TYPE TBS

CONTROL UNIT

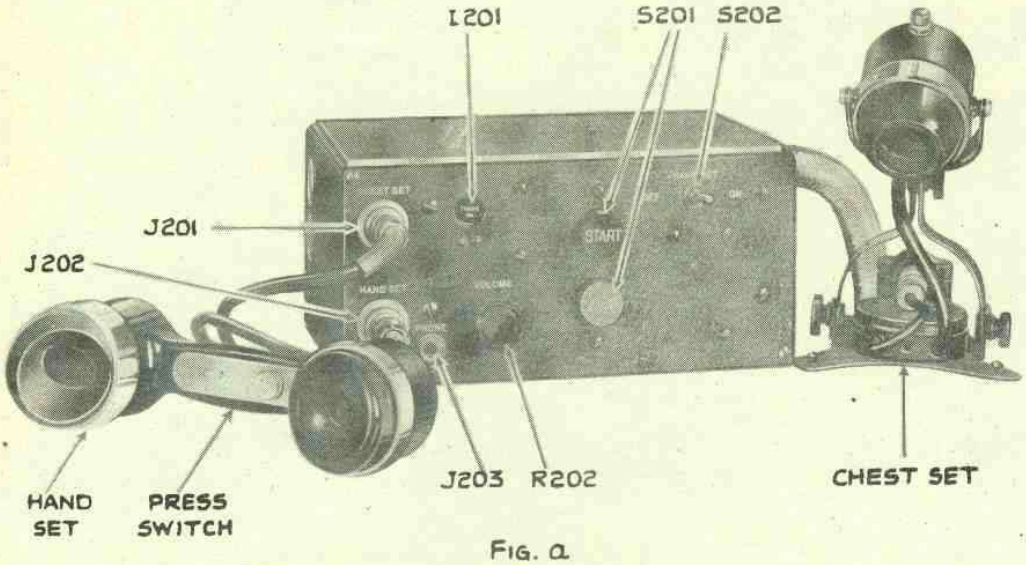


FIG. a

TRANSMITTER & RECEIVER

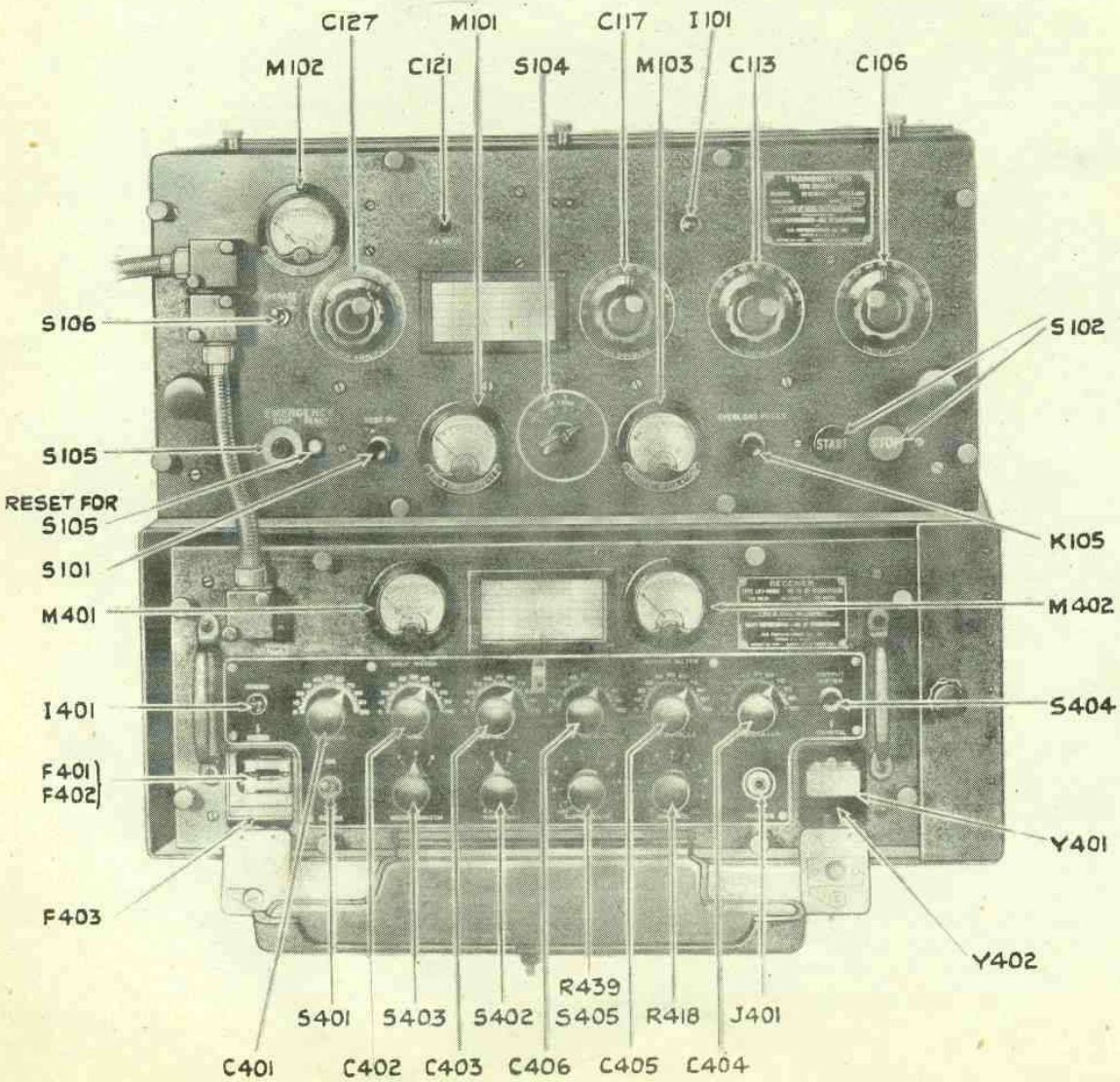


FIG. b

TYPE TBS

Type TBS is an American produced transmitting and receiving equipment designed for inter-ship R/T and W/T and may be found in Corvettes and above.

The following table gives brief details of the set and its capabilities.

Frequency Range		60 - 80 mc/s. (both transmitter and receiver are crystal controlled).
Power Output (Maximum)		50 watts.
Approximate range in miles		10
Power Supply. Transmitter	-	220 volts A.C. for filaments and 300 volts and 875 volts D.C. for H.T. supply, obtained from a dual purpose generator driven from ships D.C. mains. The generator requires 100/125 volts input at 10 amps, and in 220 volt ships is fed through a 9.5 ohm dropping resistance.
Receiver	-	115 volts A.C. (110 watts), obtained via a step down transformer from any standard A.C. outfit.
Type of Emission		R/T or M.C.W.
Type of Aerial		Half wave vertical dipole aerial designed for mounting on the mast and fed by a 70 ohm concentric type transmission line. The first few sets fitted may have a quarter wave vertical aerial with horizontal counter-poise rods.

Photographs of the equipment are given in Figs. A and B and simplified circuit diagrams are given in Figs. C,D,E,F,G and H.

When reading para. 3, which deals with controls and fittings, the item numbers quoted should be identified in Figs. A and B.

2. Construction.

The transmitter is mounted on a horizontal type chassis contained in a small crackle finish case. This case is designed for mounting on the top of the stand in which the associated receiver is mounted. The meters, dials and switches which are required for the operation of the transmitter are mounted on the front panel. A gate interlock switch is fitted and operates when the lid of the transmitter is opened and also when the transmitter panel is pulled outwards.

The receiver is fitted in a shock mounted case designed to fit inside the stand on which the transmitter is secured. All the tuning and operating controls are grouped on an engraved plate secured to the front panel and are protected when not in use by a large hinged cover. At each end of this control plate is a small hinged door for access to the crystal and fuses. Input and output meters and a calibration chart are provided on the front panel above the control plate. A small compartment is provided at the side of the receiver case to contain the set Handbook.

Two control units are provided to permit operation of the equipment from any desired remote position. Up to four additional remote positions having facilities for transmission and reception only, may also be provided.

A stowage sack for one set of transmitter and receiver crystals is provided inside the transmitter case.

3. Transmitter - CONTROLS AND FITTINGS.

Name and Item No.	Use.
OSCILLATOR TUNING (C106)	Anode tuning for Crystal Oscillator Stage. This stage is tuned to the crystal fundamental frequency.
1st DOUBLER TUNING (C113)	Anode Tuning for 1st Doubler Stage. This stage is tuned to twice the crystal frequency.
2nd DOUBLER (C117)	Anode Tuning for 2nd Doubler Stage. This stage is tuned to four times the crystal frequency.
P.A. NEUTRALISING (C121)	A preset control provided for adjusting the neutralising condenser in the P.A. Stage. This control is set during manufacture and should not normally be touched.
POWER AMPLIFIER TUNING (C127)	Anode Tuning for the R/F Power Amplifier (output) Stage.
"TRANS.ON" PILOT LAMP (I101)	Indicates when the transmitter is switched on. The pilot lamps in the control units are connected in parallel with this lamp.
OVERLOAD RE-SET (K105)	Used to re-set the overload relay (K105) which serves to protect the power amplifier valve (V104) in the event of an accidental overload. When the overload relay opens, the motor generator stops and cannot be restarted until the overload re-set push has been pressed.
R/F LINE CURRENT METER (M102)	Indicates output to feeder line and aerial.
PER CENT MODULATION METER (M103)	Indicates the approximate percentage modulation of the carrier wave. (See Admiralty Handbook of W/T Vol. II (1938), para. N14).
PL AND GRID CURRENT METER (M101)	Used as a Tuning Indicator. The meter measures the Plate (Anode) or Grid Current in the different circuits as determined by the position of the meter switch (S104).

TEST SWITCH (S101).	A push-button switch which is used to operate relays inside the transmitter to enable the set to be tuned and tested. When the switch is pressed, relays K104 and K103 are energised in turn and a carrier wave is radiated, provided the circuits are tuned.
START/STOP SWITCHES (S102)	The Start push button when pressed closes the circuit of the starting contactor in the automatic starter, thus starting the motor generator. The Stop push button when pressed short circuits the coil of the starting contactor and so switches off the generator.
METER SWITCH (S104)	Connects the PL and Grid Current meter (M101) in different circuits for tuning purposes.
EMERGENCY SWITCH (S105)	A switch provided to enable the generator to be switched off at the transmitter in emergency. The switch opens the circuit of the starting contactor in the automatic starter. The door interlock switch (S103) and the contacts of the P.A. overload relay (K105) are all connected in series with the Emergency Switch and the coil of the starting contactor.
TUNE-OPERATE SWITCH (S106)	A toggle switch which, in the 'Tune' position, introduces a resistance in the cathode circuit of all R/F valves in order to prevent excessive anode current whilst the circuits are untuned.

4. Transmitter - TUNING.

To tune the transmitter to any frequency within its range, the following procedure should be observed:-

(a) Open the transmitter access door and insert the appropriate crystal for the desired operating frequency in the crystal mounting socket which is located at the rear of the right-hand(oscillator) compartment and slide clamp over holder. Transmitter crystal holders are coloured red and are marked with both the crystal fundamental and operating frequencies, the latter being four times the fundamental frequency. The crystal holder should be installed with the nameplate towards the front of the transmitter. When held in this position, the mounting plug which is towards the left-hand side of the crystal holder may be inserted into either of the two mounting sockets.

(b) Close and secure the transmitter access door and press the START push-button (S102). This operation will start the motor generator and will apply filament power to the valves. Allow the valve heaters to operate for one minute before applying H.T. (Step e).

(c) Set the four tuning dials (C106) (C113) (C117) (C127) to zero.

(d) Throw the TUNE-OPERATE toggle switch (S106) to the TUNE position.

(e) Press the TEST switch (S101). This causes the low-voltage plate-power switching relay (K104) to operate. Operation of relay K104 will connect the 300 volt winding of the motor-generator to the low-power valves and will cause the antenna-transfer relay (K103) to operate, thus connecting the 875 volt winding of the motor generator to the transmitter.

(f) Turn the meter switch (S104) to the "OSC." position and then rotate the OSCILLATOR tuning control (C106) very slowly in a clockwise direction until the plate current suddenly drops to a minimum value as indicated on the PL. & GRID CURRENT meter (M101).

(g) Turn the meter switch to the 1 DOUB. position and then rotate the 1st DOUBLER tuning control (C113) in a clockwise direction until minimum plate current is indicated on the PL. & GRID CURRENT meter (M101). The plate current dip for this stage may be small.

(h) Turn the meter switch to the 2 DOUBLER position and then rotate the 2ND DOUBLER tuning control (C117) in a clockwise direction until minimum plate current is indicated on the PL. & GRID CURRENT meter (M101).

(i) Turn the meter switch to the Ip.PA position (omitting the Ig.PA position) and then rotate the POWER AMPLIFIER tuning control (C127) in a clockwise direction to the point where minimum power amplifier plate current is indicated on the meter (M101).

(j) Throw the Tune-OPERATE switch (S106) to the OPERATE position. The PA plate current should now be between the limits of 115 and 120 mA. to ensure subsequent full power output. If the current is not within these limits, the location of the tap on the PA anode-tuning coil (L104) must be changed. To make this adjustment, open the transmitter access door and loosen the butterfly nut which holds the tap in position. The position of the tap should then be changed by moving it in a counterclockwise direction around the coil if the plate current was too high, or clockwise if it was too low. Having adjusted the position of the tap, the nut should be tightened, the access door closed and secured, the START push-button pressed, the PA stage retuned and the plate current noted. If the plate current is still outside the indicated limits, the tap should be moved around the coil until the desired conditions are obtained. (See also Note 1).

(k) Rotate the meter switch to the Ig.PA position. After allowing the transmitter to operate for about four minutes, readjust the setting of the first and second doubler tuning controls (C113,C117) to the point that provides the maximum amount of power amplifier grid current, as indicated on the meter (M101), and lock the controls.

(l) Detune the crystal oscillator on the high-frequency side of resonance (tuning dial rotated clockwise) until the PA grid current is 35 ma. and lock the control.

(m) Rotate the meter switch to the Ip.PA position and readjust the Power Amplifier tuning to secure the minimum value of plate current. If necessary, readjust the tap on the PA anode to obtain a P.A. plate current of 115 ma. Lock the tuning control on completion

NOTE (i). Under certain conditions, when the Tune-Operate Switch (S106) is put to "operate", or when the morse key is operated, the crystal may cease to oscillate. This will be indicated by the P.A. Plate current failing to rise. If this happens, the crystal oscillator should be detuned slightly on the high frequency side of resonance (tuning dial rotated clockwise) until the crystal oscillator is stable.

NOTE (ii). When locking tuning controls, special care should be observed to avoid disturbing the settings.

NOTE (iii) A tuning chart is provided near the centre of the front panel of the transmitter. The setting of each tuning control for each frequency to which the transmitter has been tuned should be recorded on this chart. Reference should be made to the chart when the operating frequency is changed but the final adjustment should always be made by following the instructions given above.

AVERAGE CALIBRATION DATA

Frequency (Mc/s)	Control Setting			
	Oscillator	1st Doubler	2nd Doubler	Power Amplifier
60.0	8	8	8	8
65.7	33	40	35	37
73.5	58	68	63	68
80.0	72	89	82	86

5. Receiver - CONTROLS AND FITTINGS.

Name & Item No.	Use.
ANTENNA KNOB (C401)	Grid Tuning for R/F amplifier.
LINK KNOB (C402)	Anode Tuning for R/F amplifier.
DETECTOR KNOB (C403)	Grid tuning for frequency changer stage.
OSCILLATOR KNOB (C404)	Anode tuning for crystal oscillator stage.
1ST DOUBLER KNOB (C405)	Anode tuning for oscillator 1st doubler stage.
2ND DOUBLER KNOB (C406)	Anode tuning for oscillator 2nd doubler stage.
FUSE COMPARTMENT (F403)	Contains two 3 amp cartridge type fuses, one in each power input lead
POWER INDICATOR (I401)	A lamp for indicating whether or not power is applied to the receiver
PHONES JACK (J401)	Output jack for 600 ohm headphones.
INPUT METER (M401)	Indicates cathode current of the R/F amplifier, first detector and oscillator stages, as selected by the meter switch (S403). It registers full scale deflection at 3 ma and is calibrated in decibels with the zero deflection at +120db. When connected in the R/F amplifier stage (position 1) the meter indicates the signal input to the receiver in db. above 5 microvolts within a tolerance of ±20db. due to variations in valve characteristics. (See Admiralty Handbook of W/T (1938) Vol. II, Appendix A).
OUTPUT METER (M402)	When the switch (S404) is made, the meter indicates the output level of the receiver. It is calibrated in dbs. with zero reference corresponding to an output of 2 watts across the loudspeaker.
VOLUME CONTROL KNOB (R418)	Potentiometer for controlling volume level by variations in input to first A/F amplifier stage.
NOISE SUPPRESSOR KNOB (R439) (S405)	A potentiometer which, in conjunction with switch (S405), is used to make adjustments for noise suppression, in order to give a quiet background to the receiver when no signal is being received. Switch (S405) is combined with the potentiometer. A slight clockwise rotation closes the switch to apply noise suppression and further rotation in the same direction increases the grid bias in the first and second I/F amplifier stages. The setting of this control, therefore, determines the input signal necessary to cause the noise suppression circuit to function. ALWAYS USE THE LOWEST SETTING POSSIBLE ON THIS CONTROL, OTHERWISE WEAK SIGNALS MAY NOT BE HEARD.

TYPE TBS

POWER SWITCH (S401)	The receiver ON/OFF switch
A.V.C. TIME CONSTANT KNOB (S402)	A selector switch which is used to change the time constant of the A.V.C. circuit to assist in overcoming fading. When rotated clockwise additional condensers are connected across the A.V.C. voltage line.
METER SWITCH KNOB (S403)	A selector switch for transferring the input meter (M401) from circuit to circuit for tuning purposes. The three switch positions in numerical order permit measurements of cathode current in the R/F amplifier first detector and oscillator stages respectively.
OUTPUT METER SWITCH (S404)	A test switch for connecting the output meter (M402) across the receiver output

6. Receiver - TUNING.

To tune the receiver to any operating frequency proceed as follows :-

(a) Insert a crystal of the correct frequency for the signal that it is desired to receive. The holder must be inserted with the plate upwards. The crystal holders, which are coloured blue for receiver crystals, are marked with both the crystal frequency and the operating frequency. The correct crystal frequency (Fc) is one-fourth of the difference between the signal frequency (Fs) and 5.3 mc.

$$Fc\ (mc) = \frac{Fs\ (mc) - 5.3}{4}$$

(b) Throw the POWER switch (S401) to the ON position and allow about 30 seconds for the valve heaters to reach their operating temperature.

(c) Rotate the Input METER SWITCH (S403) to position 3 and adjust the various tuning controls to the settings listed on the tuning chart if known. Set the VOLUME CONTROL (R418) at approximately mid-position. Make sure that the NOISE SUPPRESSOR control (S405) is at the OFF position (fully anticlockwise).

(d) Adjust the OSCILLATOR control (C404) to a setting slightly on the high-frequency (high numbered) side of resonance to ensure stable operation and positive starting of the crystal. Resonance of this circuit will be indicated by a sudden dip (followed by a sudden rise) in the deflection of the Input Meter (M401) as the control is rotated.

(e) Adjust the 1st Doubler (C405), 2nd Doubler (C406), Detector (C403) Link (C402) and Antenna (C401) tuning controls to approximately the same setting as obtained for the oscillator tuning control.

(f) Shift the input METER SWITCH (S403) to position 2 and adjust the 1ST DOUBLER (C405) and 2ND DOUBLER (C406) tuning controls to give maximum reading on the Input Meter (M401). It may be desirable to detune the DETECTOR control (C403) about 25° on the low-frequency (anti-clockwise) side of resonance to obtain a larger deflection while adjusting the doubler stages, readjusting the DETECTOR control as necessary if the deflection is too large.

(g) Shift the input METER SWITCH (S403) to position 1. If a signal is being received, adjust the ANTENNA (C401), LINK (C402) and DETECTOR (C403) controls to resonance as indicated by a maximum reading on the scale of the INPUT METER (M401). If no signal is being received, the point of resonance will be indicated by maximum noise in the output of the receiver. (This may either be noted on the output meter (M402) or by listening in a pair of headphones plugged into the PHONES jack (J401). The adjustments are critical.

(h) Adjust the VOLUME CONTROL (R418) to obtain the desired output.

(i) With no signal being received, set the NOISE SUPPRESSOR control (R439, S405) just far enough clockwise to remove all the output from the receiver. It is necessary to check this point and determine whether or not the weakest signal to be received will actuate the noise suppressor; if not, the NOISE SUPPRESSOR control must be turned to OFF since the circuit will not discriminate between the signal and the noise. The noise suppressor is very valuable for use in removing the background noise from the receiver when no signal is being received.

Note (i). A tuning chart is provided on the front panel near the centre of the receiver unit. The setting of each tuning control for each frequency to which the receiver has been tuned should be recorded on this chart. Reference should be made to the chart when the operating frequency is changed but the final adjustment should always be made in accordance with the foregoing tuning procedure.

AVERAGE CALIBRATION DATA.

Frequency (Mc/s)	Control Setting					
	Ant.	Link	Det	2nd Dblr.	1st Dblr.	Oscillator
60	15	15	15	15	15	15
80	88	81	80	80	88	80

7. Control Units and Loudspeaker.

Controls and Fittings.	Use.
START-STOP SWITCH (S201)	This switch is connected in parallel with the START-STOP switch (S102) on the transmitter (see para. 3). Operation of the switch will start or stop the transmitter.
"TRANS.ON" PILOT LAMP (I201)	Indicates when the transmitter is switched on. The lamp is connected in parallel with a similar lamp (I101) mounted on the transmitter panel.
HAND SET SWITCH (S202)	In the OFF position this switch disconnects the hand set receiver unit.
VOLUME CONTROL POTENTIOMETER (R202)	Provides local control of the volume of the received signal delivered to the hand or chest set.
PLUG SOCKET FOR HAND SET (J201)	Plug in position for hand set.
PLUG SOCKET FOR CHEST SET (J202)	Plug in position for chest set.
PHONE JACK (J203)	Plug in position for 600 ohm headphones.
HAND SET.	Each control unit is provided with a hand set similar to a conventional telephone hand set and fitted with a Pressel (Press-to-talk) microphone switch.
CHEST SET.	A chest set consisting of a microphone unit and a Pressel Switch may be used in lieu of the handset. A jack is mounted on the breastplate for plugging in a 600 ohm telephone head set.
LOUDSPEAKER UNIT.	One loudspeaker is connected to a selected control unit. A relay (K201) functions locally to transfer the receiver output from the loudspeaker to a load resistance (R204) when the hand set or chest set push-buttons are pressed, thus preventing acoustic feedback between loudspeaker and the microphone during R/T transmission. The load resistance (R204) is fitted only in the control unit to which the loudspeaker is connected.
LOUDSPEAKER VOLUME CONTROL.	A volume control (R501) fitted on the loudspeaker for independent adjustment of the sound level.

8. Transmitter - OPERATION.

(a) Switching On. The motor generator may be started simply by pressing one of the START buttons, either on the transmitter panel or on one of the control units. On pressing this button the generator starts, and filament power is applied simultaneously to all of the transmitter valves but no anode voltage is impressed. Thus, the transmitter is placed in the standby condition ready for immediate use with voice or tone modulation as desired and should be kept in that condition during normal operation of the equipment. On first starting the equipment, however, a delay of approximately one minute should be allowed before attempting operation so that the valves may reach the proper operating temperature. An indicator lamp on the transmitter panel and an illuminated window marked "TRANS.ON" in each control unit denote whether or not the motor generator is running.

(b) Telephone Communication. The transmitter may be modulated by voice from either control unit, using the associated hand set or the chest set. If the hand set is used, put the HAND SET switch (S202) to ON; if the chest set is employed, put the HAND SET switch to OFF. Both of these accessories may be plugged into the respective receptacles of either control unit together but no attempt should be made to use both at the same time. Each set incorporates a Pressel switch, operation of which actuates a series of relays to disconnect transmitter valves. The button for this switch is located in the handle of the hand set and on the breast plate of the chest set.

Depress the Pressel switch just before starting to talk and keep it down whilst talking. During transmission, the receiver operates as a monitor and the modulation will be heard at all points of audio output except the loudspeaker. Monitoring is possible therefore, with either hand set or by means of headphones plugged into the chest set or into the PHONE jack on any control unit, or on the receiver panel. The Pressel switch must be released before any answering signal will be heard through the receiver.

(c) Telegraph Communication. The transmitter may be tone modulated and keyed for M.C.W. operating using a morse key connected to either control unit or to the transmitter. On pressing the key, a series of relays are operated to transfer the aerial from the receiver to the transmitter, apply anode voltage to the transmitter valves, and apply a modulation tone of 1000 cycles to the audio input stage of the transmitter. The carrier remains on after the key is first closed and the key thereafter controls only the tone modulation. Should the key remain up for more than approximately one second, however, the carrier will be cut off automatically and the equipment returned to the condition of reception. During transmission, the receiver serves as a monitor and side tone till be heard at all points of audio output; that is, from the loudspeaker, from any hand set, or from headphones connected to chest sets, control units or receiver panel.

POWER SUPPLIES

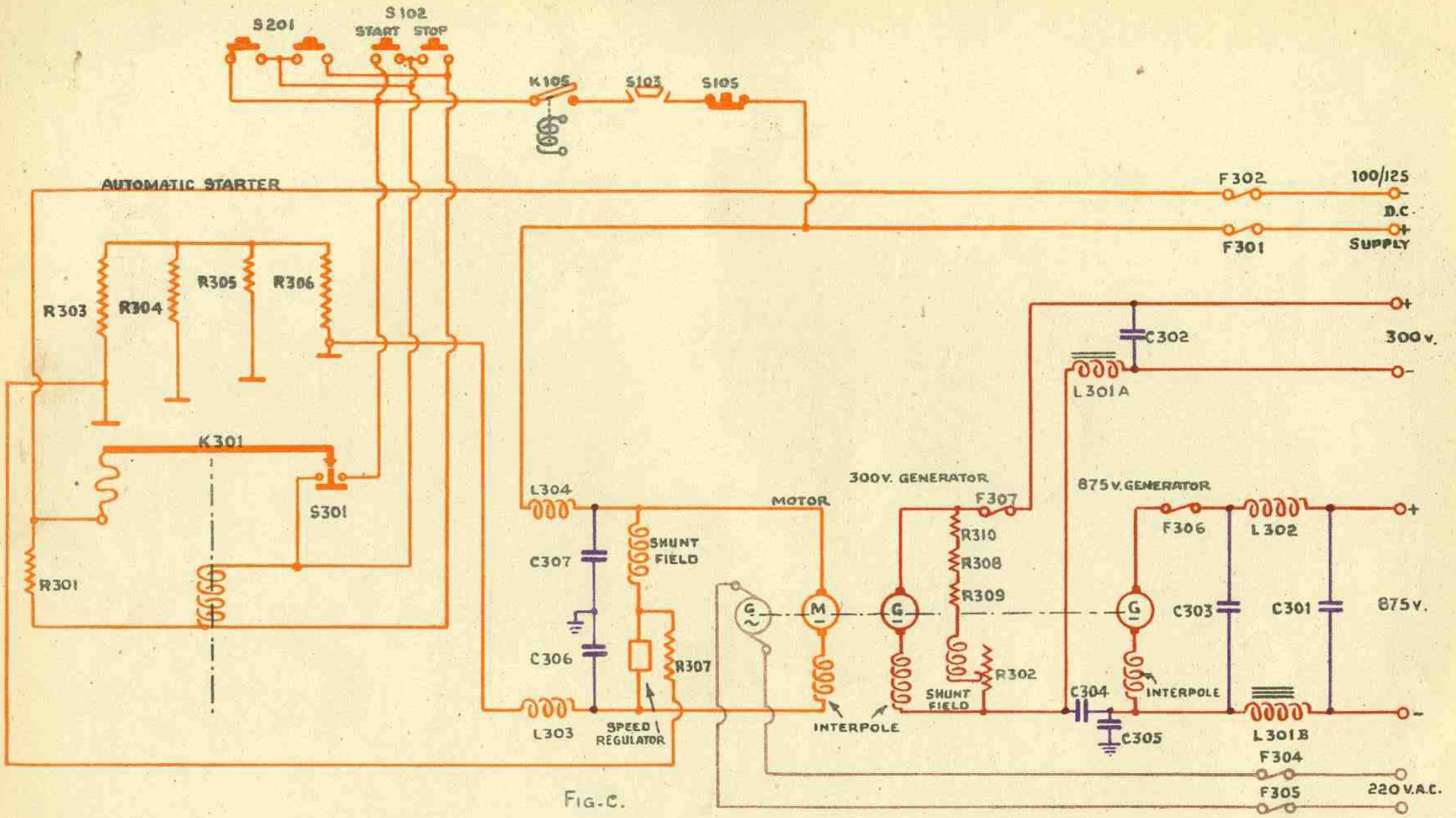


FIG. C.

(d) Switching Off. The motor generator may be stopped by pressing the STOP button on the transmitter panel or the corresponding button on either control unit. An EMERGENCY STOP switch is provided on the transmitter panel to remove voltage from the starting contactor should the transmitter fail to function at any time. If the generator is stopped by means of the EMERGENCY STOP Switch it will be necessary to press the adjacent RESET button before the motor generator can be re-started.

Provision is made in the transmitter to stop the motor generator automatically under overload conditions. Such provision is in the form of an Overload Relay (K105) connected in the Cathode circuit of the power amplifier stage and designed to operate when the Cathode current of that stage reaches approximately 160 ma. Should this relay operate first locate and correct the trouble and then press the OVERLOAD RESET button on the transmitter panel to reset the relay. The motor generator may then be restarted in the normal manner.

If for any reason it is necessary to press the STOP or START button on the transmitter or on either control unit during operation of the equipment, it should be done before or after receiving a message. This is necessary since the relay sequence in the transmitter renders the receiver inoperative for about five seconds after pressing either of those buttons.

9. Receiver - OPERATION.

Since the receiver is crystal controlled for single frequency reception, no subsequent tuning adjustments are required in operation except an occasional check and touch-up. The sound level may be adjusted by the VOLUME CONTROL knob on the front panel but it is recommended that this control be left at a setting near maximum and operational adjustments made with the VOLUME controls on the associated control units. Thus, to place the receiver in operation, it is necessary only to throw the POWER switch to the ON position and adjust the level of noise suppression as required for existing conditions of reception.

The aerial is connected to the receiver except during sending periods when it is automatically transferred to the transmitter and the receiver then operates as a monitor. Radio and monitoring signals may thus be heard in the receiver output, using headphones plugged into the PHONES jack on the panel or using one of the telephone accessories attached to the control units.

BRIEF TECHNICAL DESCRIPTION.

Transmitter.

10. The transmitter employs four R/F stages (Crystal, Oscillator, 1st Doubler, 2nd Doubler and Power Amplifier) and a modulator consisting of three push-pull A/F stages. The frequency range of the transmitter is 60 - 80 mc/s and since two Doubler Stages are used, the crystal oscillator works between 15 - 20 mc/s.

Plate modulation is employed and automatic modulation control is provided on R/T. A 1000 cycles oscillator is used for M.C.W. transmission.

The transmitter output is fed into a 70 ohm co-axial transmitter line which, in turn, feeds a half-wave vertical dipole.

Simplified circuit diagrams are shown in Figs. C, D, E and F.

11. Power Supplies (See Fig. C).

(a) Motor Generator. Power supplies are obtained from a motor generator having three separate output windings which give the following output voltages :-

220 volt 50 cycles A.C.
300 volt D.C.
875 volt D.C.

The 220 volt A.C. winding is on the D.C. motor and the output is used to supply power to the transmitter filaments via Transformer (T104). The motor generator shunt field is common to both the 300 volt and 875 volt windings and is energised from the 300 volt winding. The rheostat (R302) is in series with the field and may be adjusted to provide the correct D.C. output. This rheostat is located in the centre of the Generator Terminal Box. Choke coil (L302) and condensers (C303, C304, C305) filter out any radio-frequency voltage present in the generator which might otherwise be radiated by the leads to the generator and picked up by the receiver and Choke coils and condensers (L303, L304, C306, C307) prevent any R/F voltage in the motor from being radiated or sent back into the D.C. line.

TRANSMITTER R/F STAGES

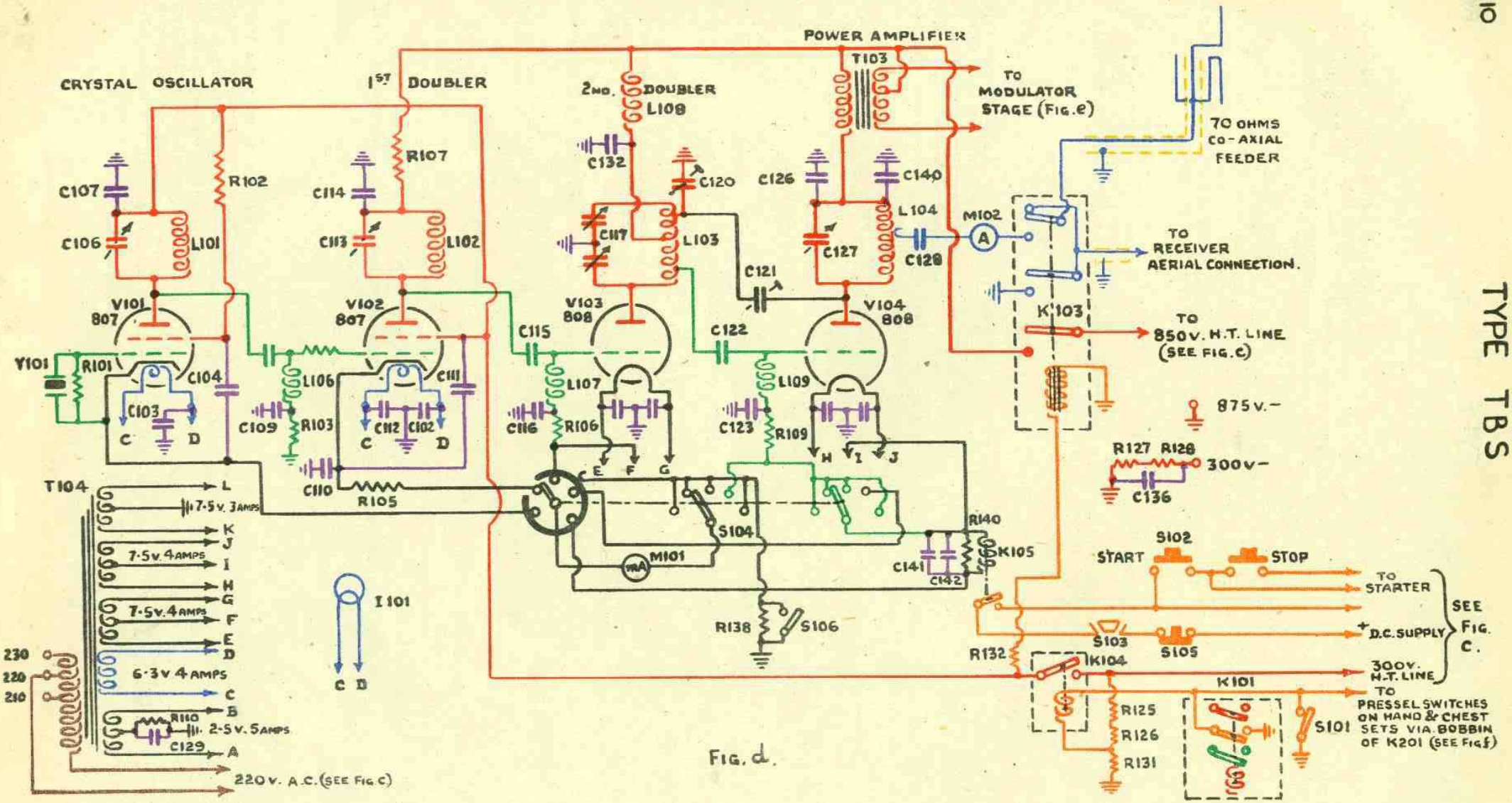


FIG. d.

TYPE TBS

Two ripple filters are located in the automatic starter and consist of the choke coil (L301A) and condenser (C302) connected across the 300 volt output and choke coil (L301B) with condenser (C301) connected across the 875 volt output. A 0.5 amp fuse (F307) is connected in the positive output lead from the 300 volt winding and a similar fuse (F306) is connected in the 875 volt winding. These fuses are located in the terminal box mounted against the generator end of the machine. A centrifugally operated motor speed regulator is fitted to the motor end of the generator and a small range of adjustment may be made by means of the dial on the end of the machine.

(b) Automatic Starter. The generator is started by means of an automatic starter controlled by the "Stop-Start" switches on either the transmitter panel or control units. When the "Start" button is pressed, the hold on contact (S301) is short-circuited and the bobbin of the starting contactor (K301) is momentarily connected to the ship's D.C. supply.

The contactor arm travels upwards and closes the hold-on contact (S301) thus keeping voltage on the contactor coil. The arm continues to move slowly upwards operating against springs and connects the motor to the D.C. supply line through three steps of resistance.

The motor generator is normally stopped by means of the "Stop" buttons which are situated alongside the "Start" buttons. When a "Stop" button is pressed the contactor bobbin is short-circuited and the contactor arm returns to rest and breaks the supply to the motor.

The overload relay (K105) Gate Switch (S103) and Emergency Switch (S105) are in series with the supply to the Contactor bobbin and when any switch is operated the contactor is thrown off and the motor-generator stopped.

Four 25 amp. fuses are located inside the automatic starter case. The upper two are in the D.C. input circuit and the lower two are in the 220 volt A.C. output circuit. A simplified circuit diagram of the automatic starter and motor generator is given in Fig. C.

12. R/F CIRCUITS (See Fig. D)

(a) Crystal Oscillator. The output frequency of the transmitter is controlled by a low temperature-coefficient quartz crystal (Y101) which is connected in the grid circuit of the Type 807 oscillator valve (V101). The crystal must be such as to have a fundamental frequency which is equal to one-fourth the desired output frequency.

The anode circuit (L101, C106) of the Crystal Oscillator is tuned to the fundamental frequency of the crystal and is capacitively coupled to the first doubler stage through condenser (C108).

(b) 1st Doubler. A Type 807 valve (V102) having its anode circuit (L102, C113) tuned to twice the frequency of the crystal oscillator is used in this stage. The R/F output of the first doubler stage is coupled to the second doubler through condenser (C115).

(c) 2nd Doubler. A Type 808 Valve (V103) is used in this stage. The anode circuit (L103)C117 and C120) is tuned to twice the frequency of the first doubler stage. Thus the R/F output is at a frequency which is four times the crystal frequency. The R/F output of the second doubler is coupled to the final R/F (or power amplifier) stage through condenser(C122).

P.A. Stage. The anode circuit (L104, C127) of this stage, which employs a Type 808 valve (V104) is tuned to the same frequency as the second doubler. The Cga of the valve is neutralised by the neutralising condenser (C121). A balancing condenser (C120) is provided to balance out the total input capacity of valve (V104) thereby ensuring that the neutralising and grid exciting voltages are kept equal over the entire frequency range and eliminating the need for adjustment of the neutralising condenser when the frequency is changed.

The modulated output of the power amplifier (P.A.) stage is fed to the transmission line from a tap on the anode coil (L104) through the condenser (C128), antenna current meter (M102) and one terminal of the antenna switching relay (K103).

An overload relay (K105) is connected in the filament return (centre tap) circuit of the P.A. valve (V104) and serves to protect this valve in the event of an accidental overload. The relay is adjusted to trip at a load of 160 mA. When the relay opens, the circuit to the starting contactor is broken, and consequently the motor generator stops. Having been stopped by the operation of the overload relay, the motor generator cannot be restarted until the 'Overload Reset' button has been pressed.

13. A/F CIRCUITS (See Fig. E).

(a) Input Stage. The audio frequency portion of the transmitter consists of three stages of push-pull amplification. The first of these is a speech amplifier having a variable gain. Two Type 6D6 valves are used. Audio signals are fed to the speech input transformer (T101) which has a characteristic input impedance of 600 ohms, from the speech-input terminals (12, 13) located on the rear of the transmitter. D.C. voltages for anode, screen and cathode bias on the speech-amplifier valves (V109, V110) are obtained from the voltage divider (composed of resistances R113, R114, R115 and R135) which is connected across the low-voltage anode supply (300v.)

(b) Driver Stage. The input stage is choke capacity coupled to the driver stage which employs two Type 2A3 valves. Grid bias for this stage is obtained from the resistance (R110) which is connected between the filament centre-tap and ground. (See Fig. D).

TRANSMITTER A/F CIRCUITS

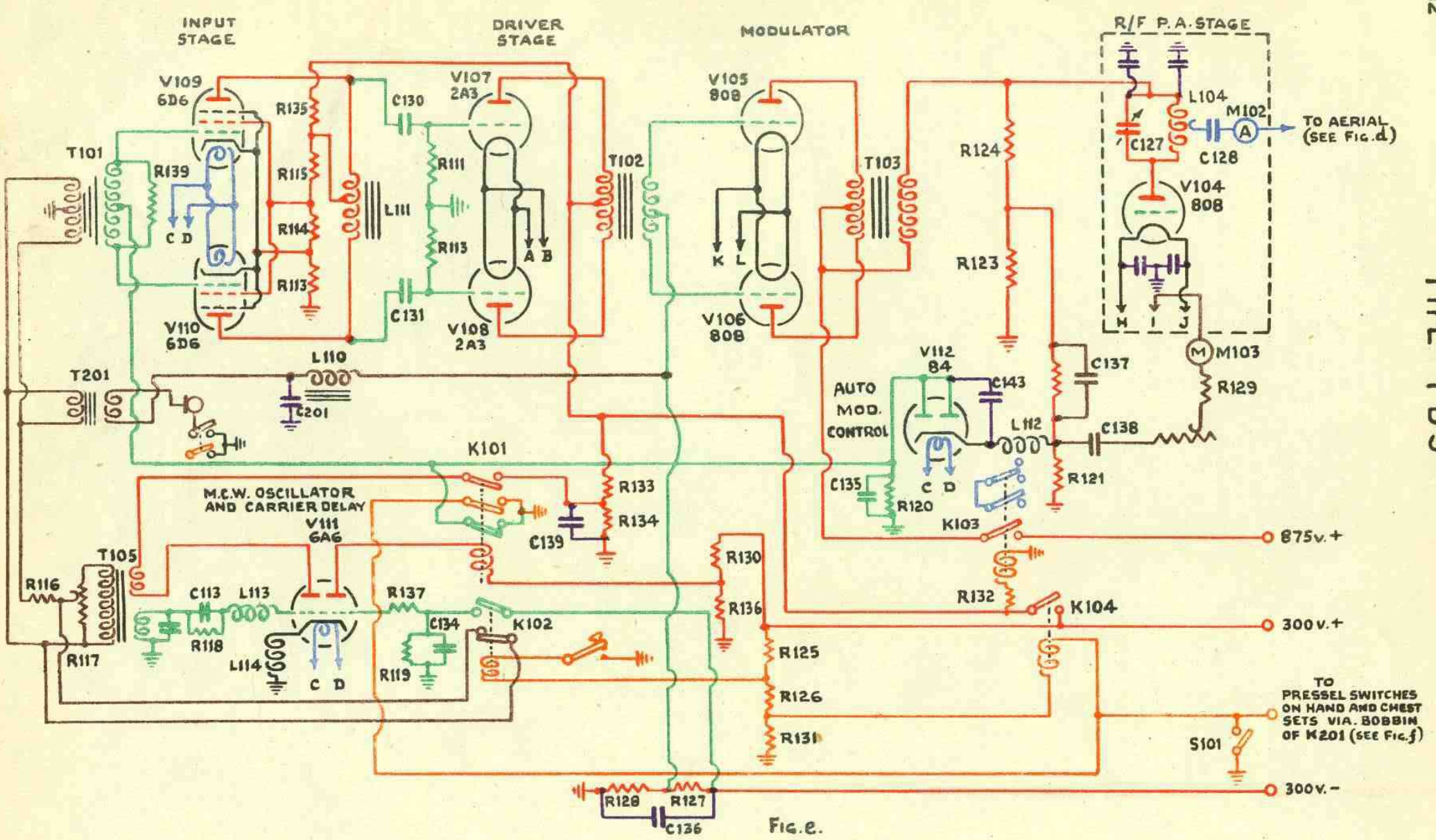


FIG.e.

To by-pass the audio-frequency component of the anode current, a condenser (C129) is connected across this resistance. Anode voltage for this stage is obtained from the low voltage anode supply (300v.)

(c) Modulator Stage. The output of the driver stage is coupled to the modulators stage through the inter-stage transformer (T102). Two Type 808 valves are used in this stage, the output of which is coupled through the modulation transformer (T103) to the anode circuit of the R/F power amplifier (V104) thus producing high level anode modulation. Anode voltage for the modulator valves is obtained from the high-voltage (875v.) generator supply. The negative voltage which is developed across resistance (R128) is used to supply bias voltage to the modulator valves and also to furnish voltage to the micro-phones which are connected to the control units.

14. AUTOMATIC MODULATION CONTROL (See Fig. E).

The voltage which is developed across the secondary winding of the modulation transformer (T103) is fed through a resistance condenser network (R121 to R124 and C137) to the cathodes of a Type 84 valve (V112) which is connected as a half-wave rectifier and which is working as a modulation limiter. The D.C. voltage resulting from rectification is developed across the resistance-condenser filter (R120, C135) and is used as D.C. bias on the speech-amplifier valves (V109, V110).

The values of the resistances (R121, R122) and the condenser (C137) are such that the D.C. bias applied to the modulation limiter valve (V112) will prevent rectification until the percentage modulation of the trans-mitter reaches 75 per cent. As a result, the amplification of the speech amplifier is linear up to this point.

Above 75 per cent modulation, rectification of the audio signal takes place in the modulation limiter valve (V112) and additional bias is applied to the speech amplifier valves (V109, V110) thus decreasing the amplification factor of these valves and providing a limiting action to the modulating voltage. An increase in input level to three times that required to produce 75 per cent modulation will produce a percentage modulation of not more than 95 per cent. Consequently wide variation in the audio input level may be tolerated without danger of over modulation.

When a high level signal appears at the input, the action of the limiter in holding down the modulation level is practically instantaneous. When the signal ceases, however the gain of the audio system increases relatively slowly (90 per cent recovery in about 3 seconds) because of the slow discharge rate of the resistance-condenser filter (R120, C135). Slow recovery action prevents the gain from varying appreciably between syllables of words, which would produce distortion.

The 'Per Cent modulation' meter (M103) indicates the approximate percentage modulation. Condenser (C138) blocks D.C. from the meter and the resistances (R108, R129) form the required multiplier. Resistance (R108) is adjusted at the factory to provide correct indication on the meter when the modulating frequency is 1000 cycles per second.

15. M.C.W. OSCILLATOR (See Fig. E).

The 1000 cycle note for M.C.W. is generated by one triode section of the Type 6A6 twin triode valve in combination with the A/F transformer (T105). To ensure oscillation at the desired 1000 cycles, a small condenser is connected across the grid winding of this transformer and sealed inside the transformer can. To control the modulation level of the transmitter when it is tone modulated, a potentiometer (R117) is connected across the secondary winding of transformer (T105). This potentiometer is mounted on the large bracket which is located on the under side of the transmitter chassis and it is adjusted at the factory to provide 95 per cent modulation under normal load conditions. The 1000 cycle note is fed to the A/F input transformer (T101) through the resistance (R116).

The other triode section of the Type 6A6 twin triode valve(V111) is used in combination with the resistance condenser network (R119, C134) to provide the carrier delay current when using M.C.W.

When the morse key at either control unit is pressed, the keying relay (K102) is actuated and a negative bias obtained from resistances(R127 and R128) is applied to the grid of the carrier delay section of the Type 6A6 twin triode valve (V111) and to the resistance condenser network (R119, C134) thus reducing the anode current of this valve to zero. As the anode current is reduced, the bobbin of the R/T M.C.W. switching relay (K101) will be de-energised and the contacts which were held open will close thereby

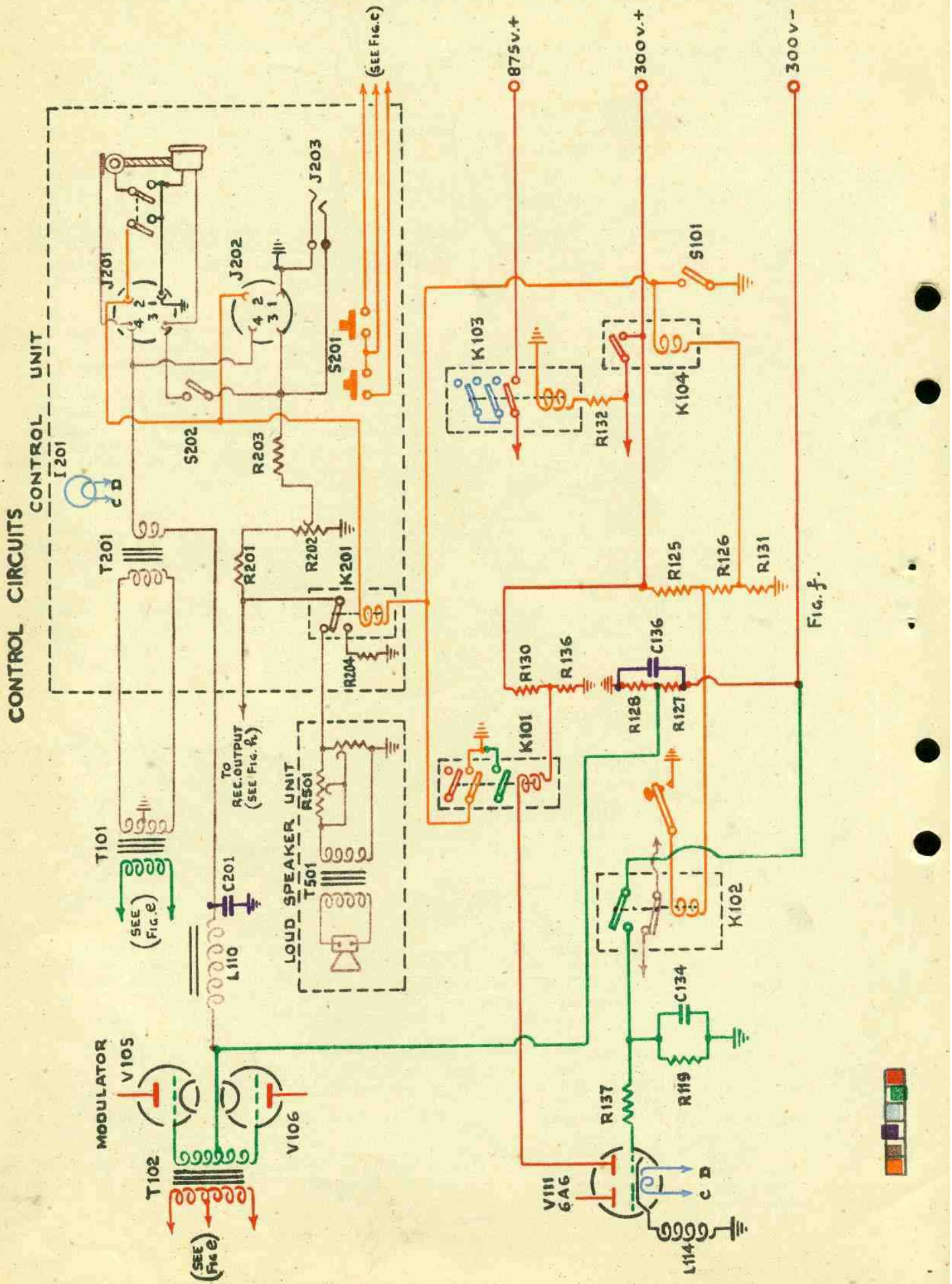
(i) connecting anode voltage to the M.C.W. oscillator section of the twin triode valve (V111)

(ii) causing the transmit-receive relay (K104) to operate to the transmit position.

(iii) short circuiting the resistance condenser combination (R120, C135), thus removing the modulation limiting action of (V112).

Consequently, a tone modulated R/F signal is emitted as long as the key is pressed. When the key is released, the keying relay (K102) opens, the secondary of transformer (T105) is short-circuited and the tone modulation ceases. The carrier and the M.C.W. oscillator however, remains on for approximately one second, or until the condenser (C134) has discharged through the resistance (R119) and allowed the R/T M.C.W. switching relay (K101) to close thus opening its contacts and thereby de-energising the transmit-receive relay (K104) and shutting off the carrier.

TYPE TBS


CONTROL CIRCUITS
CONTROL UNIT
J201
J202
J203
S201
S202
R203
R201
R202
K201
R204
T201
T101
C201
L110
(SEE Fig.e)
TO REC. OUTPUT (SEE Fig. R)
LOUD SPEAKER UNIT
R501
T501
(SEE Fig.c)
875v.+
300v.+
300v.-
S101
K103
K104
R132
R125
R126
R131
R130
R136
C136
R128
R127
K101
K102
C134
R119
R137
V111 6A6
L114
MODULATOR
V105
V106
T102
(SEE Fig.e)
Fig. f.

16. RELAYS. (See Fig. F)

Details of the operation and function of relays are tabulated below :-

Name & Item No.	Operated by	Function	Energised from
Transmit-Receive Relay (K104)	Test Switch (S101) Morse Key via relay (K102 & K101). Pressel switches on Hand and Chest sets.	Completes 300v. H.T. supply line to anodes and screens of Crystal Oscillator, A/F Input and Driver Stages and M.C.W. Oscillator, and to screen only of 1st Doubler stage. Also feeds K103 through resistance R102.	300v supply via potentiometer R125, R126, R131.
Antenna Transfer Relay (K103)	Transmit-Receive Relay (K104).	1. Transfers Aerial from receiver to transmitter. Earths receiver aerial connection. 2. Completes 375 volt H.T. supply line to anodes of 1st & 2nd Doubler valves, P.A. valve and modulator valves.	300v. supply via R132.
Keying Relay (K102)	Morse Key.	1. Removes short circuit from output of M.C.W. oscillator, thus impressing 1000v input on grids of A/F input stage valves, via transformer (T101). 2. Applies negative voltage from resistances R127 & R128 to the grid of carrier delay section of (V111), thus reducing anode current to zero and opening the R/T M.C.W. switching relay K101.	300v supply via R125, R126, R131.
R/T-M.C.W. Switch Relay (K101).	Relay K102.	1. Applies 300v H.T. to anode of M.C.W. Oscillator. 2. Operates Transmit-Receive relay K104. 3. Short circuits automatic modulation control.	Anode current of Carrier delay. Section of Valve V111.
Overload Relay (K105)	Excessive Cathode current in Valve V104.	Stops generator. Contact is wired in series with emergency and door interlock switches.	Cathode current of V104.
Loudspeaker Switch Relay.	Pressel switches on hand and chest sets.	Transfers receiver output from loudspeaker to dummy load (R204) to prevent acoustic feedback when transmitting on R/T.	300v. supply via resistance in series with K104 when a Pressel switch is pressed.

17. RECEIVER.

The receiver circuit is of the superheterodyne type and utilises an intermediate frequency of 5.3 mc/s. The oscillator stage is crystal controlled with two Doubler stages.

Excellent selectivity at the signal frequency is obtained through the use of three highly efficient tuned circuits preceding the first detector. The aerial is inductively coupled to the first tuned circuit using a degree of coupling that will provide optimum energy transfer from the concentric transmission line employed with the equipment.

To ensure best performance, all the R/F and oscillator circuits are individually tuned by separate variable condensers. All voltage supplies are adequately filtered by resistance condenser combinations to ensure good stability and freedom from oscillation.

Simplified circuit diagrams are given in Figures G and H.

R/F, I/F OSCILLATOR & A.V.C. STAGES

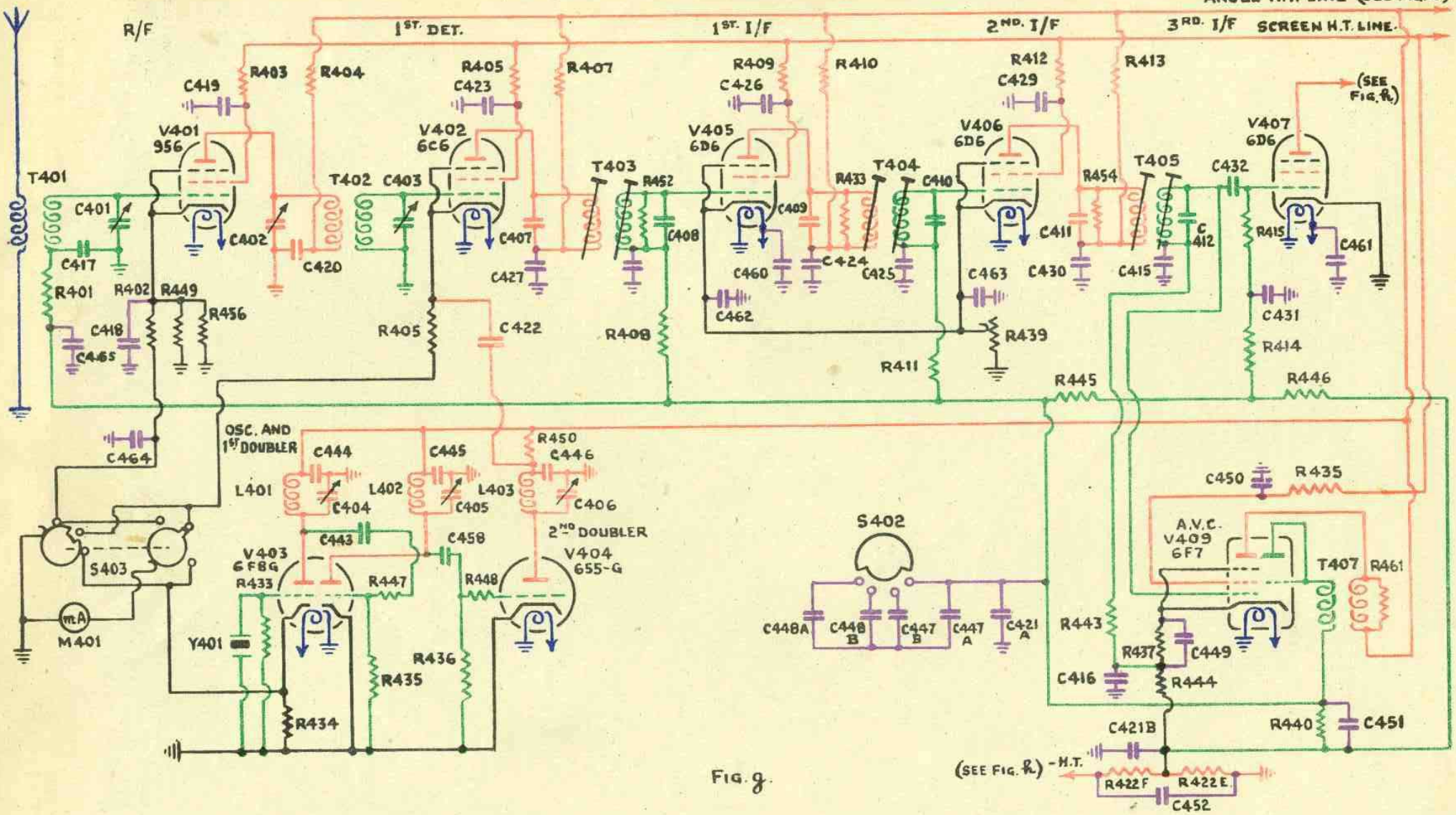


FIG. 9.

18. R/F STAGES. (See Fig. G).

The first tuned circuit precedes the R/F amplifier stage in which a Type 956 Tube is used. This stage provides sufficient gain to produce an excellent signal-to-noise ratio and avoids undue image response, overloading and spurious frequency combinations at the first detector. The other two tuned circuits form a link between the R/F amplifier and the first detector. In this link circuit the degree of coupling is adjusted to obtain an optimum balance between R/F gain and selectivity over the tunable range.

19. CRYSTAL OSCILLATOR & DOUBLER STAGES (See Fig. G).

A crystal controlled tuned anode oscillator followed by two frequency doubler stages is used to furnish heterodyning voltage to the first detector at a frequency 5.3 mc/s lower than the signal frequency. The oscillator is thus operated at one fourth of the actual heterodyning frequency. Only two valves are used for the three stages since the function of oscillator and first doubler are combined in a single valve envelope (V403). This combination valve is a twin triode Type 6F8G one triode section being utilised for each function. The second doubler valve (V404) is a Type 6J5G and both doubler stages, as well as the oscillator, are anode tuned.

20. FIRST DETECTOR. (See Fig. G)

The mixer circuit embodies a Type 6C6 valve (V402) operated as a power detector since this type of detector is inherently free from blocking and cross-modulation tendencies and produces a minimum of distortion when overloaded. Further reduction of cross-modulation and distortion is obtained by working the valve at a relatively low R/F input and only within the linear portion of its characteristic. The heterodyning voltage from the second doubler anode circuit is capacitively coupled into the detector cathode circuit, via C422. This method of coupling reduces the reaction between the tuned circuits to a minimum.

21. I/F CIRCUITS. (See Figs. G & H)

The intermediate frequency amplifier selects and amplifies the different components of the first detector anode current produced by the combination of the signal and heterodyne radio frequencies. It consists of ten fixed tuned circuits, eight of which are used in the signal channel in conjunction with three Type 6D6 valves and two in the A.V.C. channel with one Type 6F7 valve. Sufficient selectivity is obtained in the signal channel to eliminate undesirable frequency components appearing in the first detector anode circuit and thus create a high degree of adjacent channel selectivity. Effective automatic gain control is afforded by the A.V.C. channel.

The eight tuned circuits in the signal channel are grouped into four intermediate frequency transformers (T403 to T406), each consisting of two tuned circuits with coupling greater than critical to produce a selectivity curve with a broad top. In the first three intermediate frequency transformers, a resistance is connected across one of the windings to reduce the double peaking effect produced by the close coupling of the primary and secondary coils. All transformer primaries and secondaries are tuned by fixed condensers and adjustable magnetite cores.

In the A.V.C. channel, the Type 6F7 valve employed is of triode-pentode type (V409). The pentode section operates as an I/F amplifier which is parallel fed from the input to the third I/F amplifier of the signal channel and so operates at full gain at all times irrespective of the strength of the incoming signal. The triode section is connected to operate as a diode rectifier, receiving energy from the pentode section through a fifth I/F transformer (T407), the primary and secondary of which are also adjustable by means of magnetite cores. This transformer is untuned except for the associated valve capacities.

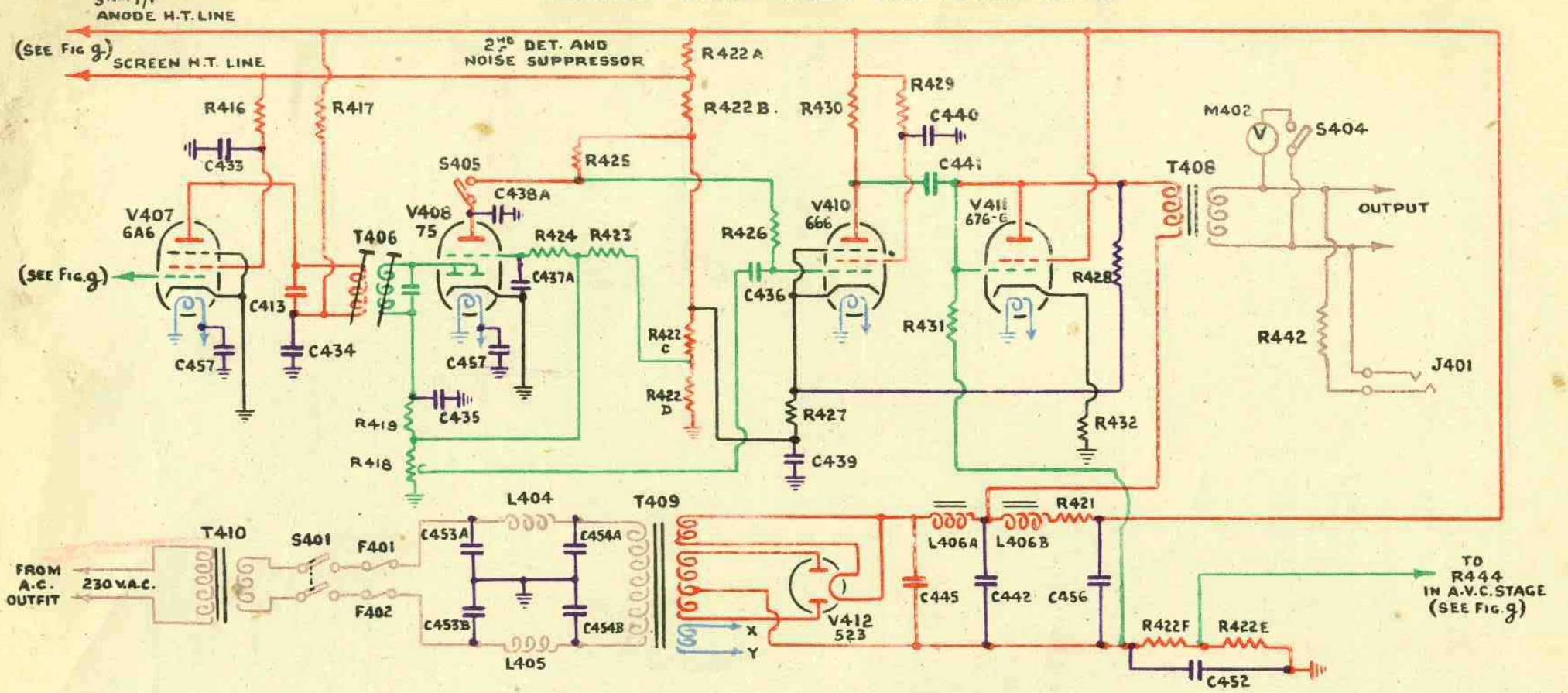
The full D.C. output of the A.V.C. rectifier developed across load resistance R440 is fed back to the control grids of the R/F stage and the first and second I/F stages. A portion of the D.C. output of this rectifier is tapped off via potentiometer R445, R446 and is connected to the grid of the last I/F amplifier stage. This combination of A.V.C. circuits and voltages produces an exceptionally flat gain characteristic.

A negative D.C. voltage delay is provided on the action of the A.V.C. rectifier, the cathode being held at a small positive potential by means of resistance R422 connected in the negative H.T. lead. This allows the output of the receiver to build up almost to a maximum value before the A.V.C. circuit starts to function, and thereafter the output will remain practically constant regardless of signal input. This delay on the A.V.C. circuit further produces an apparent increase in the weak-signal sensitivity.

Provision is made for variation of the A.V.C. time constant by the selective switching of various fixed condensers across the A.V.C. voltage. The A.V.C. time constant characteristic is such that the circuit starts to function almost instantly after a signal is applied and the A.V.C. voltage will be held for a given time after removal of the signal. The time that the A.V.C. voltage is held after removal of the signal may be controlled by the operator by means of switch S402.

Resistance condenser filters are provided in all D.C. leads to the various stages. The heater circuits to the various stages are isolated in so far as the intermediate frequency is concerned by inductance and condenser filters. This filtering, together with the shielding provided, renders the intermediate frequency amplifier free from effects of regeneration.

RECEIVER — FINAL STAGES AND POWER SUPPLY



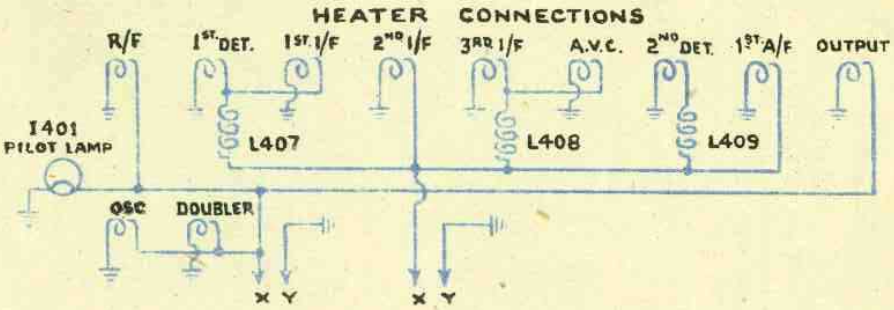


FIG. f.

22. SECOND DETECTOR AND NOISE SUPPRESSOR (See Fig. H)

A Type 75 valve (V408) is used as a second detector and noise suppressor. The diode section of this valve functions as the second detector. This type of detector has been chosen for its freedom from overload and for its low distortion characteristics. The volume control (R418), in series with R419, provides the diode load resistance and A/F output from the diode is capacitively coupled from the arm of that control via C436 to the grid of the first A/F amplifier (V410).

A portion of the D.C. voltage developed by the diode second detector across R419 is impressed on the grid of the triode section of the Type 75 to control the noise suppressor circuit. A small D.C. delay voltage is also applied to the control grid of that section from a tapping on potentiometer R422, to allow the signal to build up to a suitable value before the noise suppressor begins to function. The signal input level at which the noise suppressor begins to function is adjustable by means of a variable resistance (R439) connected in the cathode circuits of the first and second I/F amplifier stages serving to vary the gain in these two stages. A switch (S405) is mounted on the cathode variable resistance (R439) and renders the noise suppressor inoperative when the control is turned to its maximum counterclockwise position.

The noise suppressor functions in the following manner: With no signal being received and the noise suppressor connected in the circuit, there is a small positive bias on the grid of the Type 75 tube. Under this condition, anode current is flowing in the valve and produces a voltage drop across the associated anode resistance (R425). This resistance is connected in the grid circuit of the first A/F amplifier stage (V410) and the cathode of valve V410 is returned to the positive end of the resistance, so that the voltage drop biases the A/F amplifier stage beyond anode current cut-off, rendering it inoperative. When an input signal of sufficient magnitude is connected to the input of the receiver, a negative voltage will be developed across the diode resistance (R418) of sufficient amplitude to over-ride the positive delay on the grid of the noise suppressor valve and thus bias it to beyond anode current cut-off. When this condition is reached, there is no voltage drop across the anode resistance (R425) of the noise suppressor valve and consequently the first A/F amplifier returns to its normal operating condition and is susceptible to signals.

Resistance condenser filters are provided in the noise suppressor control circuits to ensure that no audio frequency voltage appears at either the grid or the plate of the noise suppressor valve.

23. A/F CIRCUITS (See Fig. H)

The audio frequency amplifier consists of two stages: A Type 6C6 valve as a voltage amplifier and a Type 6Y6G valve as a power amplifier. Resistance coupling is used between the second detector and the first A/F amplifier stage and between the two A/F amplifier stages. The power amplifier is transformer coupled to the 600 ohm output. Inverse feedback (R428, C439) is employed in the audio frequency amplifier to reduce distortion and to improve the frequency characteristics.

A telephone jack (J401) is provided for plugging in a telephone head set for monitoring purposes. The telephone head set receives its energy from the secondary of the output transformer (T408) through a series resistance (R442) of suitable value to reduce the power to the headphones to approximately six milliwatts when the receiver is delivering two watts output to the 600 ohm line.

24. POWER SUPPLY. (See Fig. H)

All power for operation of the receiver is normally obtained from a 115 volt 60 cycle single phase supply. When fitted in H.M. Ships, the supply is obtained from a standard A.C. outfit via a 230/115 volt step down transformer (T410). The R/F filter unit in the power line functions to reduce so-called "back door interference" from entering the receiver over the power lines. Adequate shielding for this filter is provided. The power transformer (T409) supplies all voltages both high and low for the operation of the receiver and a Type 83 rectifier valve is employed to supply all D.C. operative potentials. Fuses are provided in each side of the line for the protection of the equipment in case of short circuits, valve failures or the like. The power switch (S401) mounted on the front panel breaks both sides of the line, thus removing all A.C. potentials from the line filter, fuses and primary of the power transformer.