# The ARR3 Sonobuoy Receiver

## Conversion for V.H.F./F.M. Broadcast Reception

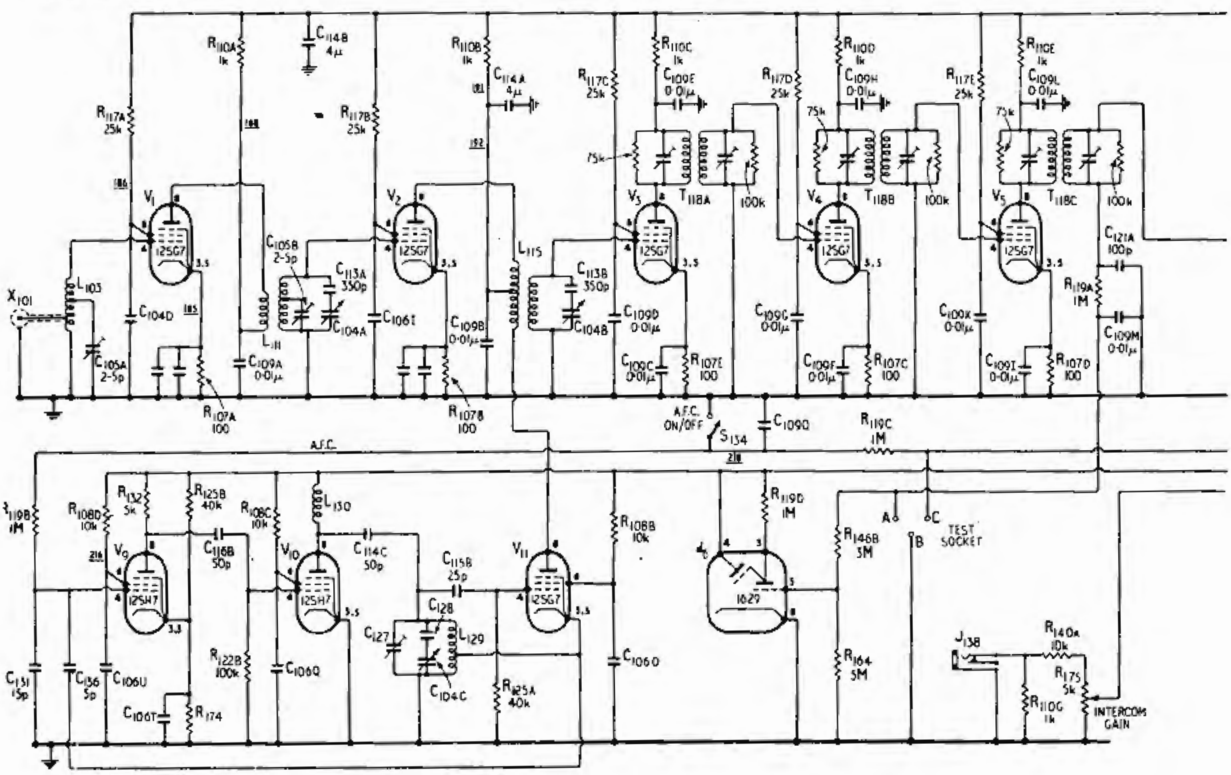
**By *CAPT. R. V. TAYLOR****

THE R2A/ARR3 is an American "Sonobuoy" receiver covering the band 60-72Mc/s. It is housed in a neat metal cabinet and is available on the surplus market at a most modest price for a 13-valve receiver. In its unmodified form it lacks a power supply but room can be found on the chassis for the necessary components to make it a complete, self-contained f.m. receiver. An older version, the R2/ARR3, is also available; it has no intercommunication facility but is otherwise an identical set.

The receiver uses 12SG7 r.f. pentodes for the two r.f. amplifiers, mixer, local oscillator and two i.f. amplifiers. The remaining stages also use valves with 12-volt heaters; the Foster-Seeley discriminator a 12H6; two a.f. stages, 12SQ7 and 12A6; two a.f.c. valves and limiter 12SH7s, and the tuning indicator a 1629. As can be seen from the circuit diagram (Fig. 1) the design contains little that is unusual. The grid circuit of $V_1$ is naturally broad band and is tuned only by a trimmer tapped down the coil. The input impedance of a 12SG7 is low at 90Mc/s and damps the tuned circuit heavily. The grid circuit of $V_2$ is tuned by a section of the three-gang variable capacitor. This stage shares the anode decoupling capacitor of the local oscillator and is inductively coupled, with the oscillator output, to the grid of the mixer. The mixer and local oscillator are tuned by the two remaining sections of the three-gang capacitor. The local oscillator operates below the signal frequency. The i.f. is 5Mc/s.

The local oscillator circuit is quite conventional except for the two connections to the reactance modulator and the phase-shifting valve. An r.f. voltage is taken from the oscillator cathode by a 5-pF capacitor to the grid of the phase shifter ($V_9$). This valve derives its grid-control voltage from the discriminator via a low-pass filter. A voltage-dividing circuit, connected across the h.t. supply, maintains the cathode at a constant positive voltage. The anode load resistor ($R_{122}$) is very low compared with the anode impedance. The output of this valve is coupled by a 50-pF capacitor to the grid of the reactance valve ($V_{10}$). The r.f. voltage at the grid of the reactance valve will be approximately 180° out of phase with the phase-shifter grid voltage, the difference from 180° depending on the control-grid voltage of the phase-shifter (which is derived

* Royal Corps of Signals.



from the discriminator) and the intervalve-coupling phase shift. The anode of the reactance modulator is coupled to the oscillator tuned circuit by a 50-pF capacitor. The a.f.c. can be switched off by earthing the control voltage, $S_{134}$ serving this function.

Two i.f. stages follow the mixer. Their tuned circuits are damped by resistors and are tuned by air-spaced trimmers; primary and secondary of the i.f. transformers are clearly marked on the screening cans. There are no iron-dust cores. The limiter is operated at low anode and screen-grid potentials and the voltage is taken from its grid circuit to operate the tuning indicator.

A Foster-Seeley discriminator follows the limiter. The 50-pF capacitor connecting the limiter anode to the centre-tap of the secondary of the transformer is housed in the can. A test socket is provided to allow test equipment to be connected to the limiter grid circuit (A), earth (B), and the centre of the discriminator load (C). The triode a.f. amplifier ($V_{12}$) has two inputs, one from the discriminator and one from the intercommunication gain control. The intercommunication input jack on the front panel is intended for connection to a low-impedance source. The output transformer has two secondary windings, one high impedance and the other 250 Ω, which are connected to two jacks on the front panel. The inner springs of these two jacks are connected to dummy load resistors.

The heaters are connected in series-parallel pairs as the set is intended for use with a l.t. supply of 24 volts. The tuning indicator and 150-mA 6.3-volt dial lamp are connected in series with a 40 Ω wirewound resistor across the 24-volt line.

All wiring of any length is run in cable forms. The ends of such wires are numbered and reference will be made to these as, for example, "lead 191". The circuit diagrams show these numbers (underlined) where this assists identification of leads.

**Modifications.**—To modify this receiver for broadcast reception the first step is to clear the space on the chassis for the power supply components. The large 4-$\mu$F capacitors, $C_{114A}$ and $C_{114B}$, are removed; the leads marked 191 and 192 to $C_{114A}$ are kept together to be connected later to a physically smaller 4-$\mu$F capacitor. The output transformer, the 10-kΩ and 500-Ω load resistors on their groupboard, the three jacks and the intercommunication gain control are also removed.

The heaters are next re-wired to allow the use of a 12-volt supply and the table indicates the method of rewiring.

**TABLE**

| (a) Disconnect lead No. | (b) From | (c) Re-connect to lead No. | Remarks |
|---|---|---|---|
| 180 | $V_2$ | 179 | Do not disconnect existing connections of the leads in column (c) |
| 177 | $V_4$ | 176 | |
| 182 | $V_7$ | 181 | |
| (a) | $V_9$ | 174 | |
| 193 | $V_3$ | 178 | |
| (b) | $V_{12}$ | 172 | |

(Refer to Fig. 1 for lead identification numbering).

This will leave one side of each valve heater (except that of $V_8$) connected to the l.t. line. The tags on $V_2$, $V_3$, $V_4$, $V_7$, $V_9$ and $V_{12}$ from which leads have been taken should be earthed, and any decoupling capacitors no longer required should be removed.

Remove the end of the lead to the heater of $V_6$ from the 40-Ω resistor and take it to the end of lead 182 at $V_8$. Earth the end of the 40-Ω resistor so that the dial lamp is connected through it to earth. The four leads 171, 172, 174 and 183 should be removed from the power switch, connected together and taped.

Remove the earth wire and lead 222 from the power switch as no earth connections are to be switched in the new role of this switch. Remove the power supply socket $X_{135}$ and blank off the hole left in the front panel. The leads from this socket should be kept intact for connection to the new internal power supply. Blank off the holes left where the top two jacks were removed.

The illustrations of a modified receiver indicate possible locations of the components to be added. (The components marked "X" are not part of the modifications described in this article.)

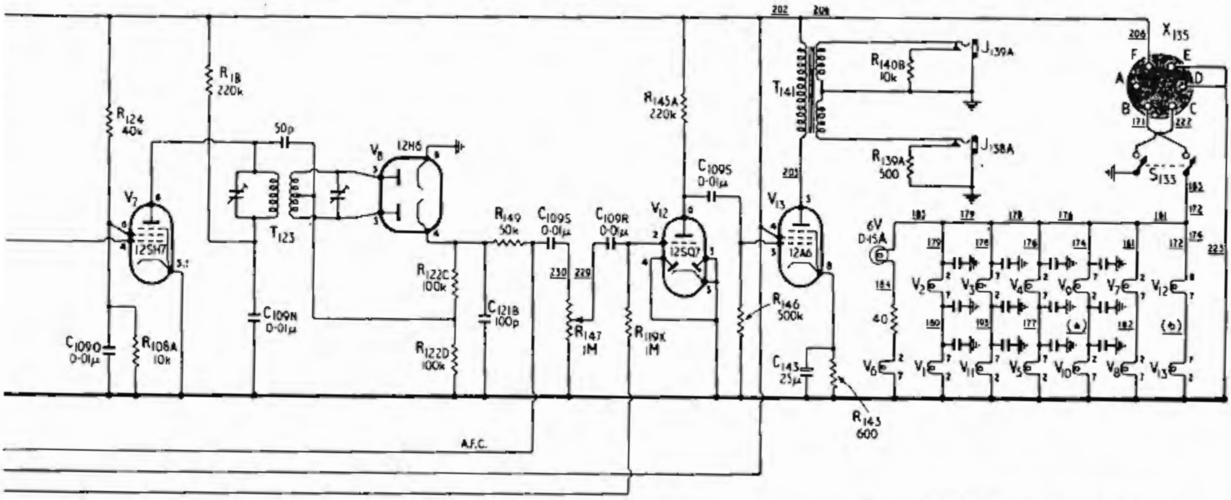


*Fig. 1. Circuit of the R2A/ARR3 before conversion. Unmarked capacitors are 500pF. Lead numbers are underlined.*

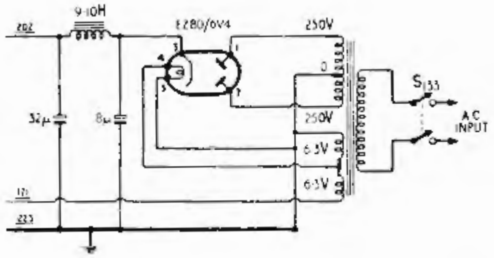



*Fig. 2. Power supply circuit and connections to existing leads in the receiver.*

A replacement type mains transformer with two 6.3-volt l.t. windings can be mounted on the right-hand rear corner of the chassis. The receiver l.t. consumption is about 2A and the rectifier requires 0.6A at 6.3V. A transformer rated at 6.3V, 2A and 6.3V, 2.5A is satisfactory. The two 6.3-volt windings must be connected in series in the correct sense to give the required 12.6 volts. The correct inter-connection is best found experimentally before the transformer is fitted. An h.t. supply of 250V, 80-90mA will be required. A B9A base for an EZ80/6V4 rectifier is fitted next to the transformer, in the space left by the removal of $C_{114A}$. A 9- to 10-H, 100-mA choke is mounted above the chassis between the 12H6 and the space left by the old output transformer. A substitute output transformer is mounted below the chassis where the group board carrying the 10kΩ and 500Ω resistors was previously fixed. Two of the jacks previously removed are replaced, one in the lower original position and one where the intercommunication gain control was fitted. The new electrolytic capacitors can be mounted below the chassis near the mains transformer, or above the chassis in any convenient spaces. Between them they should provide $8\mu$F for the reservoir and $32\mu$F for the filter of the h.t. supply and $4\mu$F to replace $C_{114A}$ which was part of the filter in the h.t. supply to the local oscillator.

The newly fitted power supply components should now be wired up, following the circuit shown in Fig. 2. The power supply switch ($S_{133}$) is used to switch the mains lead to the power transformer. One side of the series-connected heater windings is earthed and the other is taken to lead 171. The leads from the electrolytic capacitors to the smoothing choke are laced to the mains lead to the switch to make a

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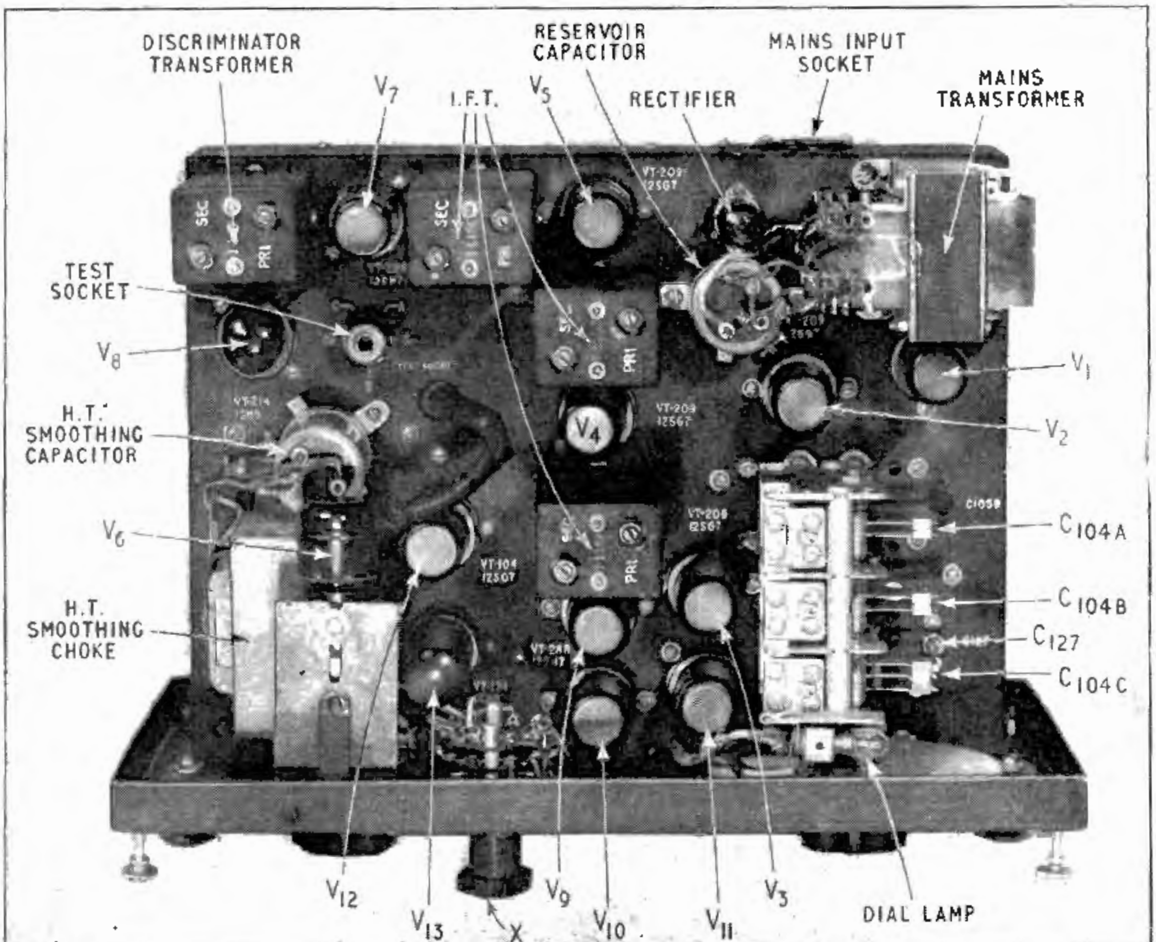
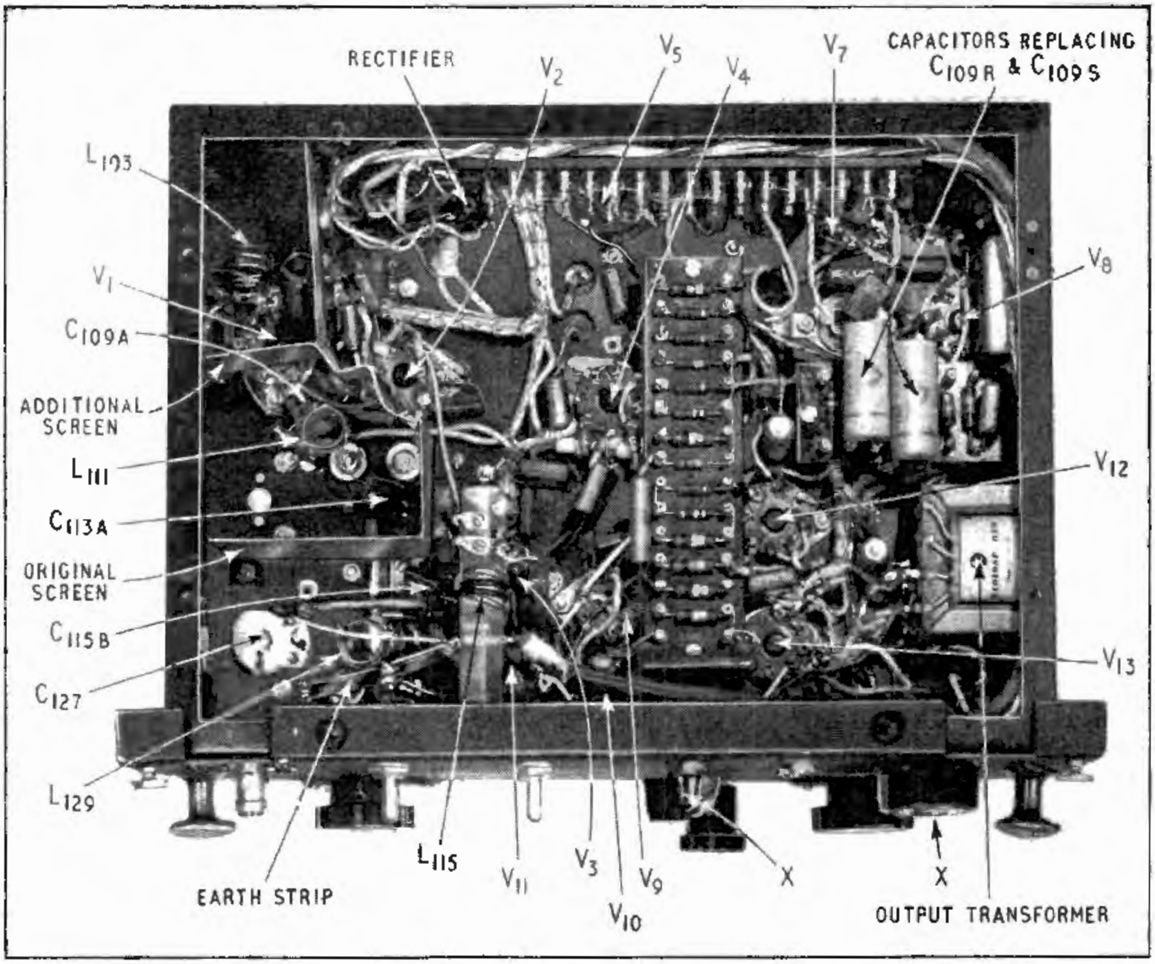



*Top view of the chassis after modification. Mains transformer, rectifier and reservoir capacitor are accommodated in the right-hand rear corner. N.B.: I.F.T.-primary trimmers are "live."*




*Under-chassis view after modification. Position of output transformer, extra r.f. screening and general lay-out are shown.*

neat job. The other power supply leads can be tucked into the angle at the bottom of the edge of the chassis.

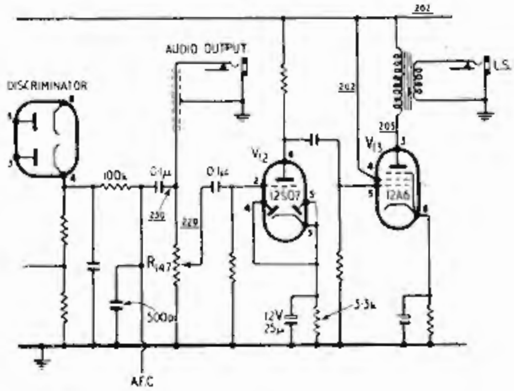
The output transformer primary is connected to the 12A6 anode and h.t. line, its secondary being taken to one of the jacks, for connection to an external loudspeaker. The 12A6 cathode-bias resistor is 600Ω which is a high value for the valve, but it keeps the h.t. current within reasonable bounds and it need not be changed. A screened lead is taken from the discriminator output (where lead 230 joins the group board) to the other jack.

The latter jack now allows the receiver to be used as a tuner together with an amplifier. $C_{109R}$ and $C_{109S}$ are removed and replaced by 0.1μF tubular paper components. These details are given in Fig. 3.

The 12SQ7 a.f. stage will operate satisfactorily without modification; but quality of reproduction might be improved by adding a cathode-bias resistor of 3.3kΩ and a 25μF by-pass capacitor. If the R2A version is being modified the "earthy" end of $R_{119K}$ (on group board between $C_{109R}$ and $C_{109S}$) must be connected to chassis.

The receiver should now be checked, using a signal generator if possible, and any faults cleared before the r.f. end is modified. It will be realized that the valves used in the r.f. stages of this receiver are not the best now available for frequencies up to 100Mc/s, but with a little rearrangement to reduce stray capacitance and shorten leads, a useful gain can be achieved. A single EF91 could be used to replace the two r.f. amplifiers and another as the mixer, but this would entail a considerable amount of stripping and rebuilding. It is simpler to use the

*Fig. 3. Modifications to the a.f. stages are shown here. Values of new components only are given.*

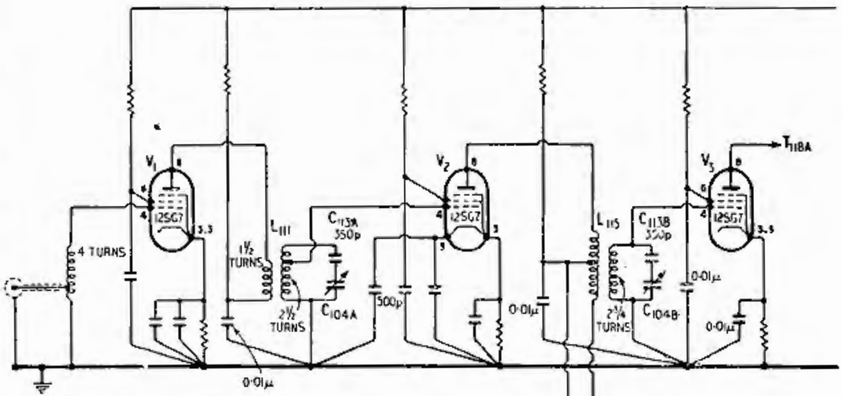


existing design as far as is possible.

Start by removing $L_{103}$ and $L_{111}$, $C_{105A}$, $C_{105B}$, $C_{113A}$ and its bracket. More screening will be required to prevent instability at the higher frequencies at which the set is now to be used. To effect this, a screen, the same depth as the existing one, is placed roughly parallel to the front panel passing over the valveholders of $V_1$ and $V_2$, so as to isolate the anode of $V_1$ and the grid of $V_2$ from the remaining pins of the valveholders. This screen cannot be straight, a couple of slight bends over $V_1$ and a 45° bend over $V_2$ will allow the screen to be made in one piece. Thin copper is the best material as the screen can then be soldered to conveniently placed earth tags. A second screen is required between the two r.f. amplifiers. This runs parallel to the side of the chassis, midway between the two valveholders, and is soldered to the earth tag already in place and to the first screen where it meets it. The amount of work involved can be reduced by first making paper templates and then transferring these to the sheet metal. The locations of these screens can be seen in the photograph of the underside of the receiver.

The r.f. stages can now be rewired where necessary. Fig. 4 shows the new circuit but most of the changes are in layout, not in circuitry. Stray capacitance must be drastically reduced to the absolute minimum. $L_{103}$ is replaced by a 4-turn coil of the same wire and diameter. This coil is damped and tuned by the input impedance of the first r.f. amplifier. The aerial is tapped one turn from the bottom. The coil is supported where it is connected to earth, aerial, and the grid of $V_1$ and a coil former is not required. It is placed so that the leads to it are as short as possible. All the 500-pF decoupling capacitors associated with $V_1$ are taken to the same earth tag on the valveholder.

$L_{111}$ is next replaced by a similar coil of 2½ turns; before this is fitted in place, the capacitor $C_{109A}$ decoupling the anode of $V_1$ (a moulded $0.01\mu F$ type) and the lead to it (188) are re-sited so that the high-potential end of the capacitor is close to the anode pin of $V_1$. The anode coupling coil of 1½ turns (insulated in the original sleeving) is interwound at the earthy end of the 2½-turn coil. The two coils are soldered in place over the decoupling capacitor, about half an inch above it, with their common axis at right angles to the chassis. A thermal shunt should be used to prevent melting of the sleeving during this operation. The grid of the second r.f. amplifier can now be tapped into the coil about half a turn from the top. The top of the coil is connected to the 350-pF capacitor $C_{113A}$ in series with the first section of the three-gang tuning capacitor. No trimmer is needed as the coil can be pulled out or compressed as required when aligning the r.f. stages. A 500-pF moulded capacitor is taken from the cathode of $V_2$ to the earthed end of the coil. A convenient point for the necessary earth tag is just at the end of $C_{109A}$, the $0.01\mu F$ anode decoupling capacitor.



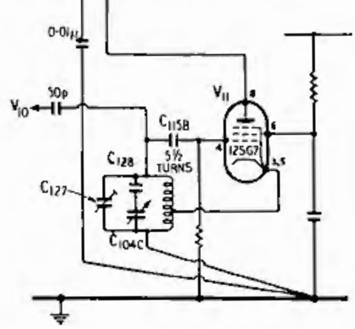



*Fig. 4. Re-arrangement of the two r.f. stages in the set. Each valveholder has two earth tags and these are used for earth return points of their respective stages.*

The mixer grid coil $L_{115}$, is now re-wound to 2¾ turns; the tag fixed to the coil former at the grid end of the coil is removed and a wire taken straight from the end of the coil to the grid tag on the valveholder. The 350-pF capacitor $C_{113B}$ is re-sited on the tag of the centre section of the tuning capacitor so that the shortest possible connection can be made direct to the grid of $V_3$. The braid leads earthing the rotor of the centre section of the tuning condenser to the chassis are replaced by leads direct to the earth tag on the mixer valveholder.

The oscillator tuned circuit in its original form is earthed to the chassis at several points. This is no longer satisfactory at the new higher frequencies to be covered. To prevent instability a flat strip of copper about a quarter of an inch wide is taken from the earth tag on the oscillator valveholder (at the mixer side) to the rotor earth contacts on the end section of the tuning capacitor ($C_{104C}$). This strip is then bent and passed back through a hole in the chassis to earth the rotor of $C_{127}$. The earth tag on $C_{127}$ must be moved through 120° to make this lead as short as possible. The strip should be insulated by sleeving where it passes through holes in the chassis.

Half a turn is then removed from the bottom of $L_{129}$ and the new end of the coil soldered to the earth strip. To make these operations easier both $L_{129}$ and $C_{127}$ should be removed. At the same time the tags and screws retaining them at either end of the coil should be removed. One turn is taken off the top end of the coil, which is reconnected to $C_{127}$ and the 500-pF capacitor $C_{128}$ in series with the end section of the tuning condenser, $C_{104C}$. An extra $0.01\text{-}\mu F$ mica decoupling capacitor should be connected from the h.t. positive end of the oscillator anode coil to the earth tag on the oscillator valveholder. $C_{127}$ is replaced and set to about 5° in mesh. The r.f. stages are now ready for alignment.

With a signal generator tuned to the h.f. end of the band and connected to the anode coil of $V_2$ (remembering that this is at h.t. potential), adjust $C_{127}$ until the signal is heard with the main tuning capacitor at nearly minimum capacity. Check that the oscillator is on the low-frequency side of the signal by increasing the capacity of $C_{127}$. Connect the signal generator to the aerial socket and adjust $C_{105A}$ and the second r.f. amplifier grid coil for maximum deflection of the tuning indicator. It is assumed that the i.f. stages are not in need of re-alignment or were re-aligned when the receiver was checked before modification of the front end. The i.f. transformer-primary trimmers are "live" to h.t. positive—an insulated trimming tool is recommended!

Should it be found that all three B.B.C. programmes cannot be tuned in, $C_{127}$ can be re-adjusted so that the Home Service is received with the tuning capacitor about 5° from the minimum capacity position. As in any one region the three programmes lie inside a band of less than 5Mc/s it should now be possible to receive all three.

The existing tuning scale can be moved round through 180° so that a blank black disc appears in the tuning window. The paint can then be scratched away to make suitable calibration markings. Alternatively, the black paint can be removed with paint remover and Indian ink used for the scale calibration.

No mention of a de-emphasis circuit has so far been made. A time constant of 50$\mu$sec is required for this circuit and the receiver is modified as follows. Remove the 50-k$\Omega$ resistor $R_{149}$ from pin 4 of the 12H6 to test point C and replace it by one of 100k$\Omega$. Connect a 500-pF capacitor across the tags of test points B and C. This will have no effect upon the a.f.c. but will provide the required top cut.

The i.f. tuned circuits may be re-aligned, if desired, to give greater bandwidth, as long as the limiter grid and anode tuned circuits are kept at the centre frequency. No measurements have been carried out but the bandwidth appears to be more than adequate as originally aligned on the centre frequency of 5Mc/s.

The modified receiver compares most favourably with the average broadcast receiver, sensitivity is good and signal-to-noise ratio high. Drift is only slight while warming up and the a.f.c. is effective except on very weak signals.