INSTRUCTION BOOK

MODELS TE, TF and TG VACUUM TUBE TRANSMITTING EQUIPMENT

Manufactured

for

NAVY DEPARTMENT

BUREAU OF ENGINEERING

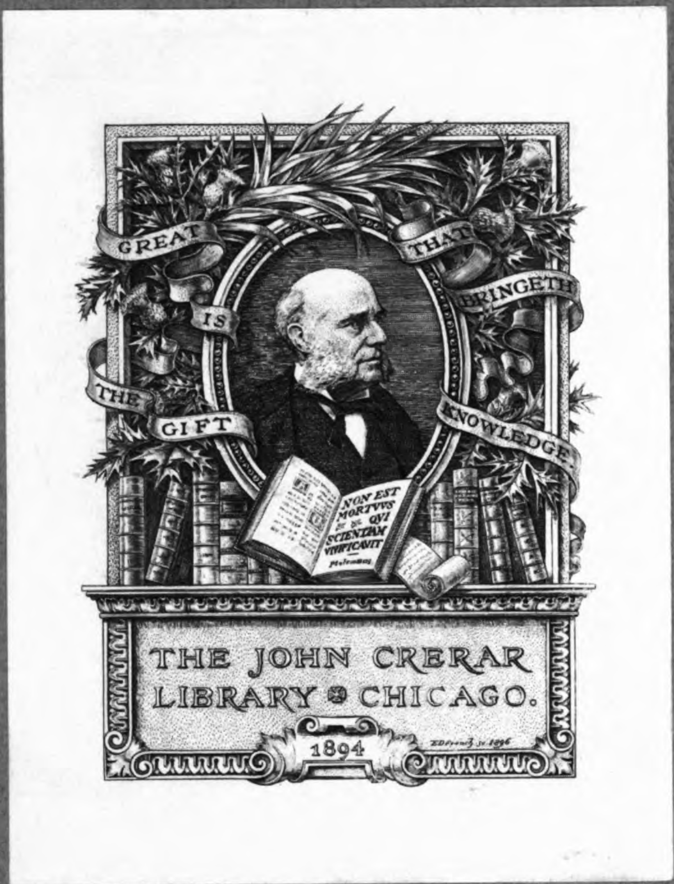
by

GENERAL ELECTRIC COMPANY

Schenectady, N. Y.

November, 1921

Instruction Book 86930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for
MODELS TE, TF and TG
VACUUM TUBE TRANSMITTING EQUIPMENTS

MANUFACTURED FOR
NAVY DEPARTMENT
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by

GENERAL ELECTRIC COMPANY
Schenectady, N.Y.

under
Contracts No. 51452 and No. 51272.

In compliance with

NAVY specifications

MODEL TE- RE 13A 166B
MODEL TG- RE 13A 171A
MODEL TF- RE 13A 167A
RE 13A 170A
RE 13A 168A

November, 1921.

This Instruction Book was compiled by the
U.S. Navy Dept., Bureau of Engineering.

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Introduction

The Model TE, TF and TG vacuum tube transmitting equipments were developed to provide a medium power vacuum tube transmitter for certain types of naval vessels. These transmitters were made to replace the worn out spark transmitters on these vessels in order to provide telegraphic and telephonic communication by means of the same equipment. They were also provided for the purpose of obtaining greater ranges than was possible with spark equipment.

Inasmuch as the three models are nearly identical, the instructions given in this book will cover the models in question. The three models were designed for use on the following type vessels:

Model TE - For Submarines
Model TF - " Submarine Tenders, Scout Cruisers and Aircraft Tenders.
Model TG - " Eagle Boats.

It can be seen that the equipments are to be used on vessels which have antennas of widely different characteristics, and consequently they are of a complicated design. In view of the complicated design provisions are made where by means of a few switches it is possible to control a number of devices.

As stated the Model TE was designed for Submarines. This, therefore, means that the equipment can be used on the single turn loop or the flat top antenna.

The Models TF and TG were designed for operation with the regular flat top antenna and, therefore, are not as complicated as the Model TE.

The following range of wave lengths are obtainable with the respective equipments:

Model TE - 500 to 975 meters.
Model TF - 500 " 1450 "
Model TG - 500 " 975 "

Using High Power the following distances is obtainable with these equipments on 975 meters during daylight hours:

MODEL TE
Submarine to Tender (continuous wave) 400 miles
Submarine to Tender (interrupted continuous wave (buzzer)). 150 miles.
Submarine to Tender (telephone) 50 "

MODEL TF
Tender to Tender or Cruiser (continuous wave) 500 miles
Tender to Tender or Cruiser (interrupted continuous wave) 175 "
Tender to Tender Cruiser (telephone) 75 "

MODEL TG

Eagle Boat to Tender (continuous wave)	400	miles
Eagle Boat to Tender (interrupted continuous wave)	150	"
Eagle Boat to Tender (telephone)	50	"

The above mentioned distances or ranges are conservative but are given to the service in order that the person operating the equipment may have an idea of the ranges which can be obtained with this equipment. If the equipment is kept in perfect condition and the antenna system is perfectly insulated it will be possible to obtain greater ranges than have been previously stated. The night transmitting range of these equipments is an unknown factor but with little static interference it may be possible to double or treble the daylight range.

All personnel who are required to operate these equipments should be thoroughly familiar with the contents of this instruction book before they attempt to operate any part of the equipment. By carefully reading the following instructions given in this book no trouble should be experienced in burning out tubes or breaking down of the insulation of the coil system or kindred troubles which are due to improper operation of the equipments.

A good understanding of the theory and operation of vacuum tube transmitters is an asset to any radio man and will be of great value to him in the future as the present trend of the art is towards the adoption of vacuum tube equipments for future replacement of spark and arc transmitters. Any interest shown by the personnel in operating the present type vacuum tube equipments will amply repay them should they, at a later date, be required to operate high power vacuum tube equipment.

Elementary Theory of Operation of Vacuum Tube Transmitter

Description of Vacuum Tube

The vacuum tube, which forms the important part of the equipments, consists of a hermetically sealed glass tube which is cemented to a metallic base. This tube is exhausted by means of an air pump to such an extent that there is very little air or gas allowed to remain within the tube. Situated within the glass tube is a metal filament (Tungsten or oxide coated platinum) which is surrounded by a mesh or grid of fine wires and around which grid is a metal plate. The filament, grid and plate are insulated from each other and leads from each terminate at certain exposed contact points in the base of the tube.

Figure I shows the constructional details of one type of vacuum tube where 1 is the glass tubing, 2 the metallic base, 3 the filament, 4 the grid, 5 the plate, 6 the metallic contacts which connect to the respective elements of the tube and 7 is the insulating material in the base of the tube which holds the contacts in place.

Electron Flow

In order to explain the theory of a vacuum tube as a generator of radio frequency currents it will be necessary to first explain the method of producing an electron flow in the tube and show how this flow is varied and made to produce radio frequency currents in the associated electrical circuits.

The electron is defined as being a negative charge of electricity which may be present in a liquid, a solid (metal) or in a gas. Suppose, for instance, a coil of wire is connected to a battery, the voltage supplied by the battery will make the electrons present in the wire, move through the wire into the battery and back again into the wire, in a continuous procession at a certain rate of speed. The higher the voltage of the battery the greater their speed through the metal in the wire. Should the voltage be too high the excessive speed of the electrons will cause the wire to heat.

Suppose in place of the coil we substitute a filament (fine Tungsten or platinum wire) and supply sufficient battery voltage so that the electron flow is capable of heating the filament to any degree of heat, we will find that the electron flow in the filament at certain temperatures makes the electrons form a so called "thick skin" on the surface of the metal, while if we increase the voltage or electron flow there will be a number of electrons which will break through this skin and leave the metal entirely. The electrons which leave the metal hover around the filament at certain distances forming, what we may say is an electron cloud.

By further increase in the battery voltage a greater number of electrons will leave the filament until a certain limit is reached where any increase in battery voltage does not increase the size of the electron cloud. This we may call a point of saturation. The question may now be asked, what becomes of the electrons which have left the filament? This may be answered as follows: as all electrons are negatively charged and the filament is positively charged, because of having lost these negative charges the tendency is for the electrons to be driven back into the filament again both because of repulsion of the other electrons in the cloud (like charges repel each other) and the attractive force of the positive filament. In time there will be just as many electrons going back into the filament per second as are being emitted.

Two Element Vacuum Tube

Having explained the action of the electron emitting source (the filament) we will now show how these electrons can be made to carry charges through a vacuum and permit a current flow in the associated circuit.

Referring to Figure 2, "F" is the filament and "P" is a metal plate which are enclosed in a glass tube having a very high vacuum. The filament is lighted by the battery "FB" and in turn emits numerous electrons into the space surrounding it. The plate is connected to the positive terminal of the battery "PB" while the negative terminal of the battery "PB" is connected to the battery "FB" as shown in Figure 2. Inasmuch as the plate "P" is charged positively the electrons (negative charges) will be attracted to this plate and will enter it and pass through the plate, connecting wires, battery "PB", ammeter "A" and back to the filament again thereby giving rise to a direct electric current as shown by the ammeter. Having established the electron flow between the filament and the plate and maintaining both batteries at constant voltage a continuous flow of electrons will circulate through the circuit which is external to the vacuum tube.

The strength of the electron flow (current) in this circuit as registered by Ammeter "A" depends on two conditions, one the number of electrons emitted by the filament (FB battery voltage) and the other the voltage of the battery PB. If the voltage of the battery PB is increased more electrons will be carried over from the filament to the plate. If decreased a lesser number of electrons will be carried over. If the PB battery voltage is kept constant and the FB battery voltage is decreased a lesser number of electrons will naturally flow through the external circuit.

Should the voltage of the PB be increased and the voltage of FB held constant it will be found that after a certain PB voltage is reached no increase in electron flow (current) in the external circuit is to be had. This condition is due to the fact that all the electrons emitted by the filament flow to the plate as fast as can be emitted, therefore, the supply is necessarily limited.

Three Element Tube

Referring to Fig. 3 we note that another element is inserted in the vacuum tube and is placed between the filament and the plate and therefore is directly in the path of the electron flow. This element which was previously described is called the grid and is the vital part of the tube.

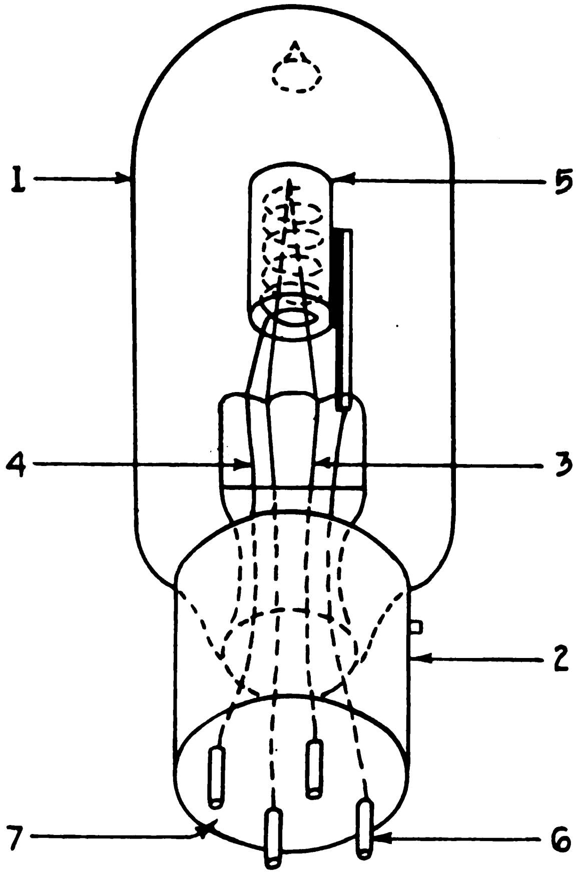


Fig.1

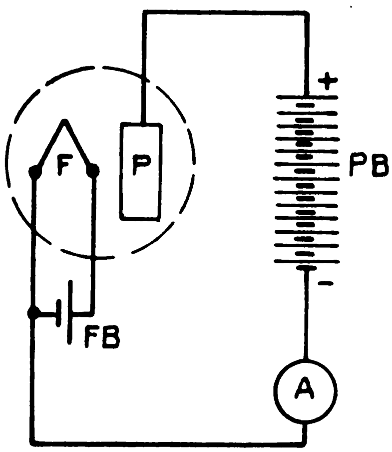


Fig. 2

Presuming there is a current flow through the external circuit as shown by the ammeter "A" which is approximately one half the maximum value which can be obtained from this tube, we may by means of supplying positive or negative voltages to the grid "G" increase or decrease the current flow through the external circuit, as indicated by the ammeter "A". This fact may be experimentally proven by means of a grid battery "GB" connected in between the filament and the grid, as shown in Fig. 3. By moving the contact on the grid battery to different terminals of the battery, negative or positive voltages may be connected to the grid. Should a negative voltage be connected to the grid the current in the external circuit will be decreased. The greater the value of negative voltage the greater the decrease while if a positive voltage is placed on the grid an increase in current will be noted, also any increase in positive grid voltage will give a corresponding increase in the current through the external circuit.

To explain this important functioning of the grid graphically, Fig. 4 is shown.

The horizontal line represents voltages applied to the grid while the vertical line represents the amount of current in milliamperes flowing through the external circuit. Referring to Fig. 4, if a positive (+) voltage of 3 volts is impressed on the grid, the external circuit current will be equal to approximately 5 milliamperes, as shown by the dotted line in the figure. Likewise if a negative voltage of 3 volts is impressed on the grid the current will be reduced to one half milliampere. Other values of positive or negative grid voltage will produce various changes in the current through the external circuit as can easily be seen by referring to the curve shown in Fig. 4.

The Oscillating Three Element Tube

Having explained the action of the different grid voltages on the current flow through the external circuit we can now explain the method used to make the vacuum tube produce radio frequency currents (oscillations).

Referring to Fig. 5, we have a typical vacuum tube oscillating system where three circuits are used to produce oscillations or currents of radio frequency. The three circuits are, No. 1, plate circuit consisting of plate "P", filament "F", plate high voltage battery PB, plate coil PC and switch "S";No. 2, Antenna or oscillating circuit consisting of antenna coil "AC" and condenser "C", which condenser represents the electrical capacity between ground "E" and antenna "A" of any antenna system, and No. 3, grid circuit, consisting of grid "G" filament "F" and grid coil "GC".

Now suppose the filament is lighted and we close the switch "S" in circuit No. 1. Then a flow of current from the high voltage battery PB will be established in the circuit. This current in flowing through "PC" sets up an electromagnetic field which field cuts across the antenna coil "AC" in circuit No. 2, thereby producing a momentary current in this circuit which makes it oscillate feebly. These feeble oscillations, due to the magnetic coupling between "AC" of circuit No. 2 and "GC" of circuit No. 3, induces corresponding voltage fluctuations in circuit No. 3. These voltage fluctuations impressed on the grid "G" cause the current flow through circuit No. 1 to decrease and increase, which in turn reacts on the antenna coil "AC" and the operation is repeated through circuit No. 3.

During the cycle of repeatedly impressing voltages on the grid, the power delivered to the circuit No.2 (antenna circuit) is gradually increased until the power generated by the vacuum tube is equal to the loss of power in heat and radiation at which point no increase in power can be obtained from the tube.

Thus we note that when a current is established in circuit No.1 it causes circuit No.2 to oscillate feebly and circuit No.3 being coupled to circuit No.2 takes up a part of the feeble oscillations which in turn affects circuit No.1 causing it to build up more oscillations in circuit No.2 and so on until the oscillatory power in circuit No.2 reaches a maximum value, which value is dependent on the power lost in heating conductors and radiation from the antenna in space. The frequency of the oscillations generated by the vacuum tube circuit is directly proportional to the inductance and the capacity of circuit No.2. The greater the inductance and capacity of this circuit the greater the wave length; likewise the smaller the inductance and capacity of this circuit the shorter the wave length.

It should be understood that the power delivered to the vacuum tube is supplied by the battery PB and that the power used in lighting the filaments only furnishes a source of electrons which carry the power supplied by battery PB across the space between the filament and the plate.

Radio Telephony

The next advance in the application of the three element vacuum tube is for the purpose of producing oscillations (radio frequency currents) which are modulated (amplitude varied) at a telephonic rate (in accordance with speech frequencies).

Fig. No.6 is a schematic diagram of a typical radio telephone vacuum tube transmitter which consists of four principal circuits. Circuit No.1 includes microphone transmitter "M", battery "B" and primary "P" of the iron core transformer

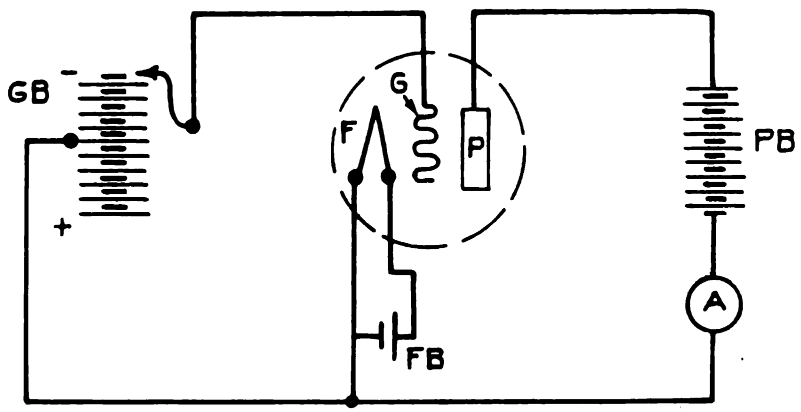

GB
-
+
F
G
P
PB
A
FB

Fig. 3

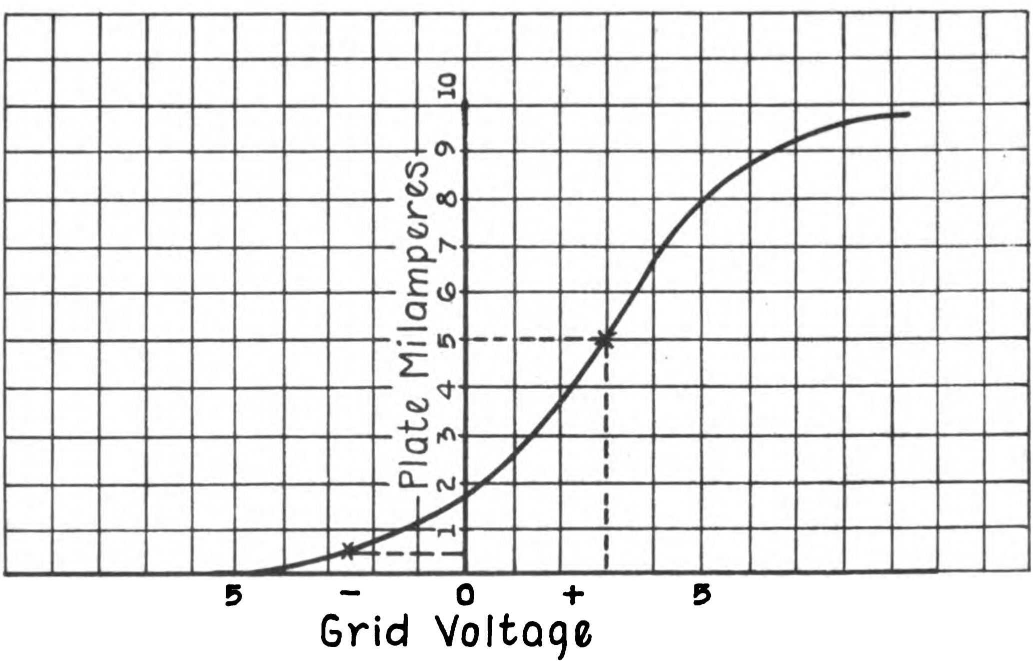


Plate Milamperes
10
9
8
7
6
5
4
3
2
1
5
-
0
+
5
Grid Voltage

Fig. 4

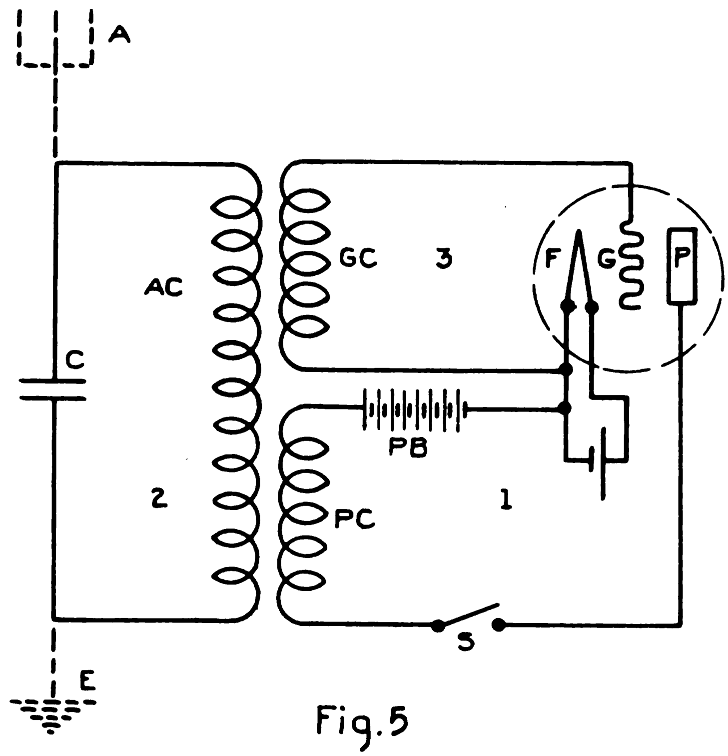


Fig. 5

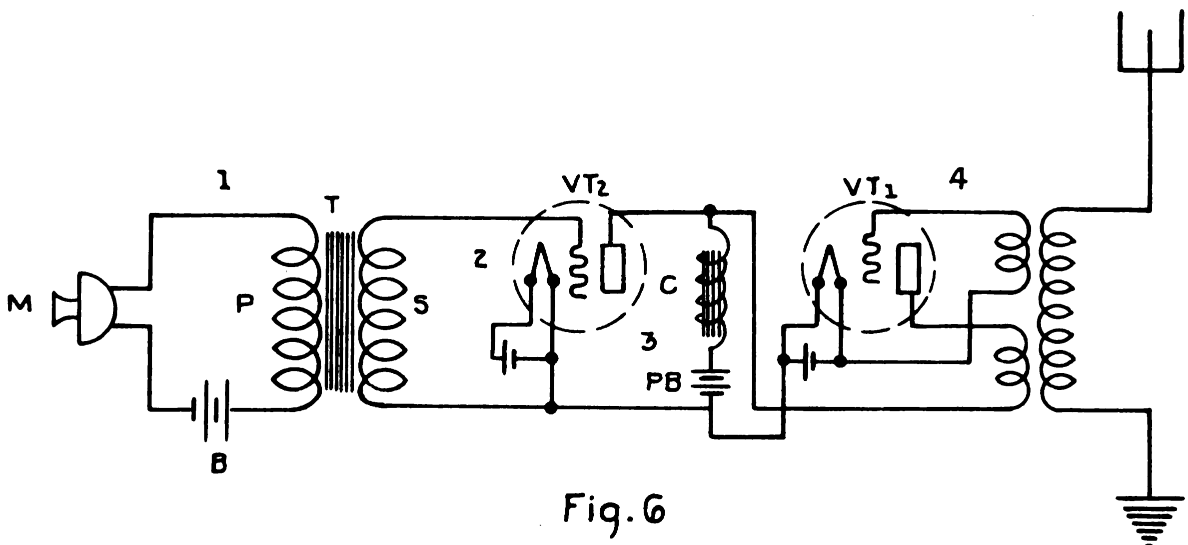


Fig. 6

"T". Circuit No. 2 includes the secondary "S" of the transformer "T" and the grid and filament of vacuum tube VT_2. Circuit No. 3 consists of the high voltage battery PB, iron core choke coil "C" and the plate and filament of vacuum tube VT_2. Circuit No. 4 is identifical to Fig. 5 with the addition of the choke coil "C" in the plate circuit.

The operation of the system may be explained as follows: voice or sound waves from person speaking into microphone impinge on the diaphragm of the microphone "M" causing it to vibrate thereby varying resistance of the circuit through "B" and "P", thus causing greater current from battery "B" to flow through this circuit than was previously flowing through the circuit when no sound waves were acting upon the diaphragm. The variation of current through "P" induces a similar current variation in the secondary "S" but due to the step-up ratio of "S" there is produced a greater voltage in "S" than there is in "P". This voltage is impressed on the grid of VT_2 which changes the current flow through the circuit No. 3.

Now we come to the important part of the system, namely, the iron core choke coil "C" and its action on the current supplied to the plate circuits of VT_1 and VT_2 by the battery PB. The word "choke" is symbolical of a means of holding back or sustaining, or in this case of maintaining a steady flow of current from the high voltage battery "PB" so that no matter what the action of the controlling grids of the tubes VT_1 and VT_2 may be, the total current supplied to both tubes will be the same. It is a well known fact that if an iron core inductance or coil is placed in series with any circuit it tends to prohibit any sudden change in the current value through that circuit due to the time it takes to magnetize or de-magnetize the iron core and in this case when we apply currents of sound frequencies to a circuit having an iron core it would be easily seen that this iron core will not allow sudden changes in current values.

Thus we can see that if VT_2 (modulator tube) takes three fourths of the total current, the oscillator tube VT_1 would only take one fourth of the current or if the modulator tube VT_2 takes one-fourth of the total current the oscillator tube VT_1 will take three fourths of the current. It can thus be seen that any variation in current flow through VT_2 will cause a change in the current flow through VT_1 which in turn directly affects the strength of the current in the antenna circuit.

Having explained the action of the choke coil in maintaining a steady current flow from PB it can be noted that the voltage in the secondary of transformer "T" resulting from the changing of the resistance of the microphone when impressed on the grid of VT_2 will affect the current flow from the plate and filament of this tube, which in turn affects the current flow from the plate to filament of VT_1 thus controlling the output of circuit No. 4.

To further explain this action let us presume at a certain fraction of a second the impressed voltage of the grid of VT_2 is negative, then the current from the plate to the filament of VT_2 will be reduced thus causing an increase of current through the plate filament circuit of VT_1 with the resulting increase in the oscillatory current in the antenna. Now during the next fraction of a second the voltage impressed on the grid is positive, thereby causing the current through the plate filament circuit of VT_2 to increase, which through the action of the choke coil causes the current through the plate filament circuit of VT_1 to decrease with the resulting decrease in the oscillatory current in the antenna.

From the foregoing explanation we note that current variations in circuit No. 1 will produce variable voltages in circuit No. 2, which circuit through the grid changes current flow in circuit No. 3, resulting in another change in the current flow through the plate filament circuit of No. 4, thus controlling the amplitude or strength of the radio frequency current in the antenna system.

Buzzer Modulated Telegraphy

The buzzer modulated telegraph system, commonly called (ICW or interrupted continuous wave), incorporated in Model TE, TF and TG equipment is similar in its operation to the radio telephone method of transmission inasmuch as identical equipment is used with the exception that a buzzer and key are substituted for the microphone used in the radio telephone equipment. The note of the received signal from this system is similar to the 500 cycle spark transmitter but is on a sharper wave, that is it tunes more sharply on receiver.

Summary

The electron flow from a vacuum tube and means for controlling this flow to produce oscillations or, in the case of radio telephony, modulated oscillations, have been explained in an elementary way. For further information on vacuum tubes and vacuum tube transmitters and receivers the reader is referred to the standard works on this subject, among which are the following:

Thermionic Vacuum Tube (Van der Bijl)
Principles of Radio Communication (Morecroft)
Robison's Manual of Radio Telegraphy and Telephony.

The theory of the special parts of the equipment is not described in this chapter but is given in the following chapter on "Description of Apparatus". The object of this chapter on Theory is to explain the theory of the main parts of the transmitter, which forms a foundation upon which the theory of the minor parts of the equipment can easily be developed.

Description of Equipment

The equipment consists of the following parts:

APPARATUS	MODEL NUMBERS		
	TE	TF	TG
1 Transmitter	CG 1332	CG 1773	CG 1774
1 Power Panel	CG 1337	CG 1337	CG 1337
1 Motor Generator	CG 1338	CG 1338	CG 1338
1 Flame Proof Key	CG 1744	CG 1744	CG 1744
1 Microphone Breast Transmitter, Stromberg Carlson Co., No. 18 L, complete with cord and plug.			
1 Antenna Break Relay	SE 3619	SE 3619	SE 3619
1 Protective Unit	CG 4009	CG 4009	CG 4009
1 Dry Battery Box	CG 1745	CG 1745	CG 1745
4 Batteries, Burgess Co., Cat. No. 2156	SE 3535A	SE 3535A	SE 3535A
1 6 volt Storage Battery			
1 Loop Unit	CG 1333	None	None
1 Emergency Send-receive switch with 4 foot leads, marked	CG 1746	None	None
1 series Antenna Condenser	None	CD 1783	CD 1783

NOTE: Vacuum tubes for use with these transmitters are supplied by the Navy Department.

The following spare parts are supplied with each Model TE, TF and TG equipment and are boxed in a Navy Standard spare part box.

(1) 1 Grid Condenser
(2) 1 Grid Leak Resistance
(3) 1 Antenna Ammeter
(4) 1 Relay, Type SE-3619
(5) 1 Complete Set of Bearings for Power Unit.
(6) 1 Microphone Transformer, Type CG 1752
(7) 1 Reactance Oscillator Plate
(8) 1 Motor Field Coil
(9) 5 Complete Sets of Brushes for Power Unit.

(10) 5 Complete Sets of Brushes, Springs
for Power Unit
(11) 6 Wave Indicator Lamps
(12) 1 Relay Coil for Grid Relay.
(13) 50 Fuses, 3 amp., 2000 volt, G.E.
Co., Cat. No. 230072.
(14) 10 Fuses, 35 amp., 250 volt, G.E.
Co., Cat. No. 34958.
(15) 10 Fuses, 15 amp. 250 volt, G.E.
Co., Cat. No. 34954
(16) 1 Complete Set of Spare Contacts for
all Relays and Contactors
(17) 1 Key for Power Lock
(18) 1 Microphone Breast Transmitter
Stromberg-Carlson Co., No. 18 L,
Complete with cord and plug.
(19) 1 Grid Relay, Type CG 1753
(20) 10 Fuses, 3 amp. 250 volt, G.E. Co.,
Cat No. 34949.

Additional Spares

TE EQUIPMENTS

Nine additional spare part boxes are supplied with the Model TE equipments in addition to those furnished with each set to be kept on board submarine tenders. Each of these sets of spares consists of the following:

(a) 1 Antenna ammeter
(b) 1 Line voltmeter
(c) 1 Plate ammeter
(d) 1 Plate voltmeter
(e) 2 Filament voltmeters
(f) 4 Grid condensers
(g) 1 Loop condenser
(h) 1 Plate condenser
(i) 2 Condenser filters
(j) 1 Wavemeter condenser
(k) 3 Relays, filament circuits
(l) 1 Relay, loop
(m) 1 Relay, grid
(n) 1 Relay, protective
(o) 4 Grid leaks
(p) 2 Microphone transformers
(q) 1 Filament transformer
(r) 1 Plate rheostat
(s) 1 Filament rehostat
(t) 4 Electrolytic cells
(u) 1 Motor armature
(v) 1 Generator armature.
(w) 1 Set motor bearings
(x) 1 Set generator bearings
(y) 1 Set Motor field coils
(z) 8 Sets motor generator brushes

(aa)12 wave indicator lamps
(bb) 1 set wavemeter coils
(cc)10 Grid and plate condensers
(dd)24 Tube socket contact springs
(ee) 1 signal switch, complete
(ff) 1 Radio frequency choke coil
(gg) 1 Microphone breast transmitter

Additional Spares

MODELS TG AND TF EQUIPMENTS

The following list of spares are packed suitably for shipment to the Navy Yard, Washington and are for use as a reserve stock for the TG and TF equipments:

Antenna ammeters
Line voltmeters
Plate ammeters
Plate voltmeters
Filament voltmeters
Grid condensers
Plate condensers
Filter condensers
Wavemeter condensers
Relays, filament circuit
Relays, grid circuit
Grid leaks
Microphone transformers
Filament transformers
Plate rheostats
Electrolytic cells
Motor armatures
Generator armature
Motor bearings
Generator bearings
Motor field coils
Motor generator brushes
Wave indicator lamps
Wavemeter coils
Grid and plate connectors
Tube socket contact springs
Signal switches, complete
Radio frequency choke coils
Microphone breast transmitters
Speed regulators

Practically all the Model TE, TF and TG equipments are identical in construction. Model TE, due to the fact that it makes use of the single turn loop antenna as an additional means of communication, is provided with loop unit, it also does not have the antenna series condenser which is supplied with the Model TF and TG sets.

All models are entirely enclosed making them flame proof throughout. All switching is done either inside the set, under the enclosing covers or the circuit is so arranged that no current is flowing when the switch is opened, as is the case with the starter transfer switch on the power panel.

TRANSMITTER

Fig. 7 and 8 show the exterior and interior of the transmitter while Fig. 9, 10 and 11 show the wiring diagram of the Model TE, TF and TG transmitters respectively.

The transmitter is enclosed in a perforated metal cabinet having a sheet brass panel. The sides and top of the enclosing case are secured by thumb screws which permit ready removal of the case for inspection of the set. The transmitter should NOT be operated with the covers removed. These sets have been very carefully designed to be flame proof throughout, and operation with any enclosing covers removed would defeat this feature of design. The following instruments and controls are mounted on the front of the panel:

(a) Power lock	Upper left corner
(b) Signal switch	Below power lock
(c) Power switch	Below signal switch
(d) Jack for microphone	Below power switch
(e) Wave indicator lamp	Left of center at top.
(f) Antenna variometer	Below wave meter dial
(g) Buzzer	Right of center at top
(h) Wave meter dial	Below indicator lamp
(i) Wave change switch	Right of center at bottom
(j) Grid relay	Right side
(k) Ground binding post	Lower right corner
(l) Radiation ammeter	" " "

VACUUM TUBES

Twelve vacuum tubes, Type CG 1144A or CW 1818 are used to generate and modulate the high frequency energy. The tubes are mounted in a spring supported rack above the top of the transmitter proper and covered by a perforated metal hood. This hood has a hinged cover and permits the operator to observe the tubes while transmitting and makes them easily accessible for inspection and replacement.

Six of the tubes are used as oscillators, five as modulators and one as a speech amplifier on telephony or buzzer modulated telegraphy. Six oscillator tubes only are used on continuous wave telegraphy, provision being made to open the filament circuit of the remaining six tubes. This is done both to prolong the life of the tubes and to prevent

Fig. 7

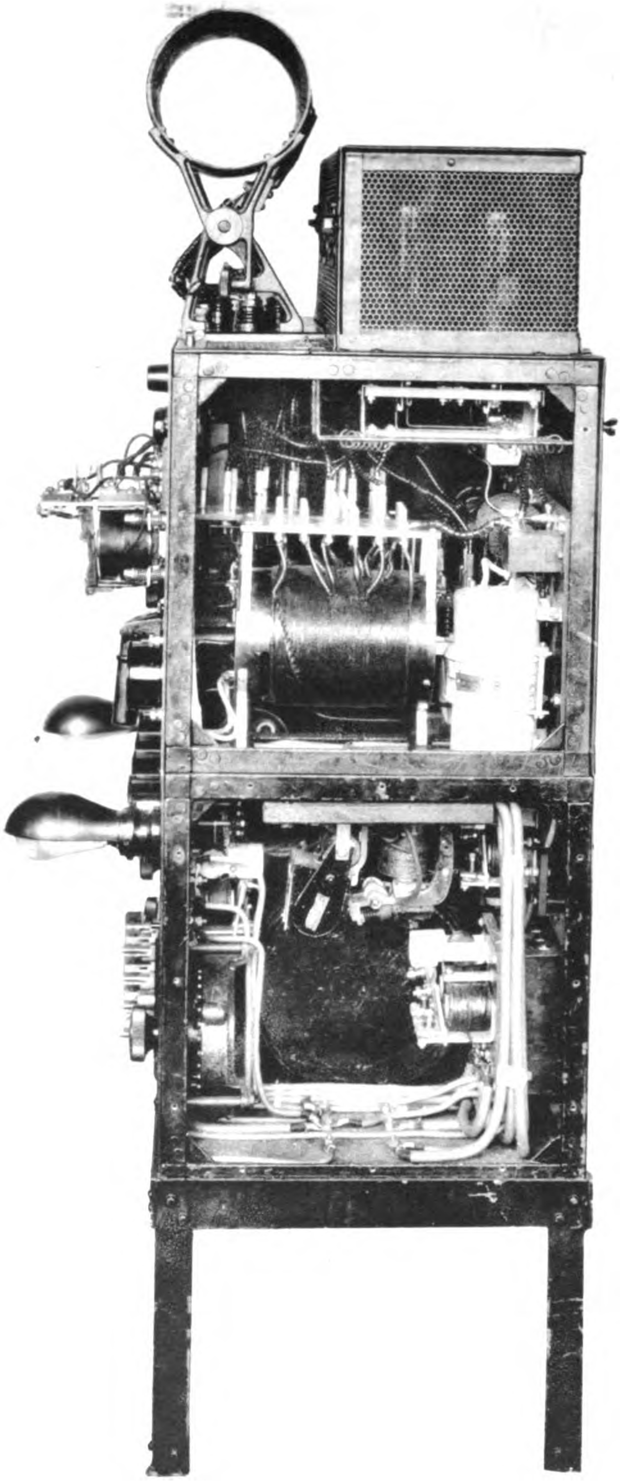


Fig. 8

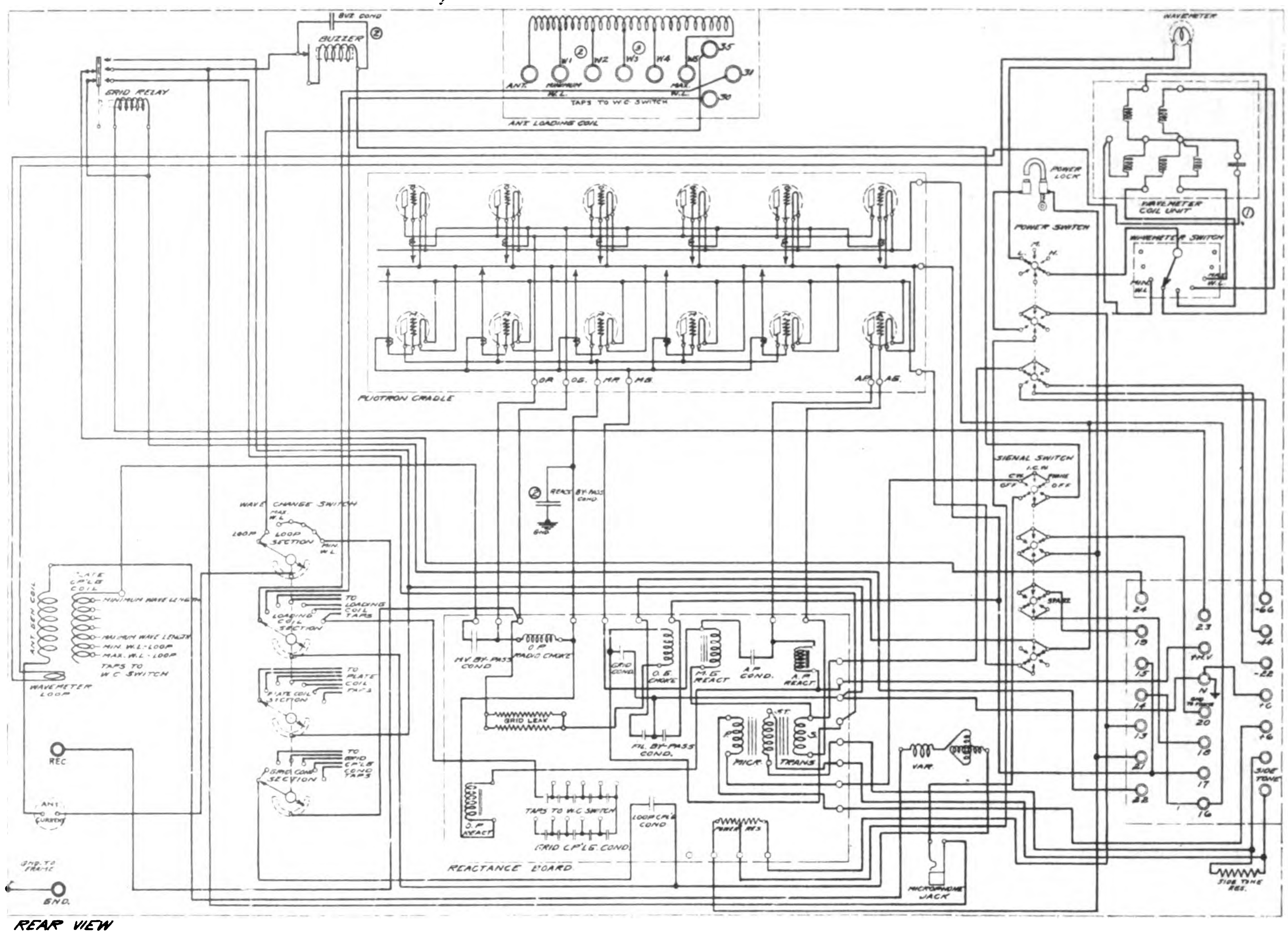
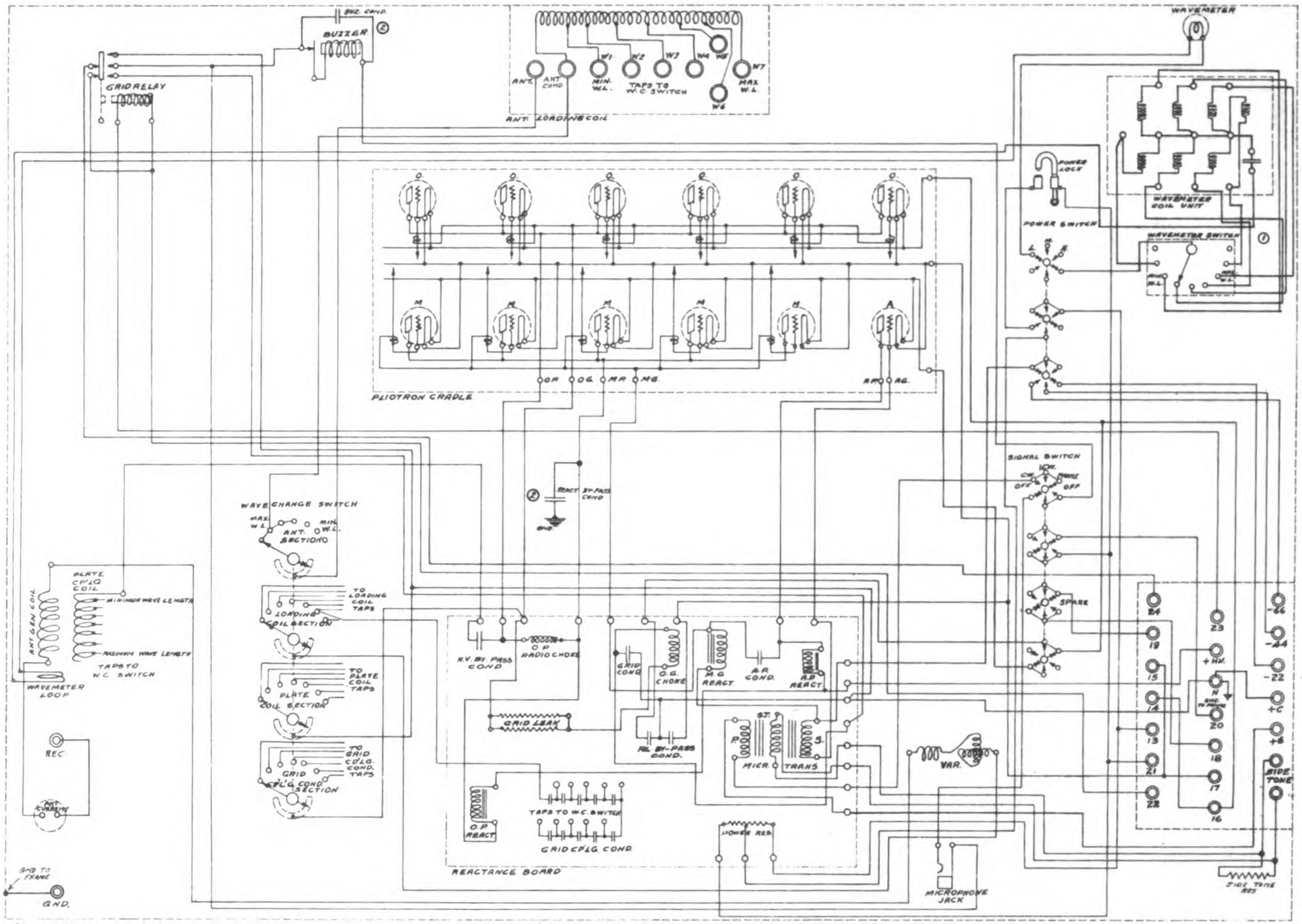

BUZ COND
BUZZER
GRID RELAY
ANT.
W1
W2
W3
W4
W5
35
31
30
MINIMUM W.L.
MAX. W.L.
TAPS TO W.C. SWITCH
ANT LOADING COIL
WAVEMETER
POWER LOCK
POWER SWITCH
WAVEMETER COIL UNIT
WAVEMETER SWITCH
PLIOTRON CRADLE
OR
OS.
MR
MB
AP.
AS.
SIGNAL SWITCH
I.C.W.
SPARE
REACT BY-PASS COND
GND
WAVE CHANGE SWITCH
LOOP
LOOP SECTION
MIN W.L.
TO LOADING COIL TAPS
LOADING COIL SECTION
TO PLATE COIL TAPS
PLATE COIL SECTION
TO GRID CP'LG COND TAPS
GRID COND SECTION
PLATE CP'LG COIL
ANT GEN COIL
MINIMUM WAVE LENGTH
MAXIMUM WAVE LENGTH
MIN. W.L.-LOOP
MAX. W.L.-LOOP
TAPS TO W.C. SWITCH
WAVEMETER LOOP
REC
ANT CURRENT
GND. TO FRAME
GND.
H.V. BY-PASS COND
O.P. RADIO CHOKE
GRID COND
O.G. CHOKE
M.G. REACT
A.P. COND.
A.P. REACT
GRID LEAK
FIL. BY-PASS COND.
MICR.
TRANS
VAR.
O.P. REACT
TAPS TO W.C. SWITCH
GRID CP'LG. COND
LOOP CP'LG COND
POWER RES
REACTANCE BOARD
MICROPHONE JACK
24
19
15
14
13
21
22
23
20
18
17
16
-66
44
-22
+C
+6
SIDE TONE
SIDE TONE RES.
REAR VIEW

Fig. 9



REAR VIEW

Fig. 10

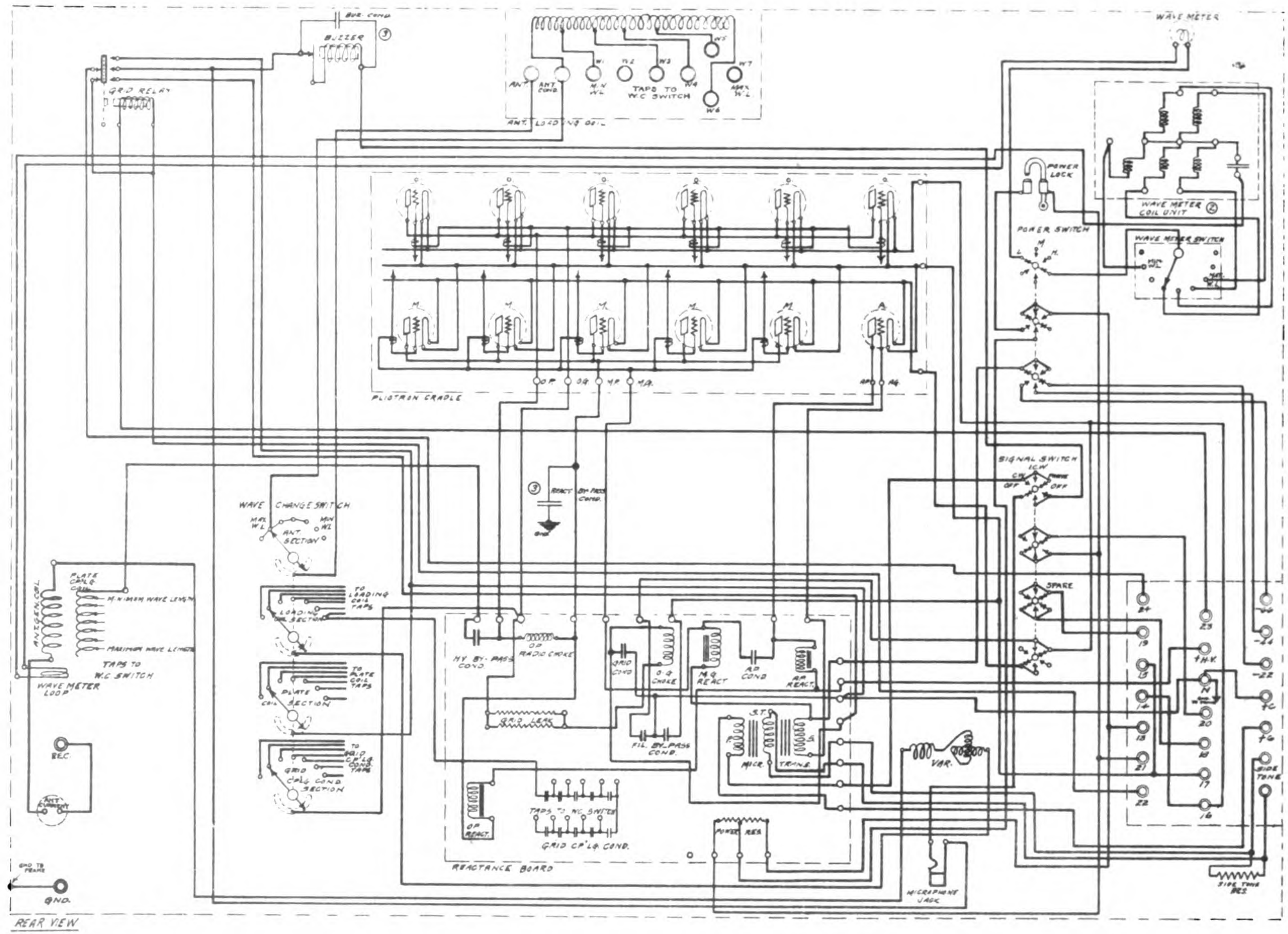

WAVE METER
BUZZER
GRID RELAY
ANT.
ANT. COND.
TAPS TO W.C SWITCH
ANT. LOADING COIL
POWER LOCK
WAVE METER COIL UNIT
POWER SWITCH
WAVE METER SWITCH
PLIOTRON CRADLE
SIGNAL SWITCH
SPARE
WAVE CHANGE SWITCH
ANT SECTION
LOADING SECTION
PLATE SECTION
TO LEADING COIL TAPS
TO PLATE COIL TAPS
PLATE COIL
MINIMUM WAVE LENGTH
MAXIMUM WAVE LENGTH
ANTGEN COIL
TAPS TO W.C SWITCH
WAVE METER LOOP
HY BY-PASS COND.
OP RADIO CHOKE
GRID COND
O.G CHOKE
M.G REACT
AP COND
AP REACT.
GRID LEAK
FIL. BY-PASS COND.
S.T.
MICR.
TRANS.
VAR.
OP REACT.
TAPS TO W.C SWITCH
GRID CP'LG COND.
REACTANCE BOARD
POWER RES
MICROPHONE JACK
SIDE TONE
SIDE TONE RES
REC.
GND.
REAR VIEW

Fig. 11

undue rise in temperature of the radio room. When changing from "C.W" operation to either "Buz". or "Tel" it is necessary to make a slight adjustment of filament voltage. These tubes are operated at a plate voltage of 1000.

COIL SYSTEMS

A modified coil system similar to that which was previously described under Theory is used in these equipments for generating radio frequency currents with the addition of an antenna loading coil and a variometer. Instead of the grid coupling coil, sufficient oscillatory voltage from the antenna coil is tapped off by means of a grid coupling condenser (See Fig. 6 for schematic diagram of circuit) and impressed on the grid through a small choke coil. This choke coil functions in holding back from the grid any oscillations or undesired frequency which might be generated in the numerous circuits within the transmitter, thereby allowing the tube to oscillate at the desired frequency. There are 10 taps on the grid coupling condenser.

Tied in with the grid circuit is the grid leak resistance, "OG" choke coil and grid condenser. The grid leak resistance due to the IR (current times resistance) drop, furnishes sufficient negative voltage to the grid to efficiently control the vacuum tube. The "OG" choke coil holds back the oscillating current which is tapped from the antenna circuit by the grid coupling condenser thereby prohibiting any short circuit of the antenna system. The grid condenser when in circuit allows the grid to become highly negatively charged thus reducing the plate current to a zero value.

The antenna loading coil is used to obtain the different wavelengths specified and is provided with ten taps. Any one of these taps can be connected to any stud on the loading inductance bank of the wave change switch through the medium of an intermediate terminal board located on top of the transmitter in front of the coil itself. These taps are selected so that the variometer gives the same percentage wave length overlap on each tap. This arrangement of the loading coil makes it sufficiently flexible so that a continuous wave length range between upper and lower limits is accomplished. Also, with the variometer adjustment it is possible to utilize any wave length within this range.

The antenna lead is connected to one end of the coil and the antenna variometer to the desired tap through the wave change switch. The loading coil is mounted across the left side of the top of the transmitter as shown in Fig. 7. The antenna variometer and the antenna and plate coils are mounted within the transmitter cabinet, having their control handles and dials on the front of the panel.

The antenna and plate coils are mounted within the panel and are coils having taps, which taps terminate in the respective tap boards where flexible leads connect coils to other circuits.

Connected in series with the plate coil and the plate is a high frequency by-pass condenser (See Fig. 12 to 15) which keeps the high voltage direct current from being short circuited through the plate coil and only allows the pulsating current of similar characteristics of radio frequency currents to pass through the plate coil. Connected between the plate and the 1000 volt generator system is a radio frequency choke coil and an "OP" reactance which is shunted by a condenser. The radio frequency choke coil holds back any radio frequency current that may back up in the direct current supply line. The condenser and reactance referred to tend to smooth out any commutator ripple that may be given off by the generator. The condenser also serves as a short circuit to ground for any radio frequency current that may work its way past the choke coil.

In the Model TE equipments when operating on the loop the same coil system and antenna ammeter are used but the loading coil is replaced by the loop unit.

SERIES ANTENNA CONDENSERS

A series condenser having a capacity of 500 micro microfarads is used with the Model TF and TG equipments on the following wave lengths:

Model TF on 507-600-675 meters.
Model TG on 507 meters only.

These condensers are mounted externally and are automatically cut out of the circuit on the higher wave lengths by the wave changing switch. These condensers function in reducing the total capacity of the antenna system in order that more turns may be used on the antenna coil, thus providing sufficient coupling for efficient working of the equipment.

CONTROLS

There are certain controls on the front of the transmitter panel and may be described as follows:

The wave change switch controls the wave length mechanism within the set and consists of a four bank seven point switch. The various wave lengths to which the set can be tuned are shown on the face of the switch. The four banks made the necessary connection to the grid coupling condenser, plate coupling coil, loading inductance, series condenser and in addition, on the Model TE equipments connects

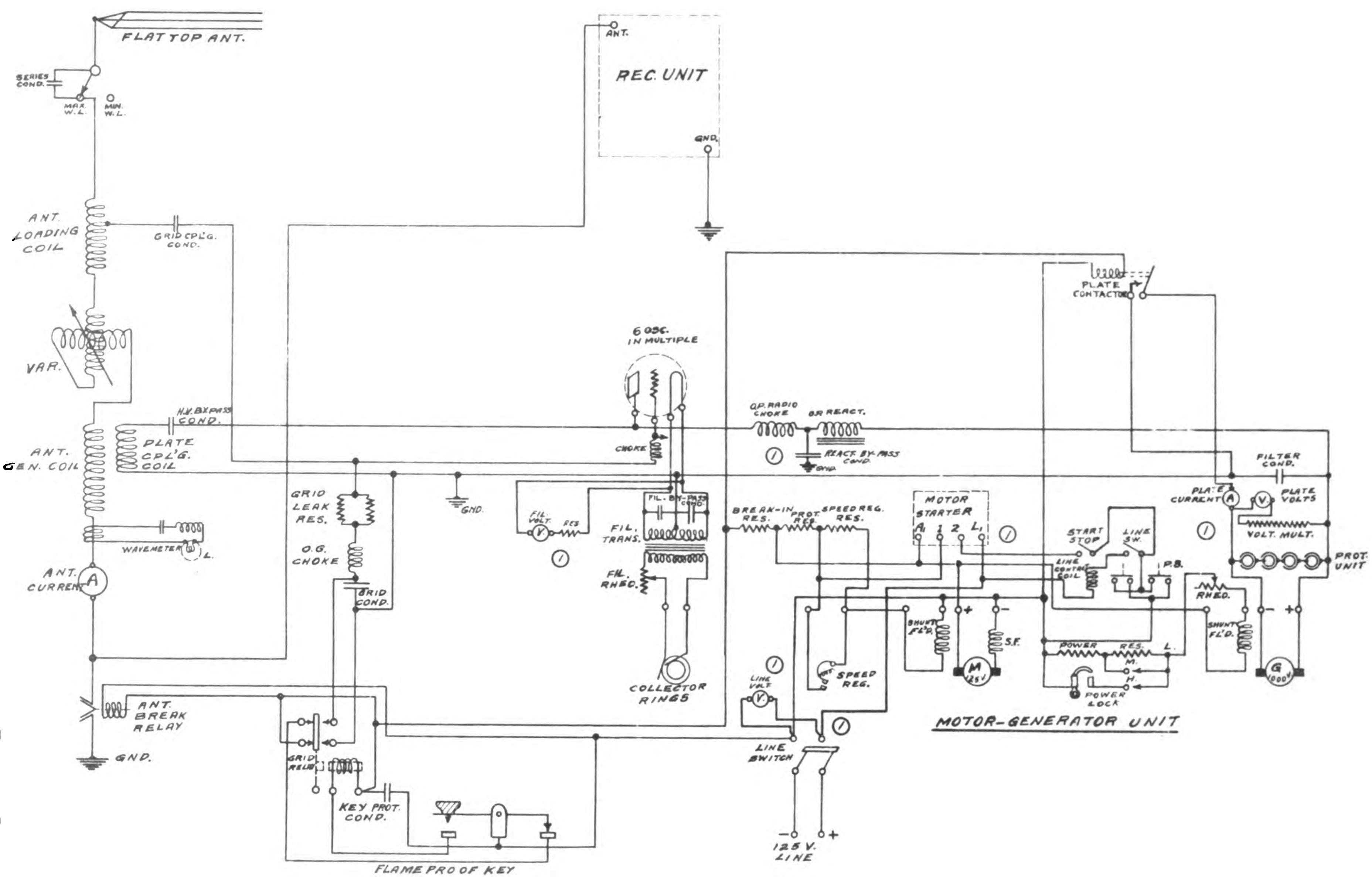

FLAT TOP ANT.
SERIES COND.
MAX. W.L.
MIN. W.L.
ANT. LOADING COIL
GRID CPL'G. COND.
VAR.
H.V. BY-PASS COND.
PLATE CPL'G. COIL
ANT. GEN. COIL
WAVEMETER
L.
ANT. CURRENT
ANT. BREAK RELAY
GND.
ANT.
REC. UNIT
GND.
GRID LEAK RES.
O.G. CHOKE
GRID COND.
GRID RELAY
KEY PROT. COND.
FLAME PROOF KEY
GND.
6 OSC. IN MULTIPLE
CHOKE
FIL. VOLT.
RES
FIL. BY-PASS COND.
FIL. TRANS.
FIL. RHEO.
COLLECTOR RINGS
O.P. RADIO CHOKE
GR. REACT.
REACT. BY-PASS COND.
BREAK-IN RES.
PROT. RES.
SPEED REG. RES.
MOTOR STARTER
SPEED REG.
LINE VOLT.
LINE SWITCH
125 V. LINE
PLATE CONTACTOR
START STOP
LINE SW.
LINE CONTROL COIL
P.B.
SHUNT FL'D.
S.F.
POWER RES.
M.
H.
L.
POWER LOCK
FILTER COND.
PLATE CURRENT
PLATE VOLTS
VOLT. MULT.
PROT. UNIT
RHEO.
MOTOR-GENERATOR UNIT

Fig. 12

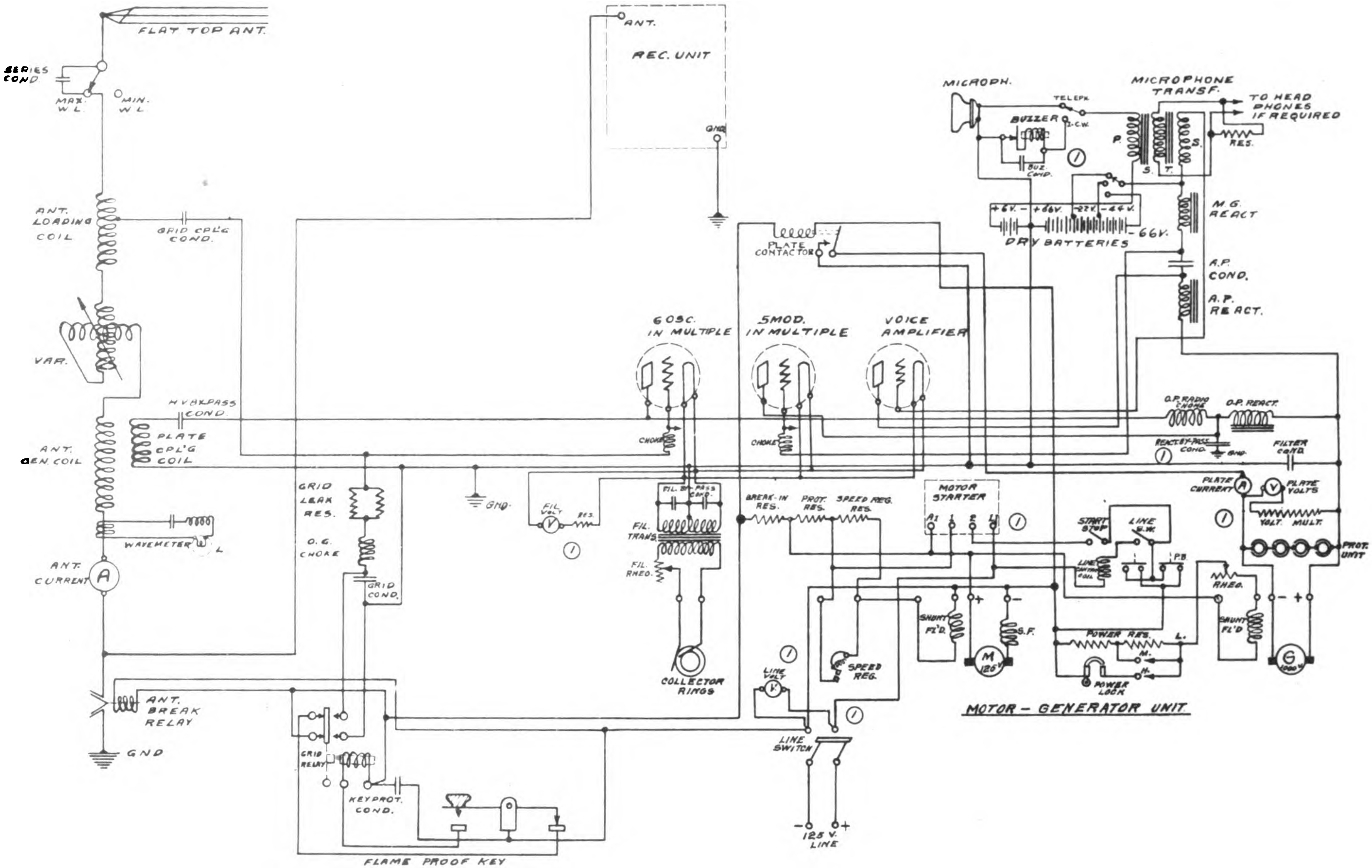

FLAT TOP ANT.
SERIES COND.
MAX. W.L.
MIN. W.L.
ANT. LOADING COIL
GRID CPL'G COND.
VAR.
HV BYPASS COND.
PLATE CPL'G COIL
ANT. GEN. COIL
WAVEMETER
ANT. CURRENT
ANT. BREAK RELAY
GND
ANT.
REC. UNIT
GND.
GRID LEAK RES.
O. G. CHOKE
GRID COND.
GRID RELAY
KEY PROT. COND.
FLAME PROOF KEY
GND.
6 OSC. IN MULTIPLE
5 MOD. IN MULTIPLE
VOICE AMPLIFIER
CHOKE
FIL. VOLT
RES.
FIL. TRANS.
FIL. RHEO.
COLLECTOR RINGS
PLATE CONTACTOR
BREAK-IN RES.
PROT. RES.
SPEED REG. RES.
SPEED REG.
LINE VOLT
LINE SWITCH
125 V. LINE
MOTOR STARTER
SHUNT FL'D.
S.F.
M 125 V
START STOP
LINE SW.
P.B.
POWER RES.
POWER LOCK
RHEO.
G 1000 V
PROT. UNIT
VOLT. MULT.
PLATE CURRENT
PLATE VOLTS
FILTER COND.
O.P. RADIO CHOKE
O.P. REACT.
REACT. BY-PASS COND.
MOTOR - GENERATOR UNIT
MICROPH.
TELEPH.
BUZZER
I.C.W.
BUZ. COND.
MICROPHONE TRANSF.
TO HEAD PHONES IF REQUIRED
RES.
DRY BATTERIES
+6V. -
+66V.
-22V.
-44V.
-66V.
M.G. REACT
A.P. COND.
A.P. REACT.

Fig. 13

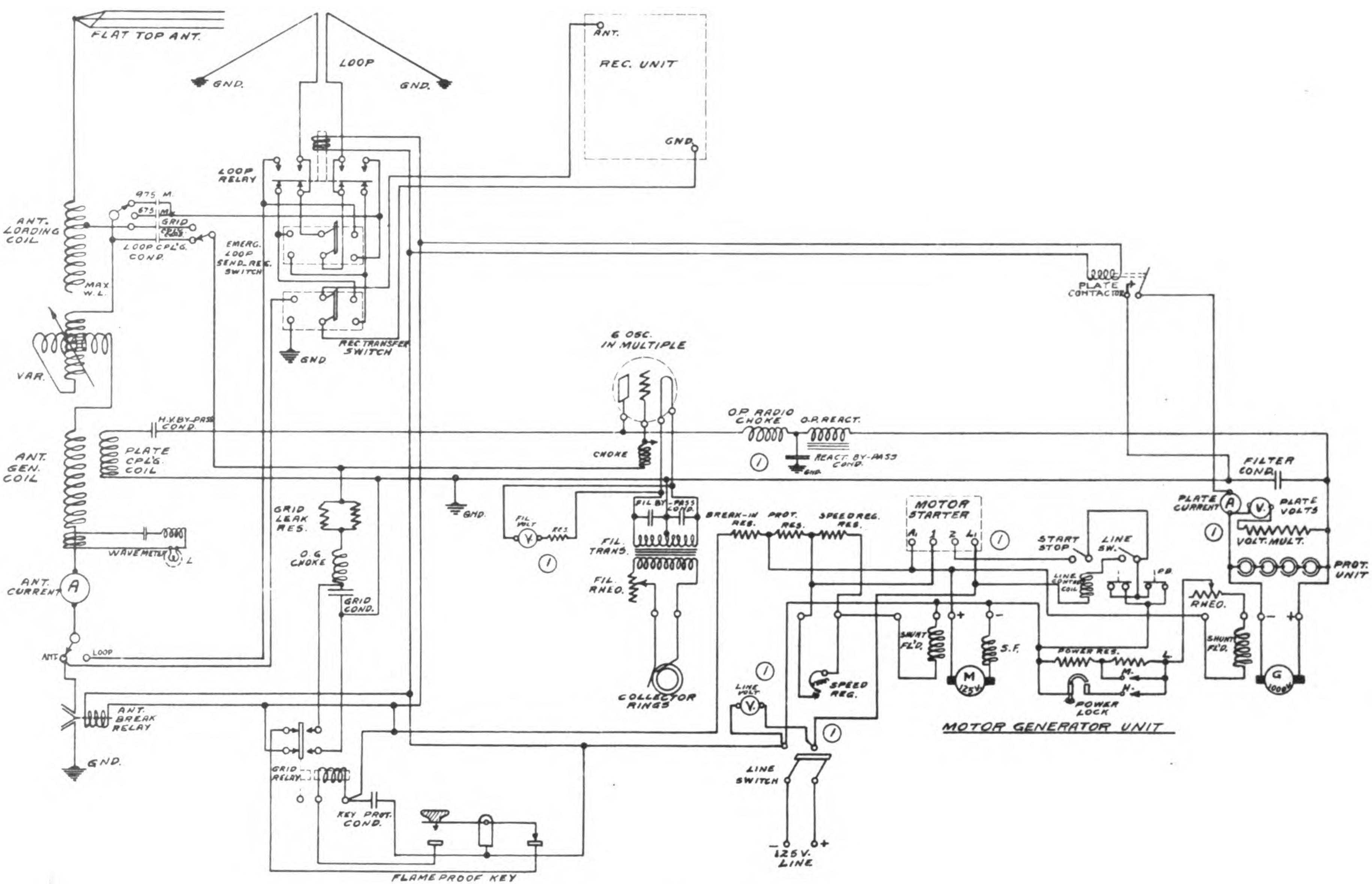

FLAT TOP ANT.
LOOP
GND.
GND.
ANT.
REC. UNIT
GND.
LOOP RELAY
975 M.
675 M.
GRID CPL'G. COND.
LOOP CPL'G. COND.
EMERG. LOOP SEND.-REC. SWITCH
ANT. LOADING COIL
MAX W.L.
VAR.
REC TRANSFER SWITCH
GND
6 OSC. IN MULTIPLE
H.V. BY-PASS COND.
PLATE CPL'G. COIL
ANT. GEN. COIL
CHOKE
O.P. RADIO CHOKE
O.P. REACT.
REACT. BY-PASS COND.
PLATE CONTACTOR
FILTER COND.
GRID LEAK RES.
O.G. CHOKE
GRID COND.
GND.
FIL. VOLT
RES.
FIL. BY-PASS COND.
FIL. TRANS.
FIL. RHEO.
BREAK-IN RES.
PROT. RES.
SPEED REG. RES.
MOTOR STARTER
START STOP
LINE SW.
LINE CONTROL COIL
PLATE CURRENT
PLATE VOLTS
VOLT. MULT.
PROT. UNIT
RHEO.
SHUNT FL'D.
WAVEMETER
L
ANT. CURRENT
ANT.
LOOP
COLLECTOR RINGS
LINE VOLT
SPEED REG.
S.F.
M 125V.
POWER RES.
POWER LOCK
G 1000V.
ANT. BREAK RELAY
GND.
GRID RELAY
KEY PROT. COND.
LINE SWITCH
125 V. LINE
MOTOR GENERATOR UNIT
FLAME PROOF KEY

Fig. 14

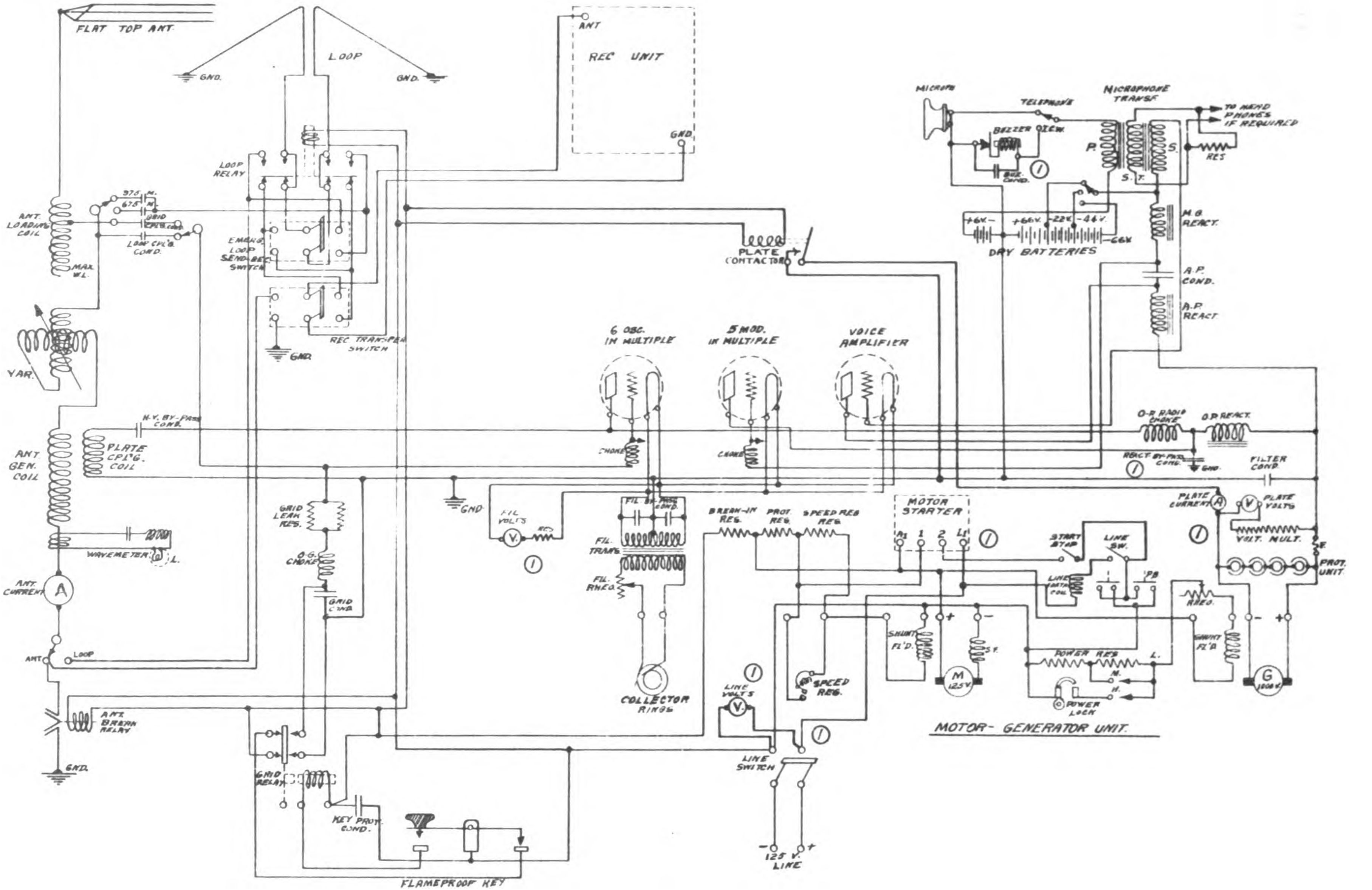

FLAT TOP ANT.
LOOP
GND.
GND.
ANT
REC UNIT
GND
LOOP RELAY
ANT. LOADING COIL
MAX. W.L.
LOW CPL'G. COND.
EMERG. LOOP SEND-REC. SWITCH
REC TRANSFER SWITCH
GND
VAR.
H.V. BY-PASS COND.
PLATE CPL'G. COIL
ANT. GEN. COIL
GRID LEAK RES.
O.G. CHOKE
GRID COND.
WAVEMETER
ANT. CURRENT
ANT
LOOP
ANT. BREAK RELAY
GND.
GRID RELAY
KEY PROT. COND.
FLAMEPROOF KEY
PLATE CONTACTOR
6 OSC. IN MULTIPLE
5 MOD. IN MULTIPLE
VOICE AMPLIFIER
CHOKE
GND.
FIL. VOLTS
FIL. TRANS.
FIL. RHEO.
COLLECTOR RINGS
BREAK-IN RES.
PROT. RES.
SPEED RES. REG.
MOTOR STARTER
SPEED REG.
LINE VOLTS
LINE SWITCH
125 V. LINE
START STOP
LINE SW.
PB
SHUNT FL'D.
S.F.
M 125 V.
POWER RES.
POWER LOCK
MOTOR- GENERATOR UNIT.
RHEO.
SHUNT FL'D.
G 1000 V.
PROT. UNIT
VOLT. MULT.
PLATE CURRENT
PLATE VOLTS
FILTER COND.
O-P RADIO CHOKE
O.P. REACT.
REACT. BY-PASS COND.
GND.
A.P. REACT.
A.P. COND.
M.B. REACT.
MICROPHONE TRANSF.
P.
S.
S.T.
RES
TO HEAD PHONES IF REQUIRED
TELEPHONE
BUZZER
BUZ. COND.
DRY BATTERIES
+6V.
+66V.
-22V.
-44V.
-66V.

Fig. 15

the flat top or loop antenna to the transmitter. These connections are all changed simultaneously when the switch is thrown from one wave length to another. The different equipments make use of the seven positions on the wave change switch as follows:

	Wave Lengths		
Switch Position	TE	TF	TG
1	507	507	507
2	600	600	
3	675	675	600
4	800	975	675
5	975	1080	800
6	Loop		
	675	1200	975
7	975	1430	

The lever on the switch can be pulled outward thereby disconnecting all circuits should such an action be desired and by depressing the lever the circuits can again be connected.

The antenna variometer switch is to the left of the wave change switch and is operated by moving the pointer to the right or to the left thus adding to or subtracting from the inductance of the antenna circuit, which in turn varies the wave length of that circuit. Above the antenna variometer switch is the wave meter switch which is so constructed that any group of wave meter coils may be connected in by turning switch to the desired wave length.

Since the transmitted radio frequency wave length is established almost entirely by the antenna circuit, the constants of which change slightly from time to time, and further since the tuning of continuous wave signals is extremely sharp, a wave meter has been included in the transmitter structure to permit ready and accurate tuning at all wave lengths. The wave meter, in connection with the antenna variometer, makes it possible to readily compensate for slight changes in the antenna constants from day to day.

The wave meter employs a fixed condenser, variable inductance and an incandescent lamp as an indicator of resonance. The inductance and condenser are enclosed in a metal box mounted on the back of the panel. The unit is operated by a switch directly below the indicator lamp, having a position for each wave length used and two "off" positions, one at each extreme end of the dial.

The wave meter is calibrated before shipment. If, for any reason it becomes necessary to re-calibrate the wave meter, the following procedure should be followed:

The transmitter should be in operation on "low" power.

Set the variometer and mark the position so that the desired wave length is read on a precision or calibrated external wave meter.

To resonate the wave meter in the transmitter, set the wave meter switch on the desired wave length, and turn the adjusting screw in the wave meter box IN to decrease the wave length or OUT to increase it, until the lamp is at maximum brilliancy, that is, if calibrating the lowest wave length of the transmitter, the wave meter switch should be set on position number one and screw number one in the wave meter box adjusted until the indicator lamp is at maximum brilliancy. If wave length number two is being calibrated, set the wave meter switch on second position and adjust screw number two, etc.

When the exact setting of the wave meter is secured, the variometer should be moved slightly in either direction and then brought back to the original position. The wave meter lamp should again be at maximum brilliancy. If this is not the case, the same procedure should be followed again until the lamp does not show maximum brilliancy when checked in this way.

The wave change switch and wave meter switch are provided with reversed etched white metal card holders for white cards on which new wave length positions of the wave change switch and new wave length calibrations of the wave meter can be marked.

This arrangement for the wave meter and wave change switch is provided so that if it is desired to change the operating wave length of the transmitter after installation, a new card may be put in the holder and the correct markings for the new wave length calibration made thereon.

PLATE AND GRID ADJUSTMENTS

For the proper selection of grid and plate coupling for each wave length, three tap boards are built in the transmitter as follows:

(a) Wave change switch tap board.
(b) Plate coil tap board
(c) Grid condenser tap board.

Instructions for the selection of these taps is included under "Initial adjustments", which is given in the following chapter:

SIGNAL SWITCH

In order to change from one method of communication to another, that is, "Tel," to "CW" or "Buz.", it is necessary to change the signal switch to the desired method as marked on the dial. Each extreme position of this switch is an "Off" position. This is the only change required when changing from one kind of signaling to another.

POWER CHANGE SWITCH

A three position power switch is provided so that the output of the set may be changed to any one of three powers:

Full Power
1/2 Full Power, approximately
1/4 Full Power, approximately.

This switch is provided with a lock so that the transmitter cannot be operated on the high power position without the use of a special key, provided with the transmitter. This lock is provided to restrict the use of high power to such times as full power is needed to cover the required range. The use of high power when not required causes unnecessary interference, and lessens the life of the transmitting tubes. Unless absolutely necessary high power should not be used with the set as the required distance can generally be obtained with medium power.

The buzzer on the panel is tied in with the microphone circuit through the signal switch, whereby when using "CW" and "ICW" methods of transmission it is substituted for the microphone, while on "Tel." position the microphone is substituted for the buzzer. The buzzer is similar to the commercial Century type buzzer and therefore needs no introduction to Naval personnel.

BREAK-IN SYSTEM

A "Break-in" system is associated with the transmitter as shown schematically in Fig. 12. This arrangement opens the short circuit across the receiver primary and enables the operator to receive between the dots and dashes of the transmitted signal. On the transmitter supplied for submarine service the break-in system also transfers the loop from the transmitter to the receiver, when the key is depressed or raised respectively. The break system is supplied to permit the transmitting operator to listen-in between his transmitted signals. The advantages of such provision are obvious.

The antenna break relay is mounted outside the transmitter and is connected in the ground side of the antenna, (See Fig. 7).

The antenna break relay operates, closing the antenna circuit and short circuiting the receiver, when the back contact of the Morse key is opened. This relay is in the ground lead of the antenna, and is connected in shunt with the primary circuit of the receiver, thus making it necessary to receive through the transmitter antenna coil system, when the back contacts of the Morse key are opened, this relay short circuits the primary circuit of the receiver.

The loop relay in the submarine transmitter operates, and transfers the loop from receiver to transmitter when the back contact of the Morse key is opened. At that time this relay transfers the single turn loop antenna from the receiver terminals to the transmitter. When the back contacts of the key are closed,, this relay transfers the loop from the transmitter to the receiver terminals.

The grid relay operates on the front contact of the Morse Key and when so operated opens the interlock contact and controls the grid circuit of the oscillators. In order to prevent the antenna break relay or loop relay from being in the receiving position when the transmitter is operated, the grid relay is provided with auxiliary contacts which are in series with the back contacts of the Morse Key and which positively open the shunt circuit across the power supply to relay system before closing the circuit across the key condenser.

The Morse Key is a hand key of the front and back contact type. The front contacts close the circuit placing power on the coil of the grid relay. The back contacts close the shunt across the power supply to the relay coils when interlock contacts on the grid relay are closed.

The relay resistance prevents the short circuit of the power supply when the back contacts of the Morse Key, and the interlock contacts of the grid relay are closed. This relay resistance also reduces the supply voltage to the proper value for the operation of the relays when the front contacts are closed.

The operation of the relays from a double contact key is required in order that a time element be introduced which lends itself to the satisfactory operation of the circuit, as follows:

It is essential that all relays associated with the break-in system be closed when a signal is being transmitted and further that the antenna break relay and the loop relay close slightly before the grid relay is closed and open slightly after this relay is opened. If the antenna break and loop relays were operated from the front contacts of the Morse Key, it would be necessary to design and carefully adjust all relays so that their operation would be in the above sequence. This sequence is brought about automatically by the back contact, assuming that all relays operate at the same speed. This sequence is due to the interval of time elapsing between the instant the back contact is opened and the instant the front contact is closed. When the back contact is opened the antenna break and loop relays are operated. However, the grid relay is not operated until the front contacts are closed. By this arrangement the antenna break and loop relays open when no current is flowing through their contacts thereby insuring longer life of these contacts.

A radiation ammeter is shown in the lower right corner of the panel and is of valuable assistance in determining whether the transmitter is working correctly. In the case of Submarine radio work this meter will instantly notify the operator when the spray is grounding the antenna insulators in which case he should switch set over to loop.

WIRING

All the low voltage control and auxiliary circuits are wired with flame proof wire. The antenna circuit is wired with copper tubing and the plate and grid circuits with brass rod. All connections to a tap-board except those from the coil associated with it are made of insulated flexible conductor.

The bare wiring is colored according to circuits as follows, to facilitate tracing of circuits:

Antenna	Blue
Grid	Green
Plate	Red
Filament	Brown

SIDE TONE

Side tone is available in all methods of transmission. The binding posts provided for connection of the side tone winding of microphone transformer to the receiver are marked "Side Tone". With this provision, the operator can hear his own signals in his head phones, when transmitting on C.W., Buz. or Tel.

POWER PANEL:

The power panel is identical in all three types of equipment and is shown in Fig. 7 and the schematic diagram of connections in Fig. 16. The mechanical construction of the power panel is in general the same as the transmitter, provision being made to mount the transmitter on the top of the power panel.

All the necessary apparatus for controlling the power equipment is mounted in the power panel. This includes the following equipment:

(a) Automatic starter
(b) Duplicate automatic starter

(c) Starter transfer switch
(d) Main line contactor
(e) Automatic starter push button
(f) Filament voltage control
(g) Plate voltage control
(h) Filament transformer
(i) Plate voltmeter 0- 1500 volts
(j) Plate ammeter 0- 2.0 amperes
(k) Filament voltmeter 0-15 volts
(l) Line voltmeter 0-150 volts
(m) High voltage filter system
(n) Power supply fuses
(o) Relay resistance for break-in system.

AUTOMATIC STARTER

The power equipment is started by means of an automatic starter which is provided with a no-voltage release. It returns to the "off" or first position when the voltage fails. This no-voltage release is entirely automatic and does not require re-setting by hand. If the voltage fails, the motor will start up when voltage is resumed, unless the "Stop" button is depressed.

The starter is so designed that it comes to the full running condition when the starting switch is closed, regardless of the speed at which the motor may be turning at the moment the switch is closed, that is, the "Start" switch may be closed immediately after having been opened.

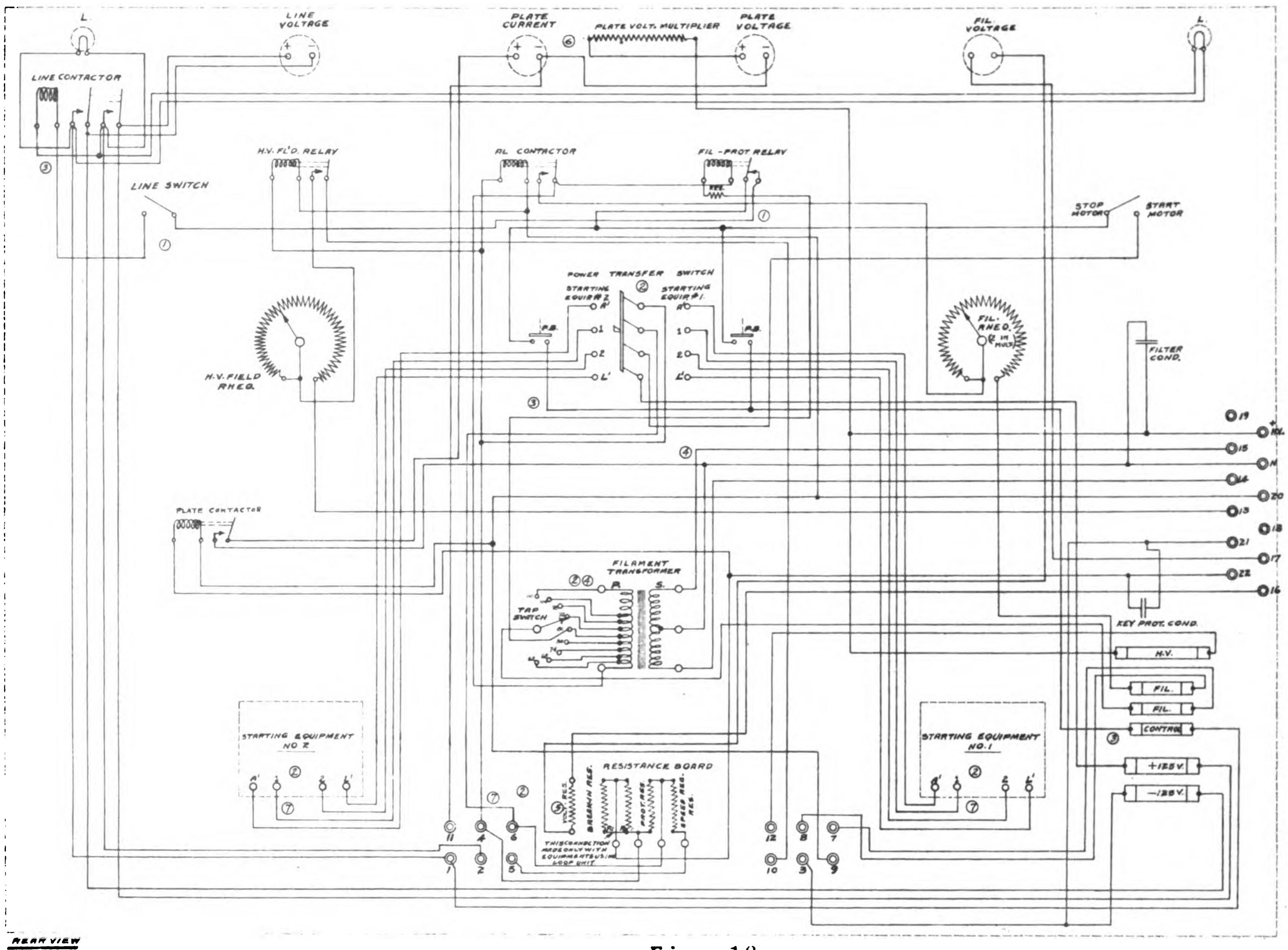
The last step of the accelerating switch cuts out all starting resistance. The starter is designed to "hold-in" over reasonable variations in power supply.

Automatic starters are supplied in duplicate with the necessary transfer switch which makes it possible to use either starter with the motor generator. The wiring of these starters is such that the starter which is not in circuit is electrically isolated.

STARTER TRANSFER SWITCH

The starter transfer switch is mounted on the front of the panel. The function of this switch has been described in the preceding paragraph. The remote control push button is so connected that a transfer from starter No. 1 to starter No. 2 also transfers the remote control circuit to that starter.

When the starter transfer switch is closed either in position No. 1 or No. 2, it engages with a small push button which closes the motor starter circuit INSIDE the transmitter. When the starter transfer switch is opened, it releases this push button, opening the starter circuit before the starter transfer switch blades break contact. This provision prevents the



L.
LINE VOLTAGE
PLATE CURRENT
PLATE VOLT. MULTIPLIER
PLATE VOLTAGE
FIL. VOLTAGE
LINE CONTACTOR
H.V. FL'D. RELAY
RL CONTACTOR
FIL-PROT RELAY
LINE SWITCH
STOP MOTOR
START MOTOR
POWER TRANSFER SWITCH
STARTING EQUIP. #2
STARTING EQUIP. #1
P.B.
H.V. FIELD RHEO.
FIL. RHEO.
FILTER COND.
PLATE CONTACTOR
FILAMENT TRANSFORMER
TAP SWITCH
KEY PROT. COND.
H.V.
FIL.
CONTROL
+135V.
−135V.
STARTING EQUIPMENT NO. 2
STARTING EQUIPMENT NO. 1
RESISTANCE BOARD
THIS CONNECTION MADE ONLY WITH EQUIPMENTS USING LOOP UNIT
REAR VIEW

Fig. 16

transfer switch from breaking current, in accordance with the requirement that the set be flame proof.

MAIN LINE CONTRACTOR

A main line contactor is provided which opens the direct current supply.

FILAMENT AND PLATE RHEOSTATS

Independent voltage control is provided for the filament supply and the plate circuit supply with sufficient range to give control over filament and plate voltage to compensate for the difference between generator voltages and the filament and operating voltages.

FILAMENT TRANSFORMER

This transformer is located within the power panel and is provided with taps in the primary side so that with an additional filament rheostat a voltage of 10.0 volts can be maintained at the tube terminals throughout a power supply voltage of from 105 to 150 volts. The rheostat is used for fine adjustment of voltage, between that obtained by the transformer taps.

FILAMENT CIRCUIT BREAKER

In addition to the fuses the filament circuit is provided with a protective relay so that the filament voltage can not exceed 10.5 volts. Thus when a rise in the supply voltage occurs, due to charging the storage batteries, the filament circuit is opened by this relay, preventing burning out of filaments.

When this relay opens it is impossible to close it until the following procedure is followed:

First: Set signal switch on "Off" position.

Second: Reduce filament voltage to a minimum by throwing both filament voltage controls to minimum voltage position.

Third: Throw signal switch on again.

Fourth: Bring up filament voltage to 10.0 volts.

Fine adjustment of filament voltage is made by the filament rheostat after the approximate voltage is obtained by changing the taps on the transformer.

FUSES

The power panel contains, in easily accessible locations, fuses in the following parts of the circuits:

(1) One fuse in actuating circuit of line contactor.

(2) One fuse in each side of power supply on the dead side of the main line switch when open.

(3) One fuse in each side of filament supply.

(4) One fuse in positive side of high voltage supply.

RELAY RESISTANCE FOR BREAK-IN SYSTEM

Two resistance units are mounted in the power panel near the top at the back of the cabinet. These resistances are provided with a strap so that in the TE equipments they can be connected in parallel thus providing the necessary energy for the operation of the loop relay. On the Model TG and TF equipments the strap is left open. This arrangement makes it possible to supply the power panel of each equipment in exact duplicate.

The power panel is mounted on an angle iron frame-work which is constructed as a separate unit. The overall dimensions of the power panel are as follows:

Width - 28¾ in. including fuse board cover
Depth - 17½ in. including controls
Height - 28¼ in. including 11¼ in. feet

MOTOR GENERATOR, TYPE CG 1338

The power necessary for the operation of the transmitter is obtained from a motor generator illustrated in Fig. 17 and wiring diagram Fig. 12. This unit comprises a direct current motor direct connected to a direct current generator mounted on a common bed plate and direct connected by flexible coupling.

The type of motor generator supplied is as follows:
2 unit, 4 bearing motor generator set consisting of:
1 direct current motor, 120 volts, 3 3/4 h.p. 1765 r.p.m.
1 direct current generator, 1000 volts, 1 1/2 KW 1765 r.p.m. separately excited at 105 volts, flat compounded.

The motor is provided with slip rings from which is supplied a single phase load of 850 watts at 74 volts, 30 cycles. The motor is also equipped with a speed regulator that can be adjusted as follows:

To raise the speed of the motor,
Take off the cover of the regulator and TIGHTEN the spring SLIGHTLY.
To lower the speed of the motor,
LOOSEN the spring SLIGHTLY.

If transmitter is functioning normally do not make any adjustments to motor generator, and only in case of trouble with current supply should the motor generator

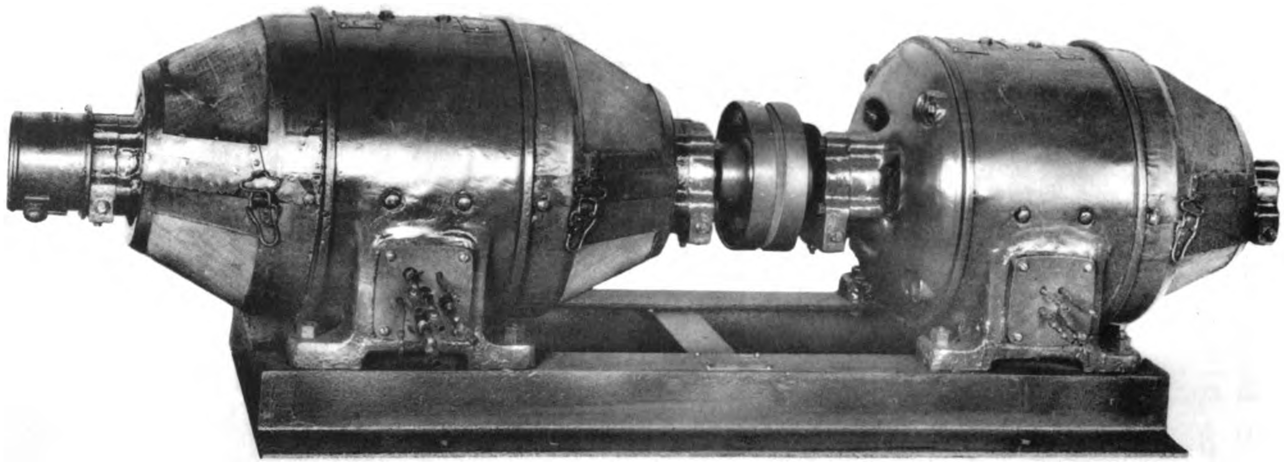


Fig. 17

be adjusted. It is advisable to let installation force do this kind of work.

The Model TE equipments are capable of satisfactory operation over a variation of voltage from 105 to 150 volts. This variation of voltage occurs because the radio equipments on board submarines are operated from storage batteries.

The motor generator is of the semi-enclosed type and is provided with a non-corrosive metal gauze shield over the openings in the end plates.

PROTECTION UNIT, TYPE CG 4009

The protection unit is illustrated in Fig. 18 and 19. It is composed of four aluminum cells in glass jars all connected in series. The design is based on the characteristics of a cell consisting of two aluminum plates, on which has been formed a film of hydroxide of aluminum immersed in a suitable electrolyte. This unit protects the high voltage generator from break down due to surges.

The cells are mounted in a sheet metal box having a hinged cover and porcelain bushings in the ends for leads.

This protection unit requires very little attention in service and should operate indefinitely without attention. If there is any indication that the unit is not working satisfactorily, such as electrolyte becoming dark, or minute sparking at the electrode surfaces, the electrolyte should be removed and replaced by fresh electrolyte. These units should be inspected approximately once a month. When re-filling the containers with electrolyte, a small amount of oil should be added on the surface of the electrolyte, to prevent evaporation.

LOOP UNIT, MODEL TE EQUIPMENT ONLY, TYPE CG 1333

A separate unit composed of a relay and two series antenna condensers is connected in series with the loop antenna.

The relay is used to transfer the loop from the transmitter to the receiver functioning as a break-in relay.

The loop condenser has two sections, one being used on 675 meters and one of 975 meters. Transfer from one to the other is made when the wave change switch is thrown. These condensers serve to bring the wave length of the loop approximately to the required wave lengths. Fine adjustment of wave length is made by means of the antenna variometer and the wave meter.

Fig. 20 is an illustration of the interior of the Loop unit.

Fig. 21 shows schematic diagram of connections for this unit.

EMERGENCY SEND RECEIVE SWITCH, TYPE CG-1746

In case the break-in system is defective or doesn't function properly, an auxiliary switch called the Emergency Send Receive Switch can be used to connect transmitter or receiver to the loop. This switch is a double pole double throw switch which will have to be manually operated. Fig. 24 illustrates constructional details of this switch.

BATTERY BOX TYPE CG-1745

In order to supply sufficient voltage for biasing the grids of the modulator tubes four 22 1/2 volt dry batteries are used. These batteries (Type SE 3535) are placed in a metal container, illustration of which container is shown in Fig. 25. The lugs on each end of the container are for the purpose of allowing the container to be made fast to a bulkhead or to the deck.

6-VOLT STORAGE BATTERY

A six volt storage battery is provided for the purpose of supplying current for the microphone and buzzer circuits.

OPERATION:

This chapter will cover operation of each part of the equipment, briefly reviewing the functioning of the parts of the equipment, and then explaining steps to be taken in starting power equipment and method pursued in adjusting transmitter to the desired wave length and power.

Two requirements must be fulfilled in a radio telephone and continuous wave telegraph transmitter:

(1) There must be provided a source of high frequency energy.
(2) There must be provided means of modulating or controlling the high frequency energy in accordance with the method of transmission employed.

HIGH FREQUENCY SOURCE

The source of the high frequency energy is the vacuum tube which acts as a converter, changing the high voltage direct current to a high frequency current. In this set six vacuum tubes are employed in this capacity and are known as oscillator tubes. The vacuum tube consists of three elements: filament, grid and plate, mounted in an evacuated glass tube. Referring to the circuit diagram, Fig. 12, it will be seen that the transmitter consists of four fundamental circuits.


TYPE CG-4009
PROTECTIVE UNIT
FOR MODEL
RADIO EQUIPMENT
MADE FOR NAVY DEPT (BU ENG) BY
GENERAL ELECTRIC CO. U.S.A.
ALUMINUM LIGHTNING ARRESTER
DIRECT CURRENT
GENERAL ELECTRIC CO.
SCHENECTADY N.Y. U.S.A.

Fig. 18

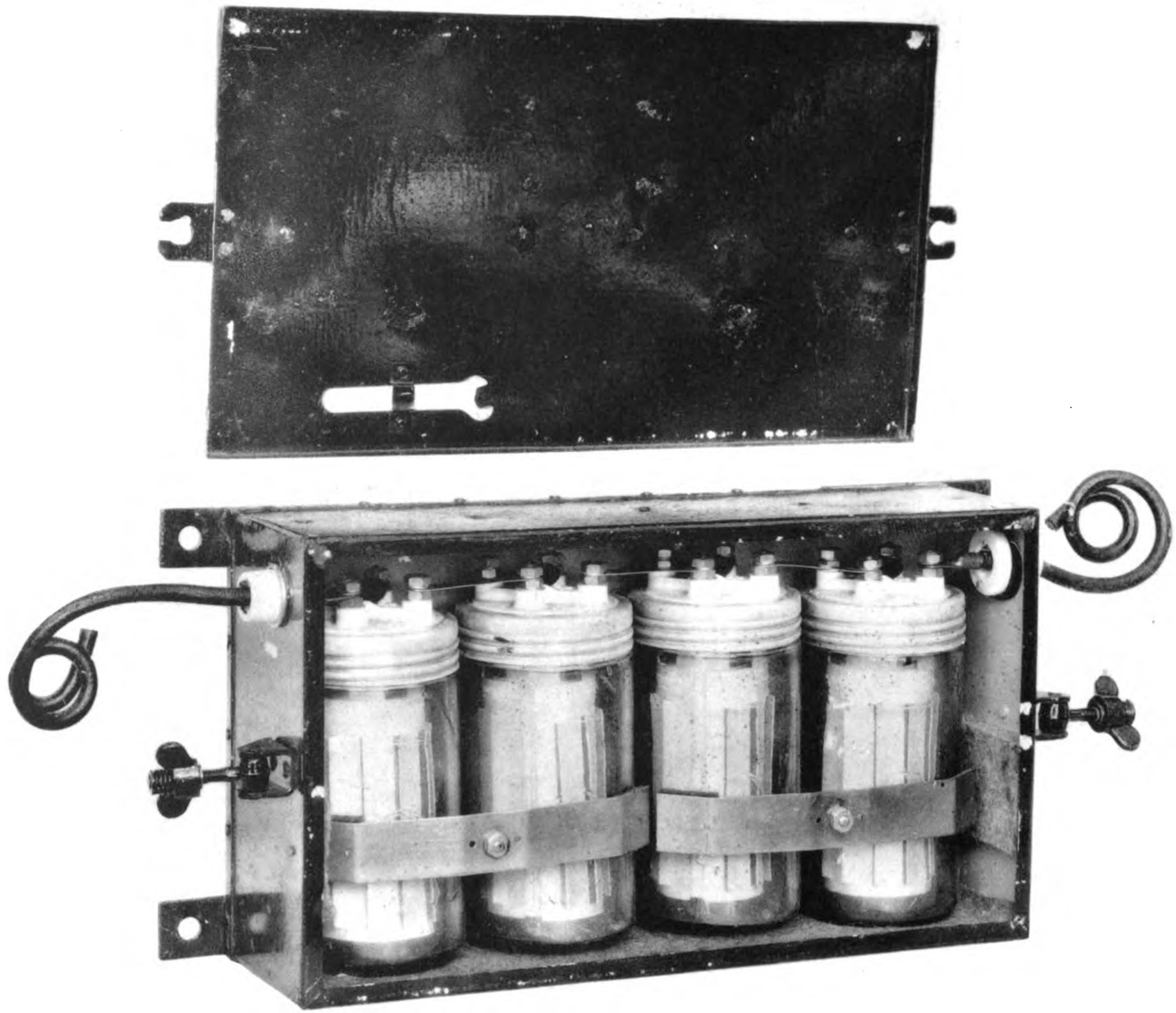


Fig. 19

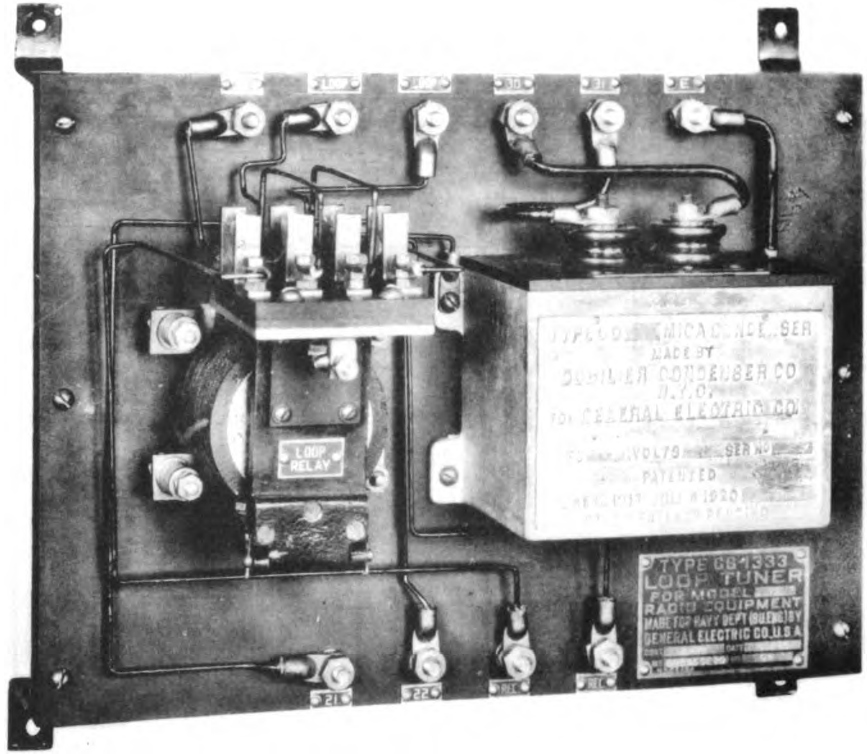
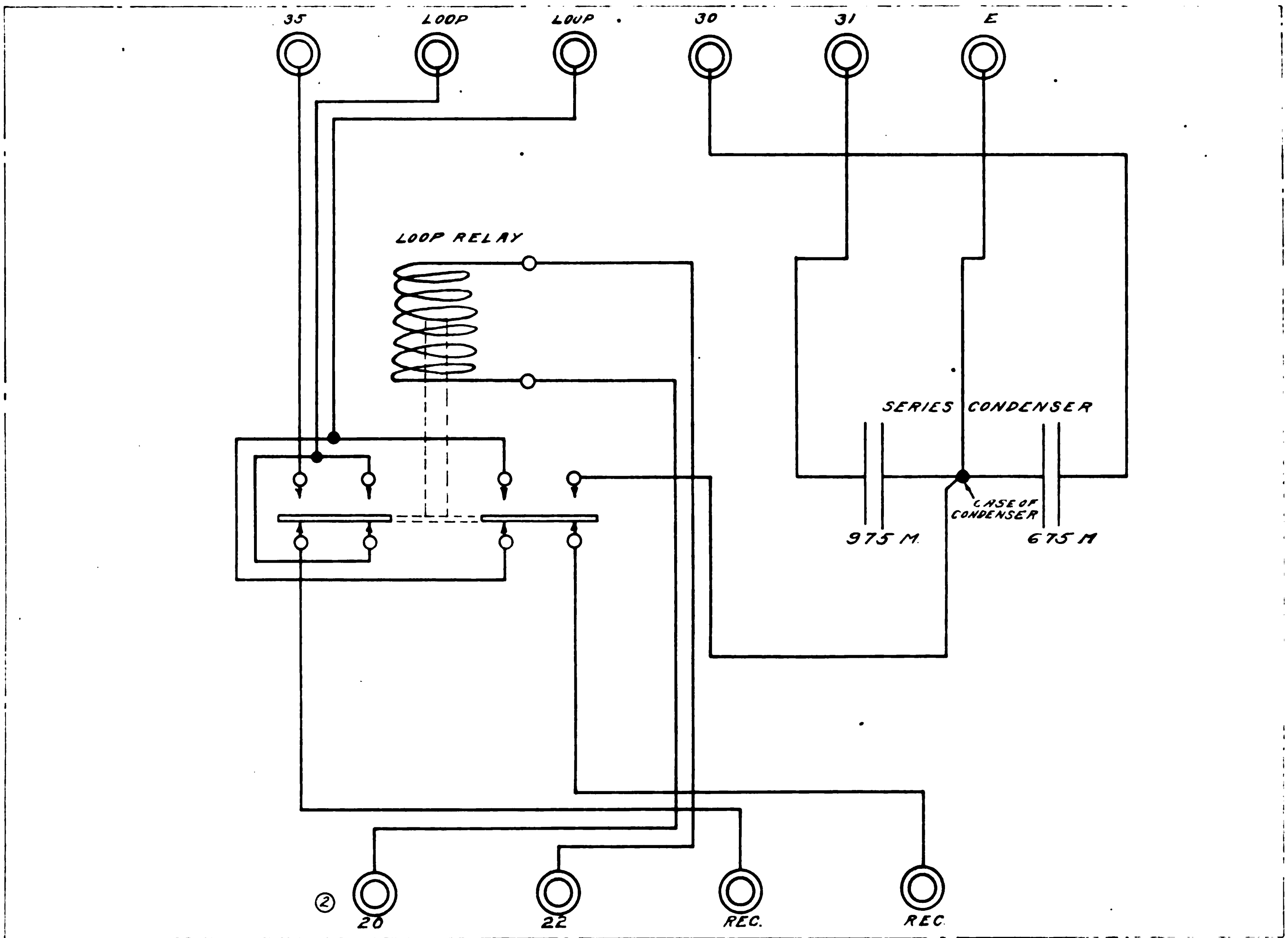

LOOP
30
31
E
LOOP
RELAY
MADE BY
DUBILIER CONDENSER CO
N.Y.C.
FOR GENERAL ELECTRIC CO
PATENTED
TYPE CG1333
LOOP TUNER
FOR MODEL
RADIO EQUIPMENT
MADE FOR NAVY DEPT (BU.ENG) BY
GENERAL ELECTRIC CO. U.S.A.
21
22

Fig. 20



TOP VIEW

Fig. 21

(1) Antenna
(2) Plate
(3) Grid
(4) Filament.

ANTENNA CIRCUIT

The antenna circuit terminates at the antenna post or terminal and at the ground terminal. Between these two terminals are connected the necessary loading inductance, generating coil, series condenser and antenna ammeter. The loading inductance is mounted on the top of the transmitter and is provided with taps so that the amount of inductance can be readily changed. The generating coil is closely coupled to the plate coil, the two forms being concentric and mounted as one unit, the plate coil over the antenna generating coil.

PLATE CIRCUIT

The plate circuit connects the plates of the oscillator tubes through the "OP" radio choke and an iron coke reactor to the positive high voltage, which in this case is 1,000 volts. The negative terminal of the plate generator connects to the grounded mid-point of the secondary of the filament transformer. The plate circuit is then completed through the plate coil and the H.F.By-pass condenser by the space between the filament and plate inside the tube. The plate coil is wound on a tube which is placed outside of, but concentric with, the tube on which the generator section of the antenna inductance is wound, thus providing coupling between the two windings. The plate coil acts as the primary of the oscillation transformer and is provided with taps to permit adjustment to the maximum output.

GRID CIRCUIT

The grid circuit passes from the grids of the oscillator tubes, through the grid choke for each individual tube, then through the grid coupling condenser, grid leak resistances and "OG" radio choke to the mid-point of the filament transformer secondary. Shunted around the grid condenser is the grid leak resistance and key which are in series. The key condenser is connected across the key contacts.

When the key is in the operative position (closed) the tubes are allowed to oscillate. With the key in the inoperative position (open) the grids of the oscillators assume a negative potential of such a magnitude that the oscillations are stopped.

FILAMENT CIRCUIT

The filament circuit consists of the filaments of the tubes and connects, through the filament transformer to the slip rings on the motor. The filament voltage is regulated by a rheostat in the primary circuit of the transformer and taps on the primary side of the transformer.

GENERATOR OF OSCILLATIONS

Upon closing the switches an instantaneous surge occurs in the plate circuit with the result that the antenna is forced into feeble oscillations whose period (frequency) depends upon the inductance and capacitance of the antenna circuit. The grid circuit due to its capacitive relation to the antenna withdraws some of this oscillating energy with the result that an oscillating potential is applied between the grid and the filament. This produces a change in the plate current, which, if the circuits are properly arranged, adds to the effect of the original surge. This cycle of operation is then repeated with the antenna current continually increasing until limited by the antenna and tube characteristics.

MODULATION OR CONTROL OF HIGH FREQUENCY ENERGY

In this particular set, three methods of communication are provided, namely, continuous wave telegraphy, buzzer modulated continuous wave telegraphy and telephony, thus necessitating three different circuit arrangements for controlling the high frequency energy.

CONTINUOUS WAVE TELEGRAPHY

The circuit diagram for this method of communication is shown in Fig. 12. In order to telegraph using continuous waves, means are provided whereby the operation of the telegraph key starts and stops the generation of high frequency energy. This is accomplished by opening and closing contacts shunted across the grid condenser. When the grid condenser is shunted, as when the key is in the operative position, oscillations are permitted to take place. When the shunt circuit is open, as when the key is in the inoperative position, the grids of the oscillators are allowed to become highly negative with the result that the oscillations are stopped.

TELEPHONE

Fig. 13 shows the circuit arrangement for this condition. In order to carry on telephone communication it is necessary to provide apparatus capable of modulating or moulding the high frequency energy. That is, an envelope is formed around the high frequency current, the shape of which envelope resembles that of the sound wave.

Modulation is accomplished in this particular set by means of five vacuum tubes, which are termed modulator tubes when used for this function. In addition to the five modulator tubes a sixth tube is employed which functions as a speech amplifier.

Referring to the circuit diagram, Fig. 13, it may be seen that the plates of the modulator tubes are connected to the positive terminal of the high voltage of plate generator through the modulator radio frequency choke and the iron core reactor. The filaments of the modulator and oscillator tubes being in parallel, the plate circuit is completed through the space between the plate and filament and the H.F. By-pass condenser, thence to the negative side of the generator. The grid of the modulator tube is connected through the biasing battery to the filament and also to the plate circuit of the amplifier tube by means of a condenser (AP). The grid of the amplifier tube connects through the secondary of the microphone transformer and biasing battery to the filament. The primary circuit of the microphone transformer, while it passes through other units, fundamentally consists of a microphone transmitter or a buzzer in series with a battery and the primary winding of the microphone transformer.

Assuming that the current through the primary of the microphone transformer is varied, then the secondary of the microphone transformer, being connected between the grid and filament of the amplifier tube, impresses on the grid of this tube an alternating voltage, the variations of which are in accordance with, and a picture of which would resemble, the sound waves spoken into the transmitter. This variation of amplifier grid potential results in a similar change in the amplifier plate circuit; in other words, the output of the microphone transformer is amplified to an extent determined by the circuit and tube characteristics. These amplified variations are in turn impressed upon the modulator grid by means of capacitive coupling, condenser (AP). The variations of modulator grid voltage produce corresponding variations in the plate current and tube impedance. These variations in the modulator plate circuit result in a corresponding increase or decrease of the power available for the plate circuit of the oscillator. This action is due to the fact that there is practically a constant total supply for the plate circuit of both the modulator and oscillator tubes due to the iron core reactor in the positive side of the plate generator.

BUZZER MODULATION

Fig. 13 also shows the circuit arrangement for this condition, in this method of communication the operation is practically the same as in telephone except that the microphone transmitter is replaced by a buzzer. The buzzer operates when the key is depressed when the signal switch is set on "Buz." position. The grid relay switch for "Buz." position of signal switch, closes buzzer circuit with the same contacts as is used to close or shunt grid condenser (See Fig. 9).

CHOICE OF TRANSMISSION BY LOOP OR FLAT TOP ANTENNA

Model TE transmitters are built for operation either on a flat top or a loop antenna, transfer from one to the other being made by means of the wave changing switch.

The choice between transmission on the flat top or the loop may be governed somewhat by the fact that, while the flat top antenna is a better radiator than the loop, it does not render as infallible service. It may be found in rainy or damp weather, or when spray is being washed or thrown over the entering insulator of the flat top antenna, that the radiation will consistently fall to practically zero and not build up again to normal value for a time in the order of one-half minute. This is caused by the fact that the moisture on the entering insulator has the effect of partially short-circuiting the antenna. The fact that the radiation comes back to its normal value is due to the drying off of this insulator. It is probable, however, that this occurrence will happen quite frequently under the conditions referred to.

Under such conditions it will be found that the loop will give absolutely reliable transmission, since it is affected in no way by atmospheric conditions.

It must be remembered that, when transmitting on the loop, the effectiveness of transmission is reduced and also that such transmission is directive, maximum ranges being obtained when the submarine is headed towards or away from the receiving station and minimum range when at right angles to the receiving station. Under this condition the loop is approximately 85 per cent as effective as the flat top. As the relative position of the submarine to the receiving station changes the effectiveness is decreased until the submarine is in a position at right angles to the receiving station, under which condition the range of the transmitter practically falls to zero. It is a rare occasion when the submarine is exactly at right angles to a station and under practical conditions communication can be maintained to a satisfactory degree when at reasonable distances.

The loop may, therefore, be considered as a standby antenna, to be used when atmospheric conditions are such that the flat top does not give reliable service, or at such other times as the flat top antenna is not in operating condition. The loop also may be used for transmission when the submarine is coming to the surface for recognition purposes. Ranges up to 800 yards have been obtained from submarine running at periscope depth when communicating with tender.

INITIAL ADJUSTMENTS MADE WHEN SET IS FIRST INSTALLED

Three terminal boards are included in the transmitter to facilitate adjustments:

(a) Wave change switch tap board.
(b) Plate coil tap board.
(c) Grid condenser tap board.

Connections are made permanently from the seven studs on the grid and plate bank of the wave change switch to the studs on (a). Connections are also made permanently between the 29 taps on the plate coil to (b) and from the 10 taps on the grid coupling condenser to (c). This series of tapboards makes possible the selection of any grid or plate tap for any of the seven wave length positions. The number "1-P", "2-P", etc. and "1-G","2-G", etc. engraved on (a) correspond with positions 1, 2, etc. of the wave change switch, position No. 1 being the shortest wave length. By plugging a jumper in "1-P" the other end of the jumper may be plugged into any of the 29 jacks on the plate tapboard. Similarly, for 2-P, 2-G, 3-P, 3-G, etc.

The jacks on the wave change switch tapboard are made in pairs, so that, in the event it is found desirable, at any wave length (say position 3) to use a plate or grid tap that has already been taken by one of the preceding wave lengths, the jumper from 3-P or 3-G may be plugged into the second jack on (a) adjacent to the one connected by jumper to the desired grid or plate tap. This will connect the same grid or plate tap to two positions on the wave change switch.

"IN INSERTING THE PLUGS, THEY SHOULD BE TURNED SLIGHTLY TO THE RIGHT WHILE ENTERING THE JACK. AFTER THEY ARE ENTIRELY IN, A SLIGHT TURN TO THE LEFT WILL LOCK THEM IN PLACE, AND THEY CAN NOT BECOME DISENGAGED BY A STRAIGHT PULL. TO REMOVE THE PLUG, TURN SLIGHTLY TO THE RIGHT AND WITHDRAW."

The above adjustments are only made when the transmitter is first installed, and at such other times as is found necessary due to change in antenna constants. This should be very infrequently.

These adjustments should be made with the high voltage reduced to approximately 500 volts. The approximate plate and grid settings for each of the different transmitters and each wave length follows:

MODEL TE

						Loop	
Wave Length	507	600	675	800	975	675	975
Plate Top	6	11	10	16	21	13	18
Grid Tap	(To be found by test as antennas are of widely						
Loading Tag	different characteristics)						

MODEL TF

Wave Length	507	600	675	975	1080	1200	1430
Plate Tap	6	10	10	17	20	27	28
Grid Tap	2	2	4	6	5	6	5
Loading Tap	1	2	1	2	3	5	5

MODEL TG

Wave Length	507	600	675	800	975
Plate Tap	8	7	9	14	16
Grid Tap	2	4	6	7	7
Loading Tap	1	0	1	1	2

The antenna current should be noted under this condition. The plate coil and grid condenser taps should then be changed, one or two taps on either side of the normal setting until maximum antenna current is obtained without exceeding a plate current of 150 milliamperes per tube when operating on C.W. It may be found that some plate and grid taps will give slightly more output than others, with a plate current in excess of the 150 milliamperes. Such operation is undesirable since the tubes will be under more severe service and operating under conditions exceeding their rating.

This process of adjustment should be repeated for all wave lengths. Once the settings for the different conditions of operation are obtained, it will be unnecessary to change them unless the antenna characteristics are changed considerably.

When the best results have been obtained on low power, change to medium and high power and readjust until the set is delivering normal full rated output.

Before changing any tap, care should be taken to see that the antenna switch is on "ground" position.

For exact tuning, the power change switch should be set on "low power", the signal switch turned to "C.W." and the wave meter switch turned to the wave length corresponding to the position of the wave change switch. By turning the antenna variometer knob until the indicator lamp assumes full brilliancy, the exact desired wave length is obtained. When this has been done, the wave meter switch should be turned to off position, so that no energy is consumed by the wave meter while transmitting.

OPERATION OF EQUIPMENT

"IT MUST BE BORNE IN MIND THAT MODEL TE, TF AND TG TRANSMITTERS, WHILE CAPABLE OF GIVING ABSOLUTELY SATISFACTORY AND UNINTERRUPTED SERVICE, MUST BE OPERATED WITH DUE CONSIDERATION TO THE FACT THAT THEY ARE NOT ENTIRELY FOOL PROOF. EFFORTS HAVE BEEN MADE TO ELIMINATE THE POSSIBILTY OF IMPROPERLY OPERATING THE SET, BUT THE INHERENT CHARACTERISTICS OF THESE TRANSMITTERS ARE SUCH THAT THE VARIOUS SWITCHING AND RHEOSTAT CONTROLS MUST BE OPERATED WITH THE SAME CARE AND FORETHOUGHT

AS WOULD BE EXPECTED IN THE OPERATION OF ANY EXPENSIVE AND SENSITIVE APPARATUS. NO ONE SHOULD ATTEMPT THE OPERATION OF THESE SETS UNTIL HE HAS BEEN CAREFULLY INSTRUCTED IN THE OPERATION OF THE SET AND WARNED OF THE PRECAUTION WHICH MUST BE TAKEN TO INSURE THE SET GIVING BEST RESULTS. HOWEVER, IF AN OPERATOR HAS BEEN SO INSTRUCTED, AND EXERCISES DUE PRECAUTION AND CARE, HE SHOULD NOT HAVE THE SLIGHTEST DIFFICULTY IN OBTAINING SATISFACTORY OPERATION AT ALL TIMES."

The following instructions are complete for operation on any one method of communication and any one wave length. To transmit on any of the other wave lengths or by the other methods of communication, it is only necessary to place in position the switches so designated and proceed in the same manner as outlined below.

Assuming all external connections are made according to Fig. 22 and 23 and all initial adjustments made as indicated under "Initial Adjustments Made When Set is First Installed".

TO START POWER EQUIPMENT

1. Make sure signal switch on the transmitter is on "Off" position.
2. Close push button line switch power now on power panel.
3. Close 4 PDT switch to Starter No. 1 or Starter No. 2.
4. Push button marked "Start Motor" motor starts.
5. Cut in all taps on filament transformer.
6. Cut in total filament rheostat.

TO TRANSMIT

"CW" operation.

1. Make sure signal switch is on "Off" position.
2. Set power switch on "Low" position.
3. Set wave change switch on desired wave length.
4. Change signal switch to "C.W." position. 6 tube filaments light dimly.
5. Adjust filament voltage to 10 volts by reducing taps used on filament transformer and filament rheostat.
6. Operate key and note radiation ammeter.

If satisfactory output is not obtained with normal plate current, readjust the plate and grid taps. When satisfactory output is obtained on low power then power switch may be thrown to "Medium" power. The equipment is now ready for "C.W." transmission.

"Buz" or "Tel"

Follow directions outlined in the first three items above and proceed as follows:

1. Make sure signal switch is on "Off" position.
2. Set power switch on "Low" position.
3. Set wave change switch on desired wave length.
4. Set signal switch on "Buz" or "Tel".
5. Readjust filament voltage to 10 volts. All tube filaments light.
6. In transmitting on "Buz" press key and note radiation ammeter. In operating on "Tel" condition talk into the microphone and note radiation ammeter.
7. Readjust grid and plate taps if output is not satisfactory.
8. When in "Tel" position, the telegraph key is used as a "Send-Receive" switch. The key must be depressed when talking and raised when receiving.

TO SHUT DOWN EQUIPMENT

1. Set signal switch on "Off" position.
2. Press motor start push button.
3. Open line switch.

NOTE: WHEN MAKING ANY ADJUSTMENT INSIDE THE TRANSMITTER THE SIGNAL SWITCH SHOULD BE SET ON "OFF" POSITION SO THAT ALL HIGH VOLTAGE IS REMOVED FROM THE CURRENT.

FAULTS AND REMEDIES:

Precautions

The following precautions are important and special effort should be made to make use of the suggestions herein given:

Don't make new adjustments on high power, use low power for this purpose, then increase power.

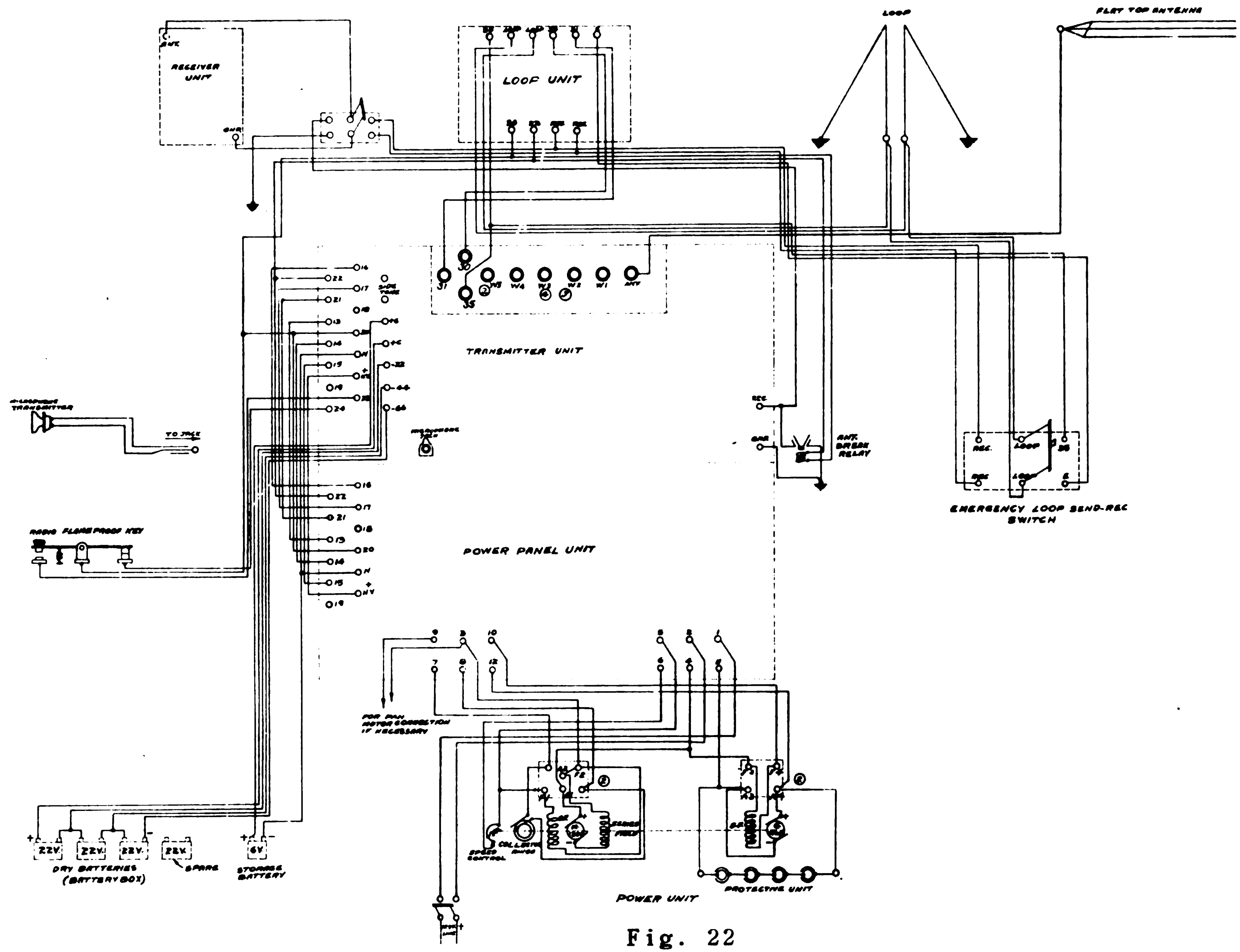
Don't operate transmitter unless antenna and ground or loop are connected. If transmitter is operated when antenna or loop circuit is open the power usually radiated by antenna or loop will necessarily have to be used in heating the tubes, which condition in most cases means burned out tubes.

Don't allow plate voltage to exceed 1000 volts. Excessive voltage causes brush discharge, punctured condensers and burned out tubes.

Don't let plate current exceed 150 milliamperes. (0.150 amperes)

Don't operate transmitter with filament voltage more than 10 volts. An increase of 3 per cent in current reduces the life of the filament to one-half its normal life, likewise a 3 per cent decrease in current through filament doubles the filament life.

Don't let tubes draw plate current if antenna ammeter does not register. The damage which may



FLAT TOP ANTENNA
LOOP
RECEIVER UNIT
LOOP UNIT
TRANSMITTER UNIT
POWER PANEL UNIT
ANT. BREAK RELAY
EMERGENCY LOOP SEND-REC SWITCH
RADIO FLAMEPROOF KEY
DRY BATTERIES (BATTERY BOX)
SPARE
STORAGE BATTERY
POWER UNIT
PROTECTIVE UNIT
SPEED CONTROL
COLLECTING RINGS
SERIES FIELD
FOR FAN MOTOR CONNECTION IF NECESSARY
TO JACK

Fig. 22

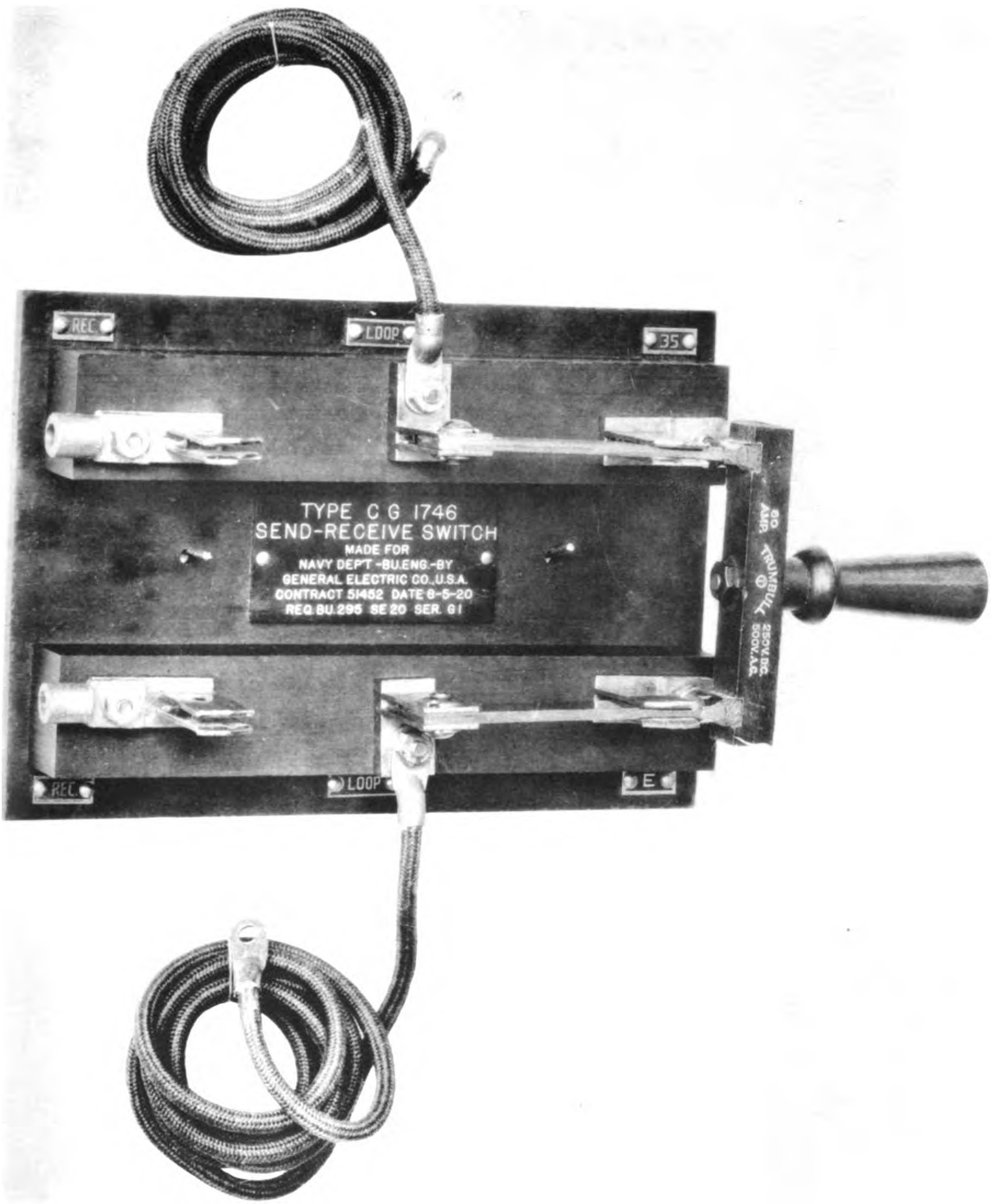

REC
LOOP
35
TYPE C G 1746
SEND-RECEIVE SWITCH
MADE FOR
NAVY DEPT -BU.ENG.-BY
GENERAL ELECTRIC CO.,U.S.A.
CONTRACT 51452 DATE 6-5-20
REQ.BU.295 SE 20 SER. 61
60 AMP.
TRUMBULL
250V.DC.
500V.AC.
REC
LOOP
E

Fig. 24

Fig. 25

occur as a result of this condition has been previously stated under paragraph (3).

Don't make any adjustments inside of the transmitter cabinet unless signal power switch is on "Off" position. The high voltage circuits within the cabinet are capable of electrocuting a person who comes in contact with them. This refers principally to the 1000 volt direct current circuits while the radio frequency circuits will produce bad burns which in certain cases leave a permanent scar.

Don't forget to put signal switch on "Off" position when through transmitting. As the 6 volt battery is connected to transmitter when signal switch is on "CW", "Tel" and "Buz" positions it is necessary that this switch be placed on the "Off" position thereby saving battery from being discharged through microphone transmitter circuit.

POSSIBLE TROUBLES

Should the transmitter fail to produce oscillations the following troubles may be responsible for this condition:

(1) Plate circuit open. Inspect switches which open and close supply circuit, also inspect tube sockets for loose or dirty spring contacts.

(2) Grid circuit open. Look over "Break-In" system and make sure that contactors which shunt grid condenser are making perfect contact. Trace out circuit for opens in choke coils and resistance.

(3) Improper grid condenser, plate and antenna coil adjustments. Reduce the low power and readjust taps.

(4) Inoperative tubes. Tubes burned out or vacuum in tubes bad, use new tubes or switch tubes from oscillating to modulating circuit or vice versa.

(5) Filament current low. Increase voltage supply to tubes, either use rheostat or increase motor speed.

(6) Open antenna circuit. See that all switches including antenna break relay are making good contact, examine radiation meter for burned out thermo-element.

(7) Grounded antenna. Wet or dirty antenna trunk insulators or antenna strain insulators will cause this condition.

(8) Generator trouble. Fuses blown or field coils open thereby not generating required current. Poor speed regulation due to defective resistance in speed regulator equipment.

Should the modulator tubes fail to modulate the radio frequency current generated by the oscillator tubes, the following faults and remedies are suggested:

(1) Modulator plate circuit open. Trace circuit, note whether fuses are blown or presence of loose connections.

(2) Defective microphone transformer, buzzer or microphone transmitter. Shake microphone to break up packed carbon granules, also adjust screw on buzzer in order to re-set vibrating contacts. Test out microphone transformer primary and secondary winding with voltmeter and battery to note whether circuits are open.

(3) Poor biasing batteries. Open battery box and test each dry battery with voltmeter to determine which battery is defective. All batteries should show at least 20 volts and if below 18 volts batteries should be replaced. New batteries should register 22 1/2 volts.

(4) Poor modulator or amplifier tubes. A poor modulator or amplifier tube will show a blue glow or the plates may look brighter than plates of other tubes. Replace such tubes.

(5) Condenser shorted or reactance open in modulator amplifier circuit. Test condenser with voltmeter and battery for short circuit, test reactance for open circuits.

(6) Storage battery discharged. Use freshly charged battery.

CONCLUSION

In concluding it is advisable to emphasize the importance of operating the equipment with due regard to the vacuum tubes, which constitute the main part of the set. These tubes are expensive, and in order to keep down the operating cost to a minimum great care should be exercised in working these tubes. Do not for the sake of a slight increase in antenna current use more than 10 volts on the filament for reasons previously stated with reference to decreased filament life.

Wherever possible low or medium power should be used. Do not resort to high power unless in case of extreme emergency. Medium power on continuous wave method of transmission will easily cover the required distance of transmission and only in the case of heavy interference or emergency should high power be used. When using telephone or buzzer method of transmission the modulator tubes should be inspected to see that each tube takes practically the same current and if it should be found that one tube takes more current than the others this tube should be replaced with a new tube and rejected tube should be retained and used for replacement of the oscillator tubes as such tubes can be used to advantage in the oscillator circuit where the individual tubes carry their share of the load and do not try to carry the entire load as is the case with certain tubes in the modulator circuit.