TUNER-AMPLIFIER B50

Date of Design:-	1938.
Frequency Range	550 to 23,000 kc/s.
Valves and method of coupling:-	Four NR51. Two NR52. One NR27A.

R/F amplifier, indirectly heated variable mu.

R/F pentode, NR51(1) coupled by transformer with tuned secondary.

First detector, indirectly heated variable mu.

R/F pentode, NR51(2). Coupled by transformer with tuned primary and secondary.

First heterodyne oscillator, indirectly heated triode.

NR27A(3). Coupled to suppressor grid of first detector.

Intermediate frequency amplifier, indirectly heated variable mu R/F pentode, NR51 (4). Coupled by transformer with tuned primary and secondary.

Second detector, indirectly heated variable mu.

R/F pentode, NR51 (5). Coupled by choke-capacity.

Second heterodyne oscillator, indirectly heated triode.

NR52(6). Coupled to suppressor grid of second detector.

A/F amplifier, indirectly heated triode, NR52(7).

Receiver Outfit CAD - Tuner-Amplifier B50 - has been designed for general purpose reception from 550 to 23,000 kc/s, covering auxiliary, aircraft spotting and H/F wave frequencies, and supersedes Receiver Outfits CP and CQ and filter-units in ships fitted with separated aerials.

Tuner-Amplifier B50 also constitutes the M/F and H/F part of Receiver Outfits CAB and CAE.

Tuner-Amplifier B50 is mounted in a standard receiving rack. Its weight is 94 lbs.

A circuit diagram of Tuner-Amplifier B50 is given in Fig.a and photographs of the model are given in Figs. c to f. Fig. b gives a simplified diagram of the tuner circuits.

Tuner-Amplifier B50 is a superheterodyne receiver with an intermediate frequency of 237 kc/s. There is a single stage of R/F amplification, separate first heterodyne oscillator and first detector valves for frequency changing, one stage of amplification at the intermediate frequency followed by a second detector and one A/F stage which may be used as a note selector. A second heterodyne oscillator is provided for beat frequency reception of C.W. signals.

A two-stage tuner precedes the R/F valve. Either one or both of these stages may be connected in circuit by plugging the aerial connection into jacks marked "Aerial 1 Stage" and "Aerial 2 Stages" respectively. The first of these aerial positions is intended for normal reception without local interference. The 2-stages position should be used when own ship is transmitting to reduce interference, and the risk of overloading the first amplifying valve.

The frequency range of the model is covered in six steps by sets of separate inductance coils. These coils are arranged around the periphery of capstan mountings which can be rotated by two handles (124) (125) on the front panel of the model so as to bring each set of coils in turn into position to make contact with springs connecting them into the circuit.

The frequency ranges of the six sets of coils are as follows:-

Position of Capstan handle	Kc/s.
1	550 - 1,000
2	1,000 - 1,900
3	1,900 - 3,600
4	3,600 - 7,000
5	7,000 - 13,000
6	13,000 - 23,000

Of the two handles for wave changing, the left hand (124) marked Range Switch "A" operates the capstan carrying the first aerial circuit and first heterodyne range coils (9) (10) (43); the right hand (125) marked Range Switch "B" changes the second aerial circuit and R/F amplifying range coils (14) (15) and (28) (29).

There are three main tuning condenser dials in Tuner-Amplifier B50. The left-hand dial (11) tunes the first aerial circuit and is only used when the aerial is plugged into aerial 2 stages position. The centre dial (44) tunes the 1st. heretodyne oscillator. The right hand dial (16) (30) tunes the second aerial circuit and R/F stage, the two tuning condensers for these circuits being ganged together. All these dials are of the quick-wave-change type. A small dial (54) near the centre of the model gives fine tuning on the first heterodyne oscillator.

The main tuning condensers (11), (16), (30) and (44) of the tuner primary and secondary, the R/F amplifier and first heterodyne oscillator respectively, all have a maximum capacity of approximately 0.0003 mfd. The two condensers (16) (30) which are ganged together are set to have equal capacities at 10 degrees of the scale by means of an adjustable coupling.

The minimum tuning capacities are set by trimming condensers (12) (17) (31) and (45). Each of the range coils of the R/F amplifier circuit has its own trimming condenser (31) so that the ganging between this circuit and the second tuner circuit can be corrected on each range. All internal adjustments to condensers are made before the model is issued and should on no account be altered.

2. TUNER CIRCUIT.

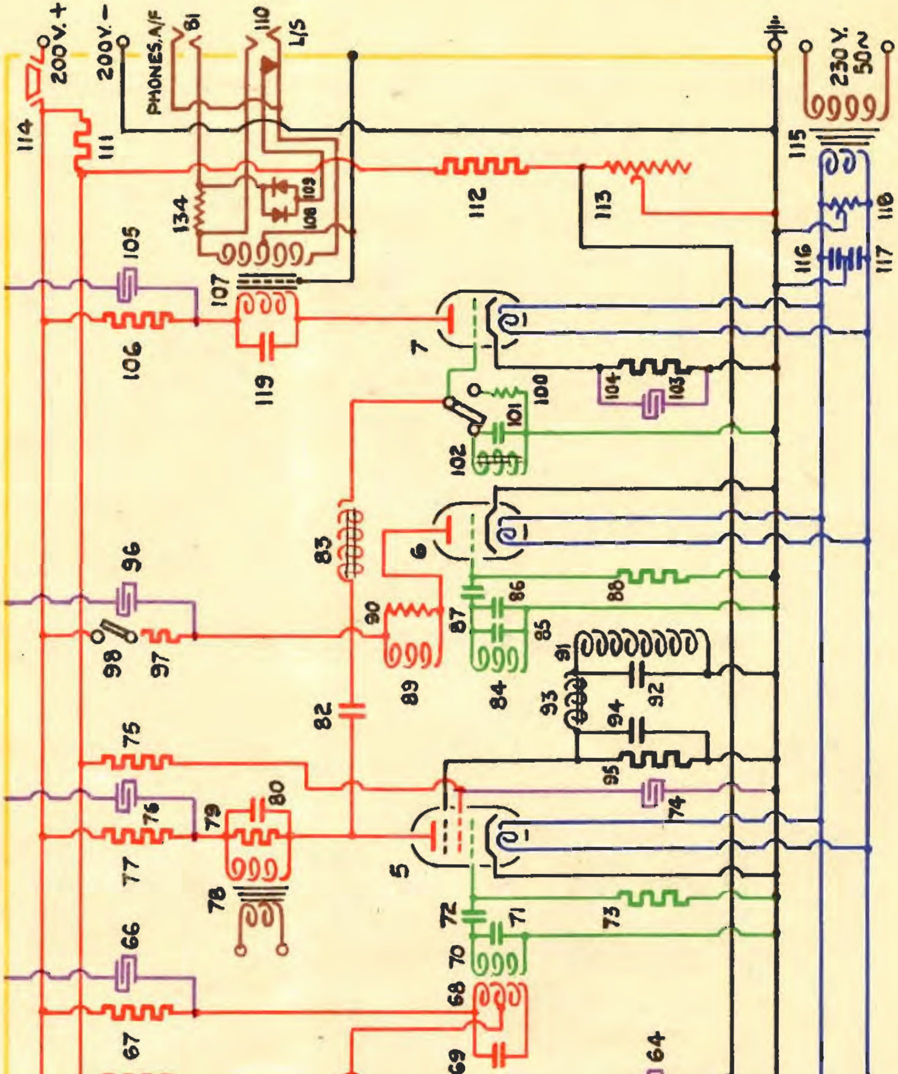
The aerial is connected to the tuner by a screened lead and 3-point plug which is inserted into the appropriate jack marked Aerial 1 stage (13) or Aerial 2 stages (8) corresponding to the number of tuned circuits in use. The screening of the lead is earthed at the model through the ring contact on the jack.

The insertion of the aerial plug into the Aerial 1 stage jack (13) disconnects the coupling from the first tuner circuit and connects the aerial to the second tuner circuit through the coupling coil (14) (see Fig.B (i)) which matches the impedance of the aerial cable (approximately 80 ohms). A similar coupling coil (9) connects the aerial to the first tuner circuit when the aerial is inserted into the Aerial 2 stages jack (8).

The two tuner circuits are inductively coupled on ranges 1 to 4 by fixed coupling coils provided by tappings on the coupling inductances (14). The inductive branch of the primary tuned circuit is through the inductance (10) in the left hand capstan to the outside contacts of the jack (13), thence through a screened cable to the right hand capstan through the upper part of the coupling coil (14) and back again through the screened cable to the earthed contact of the jack (13). (See Fig. B (ii)).

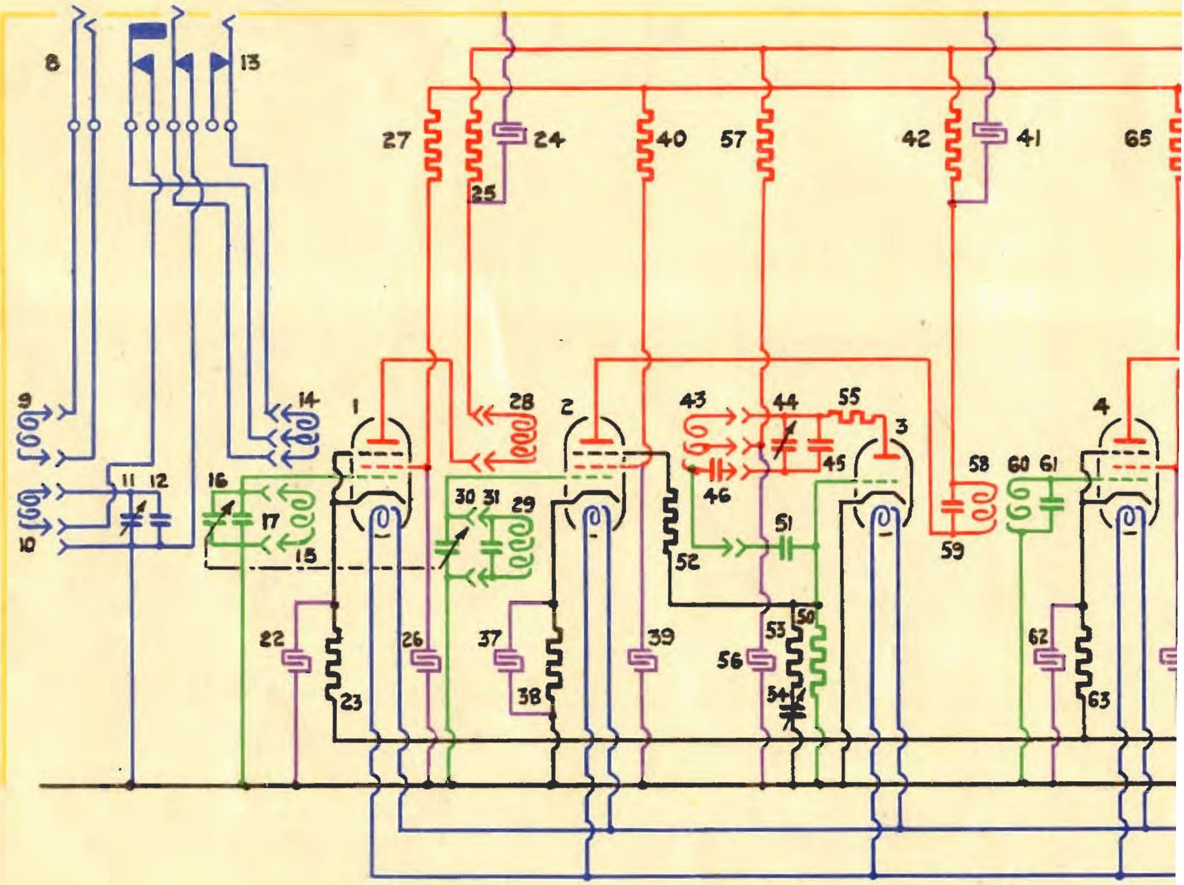
On ranges 5 and 6 capacity coupling is used, provided for by the small condensers (18) (19) and (20) (21) carried on the capstan coil mountings. (See Fig.B (iii) and (iv).). The second tuner circuit (15) (16) (17) is connected between the grid of the R/F amplifying valve (1) and earth.

TUNER AMPLIFIER B50



RAM.

CIRCUIT DIAG

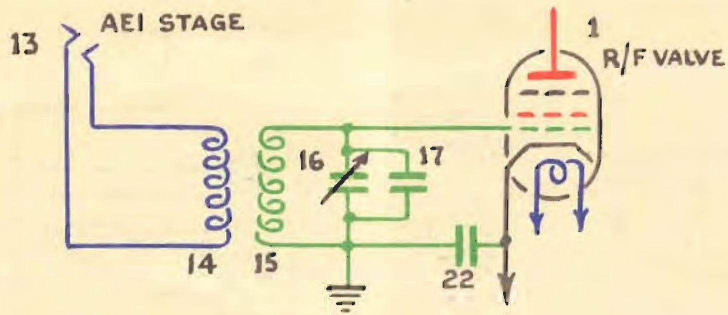


Fig

TUNER-AMPLIFIER B50

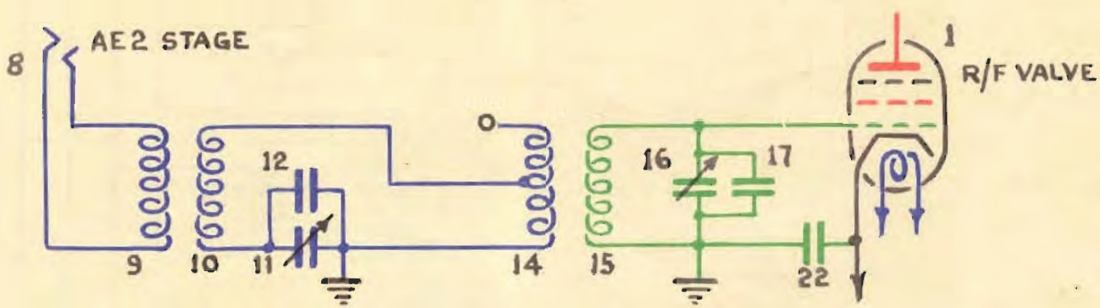
TUNER CIRCUITS SIMPLIFIED

TUNER, ONE STAGE (AERIAL PLUG INSERTED IN "AE1" JACK) RANGES 1 TO 6.



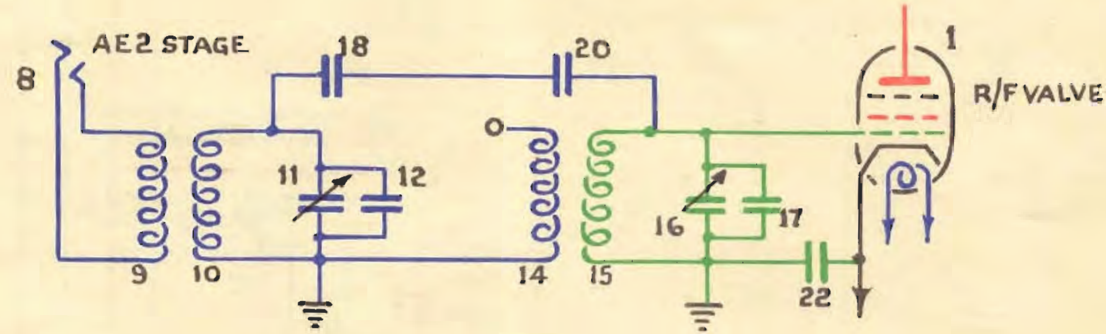
(i)

TUNER, TWO STAGES (AERIAL PLUG INSERTED IN "AE2" JACK) RANGES 1 TO 4.



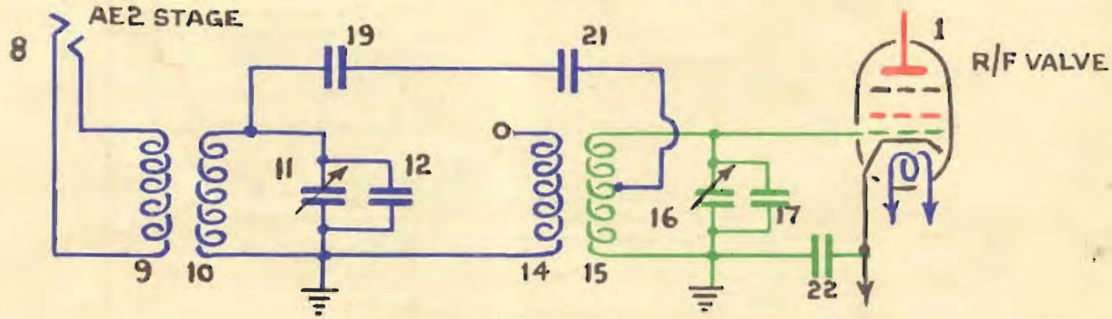
(ii)

TUNER, TWO STAGES (AERIAL PLUG INSERTED IN "AE2" JACK) RANGE 5.



(iii)

TUNER, TWO STAGES (AERIAL PLUG INSERTED IN "AE2" JACK) RANGE 6.



(iv)

FIG. 6.

3. R/F AMPLIFIER CIRCUIT.

The coupling between the R/F valve (1) and the first detector or mixing valve (2) is by means of transformers with untuned primaries (anode inductance) (28) and tuned secondary circuits (29) (30) (31). The secondary circuit is connected between the grid of the first detector valve (2) and earth.

4. FIRST HETERODYNE CIRCUIT.

The first heterodyne oscillator valve (3) has a tuned circuit between anode and grid. The inductance of this circuit (43) has a tapping point to which the H.T. supply to the valve (3) is connected, and this point is earthed for high frequencies by a short path through a decoupling condenser (56). The inductance (43) is tuned by the variable condenser (44) with its trimming condenser (45). On ranges 1, 2 and 3, three fixed condensers (represented by 46) are connected in series with the tuning condenser (44) to give the necessary frequency difference of 237 kc/s (i.e. supersonic beat frequency) between the first heterodyne oscillator and the incoming signal. On ranges 4, 5 and 6 this frequency difference is only a small fraction of the signal frequency and no series condensers are provided.

The grid of the first heterodyne oscillator valve (3) is connected through a resistance (53) to a small variable condenser (54), the other side of which is connected to earth. This condenser provides for fine tuning of the first heterodyne by virtue of the fact that it is connected through earth and (49) in parallel with half the tuning inductance (43). The series resistance (53) limits the effect of the condenser at the highest frequencies so that the tuning is not unduly sharp, while on the low frequency ranges the resistance has little effect.

The tuned circuit of the oscillator is connected to the anode of the first heterodyne valve (3) through a small resistance (55) to prevent parasitic oscillations.

The connection to the grid is through the grid condenser (51) with its associated grid leak resistance (50).

The oscillating potential of the first heterodyne is applied to the suppressor grid of the first detector valve (2) through a resistance (52). This method of coupling gives practically no interaction between the tuning of the detector and oscillator circuits.

5. I/F AMPLIFYING CIRCUITS.

The beat frequency between the first heterodyne and the incoming signal is selected by the tuned anode circuit (58) (59) of the first detector. This is tuned to the supersonic frequency - 237 kc/s - and coupled to the similarly tuned grid circuit (60) (61) of the amplifier valve (4). A similar pair of tuned circuits (68) (69) and (70) (71) couple the I/F amplifier valve (4) to the second detector valve (5), but in this case the anode of the I/F valve (4) is connected to a tapping on the inductance (68) giving greater selectivity and stability.

The condensers (59) (61) and (71) are set up and clamped to tune the I/F circuits to the correct frequency before the model is issued. These adjustments should not be altered.

6. SECOND DETECTOR.

A grid condenser (72) and resistance (73) are provided for cumulative grid detection of I.C.W. or R/T signals by the second detector valve (5). For reception of C.W. signals a second heterodyne or beating oscillator is connected to the suppressor grid of the second detector valve (5).

7. SECOND HETERODYNE.

The second heterodyne valve (6) has a tuned grid circuit (84) (85) (86) with grid condenser (87) and leak resistance (88).

The anode coil (89) is shunted by a resistance (90) to damp out harmonics near the resonant frequencies of the inductance (89) and its self capacity.

The coupling from the second heterodyne to the suppressor grid of the second detector valve (5) is through a flat resonant circuit with a small inductance (91) and comparatively large condenser (92), tuned to the I/F and a low pass filter (93) (94) terminated by a resistance (95). This coupling circuit is designed to cut out harmonics of the second oscillator which might otherwise get back into the R/F circuits and produce undesirable heterodyne whistles at a number of points on the tuning scale. The second heterodyne has an "On-Off" switch (98) in the H.T. supply lead.

8. NOTE SELECTOR AND A/F STAGE.

The detector anode circuit is provided with a telephone transformer (78) the secondary winding of which is not, however, now used. The primary winding of this transformer is flatly tuned to approximately 1000 cycles by the condenser (80) which also acts as a shunt for the I/F, and is shunted by a resistance (79) to damp out key click interference. This tuned primary winding normally acts as a tuned choke coupling to the grid of the A/F valve (7) which is connected through a blocking condenser (82) and H/F choke (83).

The note selector switch (99) connects the grid of the A/F valve to earth either (a) through a grid leak resistance (100) or (b) through a rejector circuit (101) (102) which is sharply tuned to approximately 1000 cycles per second.

9. OUTPUT LIMITER - TELEPHONE AND LOUDSPEAKER JACKS.

The telephone transformer (107) in the output circuit of the A/F valve (7) has a screened secondary winding which is earthed at the centre point and connected by screened leads to the two output jacks (81) (110) in parallel. These jacks are marked "Phones A/F" and "L/S" respectively. Two metal rectifiers (108) (109) are connected in opposition between the 'tip' contact and the opposite inside contact spring of the L/S jack (110) in such a way that they are disconnected when a plug is inserted in this jack but connected across the output when the plug is removed. These rectifiers act as a limiting device to reduce the loudness of interfering key clicks or pulse interference or to cut down the output from local transmissions when listening through without reducing the strength of weak signals. They can be connected or disconnected at will by plugging the telephones either into the "Phones A/F" jack (81) or the "L/S" jack (110). A 1000 ohm resistance (134) connected in series with the transformer secondary and one of the leads to the telephone jack (81) increases the efficiency of the limiting device. The L/S jack can be used to drive a small loudspeaker of 600 ohms impedance at a maximum output of 200 milliwatts. A 3-point output plug must always be used for connecting phones or loudspeaker to either of these jacks; if a 2-point plug is used half the secondary winding of the output transformer will be short-circuited owing to the sleeve contacts of the jacks being earthed through the frame of the model. When a 3-point plug is used with a screened output lead the screening of this lead should be connected to the sleeve contact.

10. H.T. HEATER SUPPLIES AND BIASSING ARRANGEMENTS.

The L.T. supply for the heaters of the valves is obtained from a 230/4 volts step-down transformer (115) fitted in the model. Condensers (116) (117) are connected across the 4-volt heater supply and condensers (126) (127) are connected across the first heterodyne filament circuit to reduce coupling between the valves. The 230 volts are obtained from the 50 cycle supply of the Patt. 1204 Rectifier, Design 'B' used with the outfit. This rectifier also provides a stabilised 200 volts D.C. supply for the H.T. model.

The H.T. supplies to all the valves are decoupled by series resistances (25) (42) (57) (67) (77) (97) (106) and shunt condensers (24) (41) (56) (66) (76) (96) (105). The H.T. supply to the screens of the R/F and I/F amplifying and detector valves is obtained from a fixed point on a potentiometer connected across the H.T. supply and consisting of two fixed resistances (111) (112) and a variable resistance (113) which also provides the variable grid bias to the R/F and I/F amplifying valves. Decoupling resistances (27) (40) (65) and (75) and by-pass condensers (26) (39) (64) and (74) are also used in the screen grid connections. The variable resistance (113) is controlled from the front of the model by a knob marked "Volume Control".

Grid bias is provided for the first detector and A/F valves by means of fixed resistances (38) (104).

A safety switch (114) on the door of the Tuner-Amplifier B50 disconnects the H.T. supply while changing valves or resistances.

A potentiometer (118) with variable earth tap is connected across the 4-volts winding of the transformer supplying the heaters for the cathodes of the valves. This is adjusted to reduce the hum from the A.C. supply to a minimum.

The total H.T. current required by a Tuner-Amplifier B50 is approximately 45 milliamps. The 230 volt A.C. supply for the heater transformer requires 0.15 amps.

11. SCREENING.

The following parts of the receiver are enclosed in separate screened compartments to prevent unwanted couplings between various circuits in the model.

First heterodyne oscillator circuit (43) to (51).

Second heterodyne circuits (84) to (92).

Second heterodyne filter inductance (93).

I/F transformer (58) to (61).

Second detector transformer (68) to (71).

Second detector telephone transformer (78).

Note selector inductance (102).

Output transformer (107).

Output jack and metal rectifiers (108) (109) (110).

230/4 volts heater transformer (115)

In addition many of the connecting leads are screened.

12. DOUBLE TUNING OF FIRST HETERODYNE.

In Tuner Amplifier B50, as in all superheterodyne receivers, signals are received when the first heterodyne is tuned to a frequency which differs from the signal frequency by an amount equal to the intermediate frequency (i.e., 237 kc/s in Tuner Amplifier B50), and the heterodyne frequency can either be higher or lower than the signal frequency by this amount. It should therefore be possible to receive any signal at two different tuning points of the first heterodyne. This can actually be done on ranges 4, 5 and 6 of the B50, and towards the high frequency end of ranges 2 and 3. On Range 1 and on the lower frequency end of ranges 2 and 3, this second tuning would be off the end of the condenser scale and is therefore unobtainable.

For convenience of operation, the heterodyne frequencies on every range have been adjusted so that the "HET. 1" condenser scale reading for the higher of the two possible frequencies i.e. signal frequency plus 237 kc/s shall agree fairly nearly with the readings of the "TUNER 1" and "TUNER 2" condenser scales when tuned to the signal. The receiver also gives the highest amplification for this heterodyne setting, and the approximate calibrations on the dials are for this setting. On the lower frequency ranges the two possible settings, if obtainable, are far apart on the condenser scale and there is no difficulty in selecting the correct one. On the high frequency ranges, however, the two tuning points come closer together until at 23,000 kc/s the separation is only about 2 degrees on the scale. In every case, however, the tuning which gives the highest reading on the heterodyne condenser scale is the correct one.

There is one possible case when it is desirable to use the lower heterodyne tuning for reception. This occurs when interference is experienced from a signal or harmonic 237 kc/s above the heterodyne frequency. For example, when receiving a signal on 10,000 kc/s the first heterodyne is normally tuned to 10,237 kc/s, but a strong signal on 10,474 kc/s would also give a beat frequency of 237 kc/s, which would be amplified in the I/F stages and cause interference. In this case the interference can be cleared by retuning the first heterodyne of Tuner-Amplifier B50 to the lower point giving a frequency of 9,763 kc/s (10,000 - 237). To find this tuning on the calibrated dial the first heterodyne tuning condenser only would have to be set to the adjustment for 9526 kc/s (10,000 - 2 x 237).

13. OPERATION.

(i) To set hum potentiometer (118).

(a) Set the range switch 'B' (125) to 1.

(b) Set the range switch 'A' (124) between two numbers (i.e. disconnected).

(c) Unplug the aerial.

(d) Switch off second heterodyne (i.e. pull out second heterodyne switch (98) to 'Off' position).

(e) Set volume control (113) full on.

(f) Set note selector switch (99) to 'Out'.

(g) Adjust hum potentiometer to silent point. (This adjustment should require no further attention).

(ii) To tune in a C.W. signal (or wavemeter oscillator) on a wave frequency for which the adjustments are not exactly known.

(a) Plug aerial into Aerial 1 stage (13).

(b) Switch on second heterodyne (98).

(c) Set range switches A and B (124) (125) to appropriate range.

(d) Set note selector switch (99) to "Out".

(e) Set first heterodyne condenser (44) to approximate calibration and R/F tuning condensers (16) (30) to a point near it, giving maximum noise level.

(f) Increase volume control (113) to give an appreciable noise level in telephone.

(g) Search very gradually with first heterodyne condenser (44) following up with R/F tuning condenser (16) (30).

When signal is found :

(h) Tune note up to convenient pitch with heterodyne vernier condenser (54).

(j) Carefully retune R/F condenser (16) (30) reducing the volume control (113). as necessary.

NOTE :- When tuning in a signal it is preferable to plug the telephones into the L/S jack (110) so as to disconnect the output limiter. With the telephones plugged into the "Phones A/F" jack (81) the limiter tends to reduce all strong signals to the same level as any interference, with the result that the selectivity of the receiver will appear to be poor and the tuning will be flat, also the noise level in the morse spacing may be excessive.

To avoid this effect, it is essential when tuning in a wanted signal to turn back the volume control until the signal strength is slightly below the limiting value. This point is indicated by a sudden decrease in strength as the volume control is moved gradually from maximum towards the "Off" position.

If the signal being received has a good steady frequency :

(k) Set note selector switch (99) to 'In'.

(l) Carefully adjust heterodyne vernier condenser (54) to give the best signal. When powerful interference is breaking through:-

(m) Plug aerial into aerial 2 Stages (8) and tune left hand condenser (11) slightly increasing volume control (113) if necessary.

When receiving R/T the second heterodyne should be switched off, but better signals may sometimes be obtained on I.C.W. with the heterodyne switched on.

It should be noted that increased selectivity and "readability" will always be obtained by reducing the volume control (113) when the signal has once been found. Except for loudspeaker reception full volume is never required when the circuits have all been properly tuned.

In order to avoid any possible confusion with harmonics from the second heterodyne oscillator the initial tuning of the receiver with oscillator G35 should be made with M.C.W. i.e. with the second heterodyne of B50 "Off" and the modulator of G35 "On".

14. METAL DUST IN TRIMMING CONDENSERS.

Failures have occurred in receiver B50, owing to metal dust particles collecting between the plates of trimming condensers.

These particles are caused by chemical action which is due to the method used for "tinning" the plates in manufacture. Arrangements are being made for a better method of "tinning" to be adopted.

The attention of W/T staffs of ships concerned is called to this possible reason for failure of a receiver.

To remove these particles the following procedure should be adopted:-

(i) Remove the receiver from the rack and open it up.

(ii) Disconnect one side of each condenser. (See list below).

(iii) Take the normal H.T. supply to the receiver from the rectifier and put it across the plates of the condenser. This will "burn out" the metal dust particles.

(iv) If the "burning out" process is not satisfactory the condenser will have to be removed from the receiver, stripped and cleaned.

No H.T. supply other than that from the rectifier is to be used and care is to be taken that no damage is caused to the receiver by allowing the bare ends of these H.T. wires to touch parts of the receiver other than the plates of these disconnected condensers.

The condensers found chiefly to be affected are:-

Nos. 12*, 17*, 45*, 59, 61, 69, 71, 86.

Condensers marked * may be disconnected in B50 by setting the range switches between any two numbers. The other condensers must be disconnected by unsoldering one lead.