S2

TYPE 87

TRANSMITTER

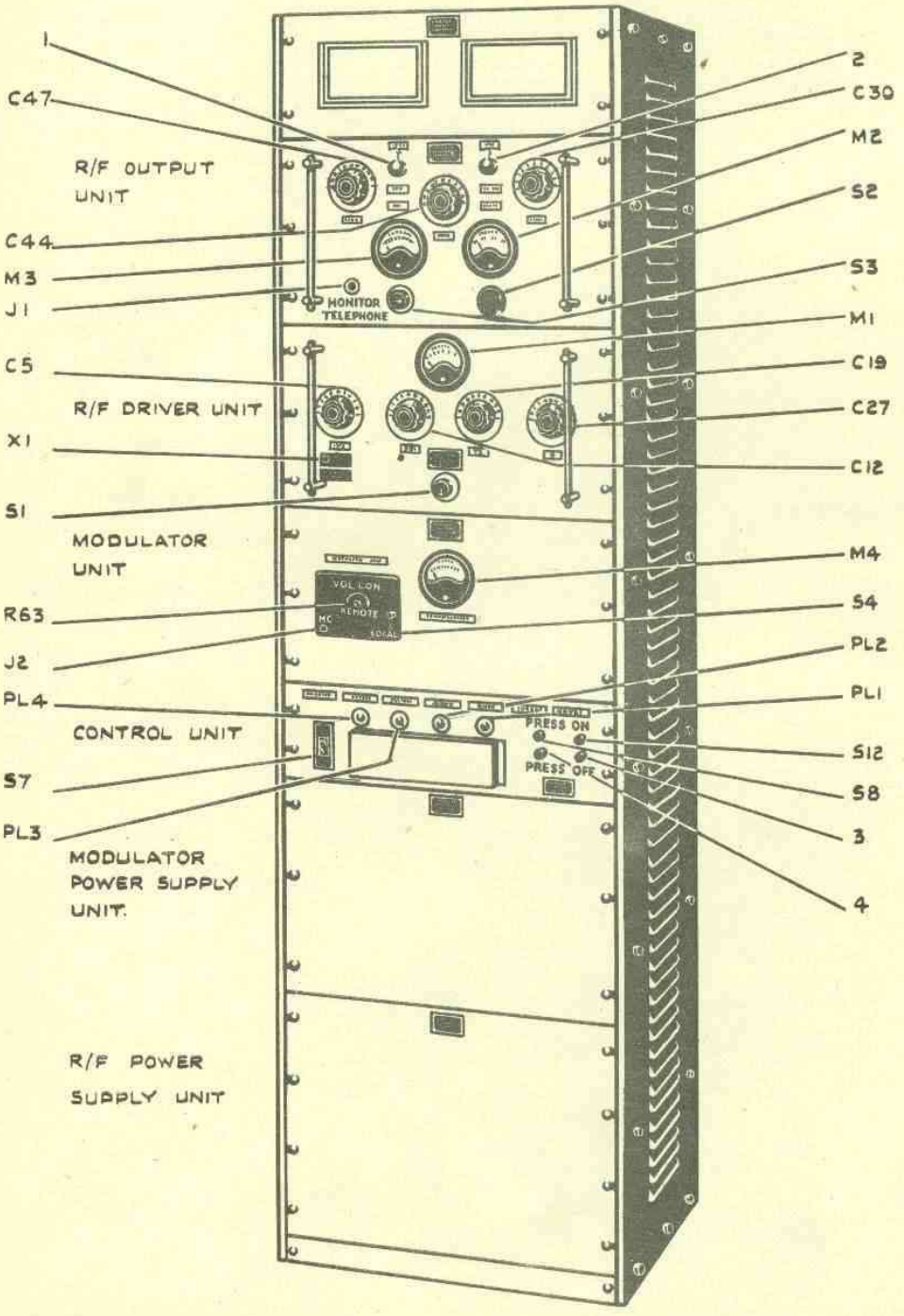


FIG. a.

TYPE 87
TRANSMITTER

1. GENERAL.

Type 87 consists of TRANSMITTER T1131, RECEIVER 1132A, POWER SUPPLY UNIT TYPE 3, for the receiver, and CRYSTAL MONITOR UNIT TYPE 4.

TRANSMITTER T1131 is a crystal controlled V.H/F transmitter designed for R/T communication with aircraft. With aircraft flying at 10,000 feet the transmitter has a range of 100 miles, but this range may be exceeded with aircraft flying at higher altitudes. An A/F oscillator is incorporated in the transmitter for M.C.W. operation.

The frequency range is 99 - 126 Mc/s.

The power output is approximately 40 watts. The transmitter is fitted in cruisers and above and is used for FIGHTER DIRECTION.

Provision is made for remote control in positions up to at least a mile distant from the transmitter.

Power Supply is derived from single phase 50 cycle A.C. mains. The normal supply voltage is 230 volts but provision is made for the use of voltages of from 200 to 250 volts, in steps of 5 volts.

Power consumption is approximately 1·2 kW.

2. CONSTRUCTION.

The transmitter consists of six units which are mounted in a rack which forms the front panel of a cabinet standing 6 ft. high, 1 ft. 9 ins. wide and 1 ft. 5 ins. deep. The weight of the complete instrument being approximately 6 cwt.

The units consist of an R/F Power Supply Unit, Modulator Power Supply Unit, Control Unit, Modulator Unit, R/F Driver Unit and an R/F Output Unit.

3. CONTROLS. (Fig. a).

The numbers and letters given to the Controls are identical with those in W/T Handbook SS118.

AERIAL COUPLING (1).	Used to vary the coupling between the Aerial Link Circuit and the Tuned Aerial Circuit. Minimum coupling is indicated by pointer to the left.
NEUTRALISING CONTROL (2).	Used to neutralise the R/F output valves by varying two ganged neutralising condensers C35, C36.
H.T. "OFF" BUTTON (3).	Forms part of the main H.T. supply switch S12 and is used for switching OFF the H.T. supply to the transmitter and modulator supply units.
L.T. "OFF" BUTTON (4).	Forms part of the L.T. supply switch S8 and is used for switching OFF the L.T. supply to the transmitter and modulator supply units and also breaks the supply to the Control Circuit rectifier transformer.
CRYSTAL OSCILLATOR (C5) TUNING CONDENSER.	Used to tune the crystal oscillator circuit to the fundamental frequency of the crystal being used in the R/F Driver Unit.
FIRST TREBLER STAGE (C12) CONDENSER.	Used to tune the First Trebler Stage Circuit to the crystal frequency multiplied by three.
SECOND TREBLER STAGE CONDENSER. (C19).	Used to tune the Second Trebler Stage Circuit to the crystal frequency multiplied by nine.
DOUBLER STAGE CONDENSER (C27)	Used to tune the Doubler Stage Circuit to the crystal frequency multiplied by eighteen.
METER SWITCH.(S1).	Is a four position switch marked C.O., T.1., T.2., and D and is used to select the circuit of Crystal Oscillator, 1st Trebler, 2nd Trebler, or Doubler, respectively, into which the meter M1 is joined.
MILLIAMMETER (M1).	Is connected into the cathode circuit of valves V1, V2, V3 and V4 by Meter Switch S1 and indicates the total current taken by each valve in its respective circuit. Used to tune the four circuits in the R/F Driver Unit.
AMPLIFIER GRID TUNING CONDENSER (C30)	Used to tune the Grid input circuit of the R/F Output Unit.
METER SWITCH (S2).	Is a three position switch marked G1, G2 and MON. In the G1 and G2 positions it joins a meter M2 in grid circuits of valves V5 and V6 respectively. In the third position, meter M2 is connected to Monitor valve V7.

TYPE 87
TRANSMITTER

MILLIAMMETER. (M2) — Indicates the grid current of valves V5 or V6 as selected by Meter Switch S2. Used to tune the grid circuit of the R/F Output Stage. In the third position of selector switch the meter indicates the D.C. component of the R/F output rectified by the Monitor Valve V7 and provides a visual indication that the R/F portion of the transmitter is operating.

AMPLIFIER ANODE TUNING CONDENSER (C44). — Used to tune the Anode Circuit of the R/F Output Stage.

METER SWITCH. (S3). — is a two position switch marked C1 and C2 and connects Meter M3 into the cathode circuits of Valves V5 or V6.

MILLIAMMETER (M3). — Indicates the total current taken by valve V5, or V6 depending on the position of Meter Switch S3. The meter is used when tuning the Anode Circuit of the R/F Output Unit.

AERIAL TUNING CONDENSER (C47). — in conjunction with Aerial Coil L27 is used to tune the Aerial Circuit to the output frequency.

MONITOR TELEPHONE JACK (J1). — By means of telephones plugged into this jack an operator at the transmitter may listen to, or check the quality of, the signal being radiated.

LOCAL INPUT JACK (J2.) — Provides a means of connecting a microphone to transmitter when the transmitter is used in LOCAL CONTROL. Used when checking modulation and also power output.

MODULATOR MILLIAMMETER. — Measures the total current taken by the two modulator valves V14 and V15. Used to indicate the depth of modulation.

RED PILOT LAMP. (PL1) (MARKED L.F.H.T.) — lights when the supply to the Modulator Supply Unit is completed. Used to indicate that the H.T. Delay Relay S11 has operated.

RED PILOT LAMP. (PL2) (MARKED R.F.L.T.) — lights when the supply to the R/F Supply Unit is completed. When the Reduced Power Switch S7 is in the Half Power position (UP) the pilot lamp will burn at half brilliancy. Used to indicate that the H.T. Delay Relay S11 has operated, the supply is complete to the R/F Supply Unit and gives an Indication of the position of the Reduced Power Switch.

GREEN PILOT LAMP (PL3). (MARKED L.F.FILAMENTS). — lights when the supply to the filament transformer T12 in the Modulator Supply Unit is completed.

GREEN PILOT LAMP (PL4) (MARKED R.F.FILAMENTS). — lights when the supply to the filament transformer T9 in the R/F Supply Unit is completed.

MODULATOR VOLUME CONTROL. (R63). — Varies the A/F input to the Modulator circuit. Used to control the depth of modulation.

LOCAL REMOTE SWITCH, (S4) — Enables the transmitter to be controlled either locally or from a Remote Control Position. When switch is to LOCAL the transmitter is keyed. This position of the switch is used when tuning the various circuits in the transmitter.

REDUCED POWER SWITCH. (S7). — Controls the power supplied to the R/F H.T. transformer T7 by inserting a choke L34 in series with the primary of the transformer. Used to reduce the R/F H.T. supply voltage to approximately half when tuning the transmitter initially.

MASTER FILAMENT SWITCH. (S8) — Used to complete the supply to the filament transformers in both the R/F and Modulator Supply Units. It also completes the supply to the Control Circuit rectifier transformer.

MASTER H.T. SWITCH (S12). — Used to switch ON and OFF the supply to the H.T. transformers in both supply units. The supply is not completed until (1) Master Filament Switch S8 has been closed. (2) The magnetic switch S11 has operated, after a delay of about 60 seconds after switch S8 has been completed. This delay is provided by a thermal delay relay in the control circuit, and provides the necessary safety arrangement which prevents H.T. being applied to the mercury vapour rectifying valves until the filaments have reached their working temperature.

CRYSTAL. (X1). — The crystal is connected between grid and cathode of valve V1. The frequency of the crystals used is from 5,500 kc/s to 7000 kc/s, and by the use of R/F multiplying stages an overall factor of X18 is provided thus covering an output frequency range of 99 Mc/s to 126 Mc/s. By this arrangement the stability of the transmitter is brought to a high order, a maximum frequency variation of one part in 100,000 is possible.

MAIN SUPPLY SWITCH (S6). — Situated on bulkhead or wall and is used to complete the A.C. supply mains to the transmitter. When switch is OFF supply mains are isolated from transmitter.

4. OPERATION.

The procedure for operating and tuning the Transmitter will be materially assisted by reference to Fig. a which shows the various tuning controls.

(a) Close the panel door at rear of transmitter and make the Main Supply Switch (Not shown in Fig. a).

(b) Press the ON button of the MASTER FILAMENT SWITCH S8. The two green pilot lamps PL3 and PL4 should light. Switch S8, as well as completing the A.C. supply to the filament transformers in both supply units, completes the supply to the Control Circuit transformer which causes the thermal delay to commence operating. The delay is approximately 60 seconds so this time must elapse before the supply to the H.T. transformers can be completed. During this interval set the REDUCED POWER SWITCH S7 to the half power position (UP). It is essential to keep S7 in this position until the preliminary tuning operations are completed.

(c) Set the LOCAL - REMOTE CONTROL SWITCH S4 to LOCAL (DOWN). The ON button of the MASTER H.T. SWITCH S12 should be depressed. When the delay relay has operated and completed S11 the two RED PILOT LAMPS PL1 and PL2 will light. The pilot lamp PL2 marked R/F H.T. will only glow at half brilliancy due to the reduced power being supplied to the R/F H.T. transformer.

(d) The tuning controls should now be set to the positions indicated in the following table.

TYPICAL DIAL READINGS ON THE TWO R/F UNITS.

CRYSTAL FREQUENCY kc/s, (X1)		5,550	5,850	6,250	6,500	7,000
FINAL FREQUENCY Mc/s.		99·9	105·3	112·5	117	126
DIAL READINGS DEGREES.						
R/F DRIVER UNIT.						
CRYSTAL OSCILLATOR	(C5)	95	78	60	50	30
1st TREBLER	(C12)	93	78	62	53	37
2nd TREBLER	(C19)	66	55	40	30	11
DOUBLER	(C27)	63	54	39	29	5
R/F OUTPUT UNIT.						
AMPLIFIER GRID	(C30)	60	54	38	27	3
AMPLIFIER ANODE	(C44)	77	71	52	40	8
AERIAL	(C47)	74	69	58	55	46

When handling the transmitter for the first time, and before inserting the crystal, it is advisable to check all static meter readings. Reference should be made to SS118, Handbook for Transmitter T1131, paragraph 82 and Table 2, in which typical readings of all meters under static conditions are given.

TUNING.

5. R/F DRIVER UNIT (LOW POWER).

(a) Insert crystal X1, output frequency of transmitter will be crystal frequency multiplied by eighteen. Turn METER SWITCH S1 to position marked C.O. (CRYSTAL OSCILLATOR). Adjust tuning control C.5 so that the tuning point is approached in a clockwise direction. The METER M1 will then show a gradual fall followed by a sharp rise. The minimum current reading should be noted and tuning control C5 set so that the meter indicates two milliamperes above this minimum, on the side of the gradual change.

(b) Set the METER SWITCH S1 to the T1 position and adjust TUNING CONTROL C12 until the anode current as indicated in METER M1 is a MINIMUM. Check that the dial reading agrees, approximately, with table of TYPICAL DIAL READINGS as it is possible to obtain a current dip in another position of the dial, but this is always well removed from the correct position.

(c) Change the METER SWITCH S1 to the T2 position and adjust TUNING CONTROL C19 until the anode current as indicated in METER M1 is a MINIMUM.

(d) Set the METER SWITCH S1 to the position marked D and adjust TUNING CONTROL C27 for MINIMUM anode current.
The R/F DRIVER UNIT is now approximately tuned but should be retrimmed later when full power is switched on.

6. R/F OUTPUT UNIT (LOW POWER).

(a) The R/F OUTPUT UNIT is also tuned initially with the Switch S7 at HALF POWER. Set the METER SWITCH S2 to the G.1 position and METER SWITCH S3 to C.1. The AERIAL COUPLING CONTROL (1) is rotated in a counter clockwise direction to reduce the Aerial Coupling to a MINIMUM. Then adjust TUNING CONTROL C30, the grid tuning condenser for maximum deflection on METER M2. It may happen that if the adjustments to the R/F DRIVER UNIT are not sufficiently carefully performed, the grid current will be barely perceptible. In this case the correct grid tuning position could be determined by tuning, in the first instance, for a MAXIMUM on METER M3.

Adjust the Anode tuning condenser C44 to give a MINIMUM reading on METER M3. When the AERIAL COUPLING CONTROL (1) is at MINIMUM, the Anode tuning is very sharp and well defined.

In the preceding tuning instructions only the current in the valve V5 has been registered on the meters. The current of V6 can be checked by turning the METER SWITCH S3 to the C2 position and METER SWITCH S2 to position G2.

The corresponding grid current readings should not differ by more than 20% and the anode current readings by more than 10%.

If the Output stage is correctly neutralised the MINIMUM of cathode current on METER M3 should correspond exactly to the MAXIMUM of grid current METER M2.

This condition provides a check that the R/F OUTPUT UNIT is correctly neutralised. If this condition is not obtained it will be necessary to neutralise the R/F OUTPUT STAGE. (See para. 16 for method of neutralising).

(b) Increase the AERIAL COUPLING (1) until the AERIAL TUNING C47 affects the Cathode current as shown on M3, causing a rise of approximately 6mA. Check that the ANODE TUNING CONDENSER C44 still gives a MINIMUM reading on M3, then increase the coupling until the Cathode Current is approximately 32mA. The Aerial Coupling must be more accurately set when full power is applied.

All tuning adjustments being now approximately correct the REDUCED POWER SWITCH S7 can be moved DOWN to the Full Power position.

7. R/F DRIVER UNIT (FULL POWER).

Switch METER M1 into CRYSTAL OSCILLATOR circuit and check that the TUNING CONDENSER C5 is adjusted to a point at which the Crystal-oscillator current is about 4 mA greater than the minimum on the side showing the gradual change.

Check that T1 tuning, T2 tuning and D tuning all give MINIMUM current. These adjustments will usually give some increase in the Output Amplifier Grid Current shown on M2 and the final adjustment should be made with this object in view.

8. R/F OUTPUT UNIT (FULL POWER).

The R/F Output grid tuning condenser C30 should be retuned for MAXIMUM deflection on M2 and the anode tuning condenser C44 retuned until cathode current on M3 is a MINIMUM.

A check should be made to ensure that neutralising condition is still correct. This will be correct when the Anode Tuning causes MINIMUM cathode current, read on M3, and MAXIMUM grid current, read on M2, to occur together.

9. AERIAL IMPEDANCE MATCHING.

The maximum carrier output is the result of correct matching of the aerial Impedance and is obtained when the following conditions are satisfied:-

(a) The ANODE TUNING is set to give MINIMUM cathode current.

(b) The AERIAL TUNING is set to give MAXIMUM cathode current.

(c) The AERIAL COUPLING is adjusted so that the cathode current is 85 to 90 mA for each amplifier valve when the conditions (a) and (b) are independently satisfied.

To obtain the three specified conditions the following method is carried out. With AERIAL COUPLING (1) at MINIMUM tune the ANODE CONDENSER C44 for MINIMUM cathode current on M3. A dip to about 40 mA should be obtained. Whilst the coupling is at MINIMUM the AERIAL TUNING, C47 will not affect the cathode current meter reading. On increasing AERIAL COUPLING, (1), gradually it will be found that, as the AERIAL TUNING, C47, is varied through resonance, a rise in cathode current will occur. This is roughly proportional to the power delivered to the aerial and will increase as the coupling is tightened. Next increase the coupling until the rise in cathode current is about 25 mA and, when this position is attained, finally adjust the AERIAL TUNING C47 to give MAXIMUM cathode current. Increase the AERIAL COUPLING (1) so that the cathode current increases to 85 to 90 mA.

The correct aerial matching has now been attained.

10. MODULATOR STAGE.

Insert the headphones plug in the LOCAL MONITOR JACK J1 on the R/F output panel. Plug a three point (tip ring and sleeve) microphone plug into the LOCAL INPUT JACK J2 on the modulator panel. It should be noted a two point plug must not be used. In the absence of speech the METER M4 will indicate about 50 mA. Speaking into the microphone will cause the current to rise and give a reading roughly proportional to the speech input level. Speech should be heard in the headphones and, if this is of good quality, it indicates that the transmitter is operating correctly up to the aerial feeder. Any fault in the transmitter will reveal itself either through absence of speech, or through severe distortion, in the headphones.

The MODULATOR VOLUME CONTROL R63 should be set, so that when speaking normally, the mean modulator anode current on M4 is approximately 120 mA . In these conditions the R/F Output anode current on M3 should kick up slightly, indicating that the carrier is being just fully modulated.

It is not essential to adjust the MODULATOR VOLUME CONTROL R63 with any great precision, or to interfere with it unnecessarily.

The METER SWITCH S2 should now be turned to the position marked MON. and the METER M2 will now read approximately 3mA. This is an indication that a carrier frequency is being delivered to the aerial feeder.

11. REMOTE CONTROL OPERATION.

Set the LOCAL-REMOTE SWITCH S4 to the REMOTE position. When the Remote Microphone Circuit is closed the transmitter is switched on and is immediately available for use.

12. SWITCHING OFF THE TRANSMITTER.

To switch off the transmitter depress the button 3 which is part of the H.T. ON-OFF SWITCH S12 and then the button 4 which is part of the L.T. ON-OFF SWITCH S8. If required to isolate the transmitter entirely the MAIN SUPPLY SWITCH S6 may be switched OFF.

13. M.C.W. OPERATION.

To key the transmitter from the LOCAL position, place the LOCAL - REMOTE CONTROL SWITCH S4 to LOCAL. Complete the power supplies by making SWITCHES S8 and S12 and after the delay relay has operated and completed S11 the transmitter will be in the ON condition and radiating the carrier frequency. On pressing the morse key, the TONE SOURCE or M.C.W. oscillator output will modulate the transmitter. The depth of this modulation may be checked on METER M4 and monitored with headphones plugged into LOCAL MONITOR JACK J1.

To key the transmitter from the REMOTE position, place the LOCAL - REMOTE CONTROL SWITCH S4 to REMOTE. The transmitter will be in the OFF position until the Microphone Circuit is completed, with S4 in REMOTE position. Thus to modulate the transmitter with M.C.W. the microphone circuit is first completed and then the morse key pressed to connect the output of the M.C.W. oscillator to the MODULATOR CIRCUIT.

14. BRIEF TECHNICAL DESCRIPTION.

The transmitter consists of six separate units mounted together in a rack and enclosed in a steel cabinet. Reading from top to bottom the units are:-

R/F OUTPUT UNIT.
R/F DRIVER UNIT
MODULATOR UNIT
CONTROL UNIT
MODULATOR POWER SUPPLY UNIT.
R/F POWER SUPPLY UNIT.

15. R/F DRIVER UNIT.

The unit contains 4 stages.

1. A crystal oscillator stage.
2. 1st Trebler stage.
3. 2nd Trebler stage.
4. Doubler stage.

A simplified drawing of the R/F driver unit is shown in Fig. b.

The crystal oscillator circuit uses a VT52 pentode valve, V1. The crystal is connected between grid and cathode of this valve. Excitation for the crystal X1 is provided by the anode-grid capacity of the valve and this is augmented by the capacity provided by two small condensers, C1 and C3, joined in series and connected between anode and control grid of valve V1. This external capacity facilitates the starting of oscillations of the crystal but, in order to limit the excitation to a safe amplitude, a 60 mA lamp fuse, F1, is included in the crystal to earth circuit.

A combination of grid leak and cathode bias is used in each of the four stages of the R/F driver unit. In the event of a failure of the crystal controlled oscillator or of any other R/F source of grid excitation, grid leak bias alone provides no protection against excessive anode current, but the bias developed across the cathode resistance will prevent excessive anode current, even should the grid drive fail.

The oscillator circuit of valve V1 is completed by a R/F choke L1 having a grid leak resistance R6 in series with it. The choke L1 prevents the crystal, X1, from being short-circuited to R/F.

Two resistances, in series, R7 and R8 are included in the cathode circuit of valve V1. The resistance R7 is the cathode bias resistance and R8 a meter resistance.

A meter M1 is provided to read the total current of each valve in the unit. The cathode circuit of each valve is completed to earth by a meter resistance R8, R18, R30 and R35 and the meter switch S1 connects the milliammeter M1 across any of these resistances.

TYPE 87
TRANSMITTER

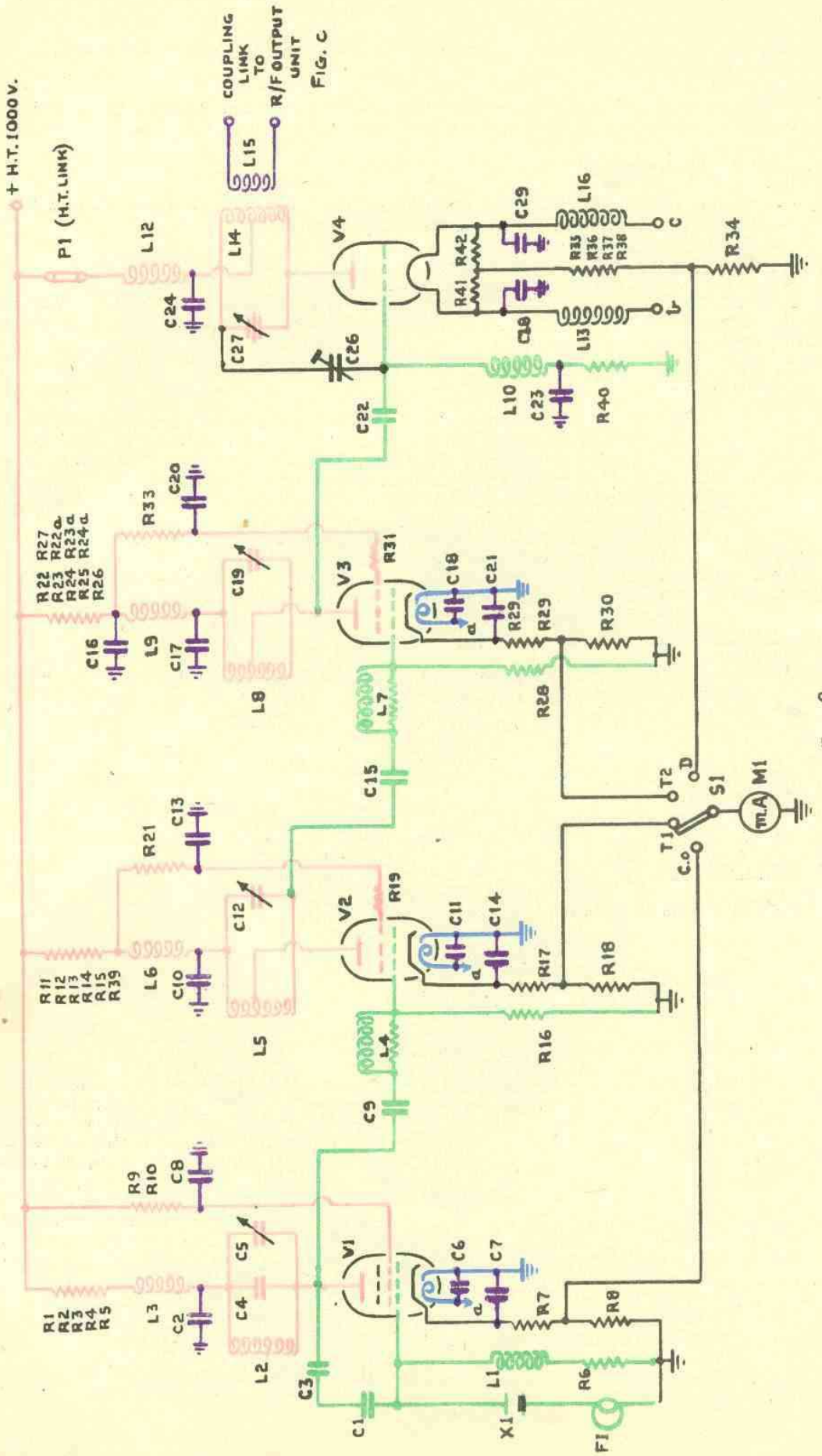


FIG. B.

Condenser C7 is a by-pass for the cathode circuit, the heater leads being by-passed by condenser C6.

The tuned anode circuit of valve V1 consists of an inductance L2, having in parallel with it a fixed condenser (C4) and a variable condenser C5. The R/F choke L3, and a bank of dropping resistances R1 to R5 complete the anode supply to the H.T. line. Two resistances R9 and R10 in series effect the necessary voltage drop for the screen grid of the valve V1. The condenser C8 holds the potential of the screen at a constant value and prevents the screen grid from assuming an R/F potential and, in consequence increasing the feed back to the crystal X1 beyond the limit of safety.

The coupling between the tuned anode circuit of the crystal oscillator circuit and the grid of the first frequency multiplier is by means of the condenser C9 and a choke L4 having a resistance bridging its windings. This arrangement provides for the damping out of parasitic oscillations and enables the grid of the valve V2 to be presented with the fundamental frequency of the crystal X1.

Resistance R16 is the grid leak resistance and R17 is the cathode bias resistance. A tapped inductance L5 and a variable condenser C12 provide the tuned anode circuit of the VT79 tetrode valve V2. The constants of this circuit are so proportioned that only a narrow band of frequencies either side of resonance to the third harmonic of the crystal frequency are amplified. Owing to the selectivity of thisstage unwanted harmonics are practically eliminated and the desired frequency passed on to the subsequent valve.

The voltage dropping resistances R39 and R11 to R15 reduce the H.T. supply to a suitable value for the anode of valve V2 and the screen grid voltage is reduced by a resistance R21, which serves to maintain the screen-grid voltage at a suitable value relative to that of the anode. A condenser C13, between the junction of R19 and R21 completes the screen grid circuit to earth with respect to R/F voltages. The resistance R19 is an anti-parasitic resistance.

The anode circuit of the valve V2 is coupled to the grid circuit of the second frequency trebler stage through a condenser C15 and a damped choke L7 in a manner similar to that coupling the anode of V1 to the grid of V2.

A VT79 tetrode valve V3 is used in this stage. The tuned anode circuit of the valve V3 consisting of an inductance L8 with a condenser C19 in parallel is designed to resonate at the ninth harmonic of the crystal frequency. The anode of valve V3 is tapped down on the inductance L8, to increase the selectivity of this stage, in a similar manner to that of the first frequency trebler valve V2.

The associated grid cathode circuits of valves V2 and V3, heater, by-passing and biasing arrangements are identical in the two stages.

The voltage dropping arrangement for the anode of valve V3 is provided by a bank of resistances R22 to R27 and R22a to R24a, which together provide a resistance equivalent to that in the previous stage. The R/F choke L9 is by-passed from each end to earth through two condensers C16 and C17. Resistance R33 provides the necessary voltage drop for the screen-grid of valve V3 and is decoupled by the condenser C20.

The output of the second trebler stage is capacity coupled, by condenser C22, to the grid of a directly heated triode valve V4, VT62. This valve is the final, or doubler valve of the R/F driver unit. A choke L10 and resistance R40 complete the grid-filament circuit. The low-potential end of L10 is by passed to earth through a condenser C23. The filament leads are also bypassed by condensers C28 and C29. Filament chokes L13 and L16, for the suppression of undesirable oscillations, are inserted in the leads from the 7·5 volt supply.

A filament centre-pointing device consists of two resistances R41 and R42, their centre-point being earthed through a bank of resistances R35 to R38 in series. This bank of resistancesmakes up the cathode biasing resistance for the valve V4, the resistance R34 being the meter resistance as previously mentioned.

At the very high frequencies used in this stage and due to the anode to grid feed back arising from the internal capacity of the valve V4, neutralisation becomes necessary to prevent this stage becoming self-oscillatory. Condenser C26 is the neutralising condenser and is adjusted and pre-set at the factory, in such a position, that the stage is neutralised over the whole frequency range covered by the stage. A link P1, in the anode supply lead to valve V4, is used when this stage is being neutralised. It is not used under normal operating conditions.

The anode tuning inductance L14 is centre fed from the H.T. line through a high frequency choke L12 which is bypassed by condenser C24. The inductance L14 is tuned to the 18th harmonic of the crystal frequency by the series tuning condenser C27.

The output of this stage is link-coupled to the R/F OUTPUT by a coupling link L15, a low impedance R/F twin-transmission line and a coupling link L16.

16. R/F OUTPUT UNIT.(Fig. c).

This stage consists of two VT62 triodes V5 and V6 operating in push-pull. The circuit consists of a neutralised tuned grid and tuned anode circuit operating at the crystal frequency multiplied by eighteen, which is the output frequency. Two meters are supplied M2 being a grid meter and M3 a cathode meter. A VT67 valve V7 is also contained in this unit. The anode and grid of this valve are strapped together and are capacity coupled to the tuned aerial circuit. The valve V7 acts as a diode and is used as a monitor valve. The rectified R/F energy can be measured on the grid meter M2 which provides a check up to the Aerial feeders that the transmitter is operating satisfactorily. The A/F output of the transmitter may also be checked by means of head-phones plugged into a jack J1 joined across the load resistance of the monitor valve.

The grid meter M2 also provides the tuning indication when the grid circuit is brought into resonance with the applied frequency from the R/F DRIVER STAGE.

TYPE 87
TRANSMITTER

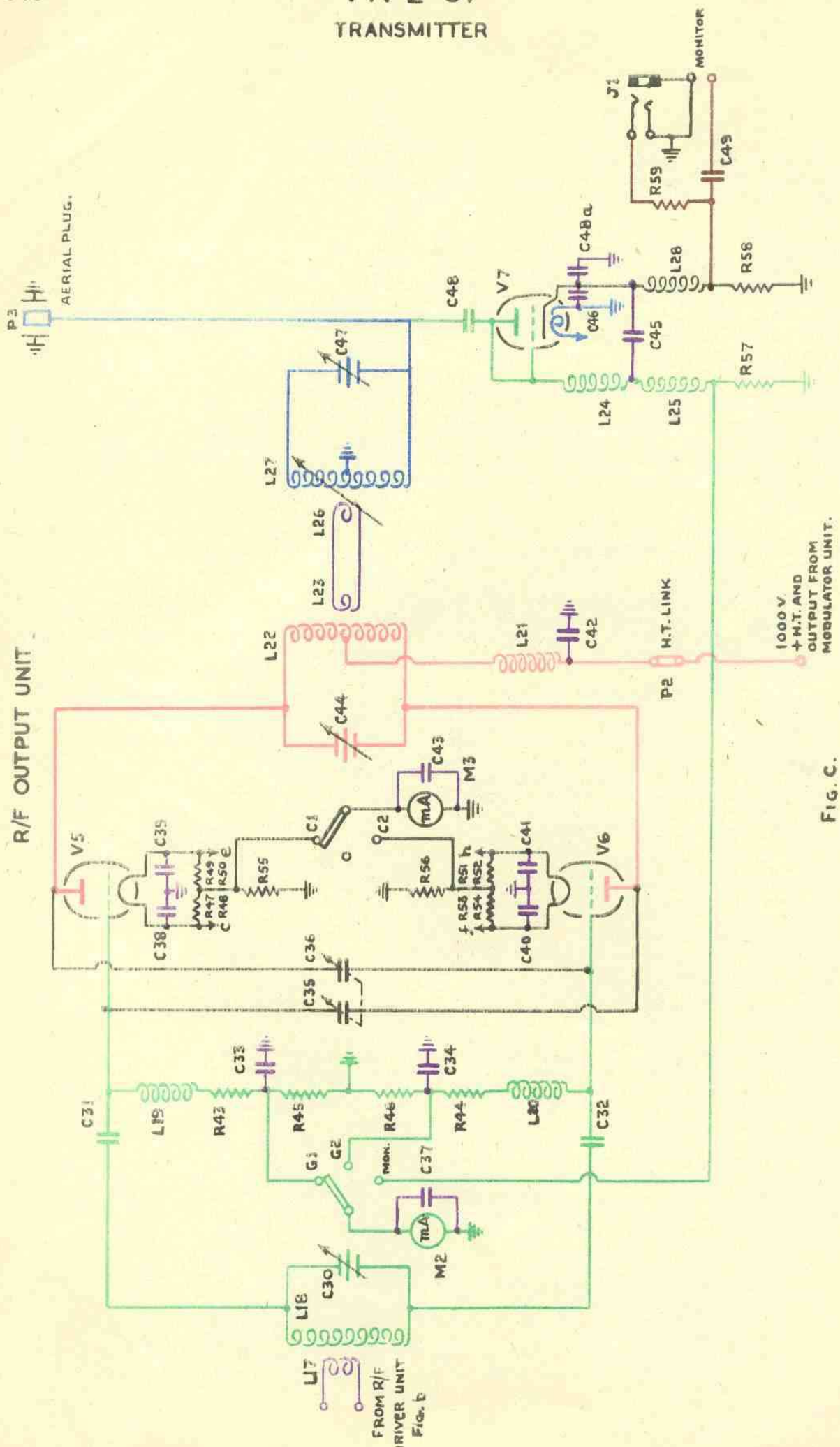


FIG. C.

The anode circuit consists of inductance L22 tuned by condenser C44.

The output from the MODULATOR circuit is fed to the anodes of the R/F OUTPUT valves V5 and V6 by a centre tap on the anode inductance L22. The anodes are thus modulated at high voltage by the output of the MODULATOR STAGE.

The neutralising condensers are ganged and are operated from the panel control 2. (Fig. a).

To neutralise the R/F OUTPUT STAGE.

(i) Open rear door of transmitter and remove H.T. link P2, at rear of output stage, thus disconnecting H.T. supply from anodes of valves V5 and V6. (Fig. c).

(ii) Close rear door and switch on supplies to Transmitter. It will be necessary to wait for the delay relay to operate.

(iii) With LOCAL-REMOTE switch in the LOCAL position, tune the R/F Driver Stage as outlined in para. 5. Then adjust C30 until the meter M2 reads a MAXIMUM. Tune the anode condenser C44 until the grid current is a MINIMUM. Then adjust the neutralising control 2, Fig. A, until the grid current is again at MAXIMUM retuning the grid circuit to give a further rise in grid current. Repeat the operations until the anode circuit tuning, by means of C44, ceases to cause a dip in the grid current reading on M2. The stage is now neutralised. Replace the link P2 thus restoring H.T. supply to anodes of output valves. It should be noted that the safety switch, that is broken when rear door of transmitter is opened, breaks the supply to all transformer primary circuits. It will therefore be necessary to wait for one minute, after replacing link and closing rear door before supplies are restored. When power is available check that the MINIMUM anode current corresponds to MAXIMUM grid current as the anode circuit is tuned through resonance. The Aerial circuit is link coupled to the tuned anode circuit of the Output Amplifier.

The Aerial circuit inductance L27 is tuned by condenser C47. The coupling between the link circuit and the Aerial circuit can be varied by the Aerial Coupling Control 1. This control as well as providing a means of transferring energy to the aerial also acts as a means of matching the impedance of the aerial to that of the Output circuit. (See Para. 9).

17. MODULATOR UNIT.

A simplified diagram of the Modulator Unit is shown in Figs. d and e.

The unit is designed to operate with a carbon granule microphone.

High voltage, class B anode modulation is used. The modulator consists of:-

1. Pre- Amplifier.
2. Push-Pull Amplifier.
3. Driver and Modulator Output Stage.
4. M.C.W. Oscillator.

(a) PRE-. AMPLIFIER. (Fig. d).

The pre-amplifier consists of two resistance capacity coupled VR67 triode valves V8 and V9. Two alternative A/F input circuits, LOCAL and REMOTE are provided. The LOCAL microphone is connected to Modulator by JACK J2, the REMOTE control circuits being connected through a distribution block in the unit. A polarising voltage of 24 volts is supplied from the CONTROL CIRCUIT RECTIFIER. To provide suitable impedance matching when the Local microphone is connected in circuit, the input transformer T1 is tapped. The LOCAL-REMOTE SWITCH S4 when in the REMOTE position, brings the whole of the primary winding of T1 across the incoming line terminals and breaks the LOCAL circuit. To maintain stability in the PRE-AMPLIFIER the valves and associated components are contained in a separate screening box. A variable resistance R63 is the volume control, varying the A/F input voltage to valve V9. The output of the PRE-AMPLIFIER is connected to MODULATOR UNIT by transformer T2. Also connected to the primary winding of T2 is the AUDIO OUTPUT of the M.C.W. oscillator. This consists of a Hartley oscillator using a VR67 triode valve V16. The heater supply for this valve also provides the keying voltage for the keying relay. A small metal rectifier rectifies the heater voltage for operating the relay by means of the morse key. The relay transfers the 1000 cycle A/F output of the M.C.W. oscillator or TONE SOURCE from earth to the primary winding of T2 when the morse key is depressed. The M.C.W. OSCILLATOR is contained in a metal screening box which is plugged into a suitable socket situated in the MODULATOR UNIT. As the output of the PRE-AMPLIFIER and the M.C.W. OSCILLATOR is permanently connected to the primary of transformer T2 no additional switching is necessary to change the type of modulation.

(b) PUSH-PULL AMPLIFIER. (Fig. e).

The secondary winding of transformer T2 is earthed at the centre point, two outer ends feeding the grids of two VR67 triode valves V10 and V11, joined in push-pull. The anodes of valves V10 and V11 are joined to the opposite ends of the primary winding of a transformer T3, the centre point of which is tapped. The H.T. positive supply to the anodes of V10 and V11 is fed to this centre tap, through the smoothing choke L29 and condensers C109 and C117, and dropping resistance R78.

(c) DRIVER STAGE AND MODULATOR OUTPUT STAGE. (Fig. e).

The output from valves V10 and V11 is taken from the secondary windings of the transformer T3 to the grids of valves V12 and V13. These are beam tetrode valves (VT75) and are connected in push-pull. The anodes of the valves are connected to the primary of a transformer T4 through anti-parasitic resistances R91 and R92, the H.T. supply being connected to the centre tapped primary of T4. The secondary winding of T4 is also centre tapped and its outer ends are connected to the grids of two VT76 valves V14 and V15. These valves are connected in Class B push-pull and run at zero bias, running into grid current when driven. The valves V12 and V13 must therefore supply considerable power to the grid circuits of V14 and V15.

To overcome the possibility of distortion, two loading resistances R93 and R94 are connected across the two halves of the secondary of transformer T4 and these resistances serve to keep the load constant. A further reduction in distortion is brought about by the introduction of a certain amount of negative feed back in valves V12 and V13 through resistances R89, R90 and condensers C114 and C115.

The anodes of valves V14 and V15 are connected to the two ends of the primary winding of a modulation transformer T5, the H.T. supply being fed to the centre point. The secondary of T5 is connected in the anode H.T. supply circuit of the R/F Output valves which is thus modulated by the A/F output from valves V14 and V15. The secondary of T5 carries the D.C. of the R/F Amplifier and the transformer is specially designed to work under these conditions. The stage comprising V14 and V15 is designed to deliver nearly 200 watts undistorted power of good efficiency. The anode current varies with the power output and the readings on meter M4 can be plotted to give an indication of power output.

The R/F OUTPUT AMPLIFIER requires approximately 90 watts A/F power for 100% modulation. To prevent over-modulation limiters W1, W2, W3 and W4 are included in the grid circuit of V14 and V15. These take the form of metal rectifiers which are biassed from the 300 volt H.T. supply by the potentiometer formed by R95 and R96. The bias is approximately 76 volts. For peak input voltages below this voltage, the limiters are inactive but, when the value is exceeded, the rectifier becomes conductive over that portion of the cycle over which the signal voltage exceeds 76 volts with consequent flattening off, or limiting of the peaks.

(d) M.C.W. OSCILLATOR. (Fig. f).

The M.C.W. OSCILLATOR or tone source consists of a Hartley Oscillator using a VR67 triode valve V16.

The heater supply for this valve also provides the keying voltage for the relay S5. A small metal rectifier, W5, rectifies the heater voltage for operating the relay by means of a morse key. A tuned circuit, consisting of inductance L30 and condenser C125, is joined between anode and grid of valve V16, and will oscillate at approximately 1000 c/s.

The circuit will oscillate continuously when the supplies are completed, and the valve output is fed into a resistance load consisting of resistances R100 and R101. Condenser C129 is a blocking condenser to prevent the H.T. supply voltage passing through the load resistances to the cathode of the valve.

With the key at rest the output of the oscillator is connected to -H.T. and earth.

When the morse key is depressed the bobbin circuit of the keying relay is completed and the contact S5 connects a portion of the output voltage, that developed between the variable tap on resistance R101 and earth, to the primary of the transformer T2.

The oscillator unit is contained in a metal screening box, the necessary connections being brought out to a plug connector P4. The unit is plugged into a socket Sk1 to which the connections are permanently wired (Fig. d).

18. POWER SUPPLIES.

The power supplies of the R/F and Modulator units are shown in the simplified sketch Fig. g.

The mains input is fed into the primaries of transformers tapped to cater for differences in the supply voltage. Voltages of 200 to 250 volts in steps of 5 volts can be accommodated. Separate power supply units are provided for the Modulator and the R/F units. The Modulator Power Supply provides 200 mA at 300 volts for all stages except the output stage. For this stage 0·5 amp. maximum at 1000 volts is available.

The R/F supply unit provides 0.5 amp. at 1000 volts. There is no separate bias supply for any valve. The microphone polarising voltage, relays and the remote pilot light are operated from a 24 volt supply unit which is mounted in the Control Unit.

The whole transmitter consumes 1·15 K.V.A. with no modulation, rising to 1·2 K.V.A. on full modulation.

The R/F Power Unit employs two mercury vapour rectifier valves V17 and V18, VU72, in a single phase full wave rectifying circuit with a choke condenser smoothing network. This arrangement provides for good regulation.

TYPE 87
TRANSMITTER

MODULATOR PRE-AMPLIFIER

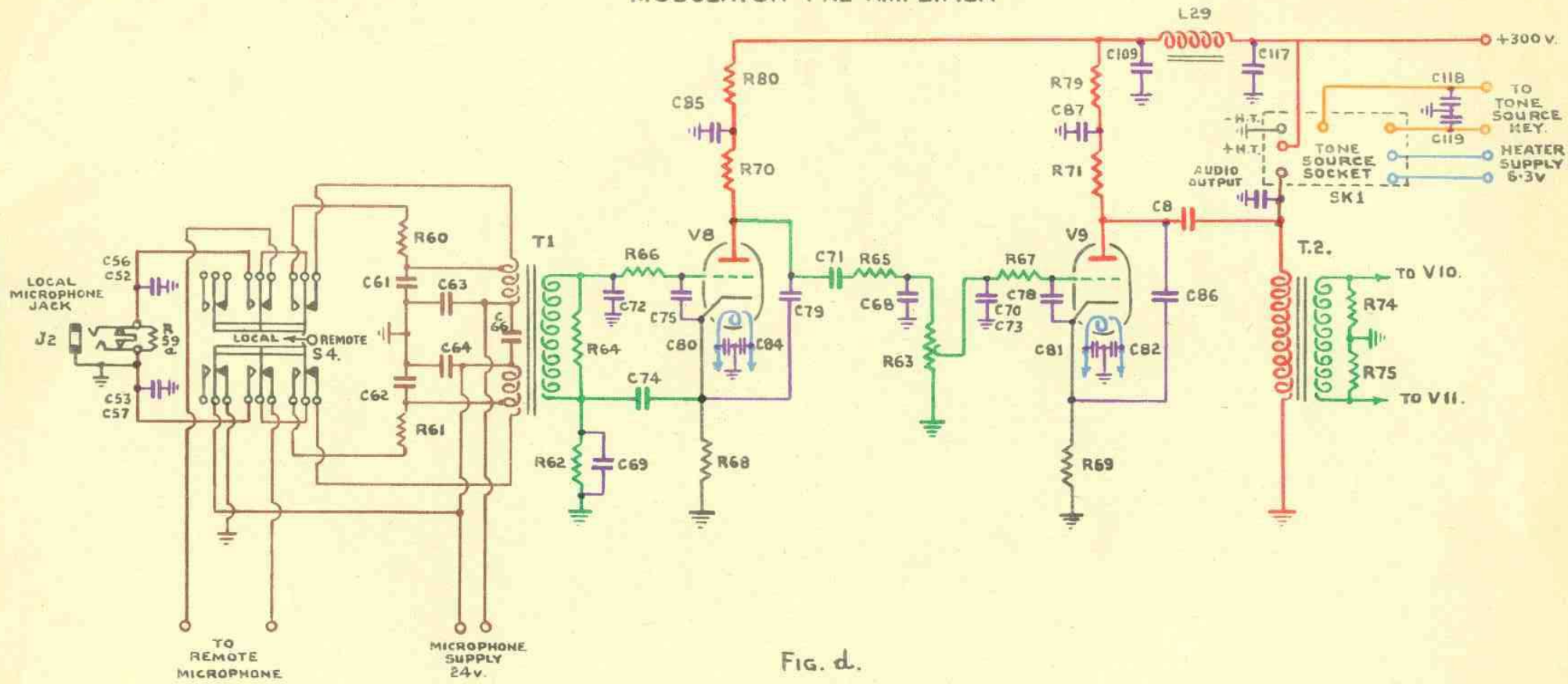


Fig. d.

MODULATOR UNIT

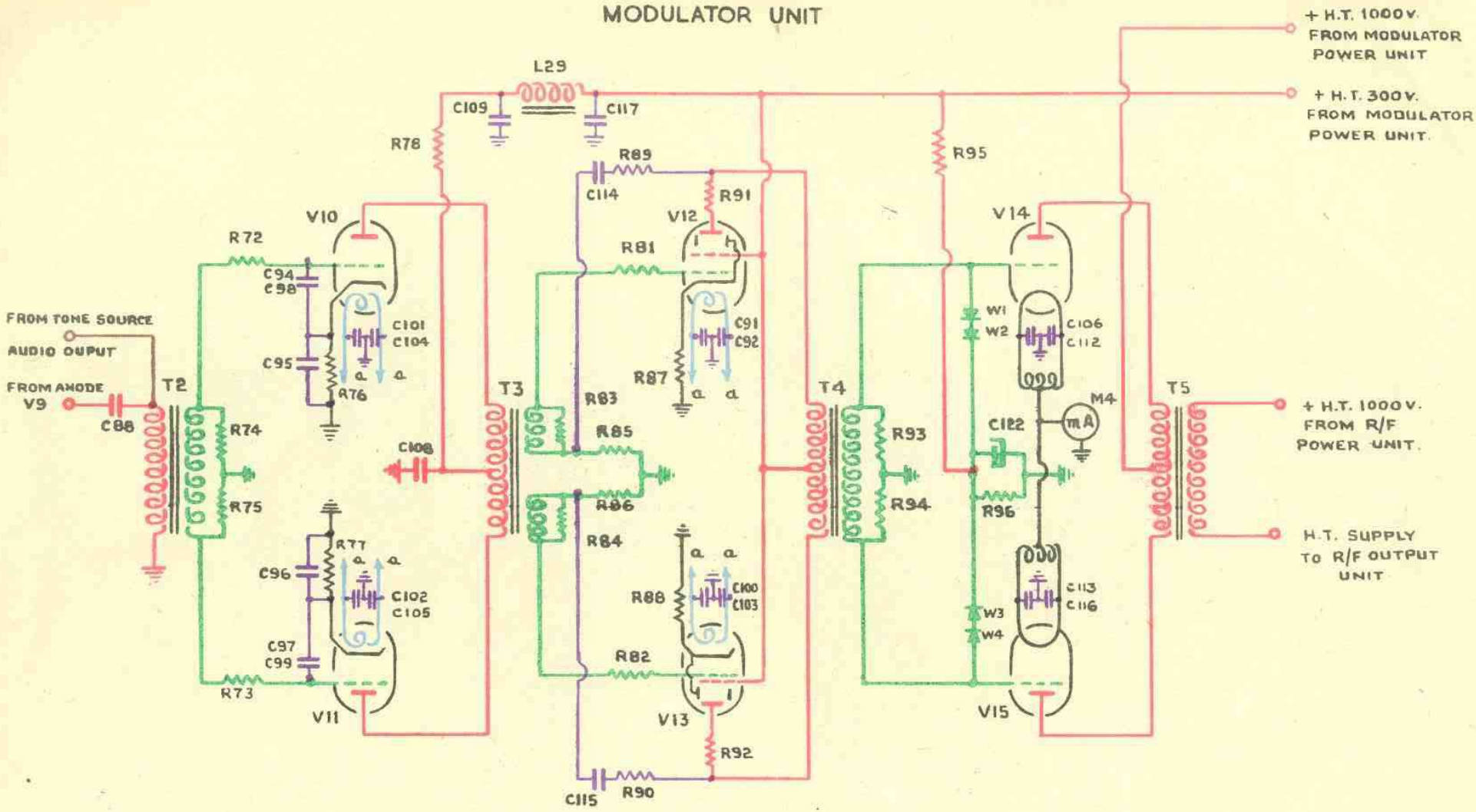


FIG. e.

M.C.W. OSCILLATOR OR TONE SOURCE

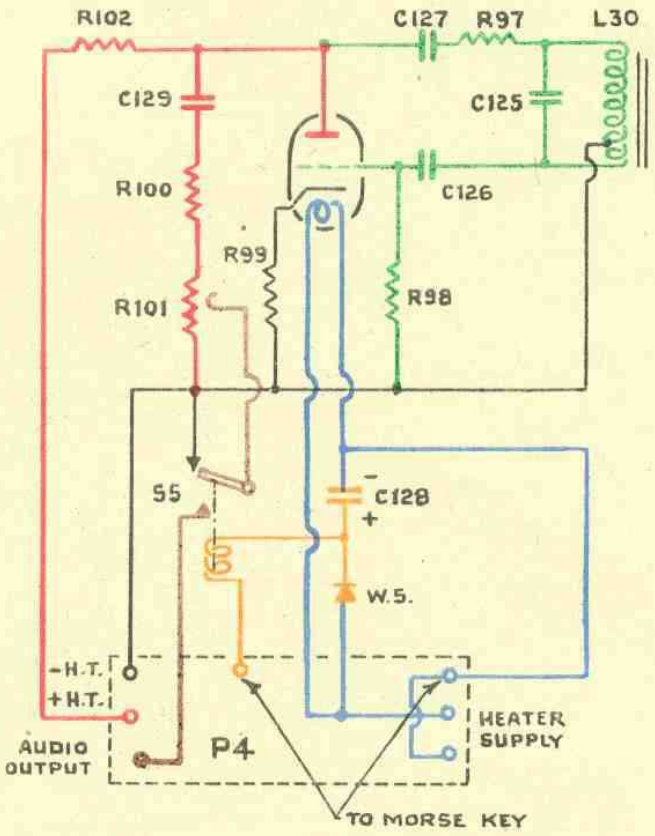


FIG. f.

A choke L34 is inserted in the supply line to transformer T7. The choke can be switched in or out by the REDUCED POWER SWITCH S7, and reduces the input voltage to half value. The transformer T7 is the H.T. transformer and has two secondaries, one supplying the rectifying valves V17 and V18 and the other supplying the H.T. pilot lamp PL2. A transformer T8 supplies the filaments of V17 and V18. The filament transformer T9 has six secondaries and supplies the heaters of the various valves. in the R/F unit and the R/F L.T. Pilot lamp PL4. The primaries of transformers T8 and T9 are joined in parallel, the supply being completed under working conditions by making the MASTER L.T. SWITCH S8.

The Modulator Power Unit has four transformers. Transformer T10 is the H.T. transformer and supplies two VU72 mercury vapour rectifying valves V19, V20, in a single phase full wave rectifying circuit with a choke condenser smoothing network. The circuit is designed to supply a well regulated voltage over a wide range of load currents entailed by the Class B output stage of the Modulator. The second secondary of T10 is not used. Transformer T11 supplies the filaments of valves V19 and V20. Transformer T12 has five secondaries and supplies the heaters of all valves in the modulator unit, the L.T. PILOT LAMP PL3 and the filaments of the rectifying valve V21. The transformer T13 has two secondaries. One provides the H.T. to a full wave hard valve rectifier VU71, V21, with a condenser choke smoothing filter. The other secondary supplies the H.T. PILOT LAMP PL1.

The primary windings of transformers T11 and T12 are joined in parallel and will also be supplied by making the MASTER L.T. SWITCH S8.

The primary circuits of transformers T7, T10 and T13 are supplied from the MASTER L.T. SWITCH S8, via the MASTER H.T. SWITCH S12 and the magnetically operated switch S11. This arrangement makes it impossible to complete the supply to the H.T. transformers until the filament supply has been completed. The magnetically operated switch, S11, being controlled by a system of relays prevents the supply to the H.T. transformers being completed until the filaments of the valves have reached their proper working temperature, although the MASTER H.T. SWITCH S12 may have been MADE simultaneously with the MASTER L.T. SWITCH S8. It should be noted that the supply to all transformers is broken by the SAFETY SWITCH S6 on opening the access door at the rear of the transmitter. After this door has been opened the delay circuits will have to complete their cycle of operation before the H.T. in both Supply Units can be completed.

TYPE 87
TRANSMITTER
R/F AND MODULATOR POWER SUPPLY UNITS AND CONTROL UNIT

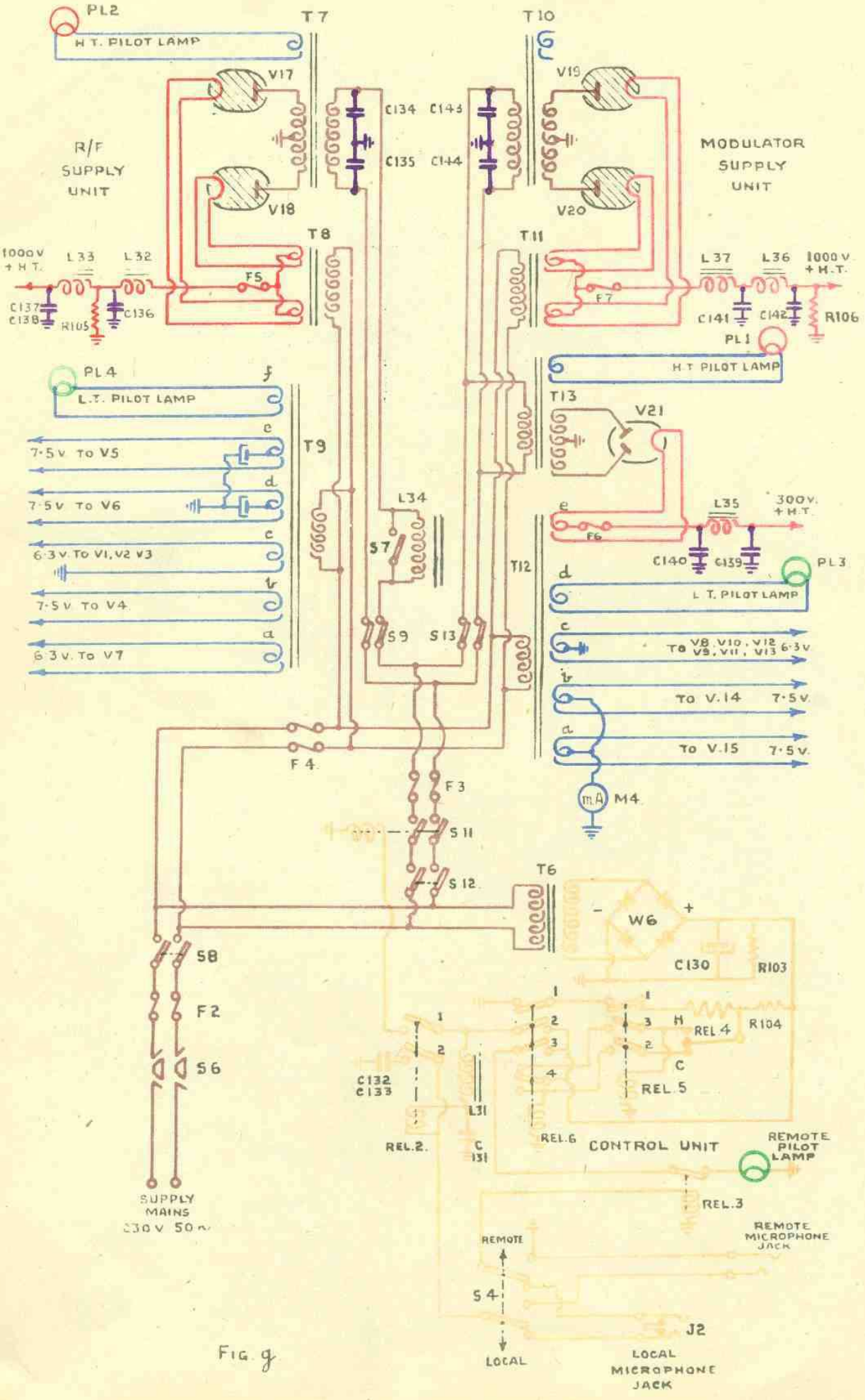


Fig. 9

19. CONTROL CIRCUITS. (Fig. g).

With the Transmitter door closed the supply mains are completed to the transformer T6 by the operation of the MASTER L.T. SWITCH S8. The secondary of this transformer is connected to the metal rectifiers W6 which provide 24 volts for operating the H.T. delay circuit.

The action of the delay and control circuit is as follows:-

The positive output of the rectifier is connected via a resistance R104 to a THERMAL RELAY REL. 4. The heater circuit of this relay is completed to EARTH via the 1st contact of REL. 5 and the 1st contact of REL. 6. The negative of the metal rectifier bridge is connected to EARTH thus completing the HEATER circuit.

The moving contact of REL. 4, with the temperature rise due to the heater circuit, moves from contact C to contact H. This operation completes the circuit through the bobbin of REL. 5 which causes this relay to operate.

With REL. 5 in the ON position, contact 1 breaks the HEATER circuit of REL. 4, contact 2 prepares the circuit for the bobbin of REL 6, and contact 3 locks the supply to the bobbin of REL 5 via contact 4 of REL 6.

As contact 1 of REL 5 has broken the supply to the heater of REL 4, the moving contact of this relay will, after the necessary time for the heater to cool, move from contact H to C.

When C contact is completed the supply is made via contact 2 of REL 5 through the bobbin of REL 6. This relay operates, completing four contacts. Contact 1 breaks the heater circuit of REL 4, contact 2 prepares the circuit of REL 2 via choke L31, contact 3 prepares the circuit for supplying the REMOTE PILOT LAMP, and contact 4 locks the supply to the bobbin of REL 6, and at the same time breaks the supply to the bobbin of REL 5 which moves to the OFF or normal position.

The operation of REL 2 depends upon the position of the LOCAL-REMOTE SWITCH S4.

With this switch in the LOCAL position the bobbin circuit of REL 2 is completed via S4, the auxiliary contacts of the LOCAL MICROPHONE JACK, the bobbin of REL 3 and earth. The single contact of REL 3 would break the supply to the REMOTE PILOT LAMP thus indicating to the REMOTE CONTROL Position that the REMOTE CIRCUITS are not connected. The completion of the bobbin circuit of REL 2 would cause this relay to operate closing two contacts. Contact 1 completes the supply to the bobbin circuit of H.T. SWITCH S11, contact 2 introduces two condensers C132 and C133 in parallel to earth in order to prevent REL 2 chattering.

The operation of S11 completes the mains supply to the primaries of the H.T. transformers T7, T10 and T13 providing the MASTER H.T. SWITCH S12 has been completed. This cycle of operations will take approximately 60 seconds from the time MASTER L.T. SWITCH S8 has been completed.

With the REMOTE-LOCAL SWITCH S4 in the REMOTE position the bobbin circuit of REL 2 is only completed when the REMOTE-MICROPHONE circuit is completed by depressing the PRESS TO SPEAK SWITCH on the REMOTE MICROPHONE. The operation of this switch therefore carries out two purposes.

(i) Completion of the microphone circuit.

(ii) Completion of the H.T. Supply to the transmitter by the operation of REL 2 and S11.

An additional EARTH is introduced on REMOTE-LOCAL SWITCH S4 which has the effect of short-circuiting through earth the bobbin of REL 3, when switch S4 is to REMOTE. The relay REL 3 will not operate under these conditions and the contact will thus complete the supply to the REMOTE PILOT LAMP indicating to the REMOTE CONTROL POSITION that the REMOTE-LOCAL SWITCH is in the REMOTE POSITION.

The choke and condenser C131 provide the necessary smoothing for the polarising voltage required by the microphone in use.

TYPE 87
RECEIVER

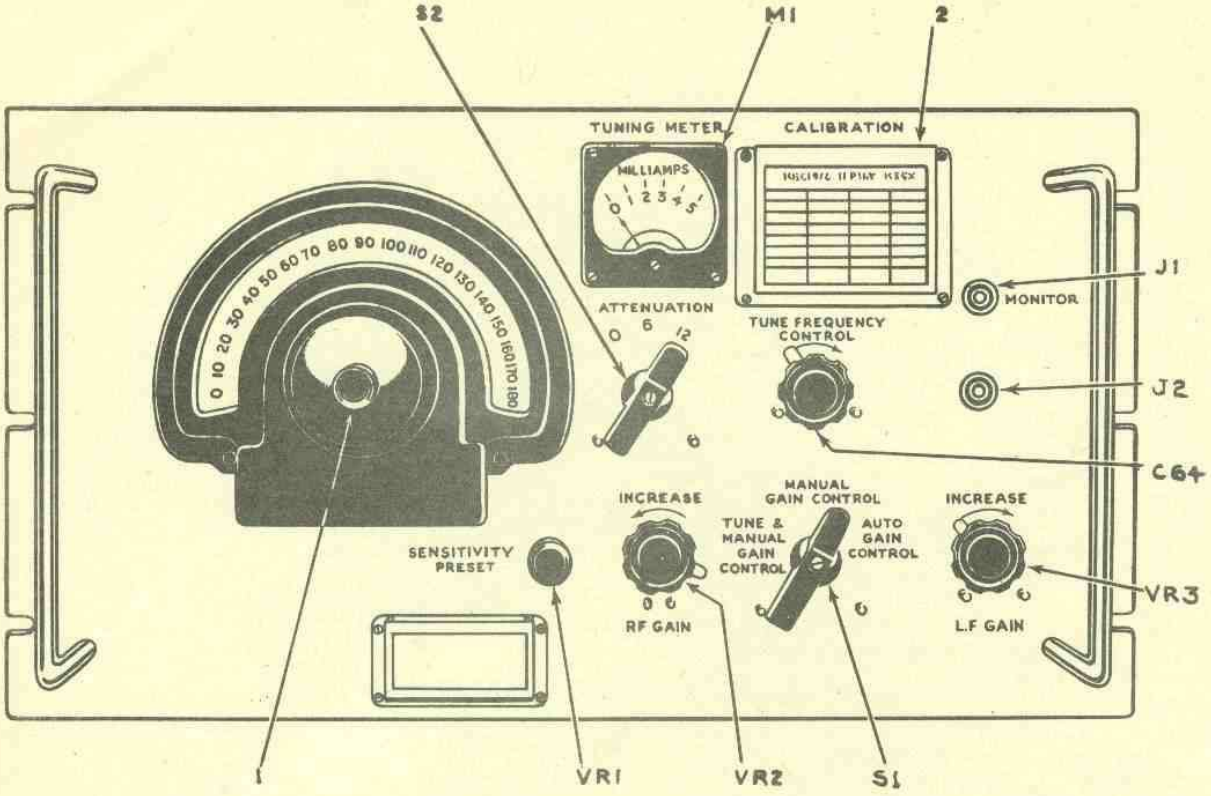


Fig. h

1. GENERAL.

DATE OF DESIGN:-	1941.
FREQUENCY RANGE:-	100 - 124 Mc/s.
WHERE FITTED:-	As a component of TYPE 87. In Cruisers and above.
USE:-	For R/T communication with fighter aircraft May also be used for the reception of C.W. signals.
POWER SUPPLY:-	R.A.F. POWER SUPPLY UNIT TYPE 3, requiring 190/250 volts 50 cycles single phase A.C. supply.

The receiver employs a superheterodyne circuit consisting of a radio frequency amplifier, followed by a frequency changer with a separate oscillator valve, three stages of I/F amplification, a combined second detector and A.C.C. rectifier valve and two stages of A/F amplification. For the reception of C.W. a beat frequency oscillator valve may be switched into the detector circuit.

The four main tuning condensers are ganged and operated through a slow motion drive fitted with a calibrated scale.

2. CONSTRUCTION.

The framework of the receiver consists of a chassis and front panel. The panel measures 19 in. x 10½ in. and the chassis 17 in. x 10½ in.

The receiver is primarily intended for rack mounting, but is also suitable for bench mounting. A dust cover fits over the chassis and plated handles are fitted to the panel to facilitate handling and to enable the receiver to be turned over on to its face for inspection, without damage to the controls.

3. CONTROLS.(Fig. h).

TUNING CONTROL (1) A slow motion drive that controls four ganged tuning condensers. It also operates the tuning pointer that moves over a dial calibrated from 0-180 degrees. Used to tune the receiver to any given frequency.

CALIBRATION CARD (2) Indicates the frequencies corresponding to the various dial settings on the TUNING CONTROL DIAL.

TONE FREQUENCY CONTROL CONDENSER (C64) — Varies the tuning of the BEAT FREQUENCY OSCILLATOR CIRCUIT and thus the pitch of the note when receiving a C.W. signal. Not used for the reception of R/T.

TUNING METER (M1). — Measures the H.T. current to the first I/F AMPLIFIER valve. When the GAIN CONTROL SWITCH S1 is set to AUTOMATIC GAIN CONTROL the meter will indicate a MINIMUM when the TUNING CONTROL 1 is adjusted accurately to the incoming signal frequency. The value of the MINIMUM obtained serves as an aid in forming an estimate of the strength of signal being received.

GAIN CONTROL SWITCH (S1). — Is a three position switch marked:-

(i) AUTOMATIC GAIN CONTROL
(ii) MANUAL GAIN CONTROL.
(iii) TONE AND MAN. GAIN CONTROL.

Positions (i) and (ii) give the operator the choice of automatic or manual gain control and the third position switches the BEAT FREQUENCY OSCILLATOR into circuit.

ATTENUATION SWITCH (S2). — Varies the output of the receiver. It has three positions marked:-

0 (Full output, 240 milliwatts).
-6 db. (60 milliwatts).
-12 db. (15 milliwatts).
Used to reduce the intensity of an excessively loud signal.

SENSITIVITY PRESET RESISTANCE (VR1). — Allows the amplification of the I/F amplifier valves to be adjusted. It is normally set to the position that gives maximum amplification.

R/F GAIN CONTROL (VR2). — Varies the amplification of the I/F amplifier valves in conjunction with SENSITIVITY PRESET RESISTANCE VR1. The R/F GAIN CONTROL VR2 is not in the circuit when the GAIN CONTROL SWITCH S1 is in the AUTOMATIC GAIN CONTROL position. Used to allow the operator MANUAL control of the R/F amplification of the receiver.

L/F GAIN CONTROL (VR3). — Used to control the output from the second detector to the A/F amplifier stages of the receiver.

MONITOR JACK (J1). — Used to monitor the output of the receiver when supplying a REMOTE CONTROL POSITION.

OUTPUT JACK (J2) — Connects the REMOTE CONTROL POSITION via a 6 point plug and socket, called a JONES PLUG, to the output of the receiver. If local headphones are plugged into OUTPUT JACK J2, the supply from the receiver to the REMOTE CONTROL POSITION will be disconnected.

4. OPERATION.

After the receiver has been mounted on the rack or bench, it should be connected up by inserting the six contact socket from the POWER SUPPLY UNIT into the plug at the rear of the receiver. Then insert aerial plug into the aerial socket. Switch on the power by means of the ON - OFF switch on the POWER SUPPLY UNIT.

Insert the telephone plug into the MONITOR JACK J1, set ATTENUATION SWITCH S2 to the - 6 db. position and put the GAIN CONTROL SWITCH S1 to the A.G.C. position. Set the L/F GAIN CONTROL VR3 so that the pointer is about vertical.

Refer to the CALIBRATION CARD 2 and from this the approximate dial setting for the desired frequency may be obtained. If it is required to tune the receiver to a frequency not shown on card, the approximate dial setting may be obtained by interpolation.

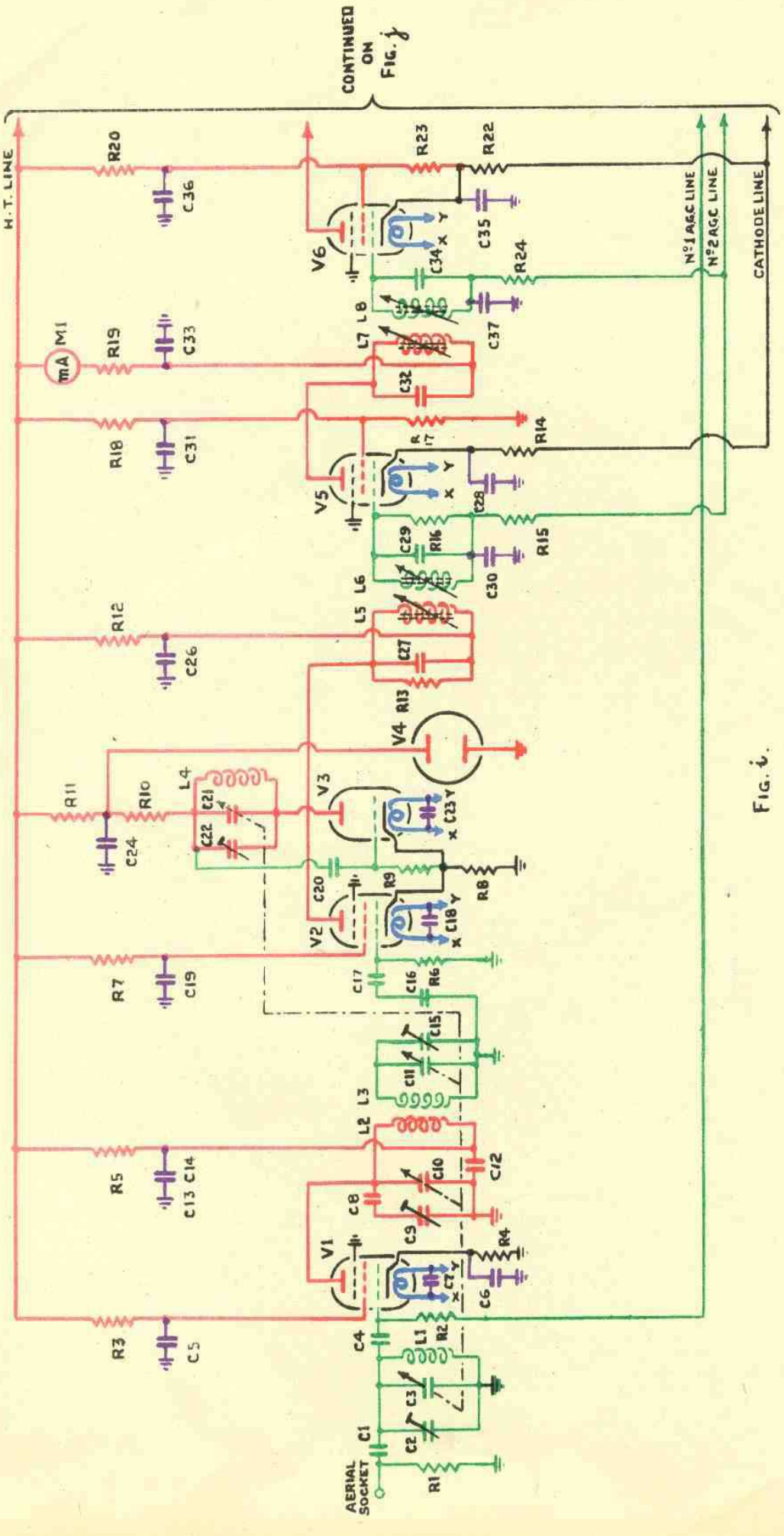
Set the tuning pointer to this position, and if a signal is present the optimum setting can be determined by rocking the condensers until MINIMUM reading is obtained in the TUNING METER M1.

If no external signal is available, the receiver may be tuned by means of a CRYSTAL MONITOR TYPE 4.

The tuning position will vary slightly whilst the receiver is warming up. It is essential therefore to allow the instrument to warm up for at least ten minutes and preferably half an hour before the final adjustments are made. No further adjustment should then be necessary for at least a day.

The TUNING METER M1 is intended primarily to facilitate accurate tuning, but it also indicates the strength of an incoming signal. A strong signal produces a large reduction in reading while a weak signal causes only a small reduction.

TYPE 87
RECEIVER



SIMPLIFIED DIAGRAM

Fig. 3.

The following table indicates the approximate values of signal strength for various meter readings.

SIGNAL STRENGTH (MICROVOLTS)	MILLIAMPS ON TUNING METER
ZERO	4·7
20	4·5
100	3·4
1,000	2·9
10,000	2·0
100,000	1·4

When the GAIN CONTROL SWITCH S1 is in the A.G.C. position, the L/F GAIN CONTROL VR3 should not be set to more than ¾ of its maximum position, otherwise distortion will result.

The ATTENUATOR SWITCH S2 should normally be set to the -6 db. position, but if the output volume is still insufficient with the L/F GAIN CONTROL VR3 set to ¾ of its maximum, then the ATTENUATION SWITCH S2 should be moved to the "0" position. Conversely, if too much volume is obtained on - 6 db. position S2 should be moved to -12 db. position.

For normal R/T work the GAIN CONTROL SWITCH S1 should always be left in the A.G.C. position. The R/F GAIN CONTROL VR2 and TONE FREQUENCY CONTROL C64 are thus switched out of circuit, and the only controls used are TUNING 1, L/F GAIN VR3 and ATTENUATION S2.

5. BRIEF TECHNICAL DESCRIPTION.

The receiver employs a superheterodyne circuit consisting of a R/F amplifier stage, a frequency changer with a separate oscillator valve, three I/F amplifier stages, a double diode detector and A.G.C. rectifier and two stages of A/F amplification. A beat frequency oscillator valve may be switched into the circuit for the reception of C.W.

A simplified diagram of the receiver is given in Figs. i and j.

The tuning of the receiver is effected by means of the ganged variable condensers C3, C10, C11 and C21. Each tuning condenser being shunted by a small pre-set trimmer.

The Aerial is coupled to the first tuned circuit L1, C3, by the coupling condenser C1. This circuit forms the tuned grid circuit of the R/F amplifier stage which uses a pentode valve VR65, V1. The resistance R1 provides some damping in the aerial circuit and improves the stability of the R/F stage. The R/F valve V1 does not provide much amplification, its chief purpose is to increase the selectivity of the receiver. Grid bias for V1 is provided by the cathode resistance R4, and the A.G.C. bias is applied to the grid of the valve via the grid leak R2.

The output of the R/F amplifier is tuned transformer coupled to the Frequency Changer V2 which uses a VR65 pentode. Three circuits, tuned to the signal frequency, are thus included before the frequency changer valve in order to reduce second channel interference from powerful transmitters on adjacent frequencies and also to reduce cross modulation effects.

Automatic gain control is not applied to V2 and the grid leak R6 is connected direct to earth.

Self bias is obtained from the resistance R8 in the cathode lead. Since R8 is common to the cathode circuits of both the oscillator valve V3 and the frequency changer V2, the oscillator frequency is introduced into the frequency changer by a form of cathode injection. The oscillator frequency differs from the signal frequency by 12 Mc/s and the oscillator is always tuned to the lower frequency. Thus while the signal frequency circuits tune from 100 to 124 Mc/s, the oscillator circuit tunes from 88 to 112 Mc/s.

The stabiliser valve V4 helps to maintain a constant oscillator frequency by preventing fluctuations in the H.T. supply voltage. The triode oscillator valve V3 is a V66 and the neon stabiliser valve V4 a VS70.

The oscillator circuit consists of a tuned circuit between anode and grid of valve V3. One end of the inductance L4 is connected to the anode and the other through the condenser C20 to the grid.

Three R/F pentodes, VR53, are employed in the I/F stages, which are coupled together by I/F transformers tuned to 12 Mc/s. The band-width of the I/F stages is approximately 150 kc/s, this provides very good selectivity whilst providing a pass band sufficiently broad to ensure that the receiver will remain in tune despite small variations in the frequency of the signal or drift of the oscillator frequency.

The anode current of the first I/F valve V5 is measured by the Meter M1, and serves as a tuning indicator.

The amplification of the I/F stages may be adjusted to a suitable value by means of the pre-set resistance VR1. This resistance is connected in series with the common return lead from the cathodes of the I/F amplifier valves. It is normally set in the position to give maximum gain e.g. minimum resistance.

TYPE 87
RECEIVER

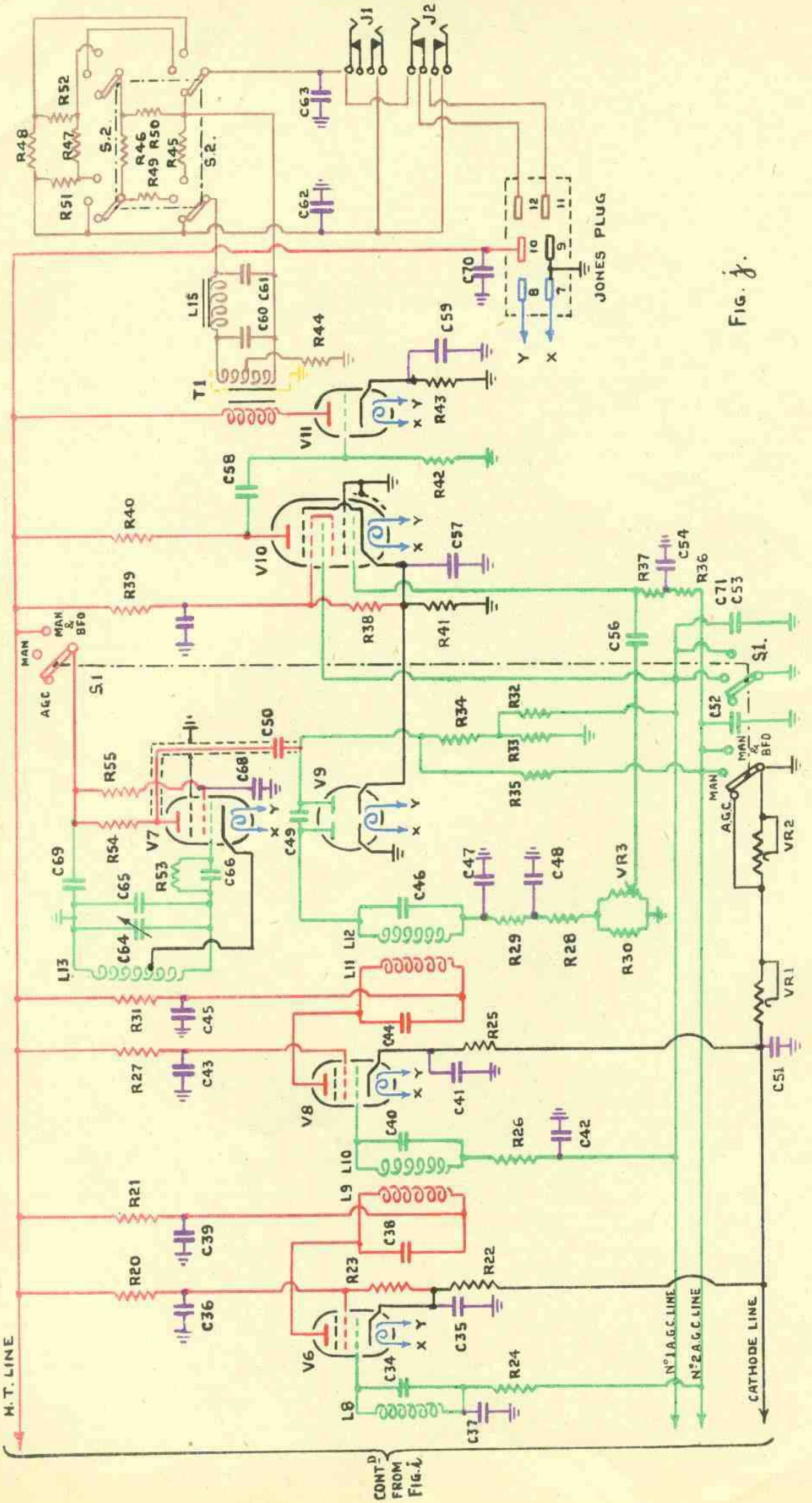


Fig. 1.

The GAIN CONTROL SWITCH S1 has three positions. In the A.G.C. position, the R/F GAIN CONTROL VR2 is short-circuited, and the R/F gain of the receiver is regulated by the action of the A.G.C. system.

In the MANUAL GAIN position the amplification of the I/F stages depends upon the setting of resistance VR2. This resistance being connected in the common cathode return lead of the I/F stages varies the cathode bias of the three I/F amplifier valves. Both the A.G.C. lines are earthed.

In the TONE AND MANUAL CONTROL position, the H.T. supply to valve V7 is completed, and the BEAT FREQUENCY OSCILLATOR comes into operation.

The B.F.O. circuit consists of a tuned circuit between anode and grid and covers a frequency range of 11·9 to 12·1 Mc/s which may be varied as desired by the TONE FREQUENCY CONTROL C64. The output of the B.F.O. is capacity coupled to the anode of the second detector valve V9 by condensers C50 and C49. The valve used in the B.F.O. circuit is a VR53.

Diode detection is used and the A/F output is filtered by R29 and C47 and C48. The voltage developed across the diode load resistances R28, R30 and VR3 is fed to the grid of the first A/F amplifier valve V10 via the slider of the L/F GAIN CONTROL VR3 and the condenser C56. The detector valve V9 is a VR54 valve and contains two separate diodes in the one envelope. The first diode is the signal diode or second detector, and the second diode provides the A.G.C. bias.

The A.G.C. voltage developed across the A.G.C. diode load resistances R34 and R33 is fed back to the grids of V1, V5, V6 and V10, thus regulating both the R/F and A/F gain of the receiver. In order to ensure that the A.G.C. will not come into operation on a weak signal the cathode of the second diode is provided with a positive delay voltage of 2·5 to 3 volts by the potential divider R39, R38 and R41.

Two stages of audio frequency amplification are provided. The first A/F valve V10 is a VR57, an octode valve of the variable gain type, and the A.G.C. is applied to grids 1 and 4. The output of valve V10 is resistance capacity coupled to the grid of valve V11. The grid leak R37 is returned to the A.G.C. line, which is maintained at earth potential for R/F by the condenser C52.

The output stage consists of a triode valve V11, VR67, in the anode circuit of which is the output transformer T1. The centre tap of the secondary winding is connected to earth through resistance R44. This gives a balanced output and an electrostatic screen between the primary and secondary windings ensure that it is suitable for direct connection to a telephone line if required. The receiver is designed to work into an output load of 600 ohms, but this value is not critical and a satisfactory performance will be obtained when operating into any load impedance between 200 and 2000 ohms.

The maximum output of the receiver is 250 milliwatts but it may be limited to 60 or 15 milliwatts by means of the ATTENUATION SWITCH S2. The three positions of this switch vary the connections to a network comprising the resistances R45 to 52. The switch position marked "0" disconnects the attenuator and provides the full output. Position - 6 db. connects one portion of the attenuator in circuit and in the third position maximum attenuation is provided. To attenuate the A/F response above 3000 C/S and so improve the signal-to-noise ratio, a filter consisting of a choke L15 and condensers C60 and C61 is included in the output circuit.

6. POWER SUPPLY.

Normally the receiver is operated from A.C. supply mains in conjunction with the POWER SUPPLY UNIT TYPE 3, which requires an input of 190/250 volts 50 C/S. For emergency operation the receiver may be operated from a six volt accumulator using a POWER UNIT TYPE 4, which incorporates a rotary transformer.

The connections between the receiver and the Power Unit are made by means of a six contact plug and socket, the plug half being built into the receiver. The heater consumption is 3·5 amps at 6·3 volts and the H.T. consumption 55 m/A at 210 volts.

The output leads to the REMOTE CONTROL POSITION are also connected to the plug on the receiver and the phone leads from the remote position to the socket. The connecting of the supply unit to the receiver automatically connects the output of the receiver to the REMOTE CONTROL POSITION.

7. REMOTE CONTROL RECEPTION IN H.M. SHIPS.

Remote control position reception in H.M. ships is effected by taking the output of the receiver from JACK J2 to an Admiralty Pattern W146 Telephone Jack Box. This unit has two telephone jacks. The operator plugs his telephones into one of these jacks and the telephone leads to the REMOTE CONTROL POSITION are plugged into the other.

TYPE 87
POWER UNIT

SIMPLIFIED DIAGRAM

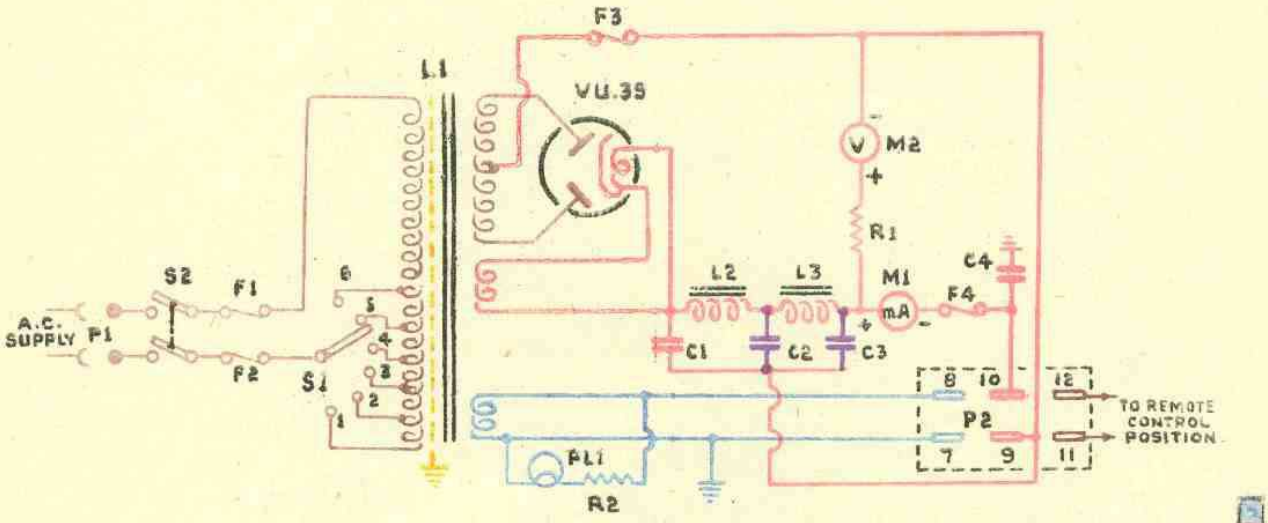


Fig. 2.

FRONT VIEW

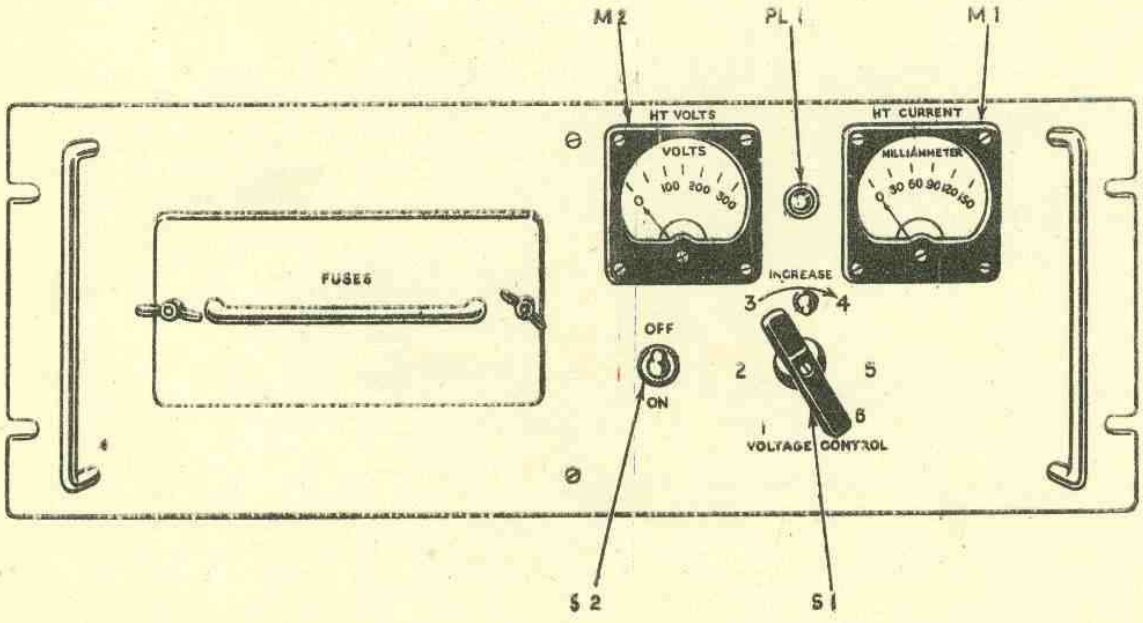


Fig. 1

TYPE 87
POWER UNIT

1. GENERAL.

The Power Unit, Type 3, provides the H.T. and valve heater supplies for RECEIVER R1132A when operated from A.C. supply mains.

A valve rectifier is used and the smoothing circuit for the H.T. supply voltage is contained in the unit.

The supply may be between 200 and 250 volts A.C. 50 c/s, a six position selector switch allowing the input voltage to be varied in steps of 10 volts. The power required from the supply mains is 60 watts.

The unit has two outputs, the H.T. supply being 55 mA at 210 volts D.C. and the valve heater supply 3·5 amps at 6·3 volts A.C.

2. CONSTRUCTION.

The unit has been designed for rack mounting but it may be accommodated on a bench adjacent to the receiver. The distance between the two instruments being governed by the length of the connecting cable.

The unit has a front panel 19 in. x 7 in. which carries a chassis 17 in. x 10 in.

3. CONTROLS AND METERS (Fig. 1).

SELECTOR SWITCH (S1).	Has six positions and allows the POWER UNIT to be used with supply voltages varying between 200/250 volts.
ON-OFF SWITCH (S2).	A double pole switch in the supply mains. Used for switching ON or OFF power to the SUPPLY UNIT and thus to the receiver.
INDICATOR LAMP (PL1).	Lights when power is being supplied to the heater winding of the mains transformer.
METER (M1).	Is a milliammeter and shows the H.T. current being taken by the receiver.
METER (M2).	Is a voltmeter and indicates the H.T. voltage supplied to the receiver.
OUTPUT SOCKET (P2).	Used to connect the output of the POWER UNIT to the plug fitted on the receiver. Four connections are used for this, the remaining two being used to connect the REMOTE CONTROL POSITION to the phone output of the receiver.

4. OPERATION.

Connect the OUTPUT SOCKET P2 to the receiver plug. Adjust SELECTOR SWITCH S1 to correspond to the voltage of supply and connect MAINS PLUG P1 to the supply socket.

After completing the supply to the unit with the ON-OFF SWITCH S2 the INDICATOR LAMP PL1 will light immediately. The rectifier valve takes approximately 30 seconds to reach its working temperature. As the valve heater warms up, the meters M1 and M2 will indicate the output of the H.T. supply to the receiver. The voltmeter M2 will slowly rise to approximately 210 volts and this output should be obtained by adjustment of the SELECTOR SWITCH S1 after the receiver has had time to reach its working temperature. The METER M1 under normal working conditions will read approximately 50 mA.

5. BRIEF TECHNICAL DESCRIPTION.

A full wave indirectly heated rectifying valve VU39 is used in the supply unit.

A simplified diagram of the unit is shown in fig. k.

The A.C. input is applied to the mains transformer through a two-pin plug P1, a double-pole switch, a pair of one ampere fuses F1 and F2 and the selector switch S1. The transformer L1 has an electrostatic screen between primary and secondary windings to prevent any interference, which may be conducted along the supply main, from passing through the transformer to the receiver.

The six point SELECTOR SWITCH S1 controls the selection of the nearest voltage tapping to the supply voltage.

The transformer L1 has three secondary windings, H.T. winding, rectifier valve heater winding, and receiver valves heater winding. One leg of this last winding is connected to earth.

The INDICATOR LAMP PL1 is connected in parallel with the receiver valve heaters.

Smoothing of the H.T. supply is provided by chokes L2 and L3 and condensers C1, C2 and C3.

The H.T. output is protected by the fuses F3 and F4. The fuses also provide protection for the milliammeter M1. Fuses F3 and F4 are 150 mA cartridge type fuses.

TYPE 87
CRYSTAL MONITOR

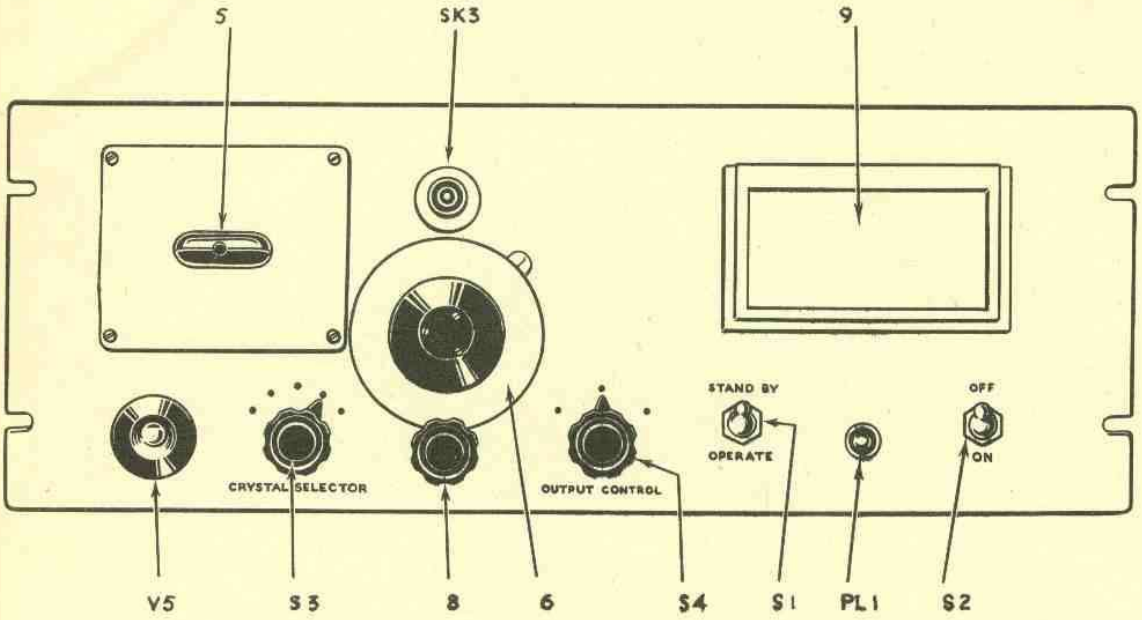


FIG. m

1. GENERAL.

The Crystal Monitor Type 4, is designed to deliver a small modulated radio frequency signal in the range 100/130 Mc/s for the calibration of V.H/F receivers.

The instrument enables rapid and accurate change of frequency to be made to any one of five spot frequencies.

Five quartz crystals of frequencies between 5·55 and 6·9 Mc/s are fitted, any one of these may be selected by means of a rotary switch. The output frequency is, in each case, 18 times that of the crystal, due to frequency multiplying stages included in the monitor.

The Power Supply is normally obtained from 50 cycle A.C. mains of any voltage between 190 and 250, a self-contained rectifier, transformer and smoothing system being incorporated. Provision is made for the alternative use of batteries for H.T. and L.T. supply.

A line drawing of the Monitor is shown in Fig. m, and a simplified circuit diagram in Fig. n.

2. CONSTRUCTION.

The instrument is designed for rack mounting but may also be used on a bench. The front panel is 19 inches wide and 7 inches deep. An inspection cover of the crystal compartment is secured to the front panel by four coin-headed screws.

3. CONTROLS.

TUNING CONTROL (8). A slow motion control for varying a three gang condenser assembly. Used to tune the Monitor to the frequency selected by CRYSTAL SELECTOR SWITCH S3. The output frequency will be crystal frequency multiplied by eighteen.

TUNING DIAL (6). Calibrated in Mc/s and in conjunction with HAIR LINE 7 is used to set TUNING CONTROL 8 to the approximate output frequency before final adjustments are made.

CALIBRATION CARD (9). Provides a means of speeding up the operation of the MONITOR and thus the time taken to tune the receiver to a new spot frequency. The following details should be entered on CALIBRATION CARD. The crystal frequency of each of the five crystals fitted in the crystal compartment. The output frequency of the respective crystals. The numbered position of the CRYSTAL SELECTOR SWITCH S3, when each crystal is being used. The position of the TUNING DIAL, when the circuits are accurately tuned by means of the TUNING INDICATOR V5, for the five spot frequencies.

CRYSTAL SELECTOR SWITCH (S3). A single pole, five position switch, used to select any one of five crystals. The crystal selected is connected between grid and cathode of valve V1 by the action of this switch. The five positions are numbered 1 to 5.

OUTPUT CONTROL SWITCH (S4). A single pole, three position switch marked MAX., MED., and MIN. Used to vary the output of the monitor and thus allow the receiver to be tuned to a high degree of accuracy.

TUNING INDICATOR (V5). Provides a visual indication to show when the modulator circuits are accurately tuned. The tuning point is indicated by the MAXIMUM illumination of the fluorescent screen or alternatively the MINIMUM amount of shadow on the screen.

CRYSTAL COMPARTMENT COVER (5). Completes the screening of the grid or crystal circuit when in position and when removed, provides access to the crystal holders.

A.C. SUPPLY PLUG (P2). Two pin plug for connecting A.C. supply mains to rectifier transformer T2, via ON-OFF SWITCH S2.

ON-OFF SWITCH (S2). Double pole switch, wired to operate as a single pole switch. When A.C. supply is used one pole completes the supply to the mains transformer. When battery supply is being used the second pole completes the L.T. supply to the heaters of all valves.

PILOT LAMP (PL1). Indicates when supply is completed to heater circuit of valves. Will operate whether supply is from A.C. supply mains or batteries providing the MONITOR SUPPLY PLUG P1 is connected to the appropriate supply socket (SK2) or (SK1). The Pilot lamp has a red shade and will light when ON-OFF SWITCH (S2) is made to the ON position.

MONITOR SUPPLY PLUG (P1). Carries the monitor supply leads and is attached to a screened flexible cable. Used to connect the monitor supply leads to the BATTERY SUPPLY SOCKET (SK1) or the A.C. SUPPLY SOCKET (SK2).

BATTERY SUPPLY SOCKET (SK1). Provides a convenient method of changing over the monitor supply to batteries in case of emergency.

A.C. SUPPLY SOCKET (SK2). Normal supply socket. In conjunction with MONITOR SUPPLY PLUG P1 connects the output of the rectifier and heater supply voltage to the monitor.

OPERATE-STANDBY SWITCH S1. Double pole switch wired to operate as a single pole switch. It has two positions marked OPERATE and STAND BY. In the OPERATE or MADE position, and normal supply socket (SK2), being used, one pole completes the negative supply of the rectifier to earth, thus completing the H.T. supply to the monitor. In the STAND BY position the H.T. is broken. The heater supply will be on continuously having been completed by the ON-OFF SWITCH (S2).
When BATTERY SUPPLY SOCKET SK1 is being used, the second pole of S1 disconnects the positive H.T. line to the monitor when in the STAND BY position, and completes H.T. supply when to OPERATE. The heater supply is controlled by ON-OFF SWITCH S2.
Used to control the operation of the monitor.

OUTPUT SOCKET (SK3). Provides the connection for the small ROD AERIAL, supplied with the monitor, to the output circuit.

4. OPERATION.

Connect A.C. SUPPLY PLUG, P2 to supply mains and set OPERATE-STANDBY SWITCH S1 to the STAND BY position. Make ON-OFF SWITCH S2 to the ON position and the PILOT LAMP PL1 will light, indicating heater supply completed to the monitor. Wait approximately thirty seconds for the heaters to reach their working temperature and then place OPERATE - STAND BY SWITCH S1 to OPERATE. Completion of the H.T. supply to the monitor will be indicated by a glow on the screen of TUNING INDICATOR V5.

Select the crystal to be used by means of CRYSTAL SELECTOR SWITCH S3 and set the TUNING CONTROL 8 to the approximate output frequency as indicated by the TUNING DIAL 6, this being calibrated in Mc/s. After setting the OUTPUT CONTROL SWITCH S4 to MAX. tuning should be continued until the TUNING INDICATOR V5 shows a maximum area of brilliancy.

Care should be taken that the setting on the TUNING DIAL 6 corresponds with that marked on the CALIBRATION CARD 9 for the setting of the CRYSTAL SELECTOR SWITCH S3 otherwise there is a possibility that the 21st harmonic of a low frequency crystal, or the 15th harmonic of a high frequency crystal, might be selected.

The OUTPUT CONTROL SWITCH S4 should then be set to MIN., and the receiver tuned until a 1000 c/s modulation note is clearly heard. If the output is insufficient, the OUTPUT CONTROL SWITCH S4 may be set to MED., though care is necessary to tune to the strongest 1000 c/s signal, as unwanted harmonics, of sufficient amplitude to be heard in the receiver, may be present in the output.

When frequent use of the monitor is anticipated, the ON-OFF SWITCH S2 may be left ON, the OPERATE-STAND BY SWITCH S1 being left in the STAND BY position except when calibration of the receiver is actually in progress.

When the monitor is operated from battery supplies the OPERATE - STAND BY SWITCH S1 should not be left in the OPERATE POSITION, when the ON-OFF SWITCH S2 is in the OFF position, and the monitor is not being used. Under these conditions, the H.T. battery will discharge through the H.T. potentiometer R7 and R8.

TYPE 87

CRYSTAL MONITOR

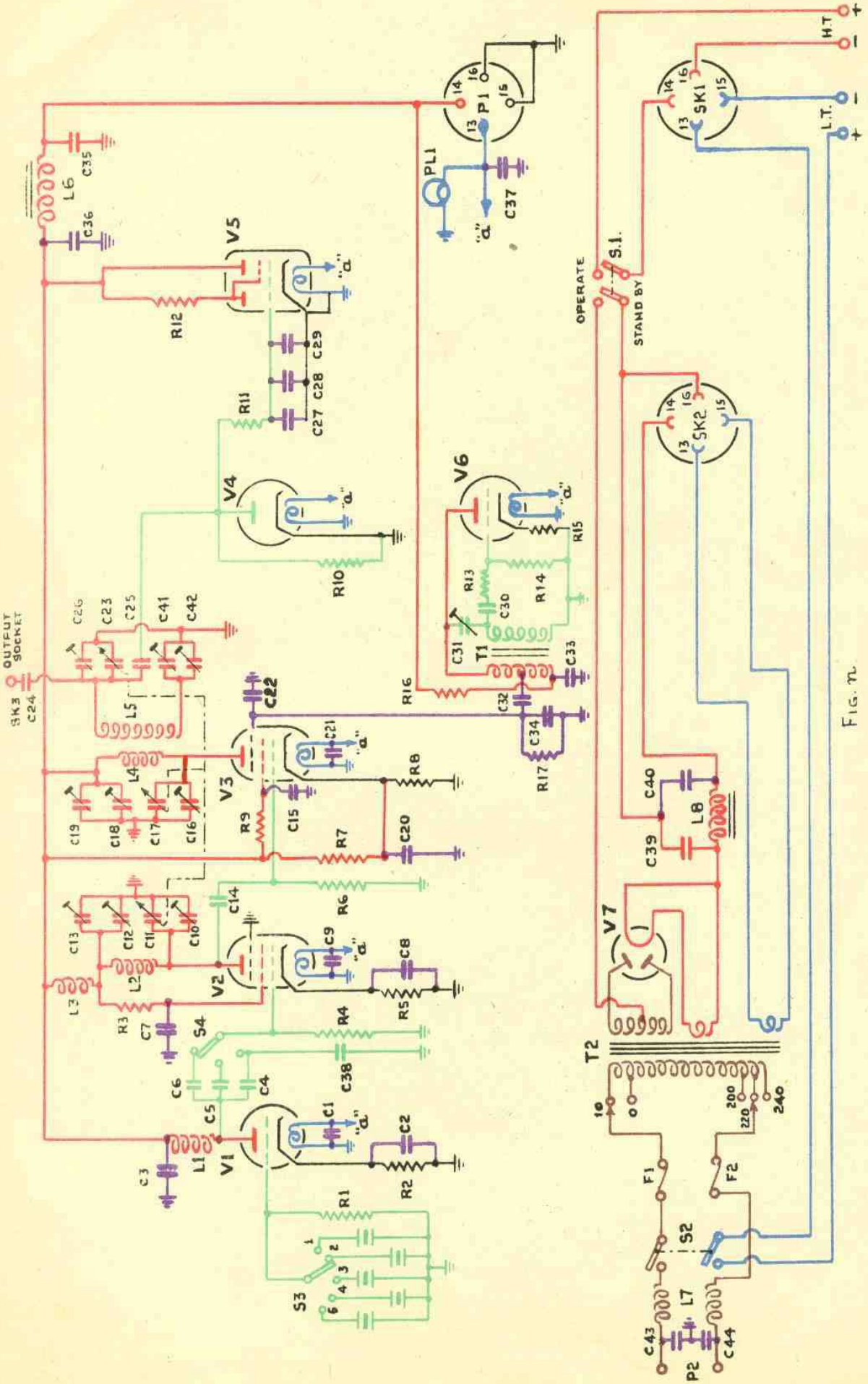


Fig. 11.

TYPE 87
CRYSTAL MONITOR

5. BRIEF TECHNICAL DESCRIPTION.

A simplified diagram of the Monitor is given in Fig. n.

The circuit consists of a crystal oscillator valve V1 followed by two pentode valves V2 and V3 operating as frequency multipliers. The second multiplying valve V3 is modulated at 1000 c/s by the A/F oscillator triode valve V6. The modulated output is fed to a local rod aerial. Part of the R/F output is capacity coupled to a diode valve V4, where it is rectified and used to operate the "Magic Eye" tuning indicator valve V5. The valve V7 is a full wave rectifying valve and supplies the H.T. voltage.

The oscillator frequency is determined by any one of five crystals as selected by the CRYSTAL SELECTOR SWITCH S3. The selected crystal operates as the tuned grid circuit of the VR66 valve, V1, and is shunted by the grid leak resistance R1 which provides part of the necessary grid bias. The anode circuit consists of an untuned R/F choke L1, which is designed to resonate at a frequency higher than that of the highest crystal frequency used. The coupling necessary for setting up oscillations is provided by the anode-grid capacity of the valve V1. Additional grid bias is obtained by means of the cathode resistance R2, which is by-passed by the condenser C2. The voltage set up across this resistance by the cathode current of the valve, provides a grid bias voltage even if the valve V1 is not oscillating, and therefore protects the valve against damage should the CRYSTAL SELECTOR SWITCH S3 be set in a position where no crystal is fitted.

The R/F voltage set up across the choke L1 is impressed upon the grid-cathode circuit of the VR91 valve V2, through one of three coupling condensers C4, C5, C6 as selected by the OUTPUT CONTROL SWITCH S4. When condenser C6 is selected the maximum coupling is obtained. When the coupling is obtained via the condenser C5, the impressed voltage is reduced, the condenser C5, in conjunction with the grid-cathode capacity of valve V2, acting as a potential divider. In the third position, the impressed voltage is further reduced, due both to the lower capacity of condenser C4 and to the insertion of a condenser C38 in parallel with the grid-cathode circuit of valve V2. The resistance R4 acts as a grid leak.

The anode circuit of valve V2 consists of the inductance L2, tuned by the variable condenser C11 and the trimming condenser C10, to parallel resonance at the sixth harmonic of the oscillator frequency. In addition a series resonant circuit is set up by the inductance L2 tuned by the condensers C12 and C13 to the mid-band frequency of the oscillator. This ensures a maximum impedance at the required harmonic frequency and a minimum impedance at the oscillator frequency, and favours the production of the required harmonics.

The H.T. supply to the anode and screen of the VR91, V2 is obtained through the R/F choke L3, the resistance R3 reducing the screen grid voltage to the required value. The condenser C7 acts as a R/F bypass. Grid bias is provided by the cathode resistance R5 which is by-passed by the condenser C8.

The voltage developed across the tuned choke L2 is capacity coupled by the condenser C14 to the grid of a VR91 valve, V3. The anode circuit of this valve is similar to that of valve V2. The inductance L4 is tuned to parallel resonance by the condensers C16 and C17, and to series resonance by the condensers C18 and C19. The resonant frequencies are respectively the 18th and the 6th harmonics of the oscillator frequency.

The lead connecting inductance L4 to the H.T. supply is designed to act as a high impedance to R/F current, and for this purpose a specially long lead is used. The voltage to the screen grid of valve V3 is reduced to the required value by the dropping resistance R9, which is by-passed by condenser C15. Grid bias is provided by a potential divider, consisting of resistances R7 and R8. The resistance R8 also carries the cathode current of valve V3 and is decoupled by condenser C20. This arrangement allows the grid bias voltage to be substantially independent of the anode current of the valve, maintaining conditions favourable to harmonic generation.

The suppressor grid of valve V3 is connected to earth through a resistance R17 the condenser C22 acting as a R/F by-pass. It is also connected through a potential divider consisting of the condensers C32 and C34 to the modulation transformer T1.

The inductance L4 is loosely coupled to the inductance L5 which is tuned to parallel resonance at the 18th harmonic of the oscillator frequency by condensers C23 and C26. It is also tuned by condensers C41 and C42, to series resonance at the 6th harmonic frequency.

The high potential end of inductance L5 is connected to the OUTPUT SOCKET SK3, through the coupling condenser C24. It is also connected through the coupling condenser C25 to the diode rectifier valve VR92, V4, which is loaded with resistance R10.

The output voltage developed across the load resistance R10, consists of the R/F component, the A/F component and the D.C. component due to the cathode current of valve V4. The D.C. voltage is applied through resistance R11 to the grid-cathode circuit of the triode portion of valve V5, VR92, the R/F and A/F components being by-passed to earth by the condensers C27, C28 and C29 respectively. The anode current of the triode part of V5 therefore varies in accordance with the R/F voltage developed across the inductance L5, and in so doing varies the voltage across the anode load resistance R12. The triode anode of valve V5 is connected internally to a deflecting electrode, shown as a grid in Fig. "O", which controls the electron flow to the fluorescent target electrode connected to the H.T. supply. The target is shown as an anode in Fig. "O". When the R/F voltage across the inductance L5 increases, the Maltese Cross shaped luminous portion of the target becomes brighter, and the arms of the cross become so wide as almost to touch each other.

The variable condensers C11, C17 and C23 are ganged together and are controlled by the TUNING CONTROL 8.

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CRYSTAL MONITOR

The VR67 triode valve V6 operates as an A/F oscillator, connected in a Hartley circuit and tuned to 1000 c/s by the condenser C31. The anode and grid coils form the two windings of the transformer T1, the grid coil being connected to the grid through the condenser C30 and the grid stopper resistance R13. Grid bias is provided by the grid leak R14 and the cathode resistance R15. The anode H.T. supply is reduced to a suitable value by the resistance R16 which is decoupled by condenser C33. A tapping on the anode coil provides the modulating voltage for the suppressor grid of the valve V3 through the coupling condenser C32.

6. SUPPLY CIRCUITS.

All the valves used in the Monitor are of the 6·3 volt indirectly heated type, and are automatically biassed. One side of the heater of each valve is connected directly to earth, and the other, marked "a" in Fig. "D", to the supply cable. The condensers C1, C9 and C21 act as R/F by-pass condensers across the heaters of the R/F valves V1, V2 and V3. The PILOT LAMP PL1 is connected in parallel with the heaters of the valves to indicate that the heater supply is completed.

The +H.T. line from the anodes of the monitor valves is connected through a filter circuit consisting of choke L6 and by-pass condensers C35 and C36, to the MONITOR SUPPLY PLUG P1. The plug P1 also carries the -H.T. connected to earth, and the heater leads, the lead "a" being earthed through condenser C37.

The MONITOR SUPPLY PLUG P1 may be placed in socket SK1 arranged for battery supply, or alternatively in the socket SK2 arranged for A.C. mains supply. When the SUPPLY PLUG P1 is placed in socket SK1, the -H.T. and -L.T. leads are connected together and earthed, the +H.T. being completed by one pole of the OPERATE-STAND BY SWITCH S1, and the +L.T. by one pole of the ON-OFF SWITCH S2.

When the SUPPLY PLUG P1 is placed in socket SK2, the L.T. leads are connected directly to the heater winding of the mains transformer T2, and the +H.T. lead to the filament of the VU39 rectifying valve V7, through a smoothing unit consisting of the choke L8 and condensers C39 and C40. The -H.T. lead is connected to the centre tap of the H.T. winding of the transformer T2 through one pole of the OPERATE-STAND BY SWITCH S1.

The outer ends of the H.T. winding are connected to the two anodes of the full wave rectifying valve V7. The filament supply for valve V7 is obtained from a secondary winding on transformer T2.

The primary winding of this transformer is connected through fuses F1 and F2 to the A.C. SUPPLY PLUG P2, one lead passing through one pole of the ON-OFF SWITCH S2.

The mains filter consisting of chokes L7 and condensers C43 and C44 prevent any radiation through the mains.

When supplied with A.C. the power consumption of the Monitor is approximately 50 watts (0·22 amp. at 230 volts). If batteries are used, the power consumption for L.T. is 2·5 amps at 6 volts, and for H.T., 60 milliamps at 200 volts, or 35 milliamps at 120 volts.