unusual master switch connections are to be made.

The Size 2 interlock contains one hole, and the Size 3 interlock contains two holes. The terminals are included in the styles for **LINESTARTER** or steel plate mounting. See Renewal Parts List.

TYPE L-41 ELECTRIC INTERLOCK

RENEWAL PARTS DATA

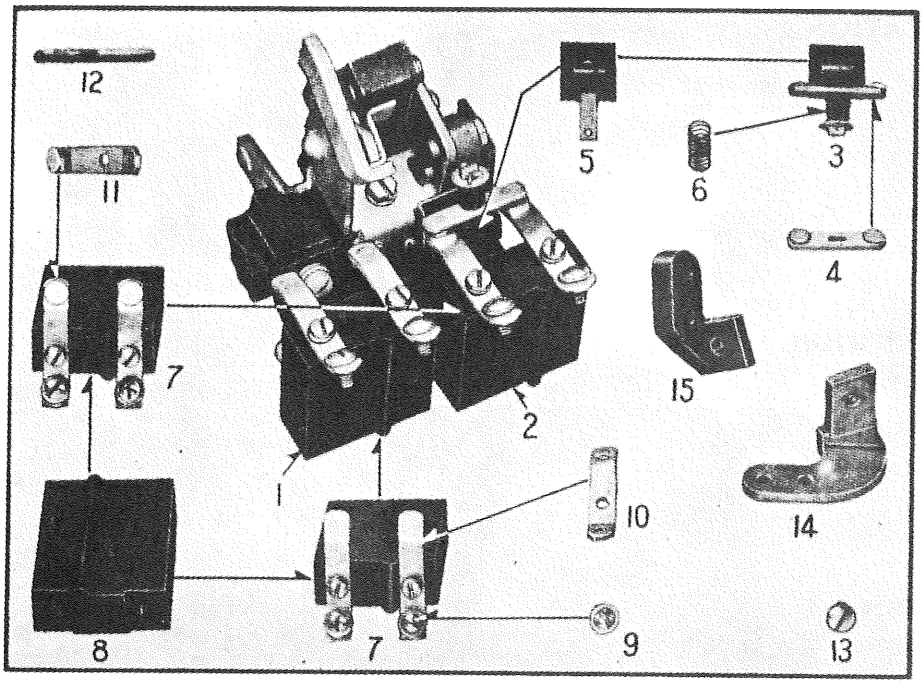


FIG. 2—RENEWAL PARTS FOR TYPE L-41 ELECTRICAL INTERLOCK

RECOMMENDED STOCK OF RENEWAL PARTS

Ref. No.	Description of Part	LINESTARTER or Steel Plate Make Ref. No. 1	LINESTARTER or Steel Plate Break Ref. No. 2	Insulation Panel Make Ref. No. 1	Insulation Panel Break Ref. No. 2	No. Per Interlock	Interlocks in Use 1	Interlocks in Use 5
	Type of Mounting							
	Contact Arrangement							
	Size No. 3 Interlock Style No.	897 835 △897 839 △972 915	897 836 △897 840 △972 916	897 837 △897 841 972 913	897 838 △897 842 972 914			
	Style No. 2 Interlock Style No.	974 326 △974 330 △974 337	974 327 △974 331 △974 338	974 328 △974 332 974 335	974 329 △974 323 974 336		Recommended for Stock	
		Style Number of Part						
3	Moving Contact Complete	897 832	897 832	897 832	897 832	1	0	0
4	Moving Contact	884 643	884 643	884 643	884 643	1	1	2
5	Moving Contact Support	884 648	884 648	884 648	884 648	1	0	0
6	Moving Contact Spring	972 843	972 843	972 843	972 843	1	0	1
7	°Stationary Contact Complete	897 833	897 834	897 833	897 834	1	0	0
8	°Stationary Contact Base	884 647	884 647	884 647	884 647	1	0	0
9	°Washer Head Screw	540 190	540 190	540 190	540 190	2	0	0
10	°Stationary Contact	884 644	... ...	884 644	... ...	2	2	4
11	°Stationary Contact	... ...	884 645	... ...	884 645	2	2	4
7	xStationary Contact Complete	974 324	974 325	974 324	974 325	1	0	0
8	xStationary Contact Base	974 009	974 009	974 009	974 009	1	0	0
9	xWasher Head Screw	540 190	540 190	540 190	540 190	2	0	0
10	xStationary Contact	884 644	... ...	884 644	... ...	2	2	4
11	xStationary Contact	... ...	884 645	... ...	884 645	2	2	4
12	Stud	... ...	... ...	361 705	361 705	2	0	2
13	Mounting Screw	970 317	970 317	... ...	... ...	2	0	2
14	°Adaptor	884 640	884 640	884 640	884 640	1	0	0
15	xAdaptor	974 129	974 129	974 129	974 129	1	0	0
‡	°Terminal	974 334	974 334	... ...	... ...	2	0	0
‡	xTerminal	974 334	974 334	... ...	... ...	1	0	0

‡ Not Illustrated.
° Used only on Interlock Size No. 3.
x Used only on Interlock Size No. 2.
△ Adaptor included in these Interlock Styles.
Parts indented are included in the part under which they are indented.

This is a list of the Renewal Parts and the quantities of each that we recommend should be stocked by the user of this apparatus to minimize interrupted operation caused by breakdowns. The parts recommended are those most subject to wear in normal operation or those subject to damage or breakage due to possible abnormal conditions.

This list of Renewal Parts is given only as a guide. The parts illustrated may not be identical in construction with the parts needed, but the views in Fig. 2 will assist ordering.

ORDERING INSTRUCTIONS

Name the part and give the complete name plate reading. State whether shipment is desired by express, freight or by parcel post. Send all orders or correspondence to nearest Sales Office of the Company. Small orders should be combined so as to amount to a value of at least $1.00 net; where the total of the sale is less than this, the material will be invoiced at $1.00.

Westinghouse Electric & Manufacturing Company

East Pittsburgh, Pa.

Printed in U.S.A. (Rep. 6-37)

ROTARY SWITCHES—TYPE W

Instrument, Control and Auxiliary Types

GENERAL

Application

The Westinghouse type W switches are of the rotary type. They are made in three classifications: namely, instrument, control and auxiliary switches for various applications. These switches are notable for their ruggedness, accessibility and smooth, reliable operation. They are recommended for use with all types of circuit breakers and other classes of apparatus which are electrically controlled. They are insulated for 600 volts and have a continuous current carrying capacity of 10 amperes which is very conservative as indicated by the curve below.

Recommended Interrupting Ratings

Alternating Current

125 Volts—10.0 Amperes
250 Volts— 7.5 Amperes
600 Volts— 1.5 Amperes

Direct Current

125 Volts—4.0 Amperes
250 Volts—2.0 Amperes
600 Volts—0.5 Amperes

The interrupting capacity depends upon the voltage, current and inductance of the circuit controlled. Control relays are to be used in conjunction with control switches on heavy current circuits.

Construction

From the front of the panel, the switch presents a pleasing appearance with its sturdy, convenient black-molded handle and light finished dial plate.

From the rear, the black polished sides and cadmium plated steel end plates make a neat looking switch.

An operating shaft, made from a

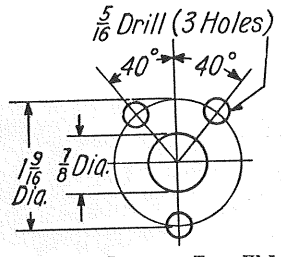


FIG. 3—DRILLING PLAN FOR TYPE W INSTRUMENT AND CONTROL SWITCHES

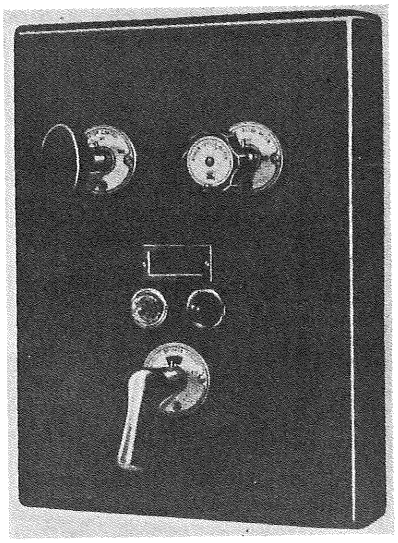


FIG. 1—ILLUSTRATION OF THE OVAL, NOTCHED AND PISTOL-GRIP HANDLES FOR THE TYPE W ROTARY SWITCHES

7/16-inch diameter cold rolled steel rod, rotates in bronze bearings which are riveted in steel end plates. The steel end plates provide ample support for

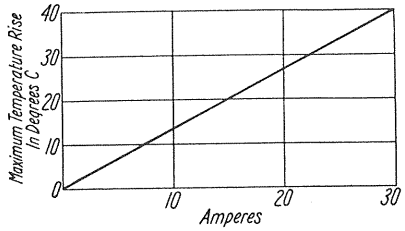


FIG. 2—CURVE SHOWING CAPACITIES OF TYPE W SWITCHES

the base and the enameled steel top which is channel-shaped to secure strength. This arrangement assures permanent alignment of the contacts.

The moving contacts are brass segments with a corrosion resisting finish. The segments are separated by spacers of molded moisture-proof composition.

All of the contacts are keyed to an insulated micarta tube which covers the steel operating shaft. These have numbered key notches to facilitate assembling. Spacers and contacts are securely clamped to the shaft.

The stationary contacts are of the self-aligning type and are made of a suitable material selected for the highest wearing and arc resisting characteristics. Good contact pressure between the moving and stationary contacts is obtained by the use of compression springs which do not carry current. This combination of contact materials operates with a high pressure, wiping action, assuring clean low resistance contacts, with long life.

Multiple laminated copper shunts conduct the current from the contacts to the terminal studs. These studs are mounted on the base in such a manner that they positively will not turn or become loose.

The base is made of an excellent grade of black molded material which has both very high mechanical and dielectric strength, and is ribbed to give ample creepage distance between studs. Each stud hole is numbered for the purpose of identifying the connections on the wiring diagram.

Sheet Micarta side plates slide in grooves in the top and bottom of the switch, snapping snugly into the closed position. This arrangement provides immediate access for the inspection of contacts.

All switches are easily mounted on panels 1/8, 1/4, 1, 1 1/2 or 2 inches in thickness without changing any of the parts except the mounting screws—the length of which depends upon the thickness of the panel. Correct shaft length is obtained by simply sliding the handle

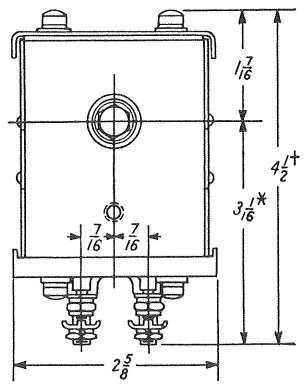


FIG. 4—REAR VIEW AND DIMENSIONS OF TYPE W INSTRUMENT AND CONTROL SWITCHES

*This dimension is 3 5/16-inches for switches Style No. 519110 and 519116.

†This dimension is 4 5/8-inches for switches Style No. 519110 and 519116.

ROTARY SWITCHES—TYPE W—Continued

GENERAL—Continued

over the shaft until the pointer screw fits into the proper tap-hole in the shaft.

Segments, contacts, studs, shunts, etc., are the same for the entire line of switches. This permits great flexibility of design so that type W switches can be easily supplied for special requirements other than those for which style numbers have been listed. The maximum number of circuits in the unit switch is 10 but multiple switches operated from one handle can be obtained with up to 40 circuits.

Style Numbers

Switch **style numbers** include mounting screws for a 2-inch panel. When required for other than 2-inch panels, add the style number of extra mounting screws.

The round notched handle is standard for instrument switches, and the pistol-grip handle is standard for control switches. Either of the switches may be obtained with the round notched, or pistol grip handle or with an oval handle.

Special combinations of keys or handles can be obtained on request.

The **style number** for instrument switches with removable keys does not include keys. Such keys are listed under separate style numbers. Other switches are supplied with non-removable handles.

INSTRUMENT SWITCHES

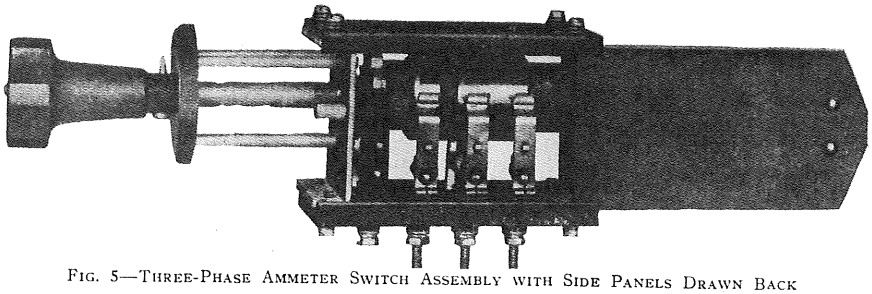


FIG. 5—THREE-PHASE AMMETER SWITCH ASSEMBLY WITH SIDE PANELS DRAWN BACK

General

All type W instrument switches, with the exception of ammeter, regulator transfer and temperature indicator switches, have removable keys.

These keys, besides being labelled, are constructed so that they can be inserted only in the proper switch and can be withdrawn only when the switch is in the off position. This precludes the possibility of trouble when several independent circuits may be connected to the same instrument through similar switches. If only one key is used, only one switch can be operated at a time. A key from any dissimilar switch cannot be inserted.

Large notched handles insure easy operation. A suitable notching device assures permanent alignment of the contact segments with the dial marking, and holds the switch in the position to which it is turned. Length of key to suit different panel thicknesses is obtained in a similar manner to that for non-removable handles.

Type W instrument switches are made in standard styles for connecting any instrument or group of instruments selectively to various circuits as may be required for metering or synchronizing.

Ammeter Switches

The ammeter switches are arranged to connect instruments to any phase without opening the secondary circuit of the current transformers. The three-circuit ammeter switch is used where other instruments are to be connected in the circuit beyond the ammeter switch.

Voltmeter Switches

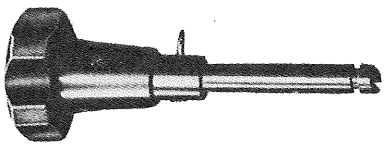


FIG. 6—OPERATING KEY FOR TYPE W INSTRUMENT SWITCH

These switches are arranged to connect the voltmeter to the individual circuit of which the voltage is to be read. Switches are supplied for reading the voltage from one to six independent circuits.

Frequency Meter Switch

This switch connects the frequency meter to one circuit only. In order to use one frequency meter on several circuits, a separate switch is required for each circuit.

Wattmeter, Power Factor Meter and Reactive Factor Meter Switches

These switches connect the instrument transformers of any one polyphase circuit to the proper instrument by means of a suitable combination of voltage and current contacts. A separate switch is required for each polyphase circuit. Power factor meter switches can be used for reactive factor meters by using a suitably marked nameplate.

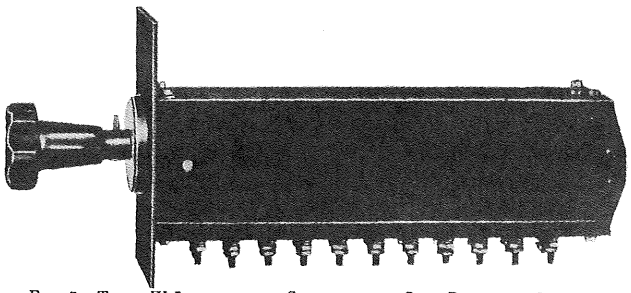


FIG. 7—TYPE W INSTRUMENT SWITCH WITH SIDE PLATES IN PLACE

ROTARY SWITCHES—TYPE W—Continued

INSTRUMENT SWITCHES—Continued

Temperature Indicator Switches

Each temperature switch is arranged to connect the temperature measuring instrument to any one of six exploring coils located in the apparatus, the temperature of which is to be read. Two forms of this switch can be supplied, single-pole and double-pole. Double-pole construction is for use with exploring coil leads of appreciably different lengths. For thermo-couple switch refer to headquarters.

Synchroscope Switch for Synchronizing Between Machine and Bus

The synchronizing switch connects the potential transformer of the circuit to be synchronized and the bus potential transformer to the synchroscope. One switch is required for each machine when synchronizing to a single bus system and two are required when synchronizing to a double bus system. One form of this switch includes interlock contacts for connecting in the control circuit of the circuit breaker to prevent closing the breaker unless the synchronizing switch is in use.

Synchroscope Switch for Synchronizing Between Machines

This type of switch is double-throw and requires a different key for each throw. One switch is required for each machine.

The running key turns the switch so as to connect the voltage transformer of the running machine to the running side of the synchroscope.

The incoming key is used in the switch of the circuit which is to be synchronized, and connects its voltage transformer to the incoming side of the synchroscope. By this means any circuit may be treated either as an incoming or a bus circuit. One form of this switch includes interlock contacts for connecting in the control circuit of the circuit breaker to prevent closing the breaker unless the synchronizing switch is in use.

Test Switches

The standard type W ammeter, voltmeter or combination instrument switch can be used as a test switch for instruments, relays, etc. The type W switch can be used in any conventional testing system, using independent connection studs, test bus, etc. The key handle can be fixed or removable, with interlocking key.

STYLE NUMBERS

SWITCHES

Description of Switches	Schematic Diagram Fig. No.	Drilling Plan Fig. No.	Dimension A, Inches*	Switch Style No.	Key Style No.
Ammeter, two-phase	8	3	5 3/8	519 108	‡
Ammeter, three-phase	9	3	5 3/8	519 109	‡
Ammeter, three independent circuits	10	3	11 9/16	519 110	‡
Voltmeter, a-c. or d-c. single-pole	11	3	4 11/32	519 111	519 126
Voltmeter, single-phase or d-c., two-pole	12	3	4 11/32	519 112	519 127
Voltmeter, two-phase or d-c., three-wire	13	3	6 7/32	519 113	519 128
Voltmeter, three-phase, four-wire	14	3	6 7/32	591 454	591 660
Voltmeter, three-phase, a-c., three-wire	15	3	6 7/32	519 114	519 129
Voltmeter, four-circuit a-c. or d-c. two-wire	16	3	7 23/32	519 115	‡
Voltmeter, six-circuit a-c. or d-c. two-wire	17	3	11 9/32	519 116	‡
Frequency meter, two-pole	12	3	4 11/32	519 117	519 132
Wattmeter, polyphase	18	3	7 23/32	519 118	519 133
Power factor meter	19	3	7 1/16	591 626	519 134
Temperature indicator, single-pole, six circuits	20	3	7 23/32	940 082	‡
Temperature indicator, two-pole, six circuits	24	3	11 9/16	895 355	....
Synchroscope to bus without interlocks	21	3	5 3/8	519 122	519 136
Synchroscope to bus with interlocks	21	3	6 7/32	519 123	519 137
Synchroscope between machines, without interlocks	22	3	4 11/32	519 124	519 138† 519 139§
Synchroscope between machines, with interlocks	22	3	5 3/8	519 125	519 140† 519 141
Regulator transfer switch	23	3	7 23/32	591 571	....

MOUNTING SCREWS FOR INSTRUMENT SWITCHES

Description—Three per set	Style No.
Screws for 1/8-inch thick panel	555 659
Screws for 1/4-inch thick panel	555 658
Screws for 1-inch thick panel	555 657
Screws for 1 1/2-inch thick panel	555 656

*Dimension A is the distance from rear of panel to rear end of switch.
†Running key.
‡Separate key not required.
§Incoming key.

ROTARY SWITCHES—TYPE W—Continued

INSTRUMENT SWITCHES—Continued

DIAGRAMS OF CONNECTIONS

NOTE—Instrument switches are shown for handle end at the top.

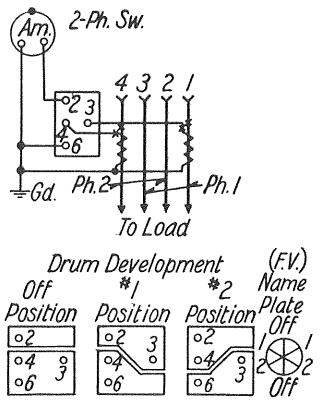


FIG. 8—TWO-PHASE AMMETER SWITCH, STYLE NO. 519108

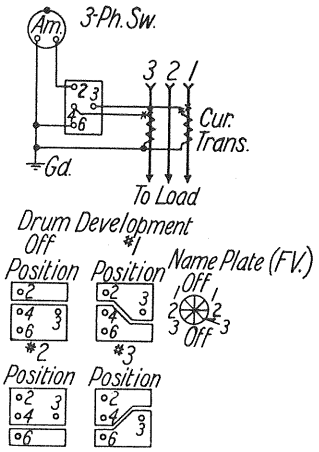


FIG. 9—THREE-PHASE AMMETER SWITCH, STYLE NO. 519109

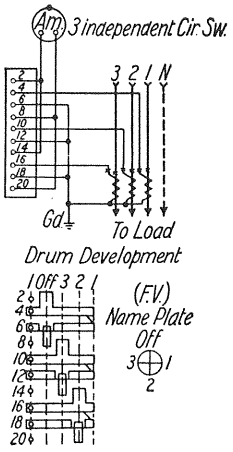


FIG. 10—AMMETER SWITCH 3 INDEPENDENT CIRCUITS, STYLE NO. 519110

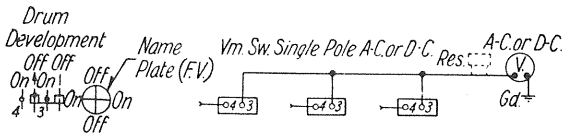


FIG. 11—SINGLE-POLE, VOLTMETER SWITCH A-C. OR D-C., STYLE NO. 519111

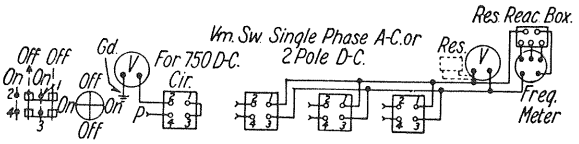


FIG. 12—SINGLE-PHASE A-C. OR TWO-POLE D-C. VOLTMETER SWITCH, STYLE NO. 519112
FREQUENCY METER SWITCH, STYLE NO. 519117

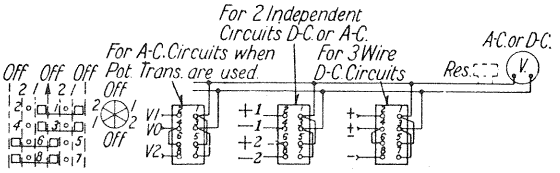


FIG. 13-A—FOR A-C. CIRCUIT WHEN POTENTIAL TRANSFORMERS ARE USED, STYLE NO. 519113

FIG. 13-B—FOR TWO INDEPENDENT CIRCUITS D-C. OR A-C., STYLE NO. 519113

FIG. 13-C—FOR THREE-WIRE D-C. CIRCUITS, STYLE NO. 519113

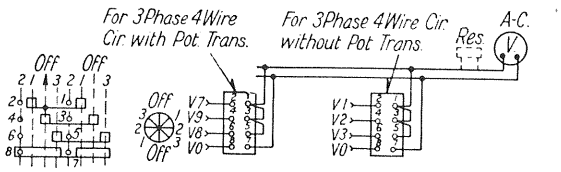


FIG. 14—VOLTMETER SWITCH, 3-PHASE, 4-WIRE CIRCUITS. STYLE NO. 591454

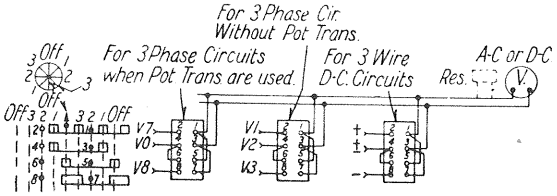


FIG. 15-A—THREE-PHASE CIRCUITS WHEN POTENTIAL TRANSFORMERS ARE USED, STYLE NO. 519114

FIG. 15-B—THREE-PHASE CIRCUIT WITHOUT POTENTIAL TRANSFORMERS, STYLE NO. 519114

FIG. 15-C—THREE-WIRE D-C. CIRCUITS, STYLE NO. 519114

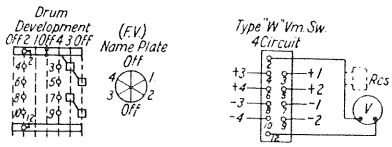


FIG. 16—FOUR-CIRCUIT, 2-POLE SWITCH, STYLE NO. 519115

ROTARY SWITCHES—TYPE W—Continued

INSTRUMENT SWITCHES—Continued

DIAGRAMS OF CONNECTIONS—Continued

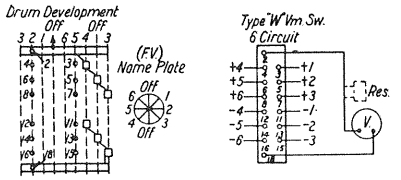


FIG. 17—SIX-CIRCUIT, 2-POLE SWITCH, STYLE NO. 591116

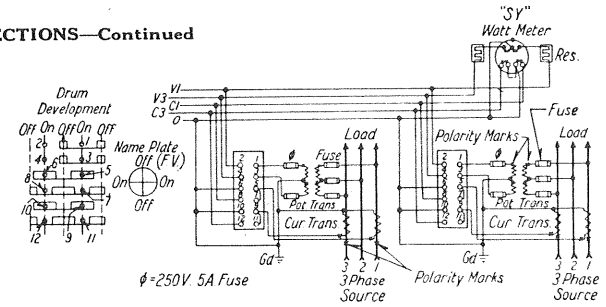


FIG. 18—WATTMETER SWITCH, STYLE NO. 519118

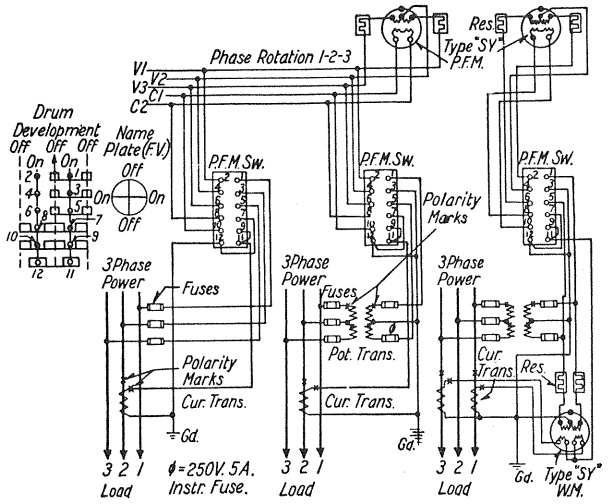


FIG. 19—POWER-FACTOR METER SWITCH, STYLE NO. 591626

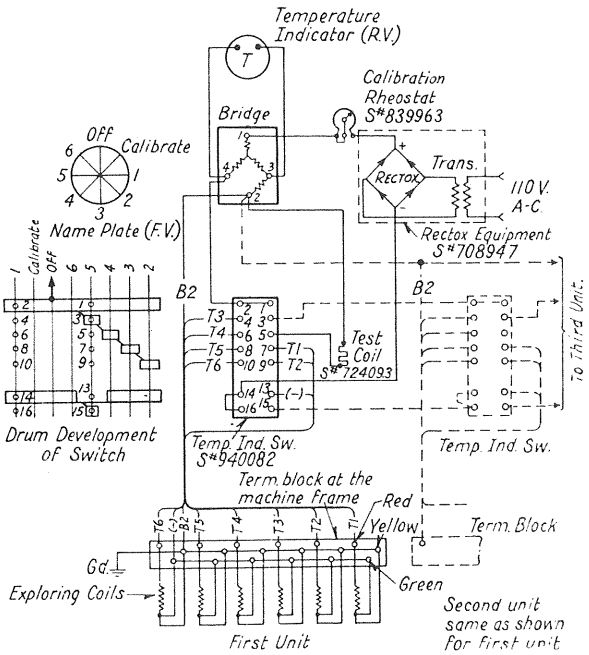


FIG. 20—TEMPERATURE INDICATOR SWITCH, STYLE NO. 940087
SINGLE-POLE SIX-CIRCUIT FOR APPROXIMATE LEAD COMPENSATION

NOTE—For six exploring coils, wire as per solid lines. For more than six exploring coils, wire as per solid and dotted lines, using two or more switches as needed. For each generator, use six hot-test coils.

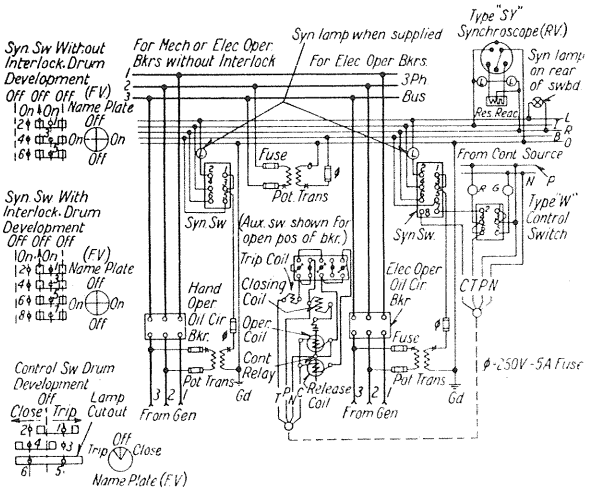


FIG. 21—SWITCH FOR SYNCHRONIZING BETWEEN BUS AND MACHINE
WITHOUT INTERLOCKS, STYLE NO. 519122
WITH INTERLOCKS, STYLE NO. 519123

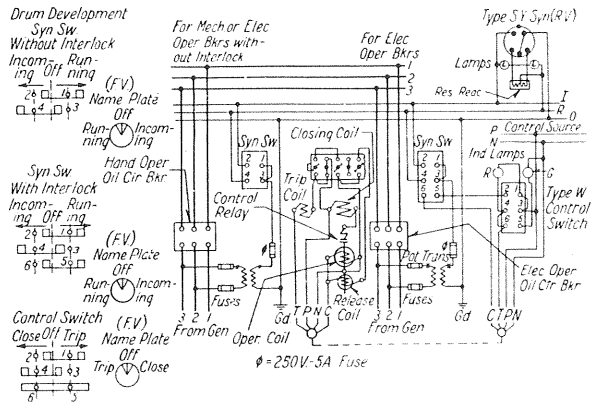


FIG. 22—SWITCH FOR SYNCHRONIZING BETWEEN MACHINES
WITHOUT INTERLOCKS, STYLE NO. 519124
WITH INTERLOCKS, STYLE NO. 519125

ROTARY SWITCHES—TYPE W—Continued

INSTRUMENT SWITCHES—Continued

DIAGRAMS OF CONNECTIONS—Continued

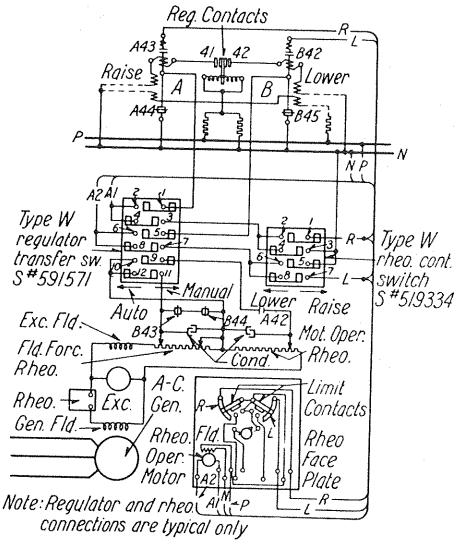


FIG. 23—REGULATOR TRANSFER SWITCH STYLE NO. 591571

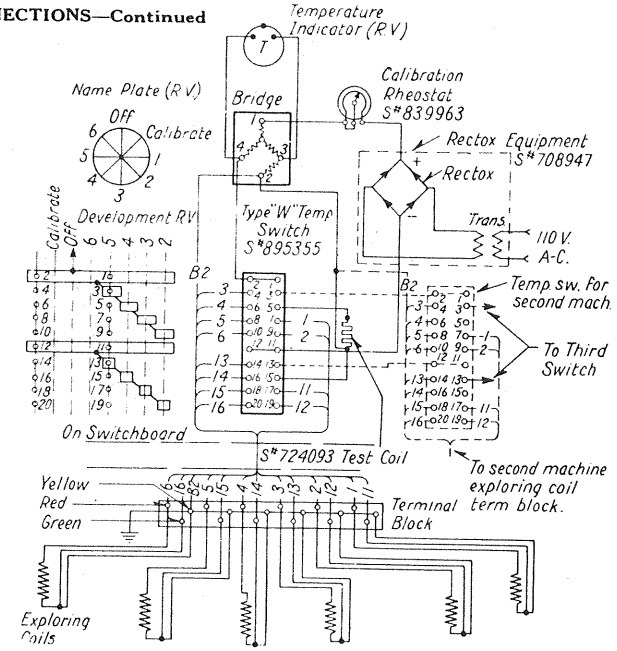


FIG. 24—TEMPERATURE INDICATOR SWITCH, STYLE NO. 895355, DOUBLE-POLE, SIX-CIRCUIT FOR COMPLETE LEAD COMPENSATION

CONTROL SWITCHES

Application

The type W control switch is for the control of electrically-operated switches and circuit breakers, rheostats, engine and turbine governors, feeder potential regulators, etc., both motor and solenoid-operated. In general control relays are operated directly from the control switches in order to handle such heavy capacity operating current as may be met with, particularly in the case of switches and circuit breakers.

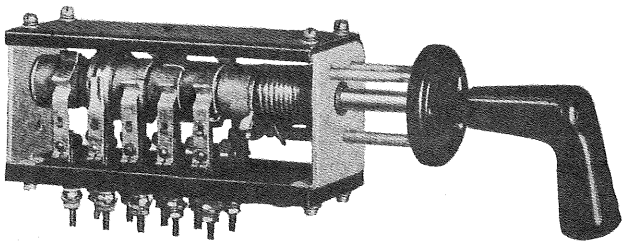


FIG. 25—CONTROL SWITCH FITTED TO STEEL PANEL WITH SIDE PLATES IN PLACE

These switches are essentially multi-circuit double-throw switches. One form of this switch is used for starting induction or synchronous motors, one position being used to close the starting breakers, the other position being used to close the running breakers. A special pull-out feature is provided in the usual "off" position to trip the breakers when desired. These control switches are also adapted for raising and lowering voltage, both in conjunction with feeder-voltage regulators of the induction type, and automatic generator-voltage regulators of any conventional type.

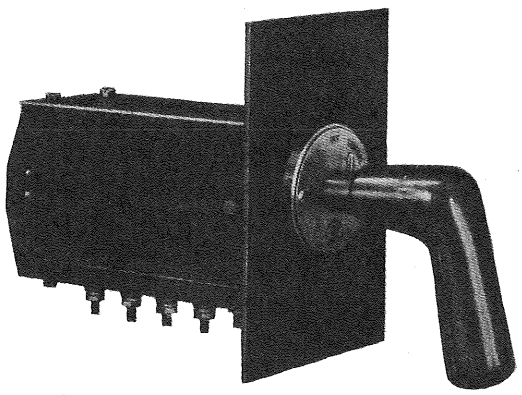


FIG. 26—CONTROL SWITCH ASSEMBLY WITH SIDE PANELS REMOVED

Operation

Trip Position—By turning the control switch to the trip position, the trip coil of the oil circuit breaker is energized. The control switch is latched in this position by pulling the handle forward which action also opens the signal lamp circuit.

Spring Return Handle—Control switches are provided with large pistol-grip handles to facilitate operation by

ROTARY SWITCHES—TYPE W—Continued

CONTROL SWITCHES—Continued

the switchboard attendant. These switches are provided with a spring return mechanism which causes the switch to return automatically to the "off" position, when released from the operating position.

Mechanical Indicator—All circuit breaker control switches are provided with a mechanical indicating device which shows a red or green marker to indicate the last manual operation of the switch.

Signal Lamp—Signal lamp cutouts may be obtained with circuit breaker control switches. This lamp cutout is in circuit with one or all of the indicating lamps.

Automatic Indicator Cutouts—This arrangement is generally used for an alarm system, causing the sounding of an alarm or the lighting of a lamp on the occurrence of an automatic operation. These contacts are also used for interlocking a common tripping circuit with several control switches.

Indicating Lamps—Suitable indicating lamps can be used in conjunction with control switches to obtain electrical indication of the position of circuit breakers or other devices.

STYLE NUMBERS

SWITCHES

Application	Description	Schematic Diagram Fig. No.	Dimension A, Inches *	Style No.
Oil circuit breaker control switches	S. P. D. T. switch with lamp cutouts	28	5 3/8	519 330
	S. P. D. T. switch with lamp and automatic indicator cutouts	29	6 1/32	519 331
	S. P. D. T. switch with lamp and two automatic indicator cutouts	30	...	780 374
	S. P. D. T. switch with overload relay contacts and lamp cutouts	31	7 1/16	519 332
	S. P. D. T. switch with overload relay contacts, lamp and automatic indicator cutouts	32	7 29/41	519 333
	S. P. D. T. switch with overload relay contacts, lamp and two automatic indicator cutouts	33	...	780 375
Voltage control switches, field rheostat and induction regulator	2-P. D. T. switch	34	6 1/32	519 334
	3-P. D. T. switch	34	7 29/41	519 335
	2-P. D. T. switch with regulator contacts	35	7 29/41	519 336
	2-P. D. T. switch (induction regulator, 5 position)	36	5 3/8	592 128
Motor control switches Speed control switch	D. T. with two-circuit pull-out trip	37	7 29/41	519 337
	2-P. D. T.	38	6 1/32	519 338

MOUNTING SCREWS FOR CONTROL SWITCHES

Description	Style No. Per Set
Screws for 1/8-inch thick panel, 3 per set	519 480
Screws for 1/4-inch thick panel, 3 per set	519 479
Screws for 1-inch thick panel, 3 per set	519 478
Screws for 1 1/2-inch thick panel, 3 per set	519 477

*Dimension A is distance from rear end of the switch to the panel.

DIAGRAMS OF CONNECTIONS

NOTE:—Auxiliary switches are shown for the open position of the breaker. Control switches are shown as top view, with the handle end at the top of the diagram.

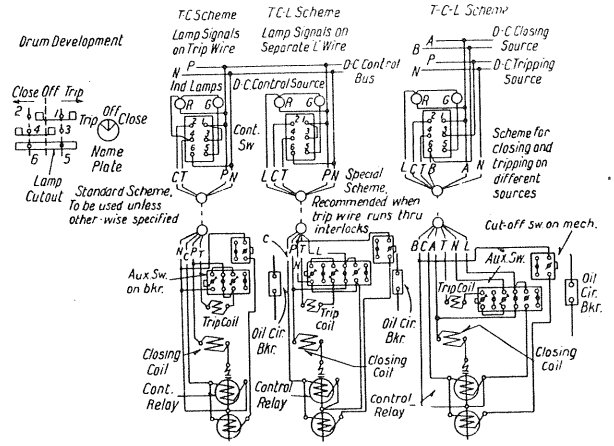


FIG. 28—CIRCUIT BREAKER CONTROL SWITCH, STYLE NO. 519330

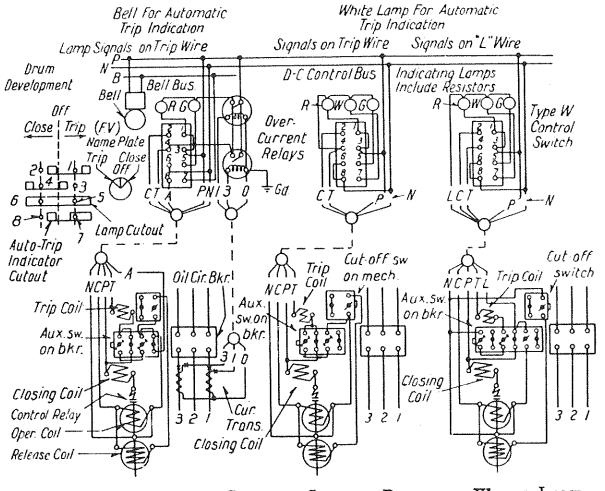


FIG. 29—CIRCUIT BREAKER CONTROL SWITCH, BELL AND WHITE LAMP FOR AUTOMATIC TRIP, STYLE NO. 519331

ROTARY SWITCHES—TYPE W—Continued

CONTROL SWITCHES—Continued

DIAGRAMS OF CONNECTIONS—Continued

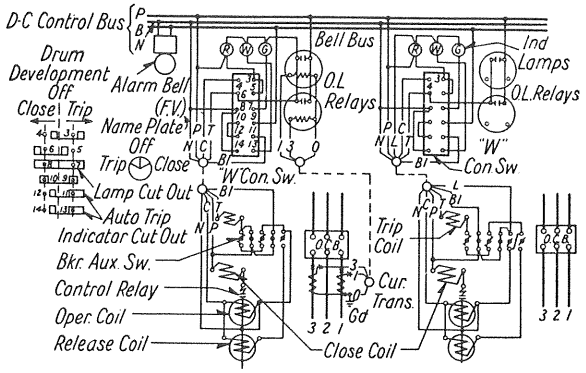


FIG. 30—CIRCUIT BREAKER CONTROL SWITCH BELL AND WHITE LAMP FOR AUTOMATIC TRIP INDICATION, STYLE NO. 780374
A—LAMP SIGNALS ON TRIP WIRES
B—LAMP SIGNALS ON L WIRES

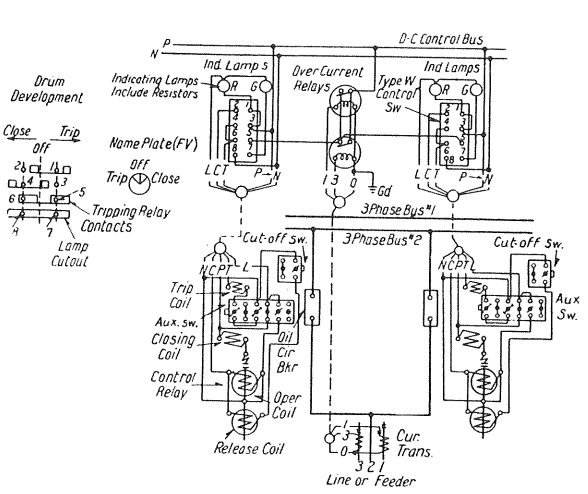


FIG. 31—STYLE NO. 519332

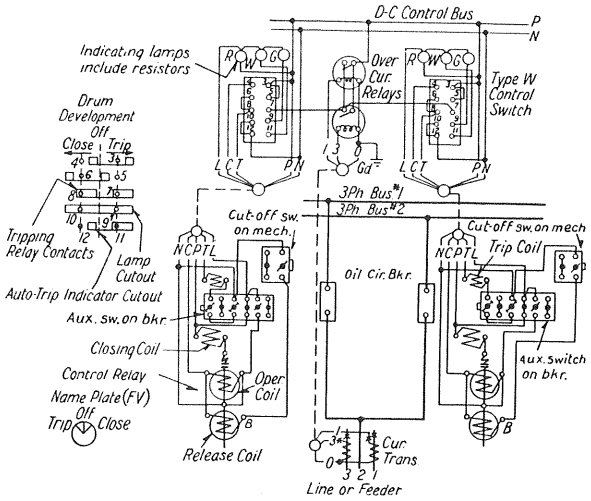


FIG. 32—STYLE NO. 519333

CIRCUIT BREAKER CONTROL SWITCHES FOR DOUBLE-BUS SYSTEMS

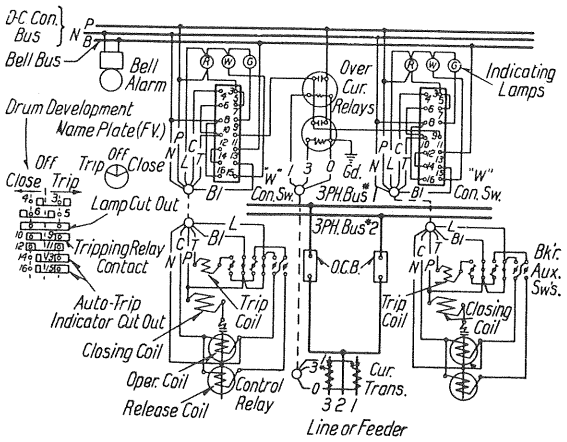


FIG. 33—CIRCUIT BREAKER CONTROL SWITCH FOR DOUBLE BUS SYSTEM, STYLE NO. 780375

ROTARY SWITCHES—TYPE W—Continued

CONTROL SWITCHES—Continued

DIAGRAMS OF CONNECTIONS—Continued

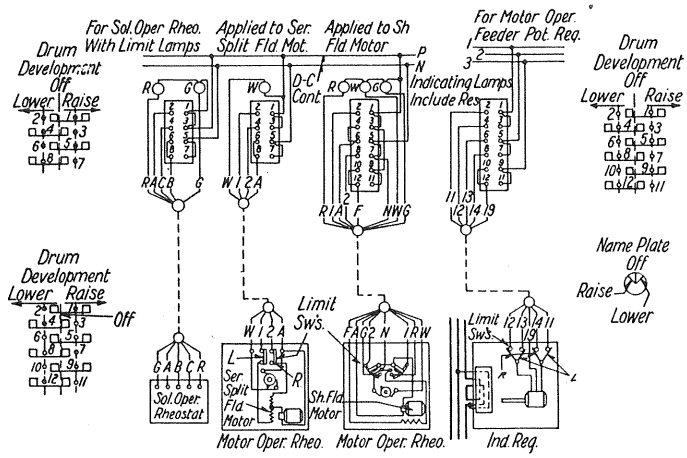


FIG. 34—SOLENOID, OR MOTOR-OPERATED RHEOSTAT AND INDUCTION REGULATOR CONTROL SWITCHES, STYLE NO. 519334, 519335

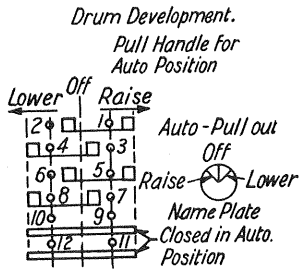


FIG. 35—RHEOSTAT CONTROL SWITCH WITH REGULATOR CUT-OUT CONTACTS, STYLE NO. 519336

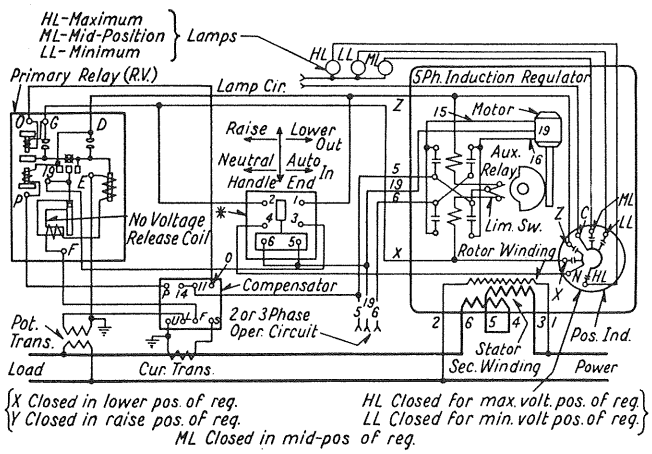


FIG. 36—INDUCTION REGULATOR CONTROL WITH INDUCTION REGULATOR CONTROL SWITCH STYLE NO. 592128

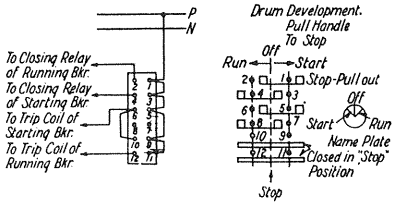


FIG. 37—SWITCH FOR MOTOR CONTROL, STYLE NO. 519337

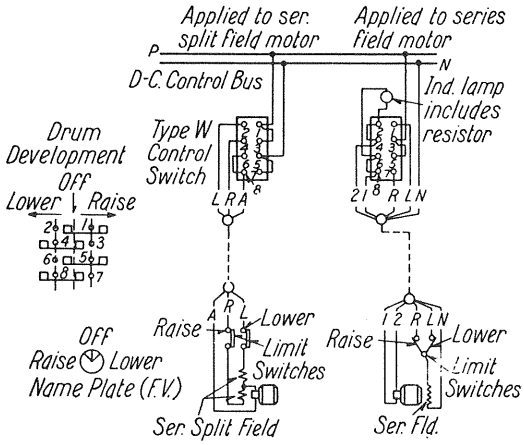


FIG. 38—GOVERNOR MOTOR-SPEED CONTROL SWITCH, STYLE NO. 519338

ROTARY SWITCHES—TYPE W—Continued

AUXILIARY SWITCHES

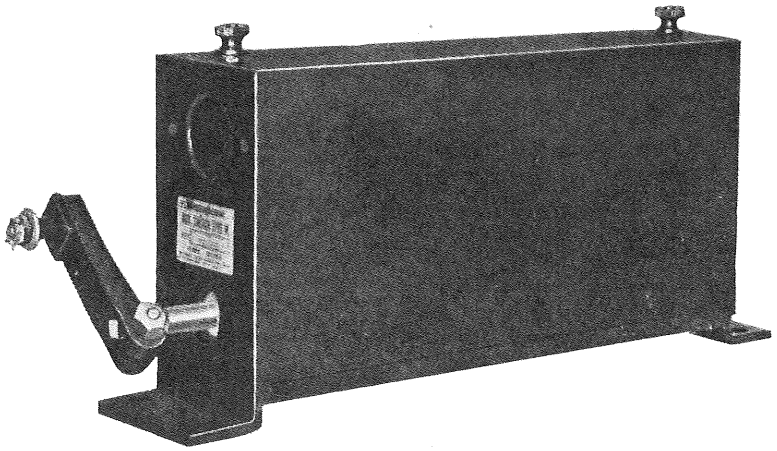


FIG. 39—AUXILIARY SWITCH COMPLETE WITH COVER

Application

The type W auxiliary switch is similar to the instrument and control switches having identical control fingers, rotor segments and molded base. They are applicable to circuit breakers, operating mechanisms, or other apparatus requiring auxiliary switches. These switches are made with 2, 4, 6 and 10 contact circuits. The rotor turns to two positions 90 degrees apart. The rotor segment makes contact with its pair of stationary fingers in one or the other 90-degree position. Any individual rotor segment can be rotated 90 degrees to change from a "make" contact to a "break" contact or vice versa. Special segments can be supplied for special switching arrangements.

The switch is made in two forms with and without terminal covers. The switch which is equipped with a Micarta cover, as shown in Fig. 39, has provision for bringing leads out of either end of the switch through holes provided in the end brackets. A cover-plate is supplied for the hole not in use.

The switch without cover is used on applications where the apparatus is otherwise housed, as for example, with the operating mechanism on outdoor oil circuit breakers. This switch is shown in Fig. 40. The operating lever of both types of switches clamp to the squared end of the rotor shaft. Provision is made for changing the length of the operating lever so as to adapt the switch to an operating rod travel of from 1 to 3 inches. The angular travel of the rotor is always 90 degrees.

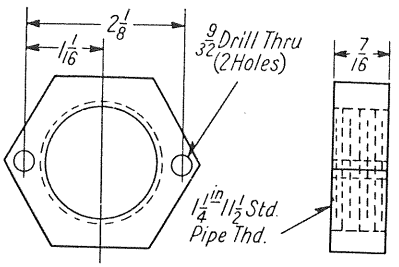


FIG. 41—PIPE FLANGE STYLE NO. 762198 FOR USE ON AUXILIARY SWITCHES

Where the wires are to be carried in conduit, the auxiliary switches are arranged to accommodate a special nut, Fig. 41, with 1¼-inch pipe threads which can be bolted to the switch bracket. The nut with mounting bolts Style No. 762198 is not included with the switch style number, but will be furnished, if desired, without additional charge.

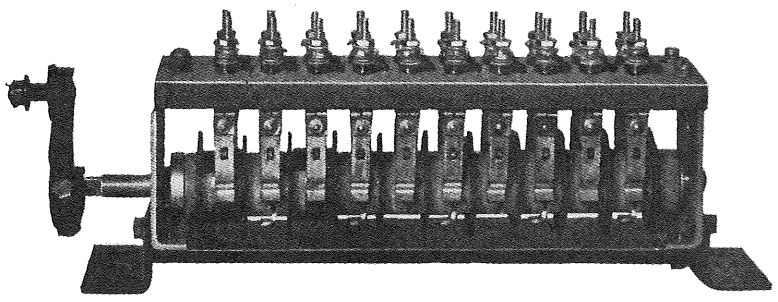


FIG. 40—AUXILIARY SWITCH ASSEMBLY

STYLE NUMBERS

Description	Over-All Length in Inches from Front of Base to Rear of Switch	Style No. With Cover	Style No. Without Cover
2-pole, 1-"a"—1-"b"*	4 5/8	676 957	591 816
4-pole, 2-"a"—2-"b"*	6 5/16	676 960	591 819
6-pole, 3-"a"—3-"b"*	8	676 963	591 822
10-pole, 5-"a"—5-"b"*	11 3/8	676 966	591 825

*The letter "a" and "b" designate "make" and "break" as shown in the N. E. M. A. hand book on switching equipment.

Order by Style Number

ROTARY SWITCHES—TYPE W—Continued

WEATHER-PROOF AUXILIARY SWITCHES

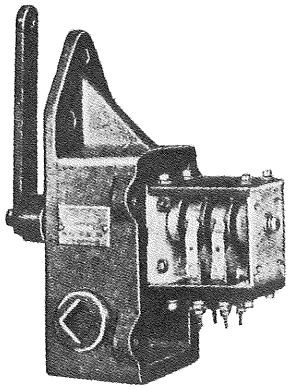


FIG. 42—2-POLE AUXILIARY SWITCH, COVER REMOVED

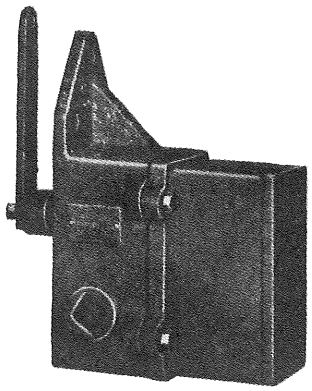


FIG. 43—2-POLE AUXILIARY SWITCH, COVER IN PLACE

The type W weatherproof auxiliary switches are completely housed for outdoor applications. See Fig. 43. They are used with remotely controlled, gang-operated, disconnecting switches, or for any other application where it is desired to give a signal or alarm as to the action of some mechanical device.

These switches can be furnished in 2, 4, 6 or 10-pole types and are manufactured from standard indoor switch parts mounted on a cast brass base to which the cover is bolted.

The base contains 3 holes for $\frac{3}{8}$-inch mounting bolts. Holes tapped for conduit connection are provided on two sides and the top, two ot which are fitted with pipe plugs. These holes are for 1-inch conduit on the 2 and 4-pole switches, $1\frac{1}{4}$-inch conduit on the 6-pole switch and $1\frac{1}{2}$-inch on the 10-pole switch.

A substantial cover, with a cast alloy flange, is provided to cover the switch. This cover contains an inner lining of insulating material. All joints are fitted with gaskets to assure weatherproof construction.

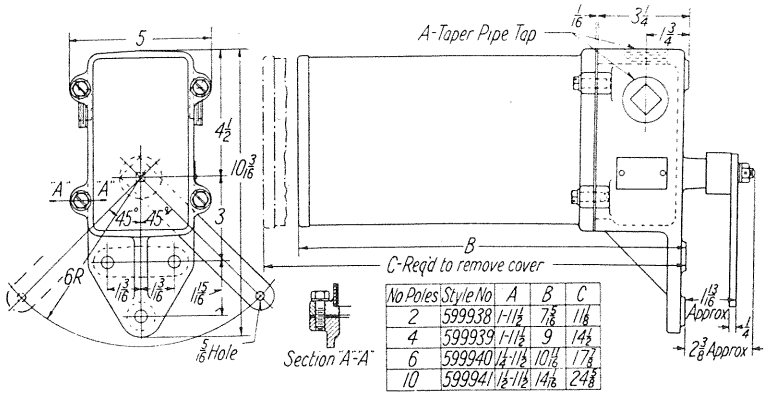
STYLE NUMBERS

Description	Over-All Length in Inches from Front of Base to Rear End of Switch	Style No.
2-pole, 1-"a"—1-"b"*	$7\frac{1}{8}$	599 938
4-pole, 2-"a"—2-"b"*	$8\frac{3}{4}$	599 939
6-pole, 3-"a"—3-"b"*	$10\frac{3}{4}$	599 940
10-pole, 5-"a"—5-"b"*	$13\frac{7}{8}$	599 941

*The letters "a" and "b" designate "make" and "break" as shown in the N.E.M.A. hand book on switching equipment.

Dimensions are for reference only. For official dimensions apply to the nearest district office.

OUTLINE DIMENSIONS IN INCHES



No Poles	Style No	A	B	C
2	599938	1-1 1/2	7 5/8	1 1/8
4	599939	1-1 1/2	9	1 4 1/2
6	599940	1 1/4-1 1/2	10 11/16	1 7 7/8
10	599941	1 1/2-1 1/2	14 1/8	2 4 5/8

FIG. 44—2, 4, 6 AND 10-POLE, 10-AMPERE, 250-VOLT AUXILIARY SWITCH

Order by Style Number

Westinghouse

Insulating Oil

for

Electrical Apparatus

INSTRUCTION BOOK

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

I. B. 65-000
Filing No. 65-000

Importance of Maintenance and Inspection

CENTRAL STATIONS and other large users of transformers, oil circuit-breakers, and feeder regulators have become more and more convinced of the necessity for making periodical inspection and tests of insulating oil and of dehydrating and purifying oil that has absorbed moisture or sediment. Where this practice has been systematically followed, it has been found that failure of apparatus from burnouts, with consequent interruption of service, has been reduced to a minimum and a resulting economy in the use of oil has been effected. Notwithstanding the fact that many central stations carefully inspect the oil in their apparatus, it is believed that the importance of this subject justifies the recommendation that all companies, in the interest of good service, adopt some system of oil inspection and test.

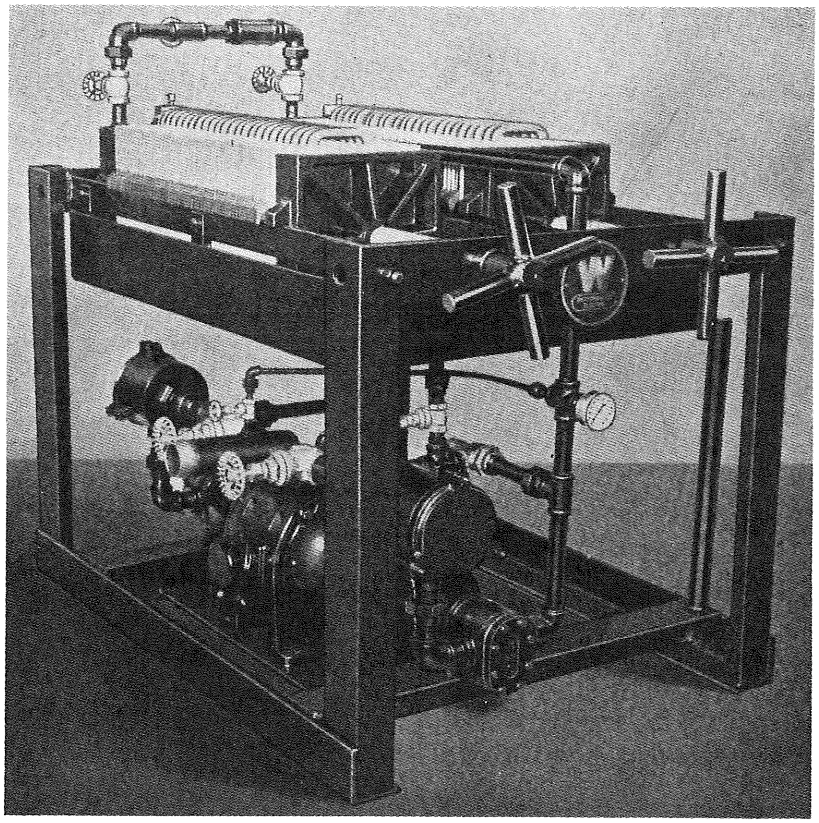


FIG. 1—A-60 FILTER PRESS

Westinghouse

Insulating Oil for Electrical Apparatus

General Information

The insulating oil furnished by the Westinghouse Electric & Manufacturing Company has been developed after many years of research work in cooperation with the oil refiners. In response to requests from customers for a reduction in the number of grades of insulating oil used in electrical apparatus, we have developed the Universal Wemco Coil which is particularly well adapted for all Westinghouse oil insulated apparatus, and may be used in transformers after arcing in circuit-breakers when purified to meet values, given on page 12. (Interchangeability after Purification.)

The insulating oil is just as much a part of the apparatus in which it is used as any of the other materials which are built into the apparatus. In order to insure the performance guaranteed for the apparatus, only the insulating oil furnished by the Westinghouse Electric & Manufacturing Company should be used. This is manufactured under our supervision so that we can assure our customers that every shipment is up to the proper standard of quality on which the design of the apparatus has been based.

As all oil is subject to deterioration in service even under the most favorable conditions, it is essential to provide for periodic inspection and test, and to purify the oil whenever it is necessary in order to maintain it in good condition.

The more handling which an insulating oil receives, the greater the opportunity for contamination unless adequate precautions are taken.

This publication gives instructions for storing, handling, inspecting, testing and purifying of insulating oil which experience has shown are important in order to maintain the quality of the oil.

Functions of Insulating Oil—In transformers the oil provides an electrical insulating medium which also will carry the heat away from the windings.

In circuit-breakers the oil serves primarily as an electrical insulating medium which interrupts the arc when the circuit-breaker operates.

Primary Requirements for Insulating Oil

For Transformers and Induction Regulators—High dielectric strength.

Freedom from inorganic acid, alkali and corrosive sulphur to prevent injury to insulation or conductors.

Low viscosity to provide good heat transfers.

Good resistance to emulsion, so that the oil will throw down any moisture entering the apparatus instead of holding it in suspension. (Water in suspension is a menace to safe operation).

FREEDOM FROM SLUDGING UNDER NORMAL OPERATING CONDITIONS.

For Circuit-Breakers—High dielectric strength.

Freedom from inorganic acid, alkali and corrosive sulphur, to prevent injury to insulation or conductors.

Low viscosity to aid in dissipating the arc when the circuit is interrupted.

Low freezing point to insure proper fluidity at all operating temperatures.

Good resistance to emulsion so that any moisture entering the apparatus or carbon formed by arcing will settle to the bottom of the tank.

It will be noted that the requirements for insulating oil for transfromers are not inconsistent with those for oil for service in circuit-breakers. A single grade of oil, Universal Wemco C oil, has been developed which is particularly well suited for both applications and for either indoor or outdoor service.

Shipment

Universal Wemco C oil is shipped in tank cars, drums and cans. The modern tank cars are usually lagged to prevent rapid fluctuations in temperature during transit and thus reduce the amount of expansion and contraction of oil. Changes in the volume of the oil due to temperature changes tend to cause breathing in of moist air resulting in condensation of moisture inside the tank and lowering of the dielectric strength of the oil.

The oil and the drums are both heated above room temperature while the drums are being filled, and the bungs are tightened immediately after filling. After cooling to normal temperature, the bungs are again tightened. The drums are provided with screw bungs having gaskets to prevent admission of water. The cans are of metal. The cans as well as the oil are heated above room temperature while being filled and are hermetically sealed immediately after filling.

Storage

Cans and Drums—As soon as a drum of oil has been unloaded the bung should be examined and tightened if it is loose. It is possible for bungs to become loosened by change in temperature or rough handling in transit.

It is very desirable that oil in drums be stored in a closed room. If it is necessary to store it out doors, protection against direct precipitation of rain or snow should be provided. Out door storage of oil is always hazardous and should be avoided if at all possible. Drums stored out doors should be placed on timbers so as to be clear of the ground. They should always be placed on their sides and never turned up on end. The bungs should be turned at an angle of about 45 degrees from the top. It is desirable to cover them with a tarpaulin.

Cans containing oil must not be exposed to the weather. They should not be unsealed before the oil is actually needed. It is not necessary to make dielectric tests on oil in sealed cans.

Screw caps are being provided on the cans, for use where the contents are only partially used after the hermetic seal is broken, to prevent contamination with moisture or dirt.

Storage Tank—The storage tank should be mounted on piers so that it will not touch the ground, and will be accessible to all points for inspection for leakage.

It is desirable to maintain the temperature of the oil and tank a little above the temperature of the surrounding air as this prevents condensation of moisture in the tank which would affect the dielectric strength of the oil.

The tank should preferably have a convex bottom, allowing the installation of a drain cock at the lowest point for removing any free water or dirt which

might settle out. When a cylindrical tank is installed with its axis horizontal, one end should be a little lower than the other with a drain cock at the lowest point, and the oil supply pipe should enter at the opposite end of the tank. The oil may enter and leave the tank by the same pipe, but this should be at some distance from the bottom to prevent stirring up any settlings when the tank is being filled. It is desirable that the pipe be provided with a swing joint and float, so that it will automatically move with the change in oil level and remain near the surface of the oil.

The same precaution should be taken in filling storage tanks as mentioned below under "Placing Oil in Service, Temperature of Oil."

Refilling of Drums—The practice of refilling drums with oil is very undesirable and should be avoided whenever possible, for unless the utmost precautions are taken, the oil is likely to become contaminated.

If it is necessary to refill drums for storage, drums should be reserved for this purpose which have been used only for oil in good condition. They should be closed immediately after being emptied, to exclude dirt and water. After refilling, they should be examined to see that they do not leak.

Whenever a drum is to be filled with oil, the temperature of the drum and of the oil should be at least 5.5°C. (10°F.) higher than the air, but the temperature of the drum need not be the same as that of the oil.

Drums which have been used for good oil only, but which have perhaps received some water should be drained, placed in an oven with the bung hole down, and heated to a temperature of at least 88°C. (190°F.) for sixteen hours. The bung should be screwed on tightly before removing from the oven. A new washer should be used with the bung each time the drum is refilled, to insure a tight seal. These washers may be obtained from the oil refineries. It is recommended that a supply of the washers be kept on hand. Rubber composition washers should never be used as they would be attacked by the oil.

Drums to be refilled with oil for storage should be plainly marked for identification by painting.

Cleaning of Contaminated Drums—The cleaning of drums which have contained used insulating oil requires great care in order to insure a thoroughly clean drum. It is preferable to return such drums to the refinery where adequate cleaning facilities are available, rather than to attempt to clean them. If it is necessary to clean such drums, the following procedure is recommended:

Rinse the drum thoroughly with gasoline or benzine, using about one gallon each time, until the solvent after using shows no discoloration. Allow it to drain, then pump out the last traces of solvent with a vacuum pump, using a brass pipe flattened at the lower end to explore the corners of the drum. (Steel must not be used, on, account of the danger of a spark igniting the vapor.) Heat the drum with bung hole down, in an oven at a temperature of at least 88°C. (190°F.) for sixteen hours. Screw the bung on tightly before removing drum from the oven. Use a new washer with the bung to insure a tight seal. A simple oven for this purpose may be made from sheet metal and heated with steam or an electric heater. An open flame must be kept away from the oven to prevent igniting inflammable gases.

Protection from Fire

Fire Risk—While the Universal Wemco C oil furnished with circuit-breakers and transformers will not take fire unless brought to a very high temperature, it should be remembered that under abnormal conditions such a temperature can be reached, so that proper precaution against fire should be taken. Suitable means should always be provided for drawing off oil from storage tanks and extinguishing fire. The best way to extinguish burning oil is to smother the flames so that the supply of fresh air is cut off. Chemical fire extinguishers are effective but water should not be used unless it is applied by a special atomizing spray nozzle.

Placing Oil in Service

The most careful precaution must be taken to insure the absolute dryness and cleanness of the apparatus before filling it with oil, and to prevent the entrance of water and dirt during the transfer of the oil to the apparatus.

Cleaning of Apparatus—When putting a new circuit-breaker or transformer into service, see that the tank is free from moisture and foreign material.

When carbonized oil is removed from a circuit-breaker or transformer in service, thoroughly clean the interior of the apparatus so that the new oil will not be contaminated. This may be done by flushing with clean insulating oil and wiping with clean dry lint-free cotton cloths. Cotton waste is undesirable on account of the lint which may be introduced into the oil.

Temperature of Oil—A drum of cold oil when taken into a warm room will "sweat", and the resulting moisture on the surface may mix with the oil as it flows from the drum. Before breaking the seal the drum should therefore be allowed to stand long enough to reach room temperature, which may require eight hours, or even longer under extreme temperature conditions.

The preparation and filling of outdoor apparatus should preferably be done on a clear, dry day; if this is not practicable, protection against water must be provided.

All vessels used for transferring the oil should be carefully inspected to see that they are absolutely dry and free from dirt.

Straining—Although the drums and tank cars are thoroughly washed and dried at the refinery before filling, a certain amount of scale is sometimes loosened from the inside in transit. Therefore, oil which has not been filtered should be strained through two or more thicknesses of muslin, or other closely woven cotton cloth which has been thoroughly washed and dried to remove the sizing. The straining cloths should be renewed as often as necessary. The cloth may be stretched across a funnel of large size.

Hose—RUBBER HOSE MUST NOT BE USED in handling oil. Always use metal hose. Oil can easily become contaminated from the sulphur in rubber and should not be allowed to come in contact with it.

Testing—The oil should be sampled and tested before being transferred to the apparatus. The oil in all apparatus should be sampled and tested before the apparatus is put into service.

Maintenance

Cause of Deterioration of Oil in Transformers—The principal causes of deterioration of insulating oil in service are water and oxidation. The oil may be exposed to moisture through condensation from moist air due to breathing of the transformer especially when the transformer is not continuously in service. The moist air drawn into

the transformer condenses moisture on the surface of the oil and inside of the tank. The oil may also be contaminated with water through leakage such as from leaky cooling coils or covers. Sludge is an oxidation product, the amount formed in a given oil being dependent upon the temperature and the time of exposure of the oil to the air. By careful refining, the components of oil which are most readily oxidized to form sludge can be removed, so as to provide an insulating oil which will not sludge under normal operating conditions. Excessive temperatures may cause sludging of any transformer oil, regardless of how well it is refined.

Transformer oil which has begun to sludge will continue to do so after it has been purified by means of the centrifuge or filter press, as these methods of purification do not remove the deterioration products which are in process of formation but have not yet been thrown down as sludge. No method is yet available in the field which will remove these products and bring sludged oil back to its original condition when new. Such oil can be refined so as to be equivalent to new oil, but this would require equipment which is only available in an oil refinery. It is not economical to send used oil to the refinery as they will allow fuel oil price which would probably be less than the cost of transportation.

Another effect of oxygen is to gradually produce organic or "fatty" acids in oil in service. These should not be confused with the mineral acid such as sulphuric acid used in refining, as in small amounts they do not have a deteriorating effect upon insulation. There is no method available in the field for purifying oil of high organic acidity.

In an effort to produce oil which has less tendency to sludge, it is possible to "over-refine" it. Such an oil developes organic acidity, which when once started, increases rapidly to a point where it becomes a menace to insulation. This high acid development is characteristic of some of the so called "water-white" oils. (Examination of one of these oils in our research laboratory showed the extremely high organic acidity of 18 mg. of KOH per gram of oil in six months at 80°C. (176°F.)

There is at present no adequate method for determining the sludging tendency of oil which is correlated with actual performance of the oil in service. The American Society of Testing Material is studying the various methods advocated, but none of them duplicate conditions in transformer service. Obviously any such method to be of value, must be correlated with data on the oil in actual transformer service.

Causes of Deterioration of Oil in Circuit-Breakers—The principal causes of deterioration of insulating oil in circuit-breakers in service are:

1. Water.
2. Carbonization of the oil caused by operation of the circuit-breaker.

Insulating oils do not absorb water, but they may receive water through condensation on the surface of the oil or on the inside of the tank due to the entrance of moist air.

All oil in circuit-breakers is subject to carbonization due to arcing between the contacts. Part of the carbon formed is deposited on the mechanism and at the bottom of the tank while the remainder continues in suspension in the oil.

Carbonization takes place not only when the circuit-breaker opens heavy short circuits, but also whenever an arc is formed, even during such light service as the opening of the charging current of the line and this latter service repeated may eventually produce enough carbon to be a source of trouble.

The carbon reduces the dielectric strength of the oil, and lowers the surface resistance of the insulation if water is present and also lowers the resistance to emulsification. The carbon may not be detected by the dielectric test, particularly if the oil is free from moisture.

In cold weather, a larger amount of carbon is formed than in warm weather on account of the increased viscosity of the oil at low temperatures. Also the carbon is not as readily dispersed through the oil.

Westinghouse Oil Testing Service

It is of prime importance that insulating oils be kept free from water and other impurities. Tests have shown that as little as .005 per cent of moisture held in suspension will reduce the dielectric strength of oil to half of its strength when dry.

Moisture may find its way into insulating oil in several ways. The oil is frequently shipped in metal drums, and if these are exposed to rain, moisture may enter around the threads of the bung, or through imperfections in the seams. In water-cooled transformers, the portions of the water pipes which extend above the oil level are always heavily lagged with a heat insulating material. If this lagging is damaged, moisture in the air inside of the transformer may be condensed on the cold water pipe and may run down into the oil. Another source to which the presence of moisture in large transformers is sometimes attributed, is the "breathing" of the transformer. When the transformer carries a load and becomes warm, both the oil and the air in the tank expand, and if there is a vent a part of the air will be forced out of the tank. When the load is cut off and the transformer cools, this action is reversed, and a corresponding volume of air is drawn into the tank from the atmosphere. This air carries a certain amount of moisture, which is condensed as the air becomes cooler and forms on the cover and tank wall.

Foreign matter may get into the oil through handling, although oil is usually handled with sufficient care to keep it clean. There is another source of dirt however that cannot be avoided with certain insulating oils used in the past which throw down a heavy precipitate or sludge when overheated. Modern oils are so prepared that this effect is practically eliminated.

In order to make sure that the dielectric strength is up to its proper value, the insulating oil in any piece of apparatus should be tested at regular intervals. The E. E. I. recommends that oil samples from all power stations and substation apparatus be tested at least once every three months, and that samples from distrbution transformers be tested at least once a year. Inertaire transformers will not require such frequent tests.

Many users of transformers and large oil circuit-breakers do not have the necessary equipment for testing insulating oil. In order that these users may be able to make the periodic tests recommended, the Westinghouse Electric & Manufacturing Company has established an Oil Testing Service.

The oil sample container shown in Fig. 3 has been developed as a part of the Westinghouse Oil Testing Service. This Service furnishes a means by which customers can mail samples of insulating oil to the East Pittsburgh Works for test, and provides:

A thoroughly dry bottle

A safe mailing container

A careful test by experienced engineers

A prompt report of test results.

The bottles are dried and sealed at our East Pittsburgh Works, and assembled in the parcel post mailing container together with the necessary packing and printed matter.

This service has been developed to make it simple for the customer to handle, and to give him a prompt report as to the condition of the oil.

After drawing the oil the customer should reseal and repack the bottle and mail it to the Engineering Laboratory at East Pittsburgh. To simplify these details, an instruction and order sheet and a printed return label have been provided, and are inserted in the carton container. The instructions cover the taking of the sample and its proper preparation for mailing. The label carries an envelope in which the customer should enclose his order covering the work of testing.

When samples of oil are received for oil testing service as outlined above they are sent to the electrical testing laboratory and tested for dielectric strength in a standard test cup, using 1" diameter flat discs spaced 0.1" apart. Extreme care is taken to see that the test cup is clean and dry before the sample is poured in and that the sample is not contaminated.

As soon as the test has been made, a report giving five breakdown test readings and the average of these is sent by mail directly to the person in the customer's organization who has been designated on the order to receive it. It is our aim to mail reports within 24 hours from the time that are samples received.

In addition to dielectric tests we are also prepared to make a physical and chemical examination.

This service consists in the examination of the oil by a competent oil chemist. Recommendations will be made as to the suitability of the oil for continued use, whether it would be desirable and economical to clean it, and in a general way, the preferred method of cleaning, if this is found to be desirable. In submitting samples for this service, the history of the oil represented should be given as completely as possible. Samples should be approximately one quart in size.

Power factor test of oil at 60 cycles can be made. Unless otherwise requested, the test will be made at a stress of 30 volts per mill.

For details refer to the nearest Westinghouse sales office.

Note—The containers will not be returned to the customer. In submitting samples, the type of service desired should be plainly indicated.

FIG. 2—STYLE NO. 310 368, SAMPLE CONTAINER FOR OIL TESTING SERVICE. STYLE NO. 688 493, COVERS SIX OF THESE CONTAINERS PACKED IN A CARTON.

Inspection and Testing

It is essential, therefore, that periodic inspection and tests be made so that the oil can be renewed when necessary.

The frequency of inspection and testing depends upon the service to which the apparatus is subjected.

Circuit-breakers which are called upon to open the circuit frequently under heavy loads require much more frequent inspection and purification of the oil than those subjected to lighter duty.

Transformers subjected to heavy duty should be more frequently inspected than those in normal or light service.

It is recommended that operators prepare a schedule for inspection based on the operating conditions. Reference to the station log, together with the record of dielectric tests of the oil should determine the frequency of inspection and test. The period between successive inspections should never be longer than six months. When the dielectric strength of the oil drops to 20 kv., in the standard dielectric test (see page 8) the oil should be looked upon with suspicion and in no case should it be allowed to drop below 18 kv.

Inertaire Transformers

A periodic purification schedule is not essential for transformers equipped with the Inertaire device since such transformers should run indefinitely without need for purification provided the inertaire equipment is properly maintained.

Inspection of oil in service should include:

Check on the Oil Level—It is essential that the proper oil level be maintained. Low oil level may cause breakdown of insulation or flashover of bushing in any apparatus, or failure of circuit-breaker to properly open heavy overloads.

Check on the Dielectric Strength—The oil should be tested regularly for dielectric strength and purified when the tests show need of it. The testing should be systematized and complete records kept. It is particularly important to check the dielectric strength after exposure to severe overload operation in a circuit-breaker.

Check on Carbonization—The presence of carbon in circuit-breaker oil introduces a hazard, due to the tendency of the carbon to lower the dielectric strength of the oil, and also to deposit on insulating surfaces reducing the insulation resistance.

Visual inspection of the oil samples should be made and if any appreciable amount of carbon is present the oil should be purified even though the dielectric test is good.

Check on Sludge—Transformers should be regularly examined for evidence of sludge. A visual inspection will indicate its presence. Appreciable amounts of sludge may clog the oil ducts and interfere with heat transfer. It is essential that such oil be purified immediately and when put in service again should be carefully watched to see that the proper dielectric strength is maintained and that the oil is purified again before sludge has formed again to such an extent as to interfere with the operation of the transformer. Oil which has once sludged, will, after being purified, sludge more quickly than the first time.

Check on Steam Emulsification—The S.E. test (see pages 11 and 12) gives a good indication of the resistance to emulsification of the oil, or its ability to throw down moisture and carbon developed through arcing in a circuit-breaker. This property of an oil is

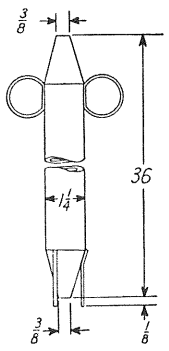


FIG. 3—DRUM THIEF

impaired when the oil has been exposed to the operation of a circuit-breaker.

The dielectric strength of oil is very greatly affected by the most minute traces of certain impurities, particularly water. It is exceedingly important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination. A great many of the low dielectric test results reported from the field have been caused by carelessness in sampling. The following instructions based on the specifications of the American Society for Testing Materials, must be strictly followed to assure accurate results:

Sampling Oil

Sampling Oil from Shipping Containers

Sample Bottle—The sample container shall be made of clear glass, of at least 8 ounce capacity, and shall be cleaned and dried. The glass bottle is preferable to the metal container as it may be examined to see if it is clean. It also allows visual inspection of the oil before testing, particularly as regards free water and solid impurities. However, any samples to be tested for color or sludge forming characteristics must be kept in the dark, as light produces changes in these properties. This is not necessary for any other tests. Use only good quality cork and use new cork for each sample.

The clean dry bottle shall be thoroughly rinsed with benzine or dry lead free gasoline which has previously withstood a dielectric test of at least 25 kilovolts in a test cup having electrodes 1″ in dia. and spaced 0.100″ apart and shall be allowed to drain. The bottle shall then be tightly corked and cork and neck of the bottle dipped in melted paraffin. DO NOT USE RUBBER STOPPERS. Oil can easily become contaminated from the sulphur in rubber.

Note: Glass jars having rubber gaskets should not be used.

It is preferable to heat the bottle and cork to a temperature of 100°C. (212°F.) for one hour after thoroughly draining, and cork the bottle while hot.

Thiefs for Sampling—Thiefs should be cleaned by rinsing with dry lead free gasoline taking special care that no lint or other fibrous material remains on them. When not in use they should be kept in a hot, dry cabinet or compartment at a temperature not less than 37.8°C. (100°F.), and shall be stored in a vertical position in a rack having a suitable drainage receptacle at the base.

Note: A convenient and simple thief (see Fig. 3) for use with 50 gal. drums may be made of tin as follows:

Length 36″, diameter 1¼″ with cone shaped caps over the ends and having openings at the ends ⅜″ in diameter. Three legs equally spaced around the thief at the bottom, long enough to hold the opening ⅛″ from the bottom of the container being sampled, aid in securing a good representative sample. Two rings soldered to the opposite sides of the tube at the outer end will be found convenient for holding the thief by slipping two fingers through them leaving the thumb free to close the opening. In an emergency a piece of glass tubing 36″ long may be used. For the tank cars, a thief employing a trap at the bottom may be used. (See Fig. 4).

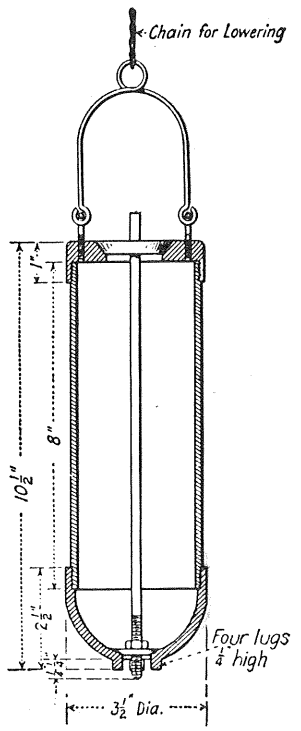


FIG. 4—THIEF FOR SAMPLING TANK CARS

Procedure—Samples shall not be drawn from containers indoors until the oil is at least as warm as the surrounding air. Cold oil may condense enough moisture on the surface from a humid atmosphere to seriously affect its insulating properties. Sampling oil from containers out of doors is undesirable due to the possibility of condensation of moisture and should be avoided whenever possible. Samples should never be taken in the rain.

The drums shall be lined up preferably on their sides and numbered, bungs up. The bungs shall be unsealed and removed and laid with the oily side up beside the bung holes. The unstoppered sampling receptacle can be placed on the opposite side of the bung holes. The top hole of the thief shall be closed with the thumb, the thief quickly thrust to the bottom of the container and the thumb removed. When the thief is filled, the thumb shall be replaced, the thief quickly withdrawn and the contents allowed to flow into the sampling receptacle. The lower holes shall not be closed with the fingers of the other hand. The free hand shall be used to guide the stream of oil by touching the thief only when necessary. The oil shall not be allowed to flow over the hand or fingers before it flows into the sampling receptacle.

When the sampling receptacle is filled, it shall be closed quickly and the bung replaced in the container and tightened. The sampling receptacle shall be taken under cover to the testing laboratory as quickly as feasible.

After using, thoroughly clean all thiefs and sampling receptacles as outlined above.

The thief shall be suitable for reaching the bottom of the container and the sample shall be taken with the thief not more than about ⅛″ from the bottom.

The tank cars of oil shall be sampled by introducing the thief through the manhole on top of the car, the cover of which shall be removed carefully so as not to contaminate the oil with dirt. The sample shall be taken as near as possible to the bottom of the tank car. This shall not be done while rain or snow is falling.

When separate samples are being taken from a consignment or part of a consignment, care should be exercised to prevent contaminating the samples. A separate thief shall be used for each sample or the thief previously used shall be well drained and then thoroughly washed with oil from the next container to be sampled, throwing away the oil thus used for washing, before taking the portion reserved for the sample. Enough thiefs shall be provided to insure thorough drainage of each thief after rinsing with oil to be sampled before using it to withdraw the sample. For obtaining only a few samples, two thiefs are sufficient, but for obtaining a large number of samples (for example, sampling a carload of drummed oil) six or more are desirable.

When one average sample of a consignment or batch is being taken, the same thief may be used throughout the sampling operation, omitting the precaution of rinsing the thief with oil before taking any of the portions that go to make up the total average sample.

Sample—It is recommended that one pint of oil be taken as a sample for dielectric tests and one quart sample be taken when complete physical and chemical tests are to be made. At least one sample should be taken from a tank car of oil. One sample may be taken from each drum, or if desired, a composite sample may be made from oil from five drums, provided all of the drums are air tight. When first loosening the bung, a hissing sound should be heard indicating that the drum has been air tight. If the test of the composite sample is not satisfactory, a sample from each of the drums represented should be tested.

When drums are stored exposed to the weather, a sample from each drum shall be tested. The sample of oil should be examined for free water, and if any is noted the sample and bottle should be discarded, as dielectric test is not necessary. If the sample is being taken from a tank car sufficient liquid should be drawn from the bottom of the tank to remove all free water before obtaining another sample of oil for the dielectric test.

Sampling Oil from Apparatus

When taking samples of oil from apparatus where a thief cannot be used, the procedure outlined above should be followed as far as practicable. In addition, care should be taken to procure a sample which fairly represents the oil at the bottom of the tank. Sufficient oil should therefore be drawn off before the sample is taken to insure that the sample will not be that which was stored in the sampling pipe. For this reason the valve and the drain pipe should be sufficiently small to be emptied with convenience and yet sufficiently large to give an even flow of oil and avoid clogging by sediment. A ¼″ pipe and valve is recommended. This, of course, may be separate from the drainage pipe and valve or may be connected to the drainage valve by means of a suitable reducer.

A glass sample bottle is recommended for this purpose so that any water present may readily be seen.

If the sample contains free water it is not suitable for dielectric test and the sample and bottle should be discarded. Sufficient liquid should be drawn from the bottom of the tank to remove all free water before obtaining another sample of oil for the dielectric test.

If the apparatus is installed outdoors care should be taken to prevent contamination of the sample by rain, snow, etc.

Test Method*

Dielectric Strength

Apparatus—The transformer and the source of supply of energy shall not be less than ½ kv-a., and the frequency shall not exceed 100 cycles per second. Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually without opening either primary or secondary circuit. The rate of rise shall approximate 3000 volts per second. The voltage may be measured by any approved method which gives root-mean-square values.

Some protection is desirable to prevent excessive flow of current when breakdown of the oil takes place. This protection preferably should be in the primary or low voltage side of the testing transformer. It is not especially important for transformers of 5 kv-a. or less, as the current is limited by the regulation of the transformer.

The test cup for holding the sample of oil shall be made of a material having a suitable dielectric strength. It must be insoluble in and unattacked by mineral oil and gasoline and non-absorbent as far as moisture, mineral oil and gasoline are concerned.

The electrodes in the test cup between which the sample is tested shall be circular discs of polished brass or copper, one inch in diameter and having square edges. The electrodes shall be mounted in the test cup having their axes horizontal and coincident, with a gap of 0.100″ between their adjacent faces, and with top of electrodes about 1¼″ below the top of the cup. A suitable test cup is shown in Fig. 5 and portable testing outfits in Figs. 6, 7 and 8.

Procedure—(a) The electrodes and the test cup shall be wiped clean with dry calendered tissue paper or with a clean dry chamois skin and thoroughly rinsed with oil-free dry gasoline or benzine until they are entirely free from fibres.

(b) The spacing of electrodes shall be checked with a standard round gauge having a diameter of 0.100″ and the electrodes then locked in position. Care shall be taken not to touch the electrodes with the gauge or in any other manner after cleaning the electrodes and cup, so as to avoid any possible contamination.

(c) The test cup shall be filled with dry lead free gasoline or benzine and voltage applied with uniform increase at the rate of approximately 3000 volts (rms.) per second until breakdown occurs. If the dielectric strength is not less than 25 kv., the cup shall be considered in suitable condition for testing the oil. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

Note: Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the oil which is being tested and the test proceeded with at once, or the electrodes should be thoroughly dried.

(d) The temperature of the test cup and of the oil when tested shall be the same as that of the room which should be between 20 and 30°C. (68 and 86°F.). Testing at lower temperatures is likely to give variable results which may be misleading.

(e) The sample in the container shall be agitated with a swirling motion to avoid introducing air, so as to thoroughly

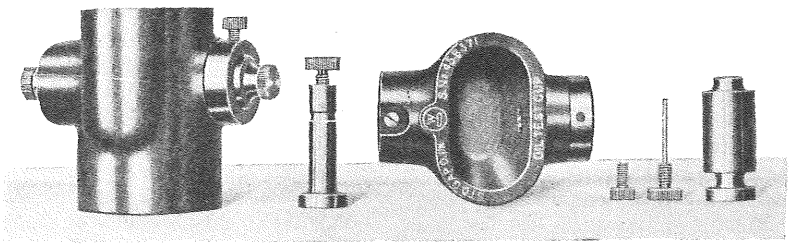


FIG. 5—OIL TEST CUP FOR DIELECTRIC TEST

* Instructions for testing correspond in general to the recommendations of the American Society for Testing Materials.

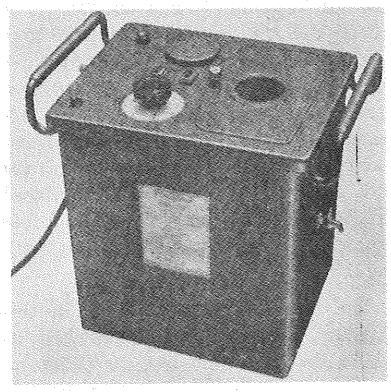


FIG. 6—PORTABLE OIL TESTING SET
½K-VA. 35,000 VOLTS

mix the oil before filling the test cup. This is even more important with used oil than with new oil as the impurities may settle to the bottom and the test may be misleading.

(f) The cup shall be filled with oil to a height of no less than 0.79" (20 mm.) above the top of the electrodes.

(g) The oil shall be gently agitated by rocking the cup and allowing it to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

(h) Voltages shall be applied and increased uniformly at a rate of approximately 3000 volts (rms.) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

(i) Provision shall be made for opening the circuit as promptly as possible after breakdown has occurred in order to prevent unnecessary carbonization of the oil. After each puncture, the testing vessel shall be jarred to loosen particles of carbon adhering to the electrodes and the oil gently agitated but not with sufficient violence to introduce air bubbles.

(j) Five breakdowns shall be made on each filling after which the vessel shall be emptied and refilled with fresh oil from the original sample. The test shall be continued until the averaged values of at least three fillings do not differ from their mean by more than 10 per cent.

Report—The report shall include the volts (rms. value) at each puncture, the average voltage for each of the three or more fillings, grand average voltage and the approximate temperature of the oil at the time of the test. The diameter of disc electrodes and the gap should also be given.

Note: A precision of about 3 per cent may reasonably be expected in 15 tests distributed among three consistent fill ings taken in succession. But if the length of the gap is readjusted and possibilities of contamination exist, the precision may be only 6 or 7 per cent. Difference as great as 10 or 12 per cent may occur between different laboratories even where the work is carefully done.

Pour Test*

The pour point of a petroleum oil is the lowest temperature at which this oil will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Apparatus—(See Fig. 8)—The test jar shall be of clear glass, of cylindrical form, flat bottom, approximately 1¼" inside diameter and 4½ to 5" high. An ordinary 4 oz. oil sample bottle may be used if the test jar is not available.

The thermometer shall conform to A.S.T.M. specifications for pour test. It may be ordered as: A.S.T.M. thermometer low cloud and pour, minus 56.7°C. (minus 70°F.) to plus 21.1°C. (70° F.).

The cork shall fit the test jar, and shall be bored centrally to take the test thermometer.

The jacket shall be of glass or metal, shall be water tight, of cylindrical form, flat bottom, about 4½" deep, with inside diameter ½" greater than outside diameter of the test jar.

A disc of cork or felt ¼" thick and of the same diameter as the inside of the jacket shall be placed in the bottom of the jacket.

The ring gasket shall be about $\frac{3}{16}$" thick, and made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

The cooling bath shall be of a type suitable for obtaining the required temperature. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. For determination of very low pour points, a smaller insulated cooling bath may be used and the test jar placed directly in it. The required bath temperature may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

Note: The freezing mixtures commonly used are as follows:

For temperature down to 10°C. (50°F.) ice and water.

For temperature down to minus 12°C. (10°F.), crushed ice and sodium chloride.

For temperature down to minus 26.1°C. (minus 15°F.), crushed ice and calcium chloride.

For temperature down to minus 56.7°C. (minus 70°F.), solid carbon dioxide and acetone or gasoline.

The last named mixture may be made as follows: In a covered metal breaker chill a suitable amount of acetone to minus 12°C. (10°F.) or lower, by means of an ice-salt mixture. Invert a cylinder of liquid carbon dioxide and draw off carefully into a chamois skin bag the desired amount of carbon dioxide, which through rapid evaporation will quickly become solid. Then add to the chilled acetone enough of the solid carbon dioxide to give the desired temperature.

Procedure—The oil to be tested shall be brought to a temperature at least 14°C. (25°F.) above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear, but such filtration shall be made at a temperature at least 14°C. (25°F.), above the approximate cloud point. The oil shall be poured into the test jar, to a height of not less than 2 nor more than 2¼". When necessary the oil shall be heated in a water bath just sufficiently for pouring into the test jar.

The test jar shall be tightly closed by the cork carrying the test thermometer in a vertical position in the center of the jar with the thermometer bulb immersed so that the beginning of the capillary shall be ⅛" below the surface of the oil.

Heat without stirring to a temperature of 46.1°C. (115°F.) in a bath maintained at not higher than 47.8°C. (118°F.). The oil shall then be cooled to 32.2°C.

* The instructions for pour test correspond in general to the recommendations of The American Society for Testing Materials.

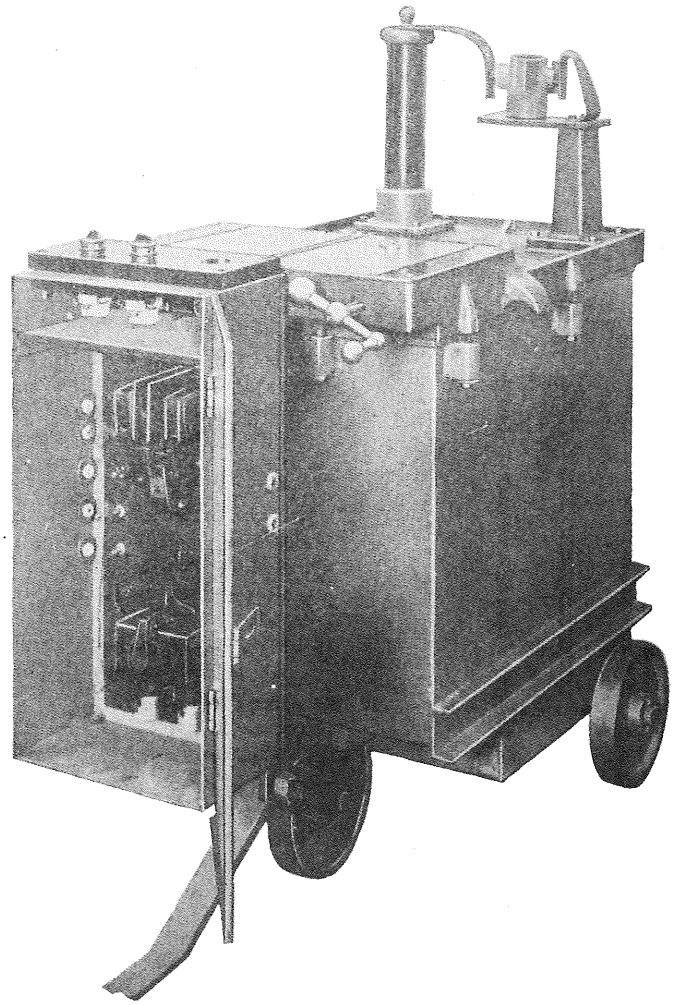


FIG. 7—PORTABLE TRUCK TYPE OIL AND INSULATION TESTING SET, 10 KV-A., 50,000 VOLTS

(90°F.) in air or in a water bath approximately 25°C. (77°F.) in temperature. Oils with which the low cloud and pour test thermometer can be used from the beginning of the test shall be cooled to 15.6°C. (60°F.) in any convenient manner before placing that thermometer in position.

The disc shall be placed in the bottom of the jacket and the test jar, with the ring gasket, 1″ above the bottom, shall be inserted into the jacket. The disc, gasket and inside of jacket shall be clean and dry.

After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

The temperature of the cooling bath shall be adjusted so that it is below the pour point of the oil by not less than 8.3°C. (15°F.) nor more than 16.7°C. (30°F.) and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1″ of the jacket projects out of the cooling medium.

Beginning at a temperature 11.1°C. (20°F.) above the expected pour point, at each test thermometer reading which is a multiple of 2.8°C. (5°F.) the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds, as noted by a stop watch or other accurate timing device and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 2.8°C. (5°F.) lower.

The test shall be continued in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 2.8°C. (5°F.) above this solid point.

Steam Emulsion Number (S. E. Number)

Apparatus—(a) The steam generator shall be made of either metal or glass of at least one-liter capacity, capable of withstanding the heat necessary for continued use in the production of steam. It shall be fitted with three outlets with suitable connections for rubber tubing. In case of a metal generator, a large opening for filling and a suitable water gauge shall be a necessary part of the apparatus.

(b) The baths shall be glass, with a capacity of 3 to 3½ liters and a depth of 7½ to 9″. A good quality of battery jar or beaker is entirely satisfactory.

(c) Heat for the steam generator shall be supplied by a suitable gas burner or electric hot plate. The separating bath may be heated by any convenient means, including an auxiliary steam line.

(d) The oil container shall be a 25 by 200 mm. test tube graduated from zero or from 10 to 50 cc. in cubic centimeters, each even 5 cc. line to encircle the tube.

(e) The steam piping or the steam delivery tube shall consist of a piece of thin-wall glass tubing, not less than 2.3 nor more than 2.7 mm. inside diameter and 12″ in length. The steam pipe shall be cut off diagonally at an angle of 30 degrees with the axis of the tube at the discharge orifice and shall be bent at right angles 10″ from the discharge orifice.

(f) Accessories shall consist of suitable wooden or metal frames or holders

for holding all containers in a vertical position in the baths; thermometers for the separating and emulsifying baths (floating type thermometers of suitable range); thermometers for the oil container tube (engraved-stem type, of suitable range, graduated in .55°C. (1°F.), 5 to 7 mm. in diameter); corks, rubber tubing and screw pinch cocks.

Procedure—(a) Preparation—The apparatus shall be assembled as shown in Fig. 9. The steam generator shall be filled one-half full of water and heat applied. The baths shall be filled with 3 liters plus or minus 60 cc. of water. The temperature in the separating bath shall be raised to and maintained at 93.3 to 95°C. (200 to 203°F.). (Care must be taken if glass battery jars are used, as direct heating by flame or electric hot point may cause breakage. Use of steam in this connection insures against breakage).

The temperature of the emulsifying bath shall be brought to not less than 19.4°C. (67°F.) nor more than 25.6°C. (78°F.) at the start of the test, and is not controlled thereafter. Twenty cubic centimeters of the oil to be tested shall be measured in the oil container at room temperature and the latter placed in the holder of the emulsifying bath. The steam pipe, or delivery tube, shall be connected to the steam generator with suitable rubber tubing, and screw pinch-cocks placed as shown in Fig. 9.

Care shall be taken to see that the apparatus, particularly the oil container, oil container thermometer and steam delivery tube, are chemically clean before using. Care shall also be taken to prevent any foreign materials from entering the steam generator as any contamination of the steam renders the test valueless.

(b) Emulsification—The steam delivery tube line shall be steamed out until all condensation disappears. A cork having two openings with the thermometer in one, shall be placed in the mouth of the oil container. The thermometer shall be adjusted so that the bottom of the bulb is ¾ to 1″ from the bottom of the oil container. The steam delivery tube shall be inserted through the second opening in the cork (Note—This fitting shall be loose), so that the end of the steam delivery tube shall touch the center of the bottom of the oil container. Steam shall be admitted at a rate that will maintain the temperature of the oil, as shown on the thermometer

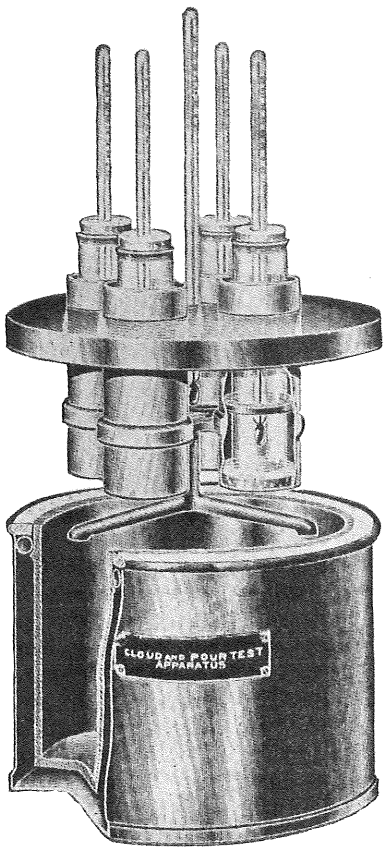


FIG. 8—APPARATUS FOR POUR TEST

in the oil container, between 87.8°C. (190°F.) and 90.6°C. (195°F.). (The usual time necessary for the temperature of the oil to come to this point is 45 to 75 seconds, depending on its character).

This control shall be effected by manipulation of the pinch-cocks on the steam delivery line and steam exhaust line from the steam generator. The steam supply shall be sufficient at all times to cause a generous discharge from the exhaust line. Steaming shall be continued until the volume of condensed steam and oil in the oil container tube is 40 cc. plus or minus 3 cc. The time required for this operation shall be 4 to 6.5 minutes, depending on the quality of the oil, altitude, etc. If condensed water amounts to 20 cc. in less than 4 minutes, it shall be taken as an indication of wet steam or incomplete steam out of the line and the test shall be rerun.

The apparent volume in the tube near the end of the steaming operation is approximately 12 to 15 cc. greater than the actual volume due to displacement caused by steam, thermometer and steam delivery tube.

(c) Separation—The steam delivery tube—shall be withdrawn as soon as the required volume is obtained. The oil container shall be transferred immediately to the separating bath which shall be maintained at 93.3 to 95°C. (200 to 203°F.). It is extremely important that the temperature of the separating bath be maintained within the given limits. As soon as the oil container has been transferred to the separating bath immediately start stop watch and observe the contents of the oil container continuously through the walls of the bath and note the volume of the separated oil layer. The cork containing the thermometer shall be removed after the oil container and contents have been placed in the separating bath. No difference shall be made between clear and turbid oil. The reading in seconds shall be taken when the volume of the separated oil reaches 20 cc. and this time in seconds shall be the S.E. number.

In cases where the interface between more or less clear oil and the emulsion is not a clear, straight, horizontal line, the position of such a line is carefully estimated to the nearest 0.5 cc.

On oils which separate into three layers having top, clear or turbid oil; middle, lacy or creamy emulsion; bottom, clear or milky water; the S.E. number is derived from the top layer.

Neutralization Number

The Neutralization Number is the weight in milligrams of potassium hydroxide required to neutralize the acid in one gram of oil.

Solutions Required.

Aqueous Potassium Hydroxide (1 cc. = 5 mg. KOH) dissolve 5.1 g. of potassium hydroxide, c.p., on one liter of freshly boiled and cooled distilled water. Add a very small amount of barium hydroxide, sufficient to precipitate any potassium carbonate present. Standardize this solution against Bureau of Standards certified benzoic acid, using phenolphthalein as an indicator according to the relation:

$$\frac{5 \text{ mg. KOH}}{x \text{ mg. benzoic acid}} = \frac{56.104 \text{ g. KOH}}{122.048 \text{ g. benz. ac.}}$$

1 cc. of KOH = 10.88 mg. benzoic acid.

This weight of benzoic acid is required for standardization.

Make necessary adjustments so that the value of potassium hydroxide equals 5 mg. KOH per cc.

Note: Fit the solution bottle with a guard tube of soda lime to prevent access of carbon dioxide. The solution should be standardized at necessary intervals.

The weight of benzoic acid should be dissolved in 50 cc. of 95 per cent alcohol and titrated cold. For blank, use same amount of alcohol and correct the titration.

Neutralized 95 per cent alcohol. Add a few drops of phenolphtalein and neutralize carefully the alcohol to a very faint pink end point with some of the above prepared alkali solution. Phenolphthalein Indicator. Dissolve 10 g. of the indicator in 1 liter of 95 per cent alcohol, preferably ethyl alcohol. Use 1 cc. of this strength for titration.

Weight of Oil: Approximately 20 g. weighed accurately.

Volume of Solvent: 100 cc. of a mixture of 1:1 neutralized alcohol and distilled water.

Procedure: Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc. of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if found necessary.

The color change is noted in the alcohol water layer.

Calculation:

$$\frac{\text{(Cubic centimeters of KOH) x 5}}{\text{Weight of oil taken}}$$

= mg. KOH per 1 g. of oil.

Purification

Impurities—New Universal Wemco C oil is clear and nearly water white in color. It is free from water, acid, alkali and deleterious sulphur compounds.

The oil is carefully refined so as to have a high resistance to emulsion; that is, the water is not held in suspension but quickly separates out. This is particularly essential in circuit-breaker service since this apparatus cannot be tightly closed like a transformer and some moisture is likely to be introduced into the oil. Universal Wemco C oil has been designed with this particular property in mind and precipitates water and carbon promptly.

However, there are developed in service certain impurities which must be removed to insure safe operation of the apparatus. The source and kind of impurities developed in the oil depend upon the type of apparatus in which it is used.

In circuit-breaker service, each time the circuit is opened some carbon is formed in the oil, even though only the charging current is being interrupted. The resistance to emulsion of the oil is also lessened, both by a change in the oil and by the presence of carbon in the oil. Oil which has been subjected to arc action in the circuit-breaker tends to slowly form organic acids, which further tend to lower its resistance to

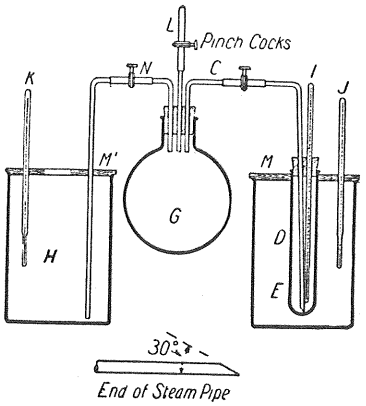


FIG. 9—APPARATUS FOR S. E. TESTS

emulsion. The major portion of the carbon slowly precipitates to the bottom of the tank, but the more finely divided carbon has a tendency to remain suspended in the oil, and lower the dielectric strength. Both carbon and moisture are attracted to the insulating surfaces of the bushings by the electrostatic field and when so deposited, lower the insulation resistance of the terminals from line to ground.

Oil in transformers is generally subjected to heat, oxidation and sometimes to moisture. Heat in the presence of oxygen produces a gradual physical and chemical change in oil and the extent of this change will depend upon the amount of heat, time and the catalytic action of exposed metals in the apparatus to which it is subjected. High temperature over a short period or somewhat lower temperature over a long time will affect the characteristics of the oil, particularly in the development of organic acidity, and sludge.

Heat in the presence of oxygen affects the unsaturated hydro-carbons, at first through formation of organic acids and later by precipitation in the form ordinarily called sludge.

Purification—The purification of oil used in circuit-breakers and transformers consist principally in the removal of water, carbon and sludge and the restoration of its resistance to emulsification, putting the oil in the best condition to separate out any water which may later be introduced.

Three types of equipment for simple purification of oil in circuit-breakers and transformer service are in general use, the centrifuge, the blotter filter press and the combination centrifuge and filter press. The combination of centrifuge with chemical treatment is particularly well adapted for the purification of carbonized circuit-breaker oil. The application of chemical treatment for purifying sludged oil or oil having high acidity for transformer service is still in the experimental stage.

Interchangeability after Purification—Universal Wemco C oil may be used in transformers after arcing in circuit-breakers, provided all carbon is removed and the purified oil meets the following values:

Specific Gravity at 15.5°C., .898 Max.

Viscosity, Saybolt at 37.8°C. (100°F.), 60 Secs. Max.

Flash Point, 132°C. (270°F.) Min.
Pour Test, -45.6°C. (-50°F.) Max.
S.E. Number, 35 Secs. Max.

Neutralization Number—Mg. KOH per gram of oil, 0.08 Max.

Corrosive Sulphur, None.

Dielectric Strength (1" dia. discs, space $\frac{1}{10}$" apart) 22 K.V. Min.

Blotter Filter Press—The filter press is essentially a number of sets of filter papers in parallel, each set containing several thicknesses. The oil is pumped through the filter paper which absorbs the water and strains out the sediment. (See Fig. 10).

The filter press is not intended to remove large amounts of free water from the oil. Obviously the changing of filter papers necessary for obtaining dry oil would so reduce the capacity as to make this method of purification impractical. In such cases the water may be removed by a centrifuge, or should be allowed to settle out and be drawn off from the bottom of the container before passing the oil through a filter press.

A description of the Westinghouse Blotter Filter Press is given on pages 14 to 16 inclusive. An Instruction Book is furnished with the equipment. There are three standard sizes divided into two classes, according to the size of the filter paper.

If the oil contains only a small amount of water, carbon or sludge, all sediment and water should be removed by passing the oil once through the outfit. If any water remains, it indicates that the filter papers are saturated with water and must be renewed. No rule can be given as to how often the filter paper should be changed, as this depends entirely upon the amount of water and carbon in the oil.

With badly fouled oil it may be necessary to pass the oil several times through the filter press to take out the more finely divided carbon which is not caught on the blotters; especially when they are new. The efficiency of the filter press for removing carbon increases as the pores of the blotters become partly clogged. This produces a material slowing down in the rate of flow through the blotters.

Filtering through blotters does not materially reduce organic acidity or improve resistance to emulsification except as the latter is affected by the presence of carbon, although the dielectric strength may be restored to a satisfactory value.

The best and quickest method for filtering or centrifuging a quantity of oil is to pump all the oil from the tank through the filter or centrifuge and into another tank that is dry and clean.

The capacity of the filter press is much reduced when operating at low temperatures.

When the oil has to be lifted at low temperatures, an additional pump in the pipe line is desirable.

Oil in transformers contaminated only by a small amount of moisture may be purified by drawing the oil from the bottom of the tank, passing it through the filter press or centrifuge and pumping it back into the top of the transformer, preferably at a point below the surface of the oil. The oil should be put through the system until a sample drawn from the bottom of the transformer gives satisfactory dielectric values. This may be done if necessary with transformers while in service with voltage on.

Pumping the oil from a circuit-breaker tank to the purifying outfit and directly back to the tank is not desirable as the clean oil is again contaminated by the carbonized oil remaining in the tank. Also it is then not possible to clean the carbon deposit from the surfaces inside the tank.

The Centrifuge—Is the most convenient equipment known for removing water from oil. It also removes solid material other than finely divided carbon. The temperature of the oil should be maintained at 48.9 to 51.7°C. (120 to 125°F.) in order to insure removal of all the water at full capacity of the machine. A higher temperature gives no advantage and if excessive, is harmful to the oil. (A 6 kw. heater will raise the oil about 15.6°C. (60°F.) per 100 gallons per hour.) The centrifuge equipment may be arranged to act as a separator, discharging the oil and water by different outlets, or as a clarifier, discharging the oil but retaining in the bowl, the water and other impurities. When there is considerable water in the oil it should be operated as a separator. The necessity of this will be apparent by the quantity of water coming from the outlet. If only a small amount of water appears through the water outlet, a larger output may be obtained by operating as a clarifier, in which case the moisture is retained in the bowl. Generally only small quantities of water are present and the clarifier is the equipment used. When operating as a clarifier the bowl should be drained at intervals, in order to insure dry oil and avoid contamination through wet oil passing into the purified oil container.

The centrifuge will remove the coarser particles of carbon from the oil. For removal of fine particles of carbon, the blotter filter press or centrifuge with suitable chemical treatment should be used.

Insoluble impurities such as sludge. carbon and free water may be removed by the centrifuge or filter press as indicated under the description of these equipments.

Soluble impurities developed by constant use of the oil in circuit-breakers or transformers **can only be removed by chemical treatment.**

Through combination of the centrifuge with a proper chemical treatment, carbon and water can be removed. Organic acidity produced in the oil in service, may be reduced to a satisfactory value, and the demulsibility of the oil can be restored. Choice of a chemical is essential in order that it may accomplish this purpose without producing harmful compounds in the oil.

The Combination Centrifuge and Filter Press—The combination centrifuge and filter press meets the need for a compact unit which may be used advantageously in the purification of insulating oil. It consists briefly of a motor driven centrifuge, electric heaters, regulating float valve, pumps and filter press or presses, mounted upon a truck.

The popularity of this combination unit is due to its ability to rapidly remove either large quantities of water, sediment, or both. When oil is contaminated with water it may be satisfactorily dehydrated by operating the centrifuge as a separate unit. If finely divided carbon or dirt is present in large amounts, the water and nearly all of the sediment may be removed by the centrifuge and the remaining finely divided material will be easily removed by the blotter press. The operation is continuous and delivers oil at full rated capacity. A drying oven is not needed for the blotter papers due to removal of the moisture by the centrifuge.

Oil Contaminated with Fire Extinguishing Agents—In general, when small quantities of oil have been contaminated with fire extinguishing agents, it is preferable to replace the oil rather than to attempt to reclaim it.

Insulating oil which has been contaminated with carbon tetrachloride or soda sulphuric acid cannot be reclaimed as it would have to be refined.

When large quantities of oil are involved which have been contaminated with other fire extinguishing agents, the reclaiming of the oil will depend upon the kind and degree of contamination. There may be other factors involved than the fire extinguishing agent; as for instance, high temperatures cracking the oil, carbonized insulation, etc., which should be considered. Any questions should be referred to the nearest Sales Office of the Westinghouse Electric & Manufacturing Company.

The Relative Advantages of Insulating Oil Purification Processes follow:

The centrifuge connected as a separator may be used where there are large quantities of water present in the oil, without waiting for it to settle out, and connected as a clarifier for removing small quantities of water. It will remove sludge and coarse carbon particles but not all finely divided carbon.

The filter press is suitable for use for the purification of oil containing small quantities of water and will remove finely divided carbon and sludge. It will not materially reduce organic

acidity or improve the resistance to emulsification except as this is caused by the presence of carbon.

The combination centrifuge and filter press may be used advantageously in the removal of large quantities of carbon and water. It unites the exceptional qualities of the centrifuge with the excellent characteristics of the blotter press. This flexibility of operation makes it very desirable as standard equipment in the reconditioning of insulating oil for the removal of large quantities of carbon from the oil. The clogging of the pores of the filter reduces the output of this combination.

Check on the Degree of Purification of Oil—The final criterion of the effectiveness of any method of purification of insulating oil is the quality of the purified oil.

Oil which has been purified by means of the filter press, centrifuge or a combination of the two should always be tested for dielectric strength before being passed into the apparatus tank. It is recommended that the tests for resistance to emulsion and neutralization value be made from time to time on oil repeatedly purified by either of these methods. There is a progressive decrease in the demulsibility and increase in organic acidity not corrected by these methods. These effects should be detected and corrected before they reach a harmful value either by chemical treatment or by replacing the oil.

The Dielectric Strength of purified oil should be at least 22 kv. when tested as described on pages 8 and 9.

The S.E. Number should not be over 35 seconds for Universal Wemco C oil or Wemco A oil when tested by the method described on pages 10 and 11, and not over 75 seconds for Wemco C oil received prior to July 11, 1924.

The Neutralization Value should not be over 0.08 milligram of KOH per gram of oil as determined by the method described on pages 11 and 12, and with no trace of alkali by the same method.

The Filter Press

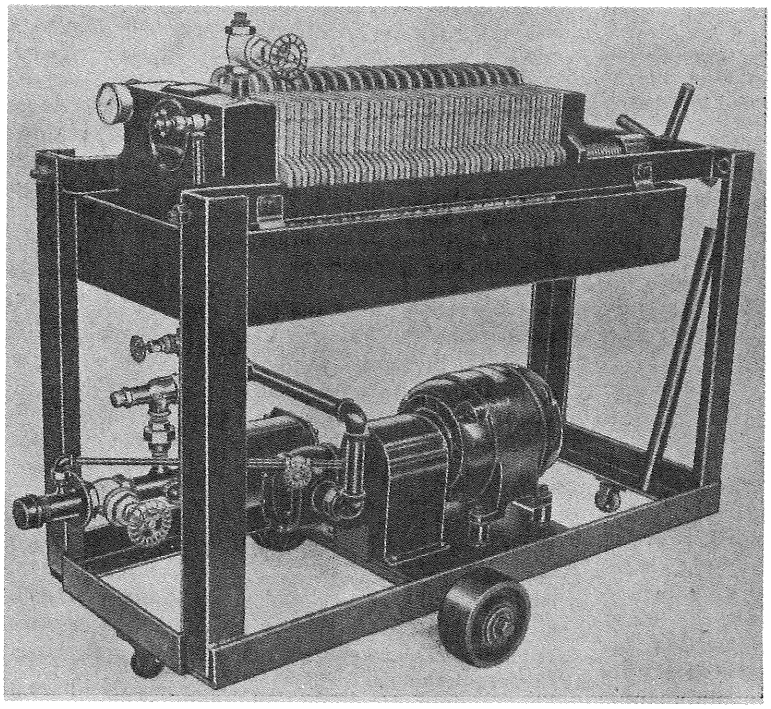


FIG. 10—A-30 OIL FILTER PRESS

General

The filter press is probably the most widely used machine for the purification of insulating oils which have become unfit for use due to the presence of carbon or other foreign matter.

Other Classes of Service

While the principal class of service for which these outfits were developed is the treatment in insulating oils, they may be used for numerous other applications, such as cleaning of low viscosity insulating compounds, benzine, petroleum, machine oil, etc. However, it is recommended that an outfit intended for insulating oil purification should not be used for other classes of work, due to danger of subsequent contamination of the insulating oil.

When it is necessary to transfer oil from warm surroundings to apparatus exposed to extremely cold weather, even when the dielectric strength at room temperature is high, it is desirable to circulate the oil through a blotter press or centrifuge at room temperature. Like procedure is also advisable in the case of apparatus erected inside, and later exposed to cold weather. The reason being, that oil will dissolve more water at higher temperatures which will be thrown out of solution at lower temperatures. This water in suspension in the oil will be reflected in the dielectric strength.

Capacity

The capacity of these outfits, with oil pressure and filtering area fixed, depends on the viscosity of the oil and its freedom from dirt. With fairly clean oil at ordinary room temperature, the capacity of the outfits will vary from normal to about 15% above normal, depending on the viscosity of the oil which varies with the temperature. It has been found that the best results are obtained when the oil temperature is about 50°C. The average working pressure of these machines is less than 40# per square inch and the pressure relief valve is set at the factory to by-pass the full flow at from 60 to 80#.

Apparatus

There are four standard sizes of filter presses B-5, B-10, A-30 and A-60. The letter designates the size of filter paper; the number the gallons per minute on 60 cycles. Refer to price list 44-020 for motor data. Figs. 1-12-14

The complete outfit consists of filter press, motor, strainer, pump, gas trap, pressure gauge, drip-pan, wheels, and piping. The piping is arranged, so the line can be tested for leaks under pressure. All outfits are mounted on a fabricated structural frame. The drip-pan can be removed by disconnecting one pipe coupling and four bolts. The strainer can be cleaned by disconnecting three bolts. The pumps are of the helical gear type to insure quietness and smooth flow of oil. The A-30 and 60 pumps are directly connected to the motor through flexible couplings. The B-5 and 10 pumps are mounted directly on the rear motor bracket and driven through a helical reduction gear.

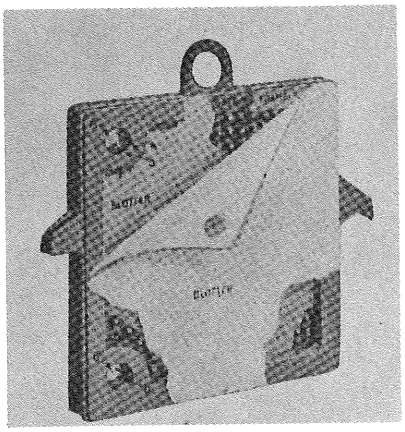


FIG. 11—ASSEMBLY OF ONE FILTER-PRESS PLATE AND ONE FILTER-PRESS FRAME, SHOWING FORMATION OF OIL CHAMBERS BETWEEN FILTER PAPERS.

The filter press proper is made up of a series of cast iron plates and frames assembled alternately, with the filter papers between them. By means of a screw and cast iron end block, the plates, frames and papers are forced tightly together. Except for a machined rim which serves as a joint to prevent the escape of oil, the plates are cast with small pyramids on both surfaces.

The plates and frames have holes, in two of the corners and supporting lugs at the sides. The plates have handles cast on the top edge. When the plates and frames are assembled with the papers between, the holes form the inlet and outlet. The frames have the holes in the upper corner connected by small ducts to the middle of the frame. The plates have ducts leading from the surface of the plate to the hole in the lower corner. (Fig. 11)

The oil enters under pressure at the top corner through the inlet formed by the holes in the frames, plates, and papers, flows into the frames through the same ducts provided and completely fills the chamber formed by the frame and two sets of filter paper. As there are no outlet ducts in the frame the oil is forced through the paper and flows along the grooves between the rows of pyramids and out through the ducts provided at the lower corner of the plates. The dry filter paper takes up the moisture and strains out all sediment from the oil.

Filter Paper—The filter used is a special grade of blotting paper about .025 inch thick and contains no coloring matter or chemicals which might injure the oil. Five sheets cut to the proper size, 12⅞ inches square for the A size and 7¾ inches square for the B size, and with holes punched to correspond with the holes in the plates and frames are used between each plate and the adjacent frames.

To obtain the best results in treating oil the paper must be perfectly dry when first placed in the press. Filter paper always takes up moisture if exposed to the air for any length of time and for this reason care must be used in handling paper. The standard paper is carried in packages containing one ream carefully wrapped in waxed paper and covered with heavy wrapping paper.

Drying Ovens—The electric oven is used for drying the filter paper. The oven is substantially built of sheet-iron with double walls. Adjustable slides are provided near the top of the oven for regulating the temperature and the circulation of air through the oven.

These ovens are furnished in three sizes, designated by types A-30, A-10 and B, to correspond to the sizes of filter paper. The type A ovens are used for large size paper that is used in the A size filter presses. The type type B oven is used with the B filter presses.

The filter papers are held in a vertical position in a rack and supported by rods through the holes in the corners of the papers. When the door in the front of the oven is opened, the rack may be withdrawn and the filter paper conveniently inserted or withdrawn. The paper should be dried for about 24 hours before being used, but this time can be decreased, depending upon the condition of the paper and degree of heat.

Ovens are listed for four different voltage ranges and may be used equally well on either alternating or direct-current circuits. Three heats are obtainable by means of a rotary snap switch mounted on the front of the oven. It will usually be found desirable, however, to use the high heat.

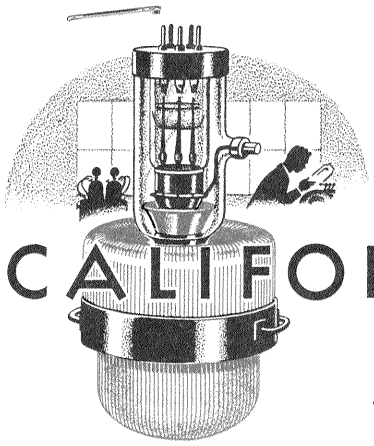
The input of the ovens will vary from low heat to high heat as follows: type A-30 from 400 to 1600 watts; type A-10 from 200 to 800 watts and type B from 100 to 400 watts.

Operation

The oil to be purified is forced through several layers of specially prepared filter paper. The sediment is strained out by the first layer of paper and the moisture is taken up by the capillary action of the paper.

The filter press is made ready for operation by placing a set of five sheets of filter paper that has been thoroughly dried in an electric oven between each filter plate and frame. The holes in the filter paper must line up with the holes in the plates and frames.

Oil which has only a very small quantity of moisture may be satisfactorily reclaimed by the filter press, but where a large quantity of water is to be removed the centrifuge or combination outfit is preferred. If any moisture remains, it indicates that the filter papers are saturated with moisture and should be renewed. No rule can be given as to how often the papers must be changed, as this depends entirely on the condition



CALIFORNIA TUBE LABORATORY

TRANSMITTING TUBE REBUILDING

1305-17TH AVENUE SANTA CRUZ, CALIFORNIA, 95062 AREA CODE 408
PHONE 475-2939

"SCOTT-CONNECTED FILAMENT SUPPLIES"

IN MOST of the 5 and 10 KW transmitters using 891R and 892R tubes, the filament power supplies are arranged in a configuration known as "Scott-Connected."

THE VOLTMETER is usually across the two outside legs, which gives a *vector* reading and does *NOT* indicate in any way, what voltage might be across *each* half of the tube filament. Herein lurks a *VILLIAN* that could be robbing you of many hours of tube life!

UNFORTUNATELY, the emitting temperature of tungsten is also up into the vaporization range, with the result that sooner or later, a filament burns out. A filament strand will burn down about .005" before parting. Published curves on the vaporization rate of tungsten show that for every .5 volts reduction, the life is doubled!!

YOU CAN NOW begin to see the importance of keeping each half of the tube filament at *exactly* the same voltage, and then running the total (vector) voltage no higher than necessary to take care of your emission requirements!

IT IS ALSO very important to consider the fact that the supply transformers are of the *reactance-type* and give voltage according to load! As a filament burns down in size, the resistance goes up and a higher voltage appears across the filament, which only aggravates a spiralling condition!!! Here again, you can see the importance of keeping the voltage adjusted alike on each half of the tube filament!

IN OUR 25 YEARS of tube experience, we have observed many tubes with one side burnt out, while the other side was burnt down only enough to barely detect with a precision micrometer!!! There is only one reason for this to happen. It is the *UN-BALANCE* of the filament voltages!

SOME STATIONS have adjusted one leg high on the primary taps and at the same time, inserted an extra series rheostat in that leg. *EXACT* voltage adjustments can then be made with no effort! A suitable rheostat would be an OHMITE Model "N", Series "A", 7.5 ohms. Such an installation on every tube will soon be paid for by increased tube life. Voltages should be checked periodically and always when a tube is changed.

AGAIN, we wish to stress the importance of the above information!

Yours for longer tube life,

CALIFORNIA TUBE LABORATORY

INSTRUCTIONS

FOR

CONVERTING TYPE BTA-5F TRANSMITTER TO TYPE BTA-10F

Printed in U. S. A.

IB-30097-1a

General

The conversion of a Type BTA-5F Transmitter to a Type BTA-10F is a very simple operation comprising essentially (1) the addition of two more RCA-828 tubes in the audio driver stage (the BTA-5F is already equipped with completely wired socket assemblies for these tubes), (2) the replacement of the modulator transformer assembly with a modulator output assembly (modulator transformer, modulator reactor, blocking capacitor and splatter filter reactor) and (3) the addition of a second power amplifier tube with its filament transformers, blower, grid leak resistors, by-pass and neutralizing capacitors and parasitic suppressor (here also the 5-F is equipped with the tube socket required for the second power amplifier).

Equipment

All equipment necessary to create a BTA-10F Transmitter from a BTA-5F is included in the MI-7267-A and -B Conversion Equipments. MI-7267-A is supplied for conversion of 60-cycle transmitters and MI-7267-B for conversion of 50-cycle transmitters. The power amplifier chassis has already been drilled to enable the rapid and simple installation of the additional parts, the location and wiring of which is illustrated in Figure 2. It should be noted that the heavy lines on the drawing represent the additions which must be made to the connections shown in Figure 1. The parasitic suppressor (1L20, 1R37) shown in Figure 2 is not furnished as part of the conversion kit because it has been included in the BTA-5F on the Low-Power R-F chassis as 1L10-1R18.

Procedure

1. Remove the combination 1L10-1R18 from the Low-Power R-F chassis and install it in place on the R-F Output chassis. Strap through the circuit where 1L10-1R18 was removed.

2. Install the following new equipment on the R-F Output chassis:

- 2 Filament transformers (1T5, 1T6).
- 1 Filament center-tap resistor (1R36).
- 1 Filament by-pass capacitor (1C50, 1C50-A).
- 1 Filament terminal board, 3 point.
- 1 Parasitic suppressor (1L21, 1R30).
- 1 Blower (1A16).
- 1 Air-flow switch (1S2, mounted on blower).
- 5 Grid leak resistors (1R31 to 1R35 inclusive).

The hardware for mounting the listed equipment is included in the conversion kit.

3. Remove the power amplifier neutralizing capacitor 1C32 and install 1C51, supplied in the conversion kit.

4. Remove the 0-1.5 ampere power amplifier plate current meter 5M7 and install the 0-3 ampere meter supplied in the conversion kit.

5. Make all connections as indicated in Figure 2.

6. Install two additional RCA-828 tubes (2V9, 2V10) in the sockets on the Low-Power A-F chassis. Using connectors supplied in the kit, connect the plate caps of the tubes to the open ends of resistors 2R94 and 2R96.

7. Remove the heater unit from the power amplifier blower circuit breaker 4S11 and install the new heater unit (AP 3.4-966479) which is supplied in the conversion kit. Check rotation of the motor for proper direction. Check the operation of the air-flow switch 1S2 to see that the filament contactor 4E18 is closed when the blower is operating and opens when the blower stops.

8. Remove the modulation transformer 6T1 and the splatter filter capacitor 6C1. Install the modulator output assembly which is furnished in the conversion kit. This assembly consists of a modulation transformer (6T3), a blocking capacitor (6C2) and a modulation reactor (6L5). To this should be added the splatter reactor 6L4 which was used with the BTA-5F. Make the connections in accordance with Figure 32 of the BTA-10F instruction book (or installation drawing P-714892).

Adjustments

Referring to R-F Adjustments in the INSTALLATION Section of the BTA-10F instruction book (IB-30141), retune and neutralize the transmitter. Readjust the bias voltage on the third audio stage in accordance with the section on A-F Adjustments. The settings of the overload relays must be increased and their final settings determined as outlined under Preliminary Adjustments.

Check the r-f line current meter in the Antenna Tuning Unit to be sure its range is adequate to handle the increased antenna current. If necessary, change the size of the meter shunt.

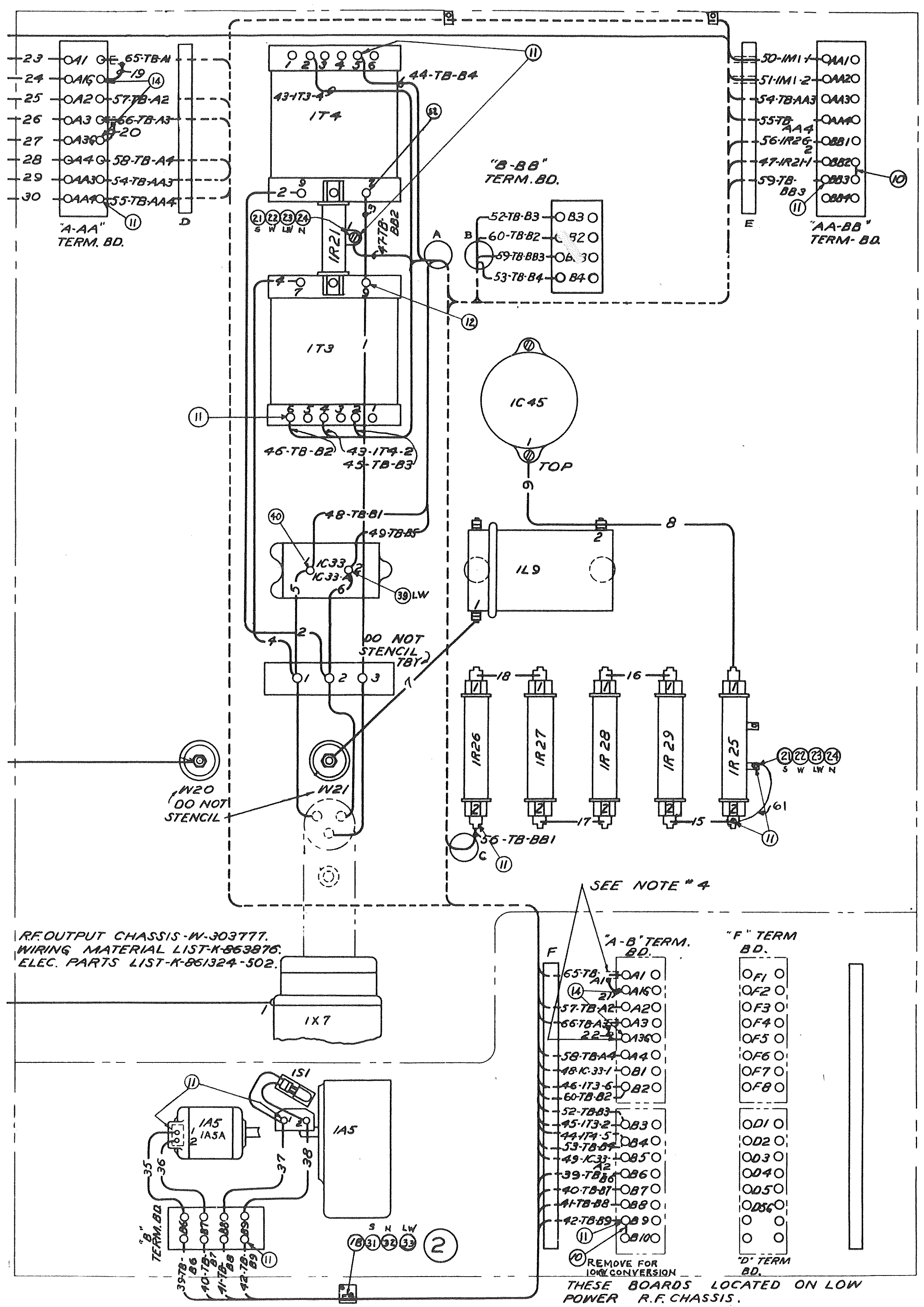
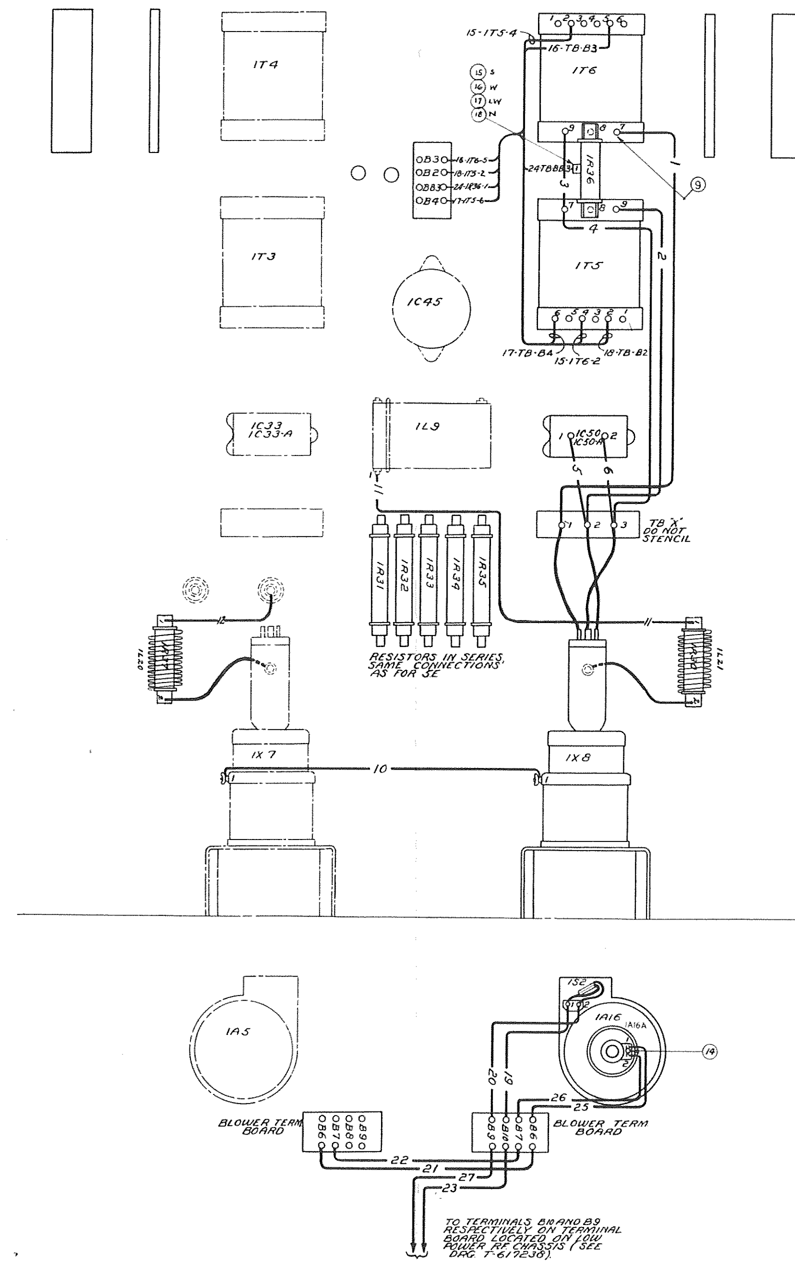


Figure 1—R-F Output Chassis (BTA-5F) (T-617238, Sub. 7)



NOTE #1:-CODING AT ENDS OF WIRES INDICATES WIRE NUMBER AND DESTINATION OF WIRE RESPECTIVELY, AS 15-1T4-5. WHEN A NUMBER ONLY IS GIVEN WIRE NUMBER IS INTENDED. A NUMBER PREFIXED BY A COMBINATION OF A LETTER AND NUMERAL INDICATES AN ELECTRICAL ITEM, AS 1T6.

NOTE #2:-ITEMS SHOWN IN DASH-DOT LINES REPRESENT COMPONENTS OF 5E RF OUTPUT CHASSIS. THOSE SHOWN IN FULL LINES REPRESENT ADDITIONAL COMPONENTS AND NECESSARY WIRING FOR THE 10E CHASSIS.

NOTE #3:-FORM WIRES 1 TO 6 INCL. AND 10 AND 11, SOLDER ON TERMINALS OR SWAGE AND PUNCH TO SUIT TERMINALS AS REQUIRED.

WIRE TABLE

PART NO. SEE K863949	DESCRIPTION	WIRE NUMBER
7	¼ O.D. x .035 WALL COPPER TUBING, SOFT, ELECTRO-TINNED, PS 563	10, 11 AND 12 1 TO 6 INCL.
8	G.E.CO. #12 GA. STRANDED SWITCH BOARDWIRE TYPE SNA-TABLE YK4280 COLOR GRAY 600V	15 TO 27 INCL.

Figure 2—R-F Output Chassis (BTA-5F to BTA-10F Conversion) (T-617241, Sub. 6)

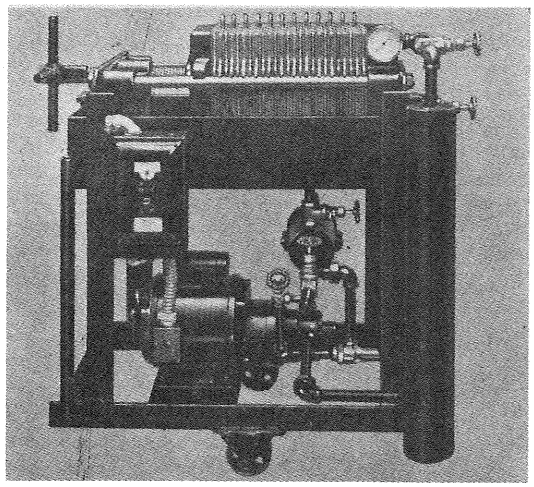


FIG. 12—B-10 FILTER PRESS

of the oil. The usual procedure is to run the machine for a period of one-half hour or so (if the oil is not in very bad condition) and then shut down; remove one sheet from the inlet side of each set and put in a new sheet on the outlet side of each set. The frame is the inlet side and the plate is the outlet side. Frequent dielectric tests should be made during this procedure as it may be necessary with wet oil to re-charge the filter press with a full set of papers before the five sheets have been removed in succession.

The quickest method of filtering a quantity of oil is to pump all the oil through the filter and into another tank which is clean and dry. If care is taken to change the filter papers before they become saturated the oil will be clean and dry. When a large percentage of water is present it is more economical to use the combination filter press and centrifuge. If a second tank for holding the oil is not available or if it is desired to filter the oil of a transformer while it is in service, the oil may be pumped from the bottom of the tank through the filter and returned to the top of the same tank under the surface of the oil to prevent aeration. This operation should be continued until the oil in the tank shows a sufficiently high dielectric strength.

When a large quantity of oil is to be filtered, the time may be shortened by using two filter presses, one being operated while the other is being re-charged.


RCA