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TUNING AERIAL CIRCUIT OF H/F TRANSMITTERS

In ships, where a single aerial is used to cover a wide band of high frequencies, the Aerial Ammeter provides a very poor indication of the power in the aerial circuit. This is due to the impedance of the aerial system varying between wide limits, according to the frequency being used.

For a given output power, the current shown by the aerial ammeter will also vary considerably, being dependent upon the effective resistance of the aerial system. As the resistance varies with the frequency being used, the current shown in the aerial ammeter will not provide a reliable indication of the power output of the aerial system.

The indications of the aerial ammeter are not necessary for the tuning of the aerial circuits of a transmitter and it is not difficult to tune and couple the aerial circuit correctly, using the Output Stage anode current meter as an indicator.

In the first instance, the aerial length should be cut to a physical length corresponding to five-eighths of a wavelength of the most used of the lower frequencies. This will give the maximum propagation in the horizontal plane.

Having erected the aerial, or on changing from one frequency to another, the following procedure should be adopted :-

(a) Set the Master Circuit by wavemeter tuning, or tune the Master Circuit to the crystal in use, according to the type of transmitter being used.

(b) Tune the intermediate stage or stages in turn to resonance as indicated by the minimum current indication shown in the anode feed meter of each stage.

(c) The final stage should be tuned to resonance, as indicated by minimum current in the anode feed meter, with the coupling to the aerial circuit at minimum.

(d) Having established resonance in the final stage, the aerial and coupling controls should be varied until a position is obtained where an increase in current to final stage is shown by the anode feed meter.

(e) The tuning of the final stage should now be re-checked and brought to a position indicated by minimum current in the anode meter again.

(f) The aerial coupling may now be again increased and the final stage tuning again re-checked for minimum current.

(g) The aerial coupling may now be increased until the anode current to the final stage reaches the permissible figure for the particular transmitter, or to a maximum. The increase in aerial coupling will probably reflect on the tuning position of the final stage and this should be checked and again brought to minimum anode current and, if necessary, aerial coupling increased to bring the final stage up to the required loading.

(h) The frequency of the Master Circuit should be checked to counter-act any change that has taken place with the transmitter circuits fully loaded.

The transmitter is now ready for use.

NOTE :- (i) It is of particular importance that the tuning position of the final stage should be re-checked after each and every change to the aerial and coupling circuits.

(ii) For normal H/F operational frequencies, the physical length of aerial wire should not be less than 40/50 feet and if this length cannot be accommodated in the vertical plane, it should be obtained by adding a roof or running a wire obliquely to some other point of anchorage.

(iii) If on a particular ship with a given combination of aerial and feeder lengths the transmitter should fail to load fully on all the operating frequencies, due to limitations in the coupling circuits of the particular transmitter, the length of aerial wire should be reduced or increased in steps of approximately 4-6 feet until a satisfactory aerial loading condition is obtained for all operational frequencies.

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FREQUENCY CONTROL PANEL FOR TYPE 57D

1. INTRODUCTION.

The Frequency Control Panel is designed to produce a radio frequency, which has stability comparable with that of a crystal oscillator and which may be varied to operate on any frequency within the limits covered by the transmitter.

Two separate valve oscillators are used. One is a fixed oscillator which is crystal controlled and the other a Variable Frequency Oscillator (V.F.O.).

The V.F.O. is used to modulate the Crystal Oscillator and the resultant frequency that can be selected, by means of tuned circuits, may be either the sum of the two frequencies or the difference between the frequencies of the two oscillators.

More than one crystal frequency is required to provide continuous frequency coverage, and in this panel, the crystal oscillator operates on either 3, 4 or 5 Mc/s. The V.F.O. has a frequency range of 1 to 2 Mc/s.

The following table shows the combination of V.F.O. and Crystal Oscillator frequencies which are used to cover the frequency range of 2-7 Mc/s.

TABLE 1.

Range Switch	V.F.O. Frequency Mc/s.	Crystal Frequency Mc/s.	Resultant Frequency Mc/s.	Sideband Selected.
1	1 to 2	4	3 to 2	Lower
2	1 to 2	5	4 to 3	Lower
3	1 to 2	3	4 to 5	Upper
4	1 to 2	4	5 to 6	Upper
5	1 to 2	5	6 to 7	Upper

With the Range Switch in position 1, the 4 Mc/s crystal is selected and the necessary circuits are arranged in order to select the "difference frequency" or, in other words, the Lower Sideband is selected. Varying the tuning of the V.F.O. from 1 to 2 Mc/s will produce a difference, or resultant, frequency of 3 to 2 Mc/s.

It should be noted that, as the frequency of the V.F.O. is increased, so the resultant frequency becomes less. This is due to the difference frequency decreasing as the V.F.O. is brought gradually nearer to the crystal frequency. This condition is applicable to range 1 and 2 only, where the lower sideband is being used.

Range 2 provides a resultant frequency of 4 to 3 Mc/s.

With the range switch in position 3, the 3 Mc/s crystal is selected and the associated circuits are arranged to select the sum of the V.F.O. and Crystal Frequency. Varying the V.F.O. from 1 to 2 Mc/s under these conditions will increase the Resultant Frequency from 4 to 5 Mc/s.

When the Range Switch is placed in position 4, the same crystal is used as in position 1, but in this case the circuits are arranged to select the sum of the two frequencies. This arrangement provides a frequency coverage of 5 to 6 Mc/s when the V.F.O. is varied over its full range.

Placing the Range Switch in position 5, the 5 Mc/s crystal is used again, but this time selecting the upper sideband and thus covering a frequency band of 6 to 7 Mc/s.

By using only three crystals and a V.F.O. it is therefore possible to produce any frequency between 2 and 7 Mc/s.

Frequencies above 7 Mc/s are obtained by trebling the resultant frequency, using a Trebler Stage, so that continuous coverage is obtained from 2 to 21 Mc/s.

The Output Stage of the transmitter will not tune a frequency less than 2·7 Mc/s as its original low frequency limit was 3 Mc/s and frequencies lower than this are only used to drive the Trebler Stage. (e.g., 7·5 Mc/s output frequency requires 2·5 Mc/s from the Mixer Stage).

A schematic diagram showing the arrangement of the various stages is given in Fig. a.

The complete panel is constructed to contain six separate units.

(i) V.F.O. UNIT containing the Variable Frequency Oscillator and a Buffer Amplifier.

(ii) MIXER UNIT contains the Crystal Oscillator, Mixer Stage and Trebler Stage.

(iii) AMPLIFIER UNIT contains the First and Second Power Amplifier Stages.

(iv) KEYING AND ABSORBER UNIT contains the relay for keying the transmitter and also the rectifier to provide the absorber circuits operating voltage.

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FREQUENCY CONTROL PANEL FOR TYPE 57D

ARRANGEMENT OF STAGES

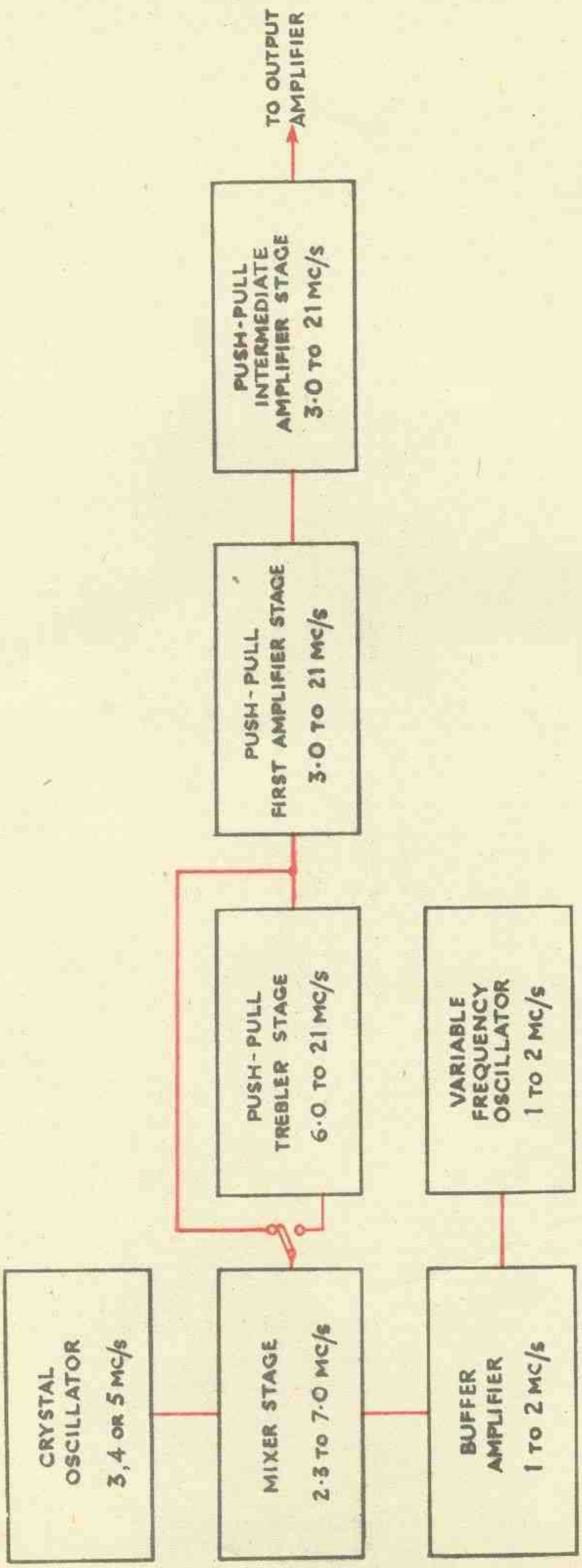

FIG. a

(v) MODULATOR UNIT contains a single valve oscillator for M.C.W. operation.

(vi) FILAMENT AND KEYING. BIAS RECTIFIERS.

2. V.F.O. UNIT. (See Admiralty Handbook 1938 Vol. II, SECTION "K", PARA. 37).

The variable Frequency Oscillator is required to provide a stable frequency suitable for feeding into a push-pull stage. The oscillator must be calibrated and the accuracy to which a frequency can be set must be of a high order.

(a) A Colpitt Oscillator of rigid design is used and, to minimise frequency drift due to heating of components, the oscillator coil is mounted well clear of any other frequency determining components. The coil is of the single layer type which provides maximum ventilation and is wound on a ceramic former. Ceramic, having a negative temperature co-efficient, will minimise frequency drift due to temperature changes.

(b) An arrangement of series and parallel condensers in the oscillator circuit causes the main tuning condenser to have an almost linear variation of frequency with angle of rotation, and they also facilitate the temperature compensation of the oscillator. The fixed ceramic condensers have been chosen so as to make the variation of frequency with temperature less than 30 cycles, per degree centigrade, change of temperature.

(c) The frequency range of the oscillator is covered in two sub-ranges. The first covering from 1 to 1·5 Mc/s and the second 1·5 to 2 Mc/s. The V.F.O. tuning condenser dial scale is divided into 100 divisions and each division, by means of the vernier control, is divided by 10. To allow for overlap of the two sub-ranges and to neglect the extreme ends of the condenser curve, which is not strictly linear, each sub-range is arranged to cover 600 kc/s therefore, each vernier division of the condenser dial will correspond to approximately 600 cycles. The vernier division may again be subdivided by two, or even by four without undue difficulty, resulting in a very high degree of accuracy in setting or resetting a desired frequency on the V.F.O. To obtain this accuracy, it is necessary that the back-lash of the condenser dial movement should always be taken up in the one direction. When setting the condenser dial, the required adjustment should always be approached in a clockwise direction. For instance, assuming a dial setting of 54·3 divisions is required to be set, the dial should be adjusted to approximately 51 or 52 divisions and then the final adjustment made by means of the vernier slow motion control being turned in a clockwise direction.

It should be noted that when using frequencies above 7 Mc/s, any error in setting the V.F.O. will be trebled as the Trebler Stage is used under these conditions.

(d) Normal operating conditions for the panel is as follows :-

(i) Ships A.C. supply mains to be within ± 5% of their nominal voltage and frequency.

(ii) The temperature of the transmitting room to be roughly the same as when the V.F.O. unit was last calibrated.

(iii) No valve replacements in the V.F.O. unit since it was last calibrated.

(iv) No excessive shocks, sufficient to displace the dust cores in the various stages, since last calibration.

Under abnormal conditions, whenever the best possible accuracy is required, the V.F.O. should be set against the Wavemeter G62.

(e) Changes in supply voltages are minimised by :-

(i) Using a Master Oscillator Unit Absorber valve and its associated circuit. In this manner, the load presented to the Master Oscillator H.T. Rectifier is kept constant under keying conditions.

(ii) The H.T. and filament supply to the Trebler Stage is completed with the other units, irrespective whether the Trebler Stage is being used or not. Variation of supply voltage due to switching on additional units according to the frequency being used is thus prevented.

(f) The output of the V.F.O. is capacity coupled to the Buffer Stage. This stage maintains a constant load upon the V.F.O., thus variations in frequency caused by different loading conditions are minimised. The circuit arrangements of the Buffer Stage are comparable with the V.F.O. and the Range Switch and Tuning Control are ganged. Two separate dust core coils are used in the Buffer Stage and, by means of these, the circuits can be accurately ganged for each sub-range. The centre point of the tuned circuit is earthed, the output of the stage is therefore suitable for feeding a push-pull circuit.

(g) For calibration of the V.F.O. Wavemeter G62 is capacity coupled to the output of the Buffer Stage. This arrangement allows the wavemeter to be switched into circuit without affecting the loading and thus the frequency of the V.F.O.

The output of the Buffer Stage is also metered so that a check on the performance of the V.F.O. and Buffer Stage is available at any time.

(h) The valve used at the initial calibration of the V.F.O. at the factory is supplied, together with the Calibration Book, with the panel.

It is advisable to make a periodic check of the V.F.O. calibration by means of the Wavemeter 062 and for this purpose it is sufficient to check points which are, say, 100 Kc/s apart.

If the calibration has changed by approximately 2 Kc/s, a re-calibration should be made at points spaced 20 Kc/s apart. This is most conveniently carried out by two operators, one changing the frequency on the wavemeter whilst the other adjusts the readings of the V.F.O. to the nearest half vernier division. This part of the calibration takes approximately one hour.

The new calibration figures should be entered on the record sheet provided in the Calibration Book. This has been so arranged that the figures of different calibrations can be directly compared, so that if there is a known reason for the change of calibration, e.g., movement to the tropics, valve replacement etc., this should be written below the new list of figures.

(i) It may be necessary, under working conditions, to shift the transmitted frequency slightly to avoid interference.

When using Range 1 or 2 on the Mixer Unit, an increase of V.F.O. dial reading will decrease the Output Frequency.

When using Ranges 3, 4 or 5, an increase of V.F.O. dial reading will increase the Output Frequency.

As each vernier division is approximately 600 cycles, the amount of frequency shift may be easily estimated. If the Trebler Stage is in use, each vernier division of the V.F.O. dial will be approximately 1800 cycles.

3. MIXER UNIT.

(a) The Mixer Unit contains three stages; a single pentode valve Crystal Oscillator, a Mixer Stage consisting of two pentode valves joined in push-pull and a Trebler Stage, also using two pentodes connected in push-pull.

The Crystal Oscillator is capacity coupled to the control grids, in parallel, of the Mixer Stage. The V.F.O. frequency is applied via the Buffer Stage to the screen grids of the Mixer Stage in push-pull. The output circuit of the Mixer Stage is also connected in push-pull. (See simplified diagram Fig. b).

MIXER STAGE — SIMPLIFIED DIAGRAM

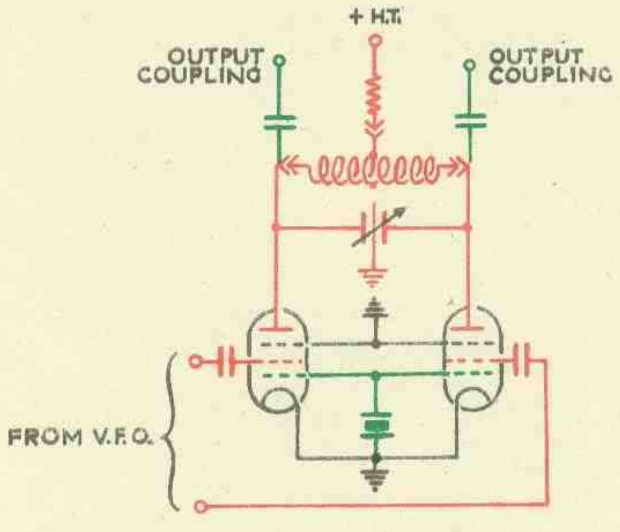

FIG. b

TRANSMITTERS

FREQUENCY CONTROL PANEL FOR TYPE 57D

When the control grids of the Mixer Stage are excited by the Crystal Oscillator alone, the anode voltages of the two mixer valves will rise and fall together so that there can be no voltage difference across the anode tuned circuit and there is therefore no output. The effect of connecting the control grids in parallel and the anodes in push-pull is that there can be no output at the control grid frequency, i.e., the Crystal Oscillator frequency.

When the V.F.O. and Crystal Oscillator frequencies are applied together, new frequencies are generated, the upper side frequency, (Crystal Frequency + V.F.O. frequency) and the lower side frequency, (Crystal Frequency - V.F.O. frequency). The Anode or Output Circuit may be tuned to either of these frequencies depending upon which we require to use. On Ranges 1 and 2 of the Mixer Unit the lower side frequency is used while on Ranges 3, 4 and 5 the upper side frequency is used.

To obtain two valves with identical characteristics is very difficult in practice, and when using valves with the usual tolerances spurious frequencies originating from the Crystal Oscillator or the V.F.O. may be observed as the tuning of the Mixer is varied over wide limits. In order to prevent spurious frequencies being selected by incorrect tuning of Mixer Control, a Nomogram is supplied which allows the approximate tuning position for any frequency to be set on the Mixer Control. The final and accurate tuning being by observed meter readings. By using the meter response in the immediate neighbourhood of the adjustment given by the nomogram the possibility of selecting a spurious frequency is reduced to a minimum.

Another advantage of a nomogram is that the whole of the adjustments required for a new frequency, can be obtained from the nomogram with the exception of the Final Power Amplifier. When the new frequency is required, the settings are put on the various controls and the stages tuned by the meters provided. The approximate setting of the Output Stage can be obtained from the curves given in the handbook on Type "57D".

(b) CRYSTAL OSCILLATOR.

The Crystal Oscillator is a fixed oscillator and is designed to operate on three frequencies, 3 Mc/s, 4 Mc/s and 5 Mc/s. The Mixer Range Switch selects the required crystal and tuned circuit automatically. The range switch has five positions and the oscillator is selected to operate on 4 Mc/s in positions 1 and 4, and on 5 Mc/s in positions 2 and 5. With the range switch in position 3, the crystal oscillator circuits are selected to operate on 3 Mc/s. (See Table 1).

The tuning of the Crystal Oscillator circuit is pre-set and is tuned at the factory when the unit is initially calibrated. Dust Core coils are used and, when selected, are joined between anode and filament of the pentode valve used in the crystal oscillator circuit. The inductance of the coil is thus in series with the anode filament capacity of the valve. Tuning is carried out by varying the inductance of the coil in use, by varying the position of the core. The output of the oscillator is capacity coupled to the control grids, in parallel, of the Mixer Stage.

(c) TREBLER STAGE.

The Trebler Stage consists of two pentodes joined in push-pull. The stage is used for trebling the Resultant Frequency from the Mixer Stage before being amplified. The frequency range of 6/21 Mc/s is covered by five dust core coils which are selected by means of the Mixer Range Switch. The use of dust core coils facilitates the ganging of the controls for the Mixer and Trebler stages.

The filament and H.T. supply is completed with the supplies to the other units whether the Trebler Stage is required or not. By this arrangement changes in the supply voltage caused by switching on, or off, an additional stage is prevented.

A two position switch is used to introduce the Trebler Stage into circuit. In one position, the output of the Mixer Stage is connected to the control grids of the 1st Amplifier Valves, in the second position, the output of the Mixer Stage is connected to the control grids of the Trebler Stage and the output of the Trebler Circuit is connected to the control grids of the 1st Amplifier Valves.

4. AMPLIFIER UNIT.

(a) First Amplifier Stage.

The First Amplifier Stage uses two pentode valves connected in push-pull. A six position range switch selects the iron dust core coils used as the anode inductance of the amplifier. The selected coil is tuned by a ganged condenser which is also used to tune the Second Amplifier Stage.

The stator and rotor of the variable condenser are both maintained at the supply voltage and are thus at the same potential. As the condenser is varied to tune the circuit, the difference of potential will vary, increasing to a maximum when the circuit is in resonance with the applied frequency. The difference of potential developed across the condenser will be due to the R/F voltage only and not, as is usually the case, due to the R/F voltage plus the D.C. potential. This arrangement allows the physical size of the condenser to be reduced as well as increasing the safety factor against flash over.

(b) Intermediate Power Amplifier.

The Second Power Amplifier is a push-pull stage also using two pentode valves.

Suppressor grid modulation is applied at this stage, when required. During C.W. operation the suppressor grids are earthed, during modulation, whether M.C.W. or R/T a negative potential of approximately 120 volts is applied via a modulation transformer to the suppressor grids. Audio frequency voltages applied to the modulation transformer will vary the standing negative potential at audio frequency. The A/F variations of suppressor grid voltage will in turn modulate the anode current of the amplifier valves. The modulated output will be amplified by the Output Amplifier.

TRANSMITTERS

FREQUENCY CONTROL PANEL FOR TYPE 57D

Three air-cored coils are used to form the tuning inductance and tappings are taken from them to the Amplifier Range Switch. Unwanted turns, which are not required on any one range, are short-circuited by the range switch. The division of the total inductance into three coils reduces the coupling between the useful turns and those short-circuited, thereby reducing the losses in the turns not in use.

The rotor of the tuning condenser is at H.T. potential for the same reason as in the first amplifying stage.

The output of the amplifier is capacity coupled to the control grids of the pentode valves in the Output Stage, which in turn is mutually coupled to the Aerial Circuit.

5. SPURIOUS SIGNALS.

A disadvantage of the Partial Crystal Control system is that several audible notes will be heard in the neighbourhood of certain frequencies.

The desired signal is always the loudest and is easily found by momentarily reducing the gain of the receiver so as to cut out the unwanted notes. The effect is most noticeable on 4·5, 6·0, 13·5 and 18·0 Mc/s but has no detrimental effect on the intelligibility of transmission.

TRANSMITTERS

DEFINITION OF STANDARD TERMS

In order to stabilise the meaning of certain technical terms, the following definitions explain the sense in which these terms are used throughout this book.

MASTER OSCILLATOR.

A valve oscillator, employed to generate a frequency at a comparatively low power, in which steps have been taken to stabilise the frequency output.

A Master Oscillator stage can be described as:-

(a) Crystal Controlled Master Oscillator.

(b) Variable Frequency Master Oscillator.

CRYSTAL CONTROL.

Intimates that the frequency being generated is basically controlled by the frequency of a crystal.

VARIABLE FREQUENCY CONTROL.

Indicates that the frequency controlling components of an oscillator consist of a coil and condenser combination that is continuously adjustable to cover the complete frequency range of the oscillator stage.

FIXED OSCILLATOR.

An oscillator designed to operate on one predetermined frequency, e.g. M.C.W. oscillator. This oscillator may be Crystal or Tuned Circuit controlled.

CRYSTAL OSCILLATOR.

An oscillator circuit using Crystal Control, but which is not a Master Oscillator, e.g Calibration Oscillator in Type TBY.

PARTIAL CRYSTAL CONTROLLED OSCILLATOR.

Consists of a unit, the output frequency of which consists of a combination of two frequencies, one being obtained from a Crystal Oscillator and the other being obtained from a Variable Frequency Oscillator.

VARIABLE FREQUENCY OSCILLATOR.

An oscillator circuit, using Variable Frequency Control, but which is not a Master Oscillator, e.g. Type 49 H/F.

TRANSMITTERS

M.O. UNIT (WITH P.C.C.) FOR TYPE 57DM/DMR

To incorporate Partial Crystal Control in the Master Oscillator of Type 57 DM/DMR, the original unit consisting of the push pull master oscillator and buffer stage has been superseded by a master oscillator unit fitted with P.C.C. The unit contains the variable frequency oscillator, crystal oscillator, mixer and trebler stages.

The output of this unit is capacity coupled to the Intermediate Stage.

The operation of a P.C.C. unit is described on Page RB 3.

The Master Oscillator Unit used with Type 57 DMR has several differences to the frequency control panel used with Type 57 DR.

The various stages have been built into the one unit to facilitate the modifying of the transmitter. Indirectly heated valves are used and the buffer stage, between the V.F.O. and mixer stage, is omitted. The efficiency of the indirectly heated valves used is considerably greater than that of the directly heated valves used in the frequency control panel.

By reducing the value of the coupling condensers between the V.F.O. and mixer stage screen grids, the loading of the oscillator has been reduced without sacrificing drive voltage, and the stability of the V.F.O. maintained within practical limits.

The frequency coverage of the A.P.W3794 master oscillator unit is identical with that detailed in Table 1. (Page RB3). The three crystals used in the crystal oscillator, the frequency coverage of the respective positions of the range switch and the sideband selected remain unaltered.

The unit also has the disadvantage of audio modulation of the output on certain frequencies. (See RB 8, para.5).

A modified master oscillator unit, A.P.W3794A, has now been introduced, bearing serial numbers 61 and above. The modification changes the frequency of the crystals used in the crystal oscillator, and the alteration of the various circuit components to conform to the new frequencies.

The crystal frequencies are 4•5, 5•5 and 6•5 Mc/s, instead of 3, 4 and 5 Mc/s originally used.

The frequency coverage of the V.F.O. remains at 1-2 Mc/s.

The following table shows the combination of V.F.O. and crystal oscillator frequencies covered by the various positions of the Range Switch.

TABLE 1.

RANGE SWITCH.	V.F.O. FREQUENCY MC/S.	CRYSTAL FREQUENCY MC/S.	RESULTANT FREQUENCY MC/S.	SIDEBAND SELECTED.
1	1 to 2	4•5	3•5 to 2•5	LOWER
2	1 to 2	5•5	4•5 to 3•5	LOWER
3	1 to 2	6•5	5•5 to 4•5	LOWER
4	1 to 2	4•5	5•5 to 6•5	UPPER
5	1 to 2	5•5	6•5 to 7•5	UPPER

It should be noted that the lower sideband is used on ranges 1, 2 and 3, thus an increase of scale reading on the V.F.O. frequency control will correspond to a reduction in output frequency.

The trebler frequency will, in all cases, equal the resultant frequency multiplied by three.

The trebler stage is introduced, on both A.P.3794 and A.P.3794A master oscillator units, when the trebler switch is placed in the RED position.

The advantage of the change of crystal frequencies is that there are no longer any "Restricted frequencies" due to audio modulation of the output frequency.
(See RB 8, para. 5).