Technical Specification of 100 watts MF, MHF and HF Marine Radio Transmitter Type A 216 V.

The transmitter consists of a rust proofed welded iron sheet cabinet in grey finish, containing a control switchboard, removable for inspection of relays etc. and, during installation, for good accessibility to the terminal board.

Mounted fixed in the cabinet are also 3 aerial switching relays, which automatically connect the aerial to the unit engaged, and grounds the aerial through a resistor when aerial not in use.

In sliding mechanisms 3 separate transmitting units are arranged. The units are connected to the fixed wiring in the cabinet by means of plugs and sockets with ample length of connecting cable allowing the units to be withdrawn without breaking connections. Yet aerial connection is made through a silvered spring contact.

The 3 transmitting units, for further specification of which see below, are:

Medium frequency transmitter, designated A 217 V
arranged for transmitting on the frequencies 410, 425, 448, 454, 468, 480, 500, 512 kc/s, A1 and A2.

Medium high frequency transmitter ("coastal telephone"), designated A 218 V
arranged for transmitting on up to 11 crystal controlled frequencies in the 1600-5500 kc/s band, crystals being supplied according to customer's need and specification (A1, A2) A3.

High frequency transmitter, designated A 219 V
arranged for transmitting in the 4, 6, 8, 12, 16 and 22 Mc/s ship's telegraphy and telephony bands, A1 (A2), A3. Crystals for one calling and two working frequencies in the telegraphy band being supplied according to customer's specification. Further a number of crystals for telephone communication may be supplied.

Facilities:

Theoretically all three units may be used for A1, A2 and A3 but of course the employment must comply with international agreements.

A main control switch has the following six positions:

1) off
2) Stand by, Hailer (Filaments heated and, when handset push button pressed, hailing)
3) A1 (telegraphy CW)
4) A2 (telegraphy MCW)
5) A3 simplex (telephony)
6) A3 duplex (telephony)

Modulation:

Combined anode and screen grid modulation in the output stage.

A modulating amplifier common to all 3 radio frequency units is built into the A 218 transmitting unit. The amplifier can supply sufficient power for 100% modulation of each transmitting unit with negligeable distortion. Negative feedback in the amplifier secures good quality, and modulation depth independent of load.

Automatic gain control ("Vogad" = voice operated gain adjusting device) and modulation limiter secures high average modulation percentage, yet avoiding overmodulation.

In addition to being used for modulation purpose the A.F. amplifier and microphone may in connection with extra supplied loudspeakers be used as a powerful loud hailer unit. Maximum power to loudspeakers: 75 watt.

Built into the modulator for producing a 1000 c/s note for A2 - transmitting is an A.F. oscillator.

The said A.F. oscillator is so powerful that a certain part of its output via a selenium rectifier can produce a D.C.voltage of some 60 volts across a 1200 ohms resistor, this voltage being used for grid biasing purposes.

Power supply:

A common power supply for the modulator and the radio frequency units is employed.

The whole transmitter may be operated either off ship's mains 110 or 220 volts A.C. or off a 24 volts storage battery according to converter employed.

When mainsoperated a transformer supplies 25 volts A.C. for filament supply (all tubes) and a rectifier 24 volts D.C. for relays and microphone, another rectifier supplies 550 volts D.C. for anode supply.

When battery operated the filaments are supplied with 24 volts direct from the battery, anode voltage 550 volts being supplied by a converter working off the battery.

The current drain from mains or battery amounts to (transmitter keyed in position A3):

At 220 volts: about 2,8 amps.
At 24 volts: about 30 amps.

Facilities for change-over between mains and battery operation is normally not included but may be furnished on special request at an extra cost.

Keying:

A built-in keying relay operated either by the telegraph key or via an auxiliary relay by the push button of the microphone handset controls change over from "receive" to "transmit", when working telegraphy and telephony simplex.

Besides the keying contact proper, the keying relay has been equipped with an extra contact which mutes the loud speaker (without affecting the earpiece output) and inserts a resistance load instead of the loud speaker.

When working "telephony duplex" the transmitter is keyed constantly by the control switch, but the push button of the handset has to be pressed for modulating the transmitter (the loud speaker consequently is muted during modulation).

The auxiliary relay is - like the keying relay - equipped with an extra contact. This contacts operates a heavy starting relay which cuts in plate voltage for the A.F. amplifier, when the latter is used for hailing.

Besides the said muting a voltage (normally 24 volts) is supplied for a muting relay in the receiver belonging to the radio station as soon as the key is pressed or, when working "telephony simplex", the handset press button is pressed (such relay normally shorts input and output terminals of receiver).

Dimensions:

Including switching panel (for either mains or battery operation - no change over) and if ordered switching and charging panel for both mains and battery operation (with change over):

Height: 1370 mm + aerial lead in 50 mm + shock absorbers 40 mm
Width: 550 mm
Depth: 400 mm + knobs + shock absorbers 40 mm
Weight: 150 kgs.

Medium frequency transmitting unit type A 217 V.

Frequencies:

410, 425, 448, 454, 468, 480, 500, 512 kc/s preset.

Output power:

100 watts A1, about 120 watts A2, to the aerial circuit. Power measured in an external aerial (losses in aerial tuning device deducted) 40-60 watts depending on the capacity of the aerial.

Provision for reducing aerial power to one tenth.

Modulation:

When transmitting A2 the modulation depth is adjusted to about 90%, giving a very good signal to noise ratio at the receiving station.

Frequency tolerance:

The transmitter is not crystal controlled but incorporates a high stability temperature compensated master oscillator with maximum tolerance of about 0,05%, all errors taken into account.

Thus the transmitter fulfils the Atlantic City Conference frequency tolerance requirements of main transmitters, the said tolerance being 0,1%.

Harmonics:

All harmonics radiated from the aerial will be attenuated at least 40 dbs in relation to the fundamental (as required by the A.C. Conference.)

Aerial:

The transmitter may in the whole range 410-512 kc/s be tuned to an aerial with a capacity between 300 and 750 pF and a resistance of 2 to 5 ohms. At 500 kc/s the transmitter will even tune to an aerial with a capacity of only 200 pF.

Artificial aerial:

The transmitter has an artificial aerial with a capacity of about 500 pF and a resistance of 3 ohms built in. A switch selects the artificial or the outdoor aerial. When power is led to the artificial aerial a red warning lamp on the front plate of the transmitter lights up.

Measuring instruments:

The transmitter is provided with a milliammeter and a switch by means of which the cathode current of each individual tube may be checked. Likewise the grid current of the R.F. amplifying tubes may be checked.

A thermocouple ammeter in the aerial circuit measures the aerial current.

Tubes:

6 tubes type 807 (or equivalent: Philips QE 06/50) are employed.

A 217 V - Diagram.

The transmitter comprises a master oscillator, a buffer stage and a power amplifier. The master oscillator tube is an 807 tetrode working in a Colpitts circuit with fixed capacitors (silvered mica and ceramic capacitors, the latter with negative temperature coefficient for compensation) and 8 separate coils with adjustable powdered iron core for the frequencies 410, 425, 448, 454, 468, 480, 500, 512 kc/s. Each of the 8 coils is housed in its own individual shielding case for maximum stability. The master oscillator operates with much reduced anode and screen grid voltages for reducing heating of electrodes and consequently reduction of frequency drift.

The buffer stage also contains an 807 tube, the anode circuit of which is aperiodic and via a blocking capacitor directly connected to the grids of the power amplifier.

The power amplifier contains 4 parallel connected (with parasitic oscillation suppressors in grids and anodes) 807 tetrodes. The anode circuit of the P.A. consists of an anode-cathode capacitor, a coil with suitable taps and a coupling capacitor, the tuning elements being connected up as a pi-circuit. The exact tuning of the tank circuit takes place (at the factory by adjusting of small trimmer coils connected to the taps of the main tuning coil.

In order that correct matching of the aerial circuit to the power amplifier should be possible under all transmitting conditions the coupling capacitor consists of two capacitors, one being fixed connected up in the circuit, the other being switched in and out according to aerial resistance. In order to keep the total tuning capacity of the anode circuit constant, part of the anode-cathode capacity is made up of a series capacitor, a compensating capacitor, one fixed connected up and another which is switched into the circuit when the corresponding coupling capacitor is switched out of the circuit - and vice versa.

For details concerning adjustment of coupling and compensating capacitors see paragraph: Operation.

The setting of the above mentioned 8 frequencies takes place by a single 8 position switch.

The aerial circuit is tuned separately by means of a continuously variable loading coil (so called variometer) with a single tap, for tuning in the whole range 410-512 kc/s to aerials with capacities between 300 and 750 pF and at 500 kc/s even to aerials having a capacity of but 200 pF.

Artificial aerial with a capacity of about 500 pF and a resistance of about 3 ohms is incorporated in the transmitter proper and a switch provided for choosing between artificial and outdoor aerial. A thermocouple ammeter reads the aerial current in both cases.

The transmitter is constructed for A1 and A2 transmission. Modulation (when transmitting A2) takes place as combined anode and screen grid modulation in the power amplifier, the modulation power being supplied by a modulator in the coastal telephony section, A 218, of the complete transmitter.

As mentioned above keying takes place by means of a keying relay which at key down condition shorts a resistor in a voltage divider across the high tension. All cathodes are brought to the tap on the voltage divider which is connected to minus high tension at key down. At key up all cathodes adopt a positive voltage of some 50 volts in relation to minus high tension (neutral pole), while the grids (through suitable resistors or filters) are connected to minus high tension. In this way the grids will become about 50 volts negative in relation to cathodes and all cathode currents are completely cut off.

A 217 V - Operation.

Set transmitter selector switch in switching panel to "MF", set power switch to "1/1", set frequency switch in MF-transmitter to the frequency in question, set "Coupling" to "1", "Aerial" switch to "outdoor" and "aerial coarse" to "1"; turn operating switch in switchboard to "stand by" for heating of tube filaments. After 15 seconds turn lever to A1 and press key. Rotate tuning knob "aerial fine" until aerial ammeter shows maximum aerial current. Cathode current of each of the tubes 3a, 3b, 3c and 3d then should amount to 100-120 milliamps. (no more than 125 milliamps.) If no resonance is obtained on "aerial coarse 1", switch to "aerial coarse 2" and repeat tuning procedure.

If cathode current of each of the no. 3 tubes is as low as 70-80 milliamps. with aerial tuned to resonance, switch to "coupling 2" and repeat aerial tuning.

If A2 operation is wanted then set operating switch in switchboard to A2 - and transmit.

During installation of transmitter, coupling capacitors should, according to directions given below, be adjusted so, that each of the no. 3 valves will draw a cathode current of 100-120 milliamps. in fair (dry) weather with "coupling" set to "1".

When aerial insulators and aerial lead-through get wet during rain or gale (salt water spray) the effective aerial resistance will increase and the aerial current decrease substantially. Due to coupling mismatch, loading of the power amplifier will further decrease and the cathode current of tubes no. 3 will decrease as much as to perhaps 60-70 milliamps. Under these circumstances load matching can be recovered by changing to "coupling 2". Cathode current of the no. 3 tubes then will assume their normal value and aerial current increase, although the "fair weather value" of aerial current will not be obtained.

If the outdoor aerial has a resistance different from the built-in artificial aerial ("dummy aerial", the resistance of which is normally adjusted to 3 ohms from the factory) the cathode current of the no. 3 tubes and the aerial current will not have the same value when transmitting on the artificial aerial as on the outdoor aerial.

Yet the outdoor aerial is decisive as to the values of coupling and compensating capacitors.

If wanted resetting the resistance value of the resistor of the artificial aerial might make conditions of "dummy" and "outdoor" transmitting equal.

Adjustment of coupling capacitors:

If in fair weather each of the no. 3 tubes draws a cathode current different from 100-120 milliamps. with the outdoor aerial correctly tuned and "coupling" set to "1" the value of capacity must be changed. If the tubes draw too high a cathode current the value of coupling capacity must be increased, if the tubes draw too small a cathode current the capacity must be reduced.

The coupling capacity consists of two mica capacitors CK 1 (about 20000 pF), permanently cut in, and CK 2 (about 10000 pF) which by means of switch "coupling" may be connected in parallel with CK 1, giving a total coupling capacity of 30000 pF (coupling 1). Both capacitors may easily be replaced by others, as they are equipped with plugs which fit into corresponding sockets.

As the total capacity of the tank circuit of the power amplifier should remain constant when switching from "coupling 1" to "coupling 2" two compensating capacitors have been inserted in the circuit, one CU 1 (about 10000 pF), permanently cut in, and CU 2 (about 2000 pF) which is cut in when CK 2 is cut out and vice versa. The compensating capacitors likewise are equipped with plugs for easy replacement.

If it has been decided to change the coupling capacity, replace CK 1 by another capacitor which according to the above mentioned lines is likely to give the correct coupling and replace CK 2 by a capacitor about half the value of CK 1. Disconnect the outdoor aerial (switch "dummy/outdoor aerial" should be set to "outdoor"), press the key and notice the cathode current of the no. 3 tubes. If each tube draws a cathode current exceeding 60 milliamps. the compensating capacitor CU 1 has to be changed in the opposite direction of the coupling capacitors until tubes no. 3 draws about 50-55 milliamps each.

Next the aerial is connected up again, tuned to resonance, and the cathode current of the no. 3 tubes checked. Does each tube draw 100-120 milliamps. the value of CK 1 plus CK 2 has been correctly chosen. Is the cathode current not yet correct the procedure has to be repeated.

When the transmitter has been correctly matched to the aerial (in fair weather condition) according to the above mentioned procedure with "coupling" set to "1", disconnect aerial and set "coupling" to "2", press the key and notice the cathode current of tubes no. 3. Is the current higher than 60 milliamps. compensating capacitor CU 2 has to be changed until cathode current of each of the no. 3 valves is depressed to about 55 milliamps.

Then the aerial may be connected up again. A short touch of the key will now show a cathode current of more than 150 milliamps. without appreciable increase in aerial current. As such cathode current quickly will damage the tubes never use "coupling 2" except in bad weather when the cathode current with "coupling" set to "1" has fallen appreciately below normal. Switching to "coupling 2" in this case will bring the cathode current up to normal.

Coastal Telephone Transmitter unit

type A 218 V.

Frequency range:

11 crystal controlled frequencies in the 1600-5500 kc/s band. Crystals being supplied according to customer's specifications.

Output power:

100 watts carrier wave measured in an artificial aerial of 15 ohms resistance and a capacity of 250 pF.

Switch for reducing power to about 10 watts.

Modulation:

Modulation up to 95% when transmitting A3 (peak limiter).

Frequency tolerance:

The frequency tolerance is better than 0,02% thus fulfilling the A.C. Conference requirements.

Harmonics:

All harmonics radiated from the aerial will be attenuated at least 40 dbs in relation to the fundamental.

Aerial:

A very elaborate aerial matching network render correct loading of the R.F. power stage and correct tuning of the aerial circuit possible with any aerial more than 15 meters long (total length including down lead). Such matching takes place merely by turning knobs on the front of the transmitter - no internal adjustments or soldering during installation is needed.

Space for putting down figures, indicating the setting of the aerial tuning knobs and dial, is provided for each individual frequency.

Measuring instruments:

The transmitter is provided with a milliammeter and a switch by means of which the cathode current of each individual tube may be checked.

Likewise the grid current of the R.F. power tubes may be checked.

A thermocouple ammeter in the aerial circuit measures the aerial current.

Tubes:

12 tubes type 807 (or equivalent: Philips QE 06/50) are employed.
2 tubes type EF 41
1 tube type EZ 40

A 218 V - Diagram.

Crystal control is employed throughout, 11 frequencies in the band 1600-5600 kc/s being available. An 807 tetrode is used as a crystal controlled oscillator, crystals in the grid circuit are switched in by a switch, which also engages coils and capacitors for the frequency in question. Crystals are connected between grid and chassis (zero potentiale), the cathode being connected to a capacitive voltage divider between grid and chassis. The screen grid is decoupled to chassis by a large capacitor and the coupling to the anode circuit is electronic. The anode circuit consists of a coil (on a ceramic former) with taps and the interelectrode capacity of the valves plus stray capacities in the range 3800-5600 kc/s; in the range 2500-3800 kc/s an 100 pF capacitor (in fact two series connected 200 pF capacitors) is connected in parallel with the coil, and in the range 1600-2500 kc/s a 250 pF capacitor (in fact two series connected 500 pF capacitors) is connected in parallel with the coil (instead of the 100 pF).

In the radio frequency amplifier 4 tetrodes 807 are connected in parallel, the grids being connected to the above mentioned buffer stage, while their anodes are connected to a pi-filter consisting of an anode-cathode capacitor, an inductance coil and a coupling capacitor. The anode-cathode capacitor consists of a 406 pF (in fact two series connected 812 pF) capacitors in the range 3800-5600 kc/s; in the range 2500-3800 kc/s an extra 225 pF capacitor (in fact two series connected 450 pF capacitors) is coupled in parallel with the latter capacitor and in the range 1600-2500 kc/s an extra 636 pF (in fact two series connected 1272 pF capacitors) is coupled in parallel with the 406 pF capacitor instead of the 255 pF capacitor. The coupling capacitor in the range 3800-5600 kc/s consists of a 670 pF capacitor, built in 11 sections of different size. Each section is connected to a contact in an 11 pole switch by means of which the coupling between the tank circuit and the aerial circuit may be varied in 11 steps without detuning the former. In order to keep the proportion between the anode-cathode capacity and the coupling capacity constant an extra 350 pF capacitor is coupled in parallel with the coupling capacitor in the range 2500-3800 kc/s and an 915 pF capacitor in parallel in the range 1600-2500 kc/s.

The aerial circuit consists of the antenna proper, a matching network comprising a variometer (continuously variable inductance) and a tapped capacitor, a switch giving 11 possible combinations of the latter components, the coupling capacitor (part of same) and the earth connection. A thermocouple ammeter reads the aerial current.

The stator and rotor of the variometer may (by the said switch) be coupled in series or in parallel producing an inductance of 15-60 microhenries and 4-16 microhenries respectively. The aerial capacitor consists of 12 series connected 800 pF mica capacitors, having taps for the following capacities: 67, 100, 200 and 400 pF.

For correct matching of the aerial circuit thus 3 knobs are available: coupling, aerial tuning coarse (11 steps) and aerial tuning fine (rotating the rotor of the variometer).

This very improved antenna matching network will match the transmitter to any aerial encountered onboard ships.

Modulation takes place as combined anode and screen grid modulation of the radio frequency power stage. The modulation power is produced by four 807 valves working as class A/B audio amplifiers in parallel - push pull with fixed grid bias (30 volts) derived from the bias rectifier. The modulator is matched to the r.f. power stage by a transformer through the secondary of which the anode and screen grid current of the r.f. power valves flows. An extra winding on the transformer with a nominal impedance of 5 ohms can produce 75 watts of audio frequency power to one or more loud speakers for hailing, when the control switch is set to position "Hailer".

The four modulating valves get their grid excitation from a push pull driver stage containing two type 807 valves working as class A amplifiers. The grids of the driver valves are via a normal resistance-capacity network excited by a push pull class A stage containing two small pentodes EF 41 with variable mutual conductance. The "cold" ends of the two grid leaks of the driver valves are connected to taps on a voltage divider, which is connected across the modulation transformer primary. In this way a negative feedback is applied to the amplifier, reducing distortion and making the modulation transformer secondary voltage fairly independent of the load, thus keeping modulation pretty constant when changing from full power to reduced power and preventing damage to the transformer if by accident it should run idle (no load connected).

24 volts of the 30 volts grid bias of the two driver valves, is derived from the voltage drop across a common 250 ohms resistor in the cathode circuit; the resistor is connected to the negative pole of the anode supply; the cathodes thus adopt a voltage about 24 volts more positive than this pole; the d.c. potential of the grids will be about 6 volts more negative than this pole, being composed of two voltages: a positive voltage of about 24 volts resulting from the d.c. drop acorss the above mentioned voltage divider across the modulation transformer and a negative voltage of 30 volt originating from the grid bias rectifier and supplied through the above mentioned midpoint.

The grids of the two variable-mu valves are connected to the outer ends of the symmetrical secondary of the input transformer. The midpoint of the transformer secondary is through a 2 MΩ resistor connected to a tap in a resistor chain in the cathode circuit of the variable-mu valves. One of the resistors in the chain is variable and setting of the latter determines the working point on the grid bias/anode current curve of the said valves and consequently the amplification of the stage when no other D.C. voltages are present in the grid circuit.

The midpoint of the input transformer secondary however, is also through a suitable filter connected to a balanced rectifier, containing an EZ 40 full wave rectifier valve, two 0,1 MΩ load resistors and two 0,01 mfd. capacitors coupled to the "hot" ends of the modulation transformer primary. The cathode of the rectifier is connected to a point about 350 volts positive relative to minus high tension.

Thus when the peak values of the voltage across each half of the modulation transformer primary exceeds 350 volts (corresponding with a modulation percentage of 85-90%) the rectifying valve begins rectifying and produces a negative D.C. voltage which is applied to the grids of the variable-mu valves, reducing the amplification. The net result is, that within very wide limits of speech intensity the modulation percentage will be very high and yet no overmodulation will take place.

Suitable filters are inserted to make the amplifier reduce the amplification immediately a voltage higher than corresponding to 85-90% modulation appears in the modulation transformer and slowly increase the amplification when the speech intensity falls below the value corresponding to 85% modulation.

The total audio frequency distortion amounts to about 6 per cent measured at a modulation depth of 90 per cent and a test tone of 1000 c/s.

As the transmitter is constructed for as well A2 as A3 transmitting two primaries are supplied on the input transformer, one connected to the microphone through a low pass filter which cuts off at about 3000 c/s, the other via a potentiometer for adjusting the modulation depth, when transmitting A2, to an audio frequency oscillator, giving a pure note of frequency 1000 c/s.

The said low pass filter yields an attenuation of about 15 dbs at 3500 c/s and about 40 dbs at 5000 c/s. The microphone of the handset has a nominal resistance of 50 ohms and an A.F. charachteristic rising about 6 dbs per octav from 200 c/s to 2000 c/s, substantially flat from 2000-3500 c/s and about 10 dbs down at 5000 c/s.

Output of the microphone (at a D.C. current of 60 milliamps.): At 2000 c/s about 0,5 volts A.C. at a sound pressure of 10 dynes pr. square centimetre. The modulation amplifier requires at the input terminals about 100 millivolts for a 85% modulation depth with potentiometer for adjusting sensitivity of amplifier set to maximum amplification. Yet an input of 1 volt (from the microphone) will not modulate the transmitter more than 95%.

Suitable setting of the sensitivity control (potentiometer) is about three quarters up, which setting will give 85% modulation for an A.F. input of about 200 millivolts.

When transmitting A2 the vogad system is cut out by a contact in a relay operated by the main control switch in the switchboard. The aforementioned audio frequency oscillator (1000 c/s) besides working as a source of the A2-note also serves a quite different purpose: in the anode circuit of the oscillator a step-down transformer is inserted, a selenium rectifier connected across the low voltage secondary and the D.C. output of the rectifier filtered by a suitable low pass filter and fed to a voltage divider consisting of fixed resistors. From a tap on the voltage divider grid bias for the modulating valves and for the valves of the M.F. and M.H.F. transmitters A 217 and A 218 and from another tap grid bias for the valves of the H.F. transmitter A 219 is derived.

As mentioned above keying takes place by means of a keying relay which at key down condition shorts a resistor in a voltage divider across the high tension. All cathodes except for the one belonging to the MCW/bias generator are brought to the tap on the voltage divider which is connected to minus high tension at key down. At key up the cathodes adopt a positive voltage of about 50 volts in proportion to minus plate voltage while the grids keep their voltages. In this way all plate and screen grid currents are cut completely off.

The MCW/bias generator is not keyed but oscillates continuously for, under all conditions, to provide negative voltages for biassing.

A 218 V - Operation.

Set transmitter selector switch in switching panel to "coastal", set power switch to "1", set frequency switch in transmitter to the frequency in question, set "coupling" to "1", "aerial coarse" to "1". Turn operating switch in switching panel to "stand by". After 15 seconds turn lever to A1 and press key (or to A3 simplex and press push button of handset). Rotate tuning knob "aerial fine" and note aerial ammeter (below knob). Tune for maximum aerial current. Note cathode current of tubes nos. 5a, 5b, 5c and 5d. The cathode current should increase and decrease simultaneously with the aerial current and assume a value of 90-100 milliamps. when aerial is tuned to true resonance.

If no resonance is obtained at "aerial coarse""1" set "aerial coarse" to "2" and repeat tuning of "aerial fine". If no resonance at "aerial coarse" "2" proceed to"3"and so on until a true resonance point has been found.

If cathode current of tubes 5a, 5b, 5c, 5d does not come up to a value of at least 90 milliamps. turn "coupling" to "2" and repeat tuning procedure. Continue with coupling"3","4"and so on until cathode current of each of the no. 5 tubes assumes a value of 90-100 milliamps.

A good check on the tuning being correct is to compare aerial current and cathode current (of the no. 5 tubes) at settings of "coupling" higher or lower than the correct setting: aerial current will decrease whether coupling is too "tight" (too high a coupling setting number - cathode current too high) or too "loose" (too low a coupling setting number - cathode current too low).

Yet it is a much better plan to use too loose a coupling than too tight coupling as tubes in the latter case will be ruined - and modulation bad.

When transmitter has been correctly tuned operating switch in switchboard may be turned to "A3 duplex" if wanted.

If the settings of the aerial levers and dials are known and the knobs set accordingly the operating switch may immediately be rotated to the mode of transmitting wanted, and after a warming-up period of 15-20 seconds the transmitter is ready for use.

For quick resetting of the aerial matching elements the settings of the levers "coupling" and "aerial tuning coarse" and the knob "aerial tuning fine", when once found, should be put down (by pencil or ink) in the lower part of the white space ("windows") containing the frequency labelling of the frequency switch.

Setting up of channels:

If a new channel, which has bot been set up by the factory, is wanted, first procure a crystal for the desired frequency (same as the transmitting frequency). It is recommended to order a crystal with a frequency tolerance of not more than $\pm$0,01%. Also when ordering the crystal draw the manufacturer's attentiom to the fact that the crystal should be calibrated with a capacity of 50 pF in parallel. Plug the crystal in an idle socket (note the manner of numbering: top line, from left: 1-2-3-4-5-6, no. 2 line from top, from left: 7-8-9-10-11).

First the plate circuit of the oscillator has to be tuned, If the transmitting frequency is lying in the range 3800-5600 kc/s no extra tuning capacity is needed. If the frequency lies in the range 2500-3800 kc/s an additional 100 pF tuning capacitor (fixed) has to be connected in parallel with the coil and if it lies in the range 1600-2500 kc/s an additional 250 pF (no 100 pF capacitor connected on this range) should be connected in the same manner. Cutting-in of these capacitors is carried out by wafer no. 3 of the frequency switch. The "hot" end of the tuned plate circuit has been connected to the moving contact of wafer no. 3, while the 100 pF capacitor has been connected to the fixed contact no. 11 of the same wafer and the 250 pF capacitor to contact no. 1 of the same wafer. For the rest all of the 11 fixed contacts have been mutually connected by a tinned wire, soldered to each individual contact.

Normally the crystals have been inserted in such sequence that the emergency frequency 2182 has been numbered 1 and the remaining crystals inserted so that increasing number of position corresponds with increasing frequency.

If for instance frequencies nos. 1-6 are lying in the range 1600-2500 kc/s the 250 pF capacitor must be cut in in these 7 positions. If the remaining 5 frequencies (nos. 7-11) are lying in the range 2500-3800 kc/s the 100 pF capacitor must be cut in in these 5 positions. If now the wire connecting the fixed contacts is cut between contacts nos. 6 and 7 the said capacitors automatically will be cut in, when the frequency switch is set to the appropriate positions.

If - as an exception - a frequency in the range 3800-5500 kc/s has to be set up each connection to the appropriate contact of wafer no. 3 has to be unsoldered.

The value of inductance of the oscillator plate circuit is selected by wafer no. 2 of the frequency switch. Connecting wires from this wafer are carried to a ceramic support mounted horizontally above the tuning coil.

Clip a short piece of wire to the wire end with the number in question. Set transmitter to reduced power (1/10 power), set cathode/grid current switch to "grid 7" (gitter 7), set control switch to "Telegraphy CW" and press the key. Clip the other end of the short piece of wire to a tap on the coil which one finds reasonable for the frequency concerned and note the grid current on the milliammeter. Find the tap which will produce maximum grid current, about 20-25 milliamps. Practically it has shown desirable to tune the plate circuit of the oscillator to a frequency slightly higher than resonance; so a coil tap 1, 2 or 3 turns less than necessary for resonance is chosen (1 turn on the higher frequencies, 3 turns on the lower ones.) A tap chosen along this line will produce a grid current of 14-16 milliamps. which is adequate for driving the r.f. power stage. (Moreover too high a value of grid current will lower the available output of the power stage). Both ends of the connecting wire are soldered. (Less turns means a coil tap farer off the front plate).

Next the tank circuit of the r.f. power stage has to be tuned. Switch "coupling" is set to 0 (zero), and switch "aerial tuning, coarse" is also set to 0 (zero). If the transmitting frequency is lying between 3800 and 5600 kc/s no additional capacitor should be connected across the tank circuit tuning capacitor (fixed). If the transmitting frequency lies between 2500 and 3800 kc/s an additional 350 pF capacitor has to be connected in parallel with the coupling capacitor and a 225 pF capacitor in parallel with the anode-cathode capacitor. If the frequency, lies between 1600 and 2600 kc/s an additional 915 pF capacitor has to be connected in parallel with the coupling capacitor (instead of the said 350 pF capacitor) and a 635 pF capacitor in parallel with the anode-cathode capacitor (instead of the above mentioned 225 pF capacitor).

Cutting-in of these capacitors is carried out by wafers nos. 4 and 5 of the frequency switch. The 350 pF supplemental coupling capacitor has been connected to contact no. 11 of wafer no. 4, while the 915 pF supplemental coupling capacitor has been connected to contact no. 1 of wafer no. 4. In the same way the 225 pF supplemental tuning capacitor has been connected to contact no. 11 of wafer no. 5 and the 635 pF supplemental tuning capacitor connected to contact no. 1 of wafer no. 5. And as in wafer no. 3 contacts 1-11 of wafer no. 4 and 5 respectively has been mutually connected by a tinned copper wire soldered to each individual contact.

If as above supposed, frequencies nos. 1-6 are lying in the range 1600-2500 kc/s and the remaining 5 frequencies (nos. 7-11) are lying in the range 2500-3800 kc/s, in wafers no. 4 and 5 the wire connecting the fixed contacts has to be cut between contacts nos. 6 and 7. This done the capacitors automatically will be switched in when necessary by the frequency switch.

If a frequency in the range 3800-5500 kc/s has to be set up, each connection to the fixed contact in question must be unsoldered.

At length a tap on the tank circuit tuning coil has to be selected. A flexible lead is clipped to the tag on the insulating strip (the one nearest the front plate) which has the same numbering (count from left) as the crystal socket concerned and which has a wire connection with a contact on wafer no. 6 of the frequency switch. The free end of the flexible lead is clipped to a tap on the tank coil, which one finds reasonable. A tap should be selected which will give a distinct fall of the cathode current of the no. 7 valves. If difficulty in finding the correct tap is encountered with the transmitter set to reduced power, full power may be employed, provided that the transmitter is keyed but for a very short time. When the correct tap has been found a 2 mm tinned copper wire is drawn between the coil tap and the tag on the rear insulating strip with the same numbering as the crystal socket concerned. The wire is carefully soldered at both ends.

Finally the tank circuit is tuned fine by means of a trimmer coil, the number of turns being found by trial. The trimmer coil is placed between the soldering tags on the front and rear insulating strip.

When the tank circuit is correctly tuned the cathode current of the four no. 7 valves will amount to about 100 milliamps. with the transmitter on full power. The trimmer coil is carefully soldred after checking the cathode current of the no. 7 valves with the chassis pushed in. The iron cabinet may have a slight influence on the tuning of the tank coil, reducing the inductance a trifle, and a small readjustment of the trimmer coil may be necessary. Ordinarily pressing the turns of the trimmer coil slightly tigther will increase the inductance sufficiently for correct tuning of the tank circuit with the chassis pushed in.

If in special cases one "channel" has to be used with two crystals, differing no more than 0,5 per cent in frequency, the transmitter should preferably, be tuned with the crystal with the higher frequency inserted in the (common) socket. No difficulty whatever will then be encountered when the crystal with the lower frequency is inserted instead.

If a crystal which otherwise is assumed to be alright should refuse oscillating or start too slowly (dots too short when keying) the reason generally will be that the coil in the plate circuit of the oscillator valve is too large. A coil tap one or two turns farer-off the front plate is the remedy.

The degree of modulation can hardly be checked correctly without the use of an oscilloscope. The sensitivity of the modulator i.e. the maximum amplification of the modulation amplifier is set by the potentiometer labelled "A3", the slotted spindle of which projects above the chassis in the left end of the chassis.

When the setting of the A3 potentiometer is fixed, next set the A2 potentiometer for about 80-90% modulation. The slotted spindel of the A2 potentiometer projects above the chassis in the right hand end of same.

Note:

If the amplification is set too high by means of the A3 potentiometer, noise from the room will be heard at the receiving end when the handset push button is pressed and no speaking takes place. As soon as one begins speaking the sensivitity of the amplifier is automatically adjusted to a level corresponding with the strength of the speaking voice, the noise becoming weaker the louder one is speaking.

NB: When trimming the transmitter special caution to the high tension 550 volt has to be paid. The coils and connecting wires mentioned above are not themselves carrying the dangerous voltage, but all anodes (plates) which are brought out in top of the valves are "live" and dangerous.

H.F. Telegraph and Telephone Transmitter unit Type A 219 V.

Frequency range:

The transmitter covers the 4, 6, 8, 12, 16 and 22 Mc/s ships' telegraphy and telephony bands. In each band 3 telegraph frequencies are available, i.e. one calling and two working frequencies. For this purpose three 2 Mc/s crystals, the harmonics of which are used in the 4 - 6- 8 - 12 - 16 Mc/s bands, and three 2,7 Mc/s crystals the harmonics of which are used in the 22 Mc/s band are provided.

Further a total number of 14 frequencies in the 4, 8, 12, 16 and 22 Mc/s ships' telephony bands are availabel.

Crystals are supplied according to customer's specifications, accomodation for a total number of 20 crystals being available.

Aerial power:

100 watts carrier wave measured in an artificial aerial having a resistance of at least 40 ohms. Means for reducing aerial power to about one tenth.

Modulation:

Modulation up to 95% when transmitting A3 . (Peak limiter).

Frequency tolerance:

When equipped with crystals supplied by the manufacturer of the transmitter the frequency tolerance is better than 0,02% for telegraph frequencies and better than 0,005% for telephone frequencies as required by the A.C. conference 1947.

Harmonics:

All harmonics radiated from the aerial will be attenuated at least 40 dbs in relation to the fundamental.

Aerial:

A very elaborate aerial matching network render correct loading of the R.F. power stage and correct tuning of the aerial circuit possible with any aerial encountered on board ships.

Such matching takes place merely by turning knobs on the front of the transmitter - no internal adjustments or soldering during installation is needed.

Space for putting down figures indicating the setting of the aerial tuning knobs and dials is provided for each H.F. band.

Measuring instruments:

The transmitter is provided with a milliammeter and a switch by menas of which the cathode current of each individual tube may be checked.

Likewise the grid current of the R.F. power tubes may be checked.

Aerial power is indicated by the glow of a neon voltage indicating lamp; tuning being accomplished by means of the above mentioned milliammeter.

Tubes:

4 tubes type 807 (or equivalent: Philips QE 06/50)
2 tubes type QQE 06/40 (Philips)
2 tubes OA 2 (Philips)

A 219 V - Diagram.

The transmitter covers the following H.F. bands allotted for ships' telegraphy and telephony:

4063	-	4238	kc/s
6200	-	6357	-
8195	-	8476	-
12330	-	12714	-
16460	-	16952	-
22000	-	22400	-

Crystal control is employed throughout, an 807 valve acting as a crystal controlled Pierce-oscillator.

The plate circuit of the oscillator is coupled direct to the grid of the 807 buffer tube (tube no. 2), the plate circuit of which by means of coil L1 and trimmers C1a+C1b is tuned to 2 Mc/s when transmitting on 4, 6, 8 and 12 Mc/s, by trimmer C2 to 4 Mc/s when transmitting on 16 Mc/s and by C3 to 5,5 Mc/s when transmitting on 22 Mc/s.

The plate circuit of tube no. 2 is for transmitting on 4 and 6 Mc/s connected direct to the grid of tube no. 4, while for transmitting on 8, 12, 16 and 22 Mc/s it is connected to the grid of tube no. 3. On bands 4 and 6 Mc/s the grid of tube no. 3 is connected to ground by a large capacitor, cutting the tube quite out of action. When transmitting on 8, 12, 16 and 22 Mc/s the plate circuit of tube no. 3 is by means of coil L2 and trimmers C4, C5, C6, C7 tuned to 4, 6, 8 and 11 Mc/s.

The plate circuit of tube no. 3 is for transmitting on bands 8, 12, 16 and 22 Mc/s connected to the grid of tube no. 4. The latter consequently is fed with 2, 2, 4, 6, 8 and 11 Mc/s oscillations when transmitting on frequencies 4, 6, 8, 12, 16 and 22 Mc/s. The plate circuit of tube no. 4 is by menas of coil L3 and trimmers C8, C9, C10, C11, C12 and C13 tuned to 4, 6, 8, 12, 16 and 22 Mc/s.

The plate circuit of tube no. 4 is connected direct to the grids of the two parallel connected twin tubes QQE 06/40 (each glass envelope containing two electrode systems). These tubes are working as plain class C amplifiers with their plate circuit tuned to the same frequency as their grid circuit. The plate circuit of the power amplifier has been built as a pi-filter, consisting of an anode-cathode capacitor, an inductance coil and a coupling capacitor. Two sections of the frequency switch take care that suitable fixed capacitors are cut in and suitable taps on the coil are cut in on the different bands, while a trimmer C18 with its shaft brought out in the front panel and provided with a knob covers the individual bands.

The anode-cathode capacitors are: C14: 525 pF (4 Mc/s), C 15: 160 pF (6 Mc/s), C 16: 110 pF (8 Mc/s). On bands 12, 16 and 22 Mc/s the trimmer is the only tuning capacitor (besides tube capacities etc.)

The coupling capacitor consists of a 280 pF capacitor, C 52, consisting of 11 series connected capacitors of different value, with taps brought out to an 11 position switch. The coupling capacity, that means the part of the coupling condenser which is common to the tank circuit and the aerial circuit, in this way may be varied between about 1700 and 280 pF without noticeable detuning of the tank circuit.

In order to keep the proportion between the anode-cathode capacity and the (total) coupling capacity approximately constant fixed capacitors are switched in in parallel with the 280 pF coupling capacitor on the bands where extra capacitors are switched in parallel with the anode-cathode capacitor. The extra coupling capacitors are: C53: 1150 pF (4 Mc/s), C54: 667 pF (6 Mc/s), C55: 412 pF (8 Mc/s).

As the transmitter covers as well the telegraph as the telephone frequencies on all H.F. bands allocated to ships' radio communication certain precautions have been made to simplify operation within the bands. The power amplifier tank circuit is tuned correctly by the trimmer in the front.

The doubler (tripler) circuits with coils L1 and L2 are so broadly tuned (so heavily damped) that they cover the bands without retuning and without special precautions. The circuit consisting of coil L3 and the trimmers (semi fixed) C8-------C13 must produce drive of correct amplitude for the grid circuit of the power amplifier on all bands and on all frequencies within the bands. This is accomplished by suitable damping resistors connected across different parts of the coil L3 on the different bands.

Grid bias for all tubes in the H.F. transmitter is derived from a bias generator in the A 218 transmitter section.

Screen grid voltages are derived from the plate voltage through suitable dropping resistors. Screen grid voltage for the power amplifier is taken from the modulated plate voltage of the power amplifier, also through a dropping resistor. In order to keep the screen grid voltage below about 300 volts also with key up (in which case the screen grid current is zero and the voltage across the dropping resistor consequently zero) two series connected neon stabilizers have been connected between screen grid and minus H.T.

In order that the modulation voltages (when transmitting A3) at the screen grids of the power amplifier should not be shortcircuited by the stabilizers an A.F. choke (about 9 henries) is connected in series with the stabilizers.

Modulating power for A3 transmitting is provided by the modulator built into the A 218 Section.

As mentioned above keying takes place by means of a keying relay which at key down condition shorts a resistor in a voltage divider across the high tension. All cathodes are brought to the tap on the voltage divider which is connected to minus high tension at key down. At key up all cathodes adopt a positive voltage of some 50 volts (while the grids keep their negative voltage). In this way plate and screen grid current of all tubes are cut completely off.

Without grid drive (no crystal inserted or crystal not oscillating) but key down, the cathode current of the power amplifier is also practically zero.

Aerial circuit:

A very elaborate aerial matching system has been provided for correct tuning of the aerial circuit and correct loading of the power amplifier irrespectively of the size of the aerial.

The aerial tuning elements consist of a coil L5 with taps (0-17 microhenries) and a variable capacitor 25-275 pF. By means of an 11 position switch ("aerial coarse") part of the coil and the variable capacitor may be connected in series (position 1-6) or in parallel (position 7-11) rendering possible outbalancing of positive or negative reactances within very wide limits. Correct loading of the tank circuit of the power amplifier is accomplished by the 11 position switch "coupling".

For correct matching and tuning so three levers and dials are available: "coupling", "aerial coarse" and "aerial fine". Once the settings have been found for each band (only slight retuning will generally be necessary within the bands) the figures of the settings are put down in the "window" above the band switch, making resetting of dials and knobs very quick and easy. For convenience also the setting of "trimmer" for crystalfrequency no. 1 (i.e. calling frequency) is put down in the same window.

A 219 V - Operation.

Set transmitter selector switch in switching panel to "HF", set power switch to "1/10", set band switch in H.F. transmitter proper to the correct band, set crystal switch to correct channel (according to table in front plate), set "coupling" to 0 (zero), set cathode current switch to one of the no. 5 tubes. Turn operating switch in switchboard to "stand by". After 15 seconds turn lever to A1, press key and rotate knob "trimmer" till minimum cathode current of the no. 5 tubes is obtained. Set power switch to 1/1 and readjust "trimmer". Cathode current then should amount to 50-55 milliamps.

Next set "coupling" to "1", "aerial coarse" to "1" and rotate "aerial fine" from one end of the dial to the other and note if the cathode current rises to a maximum during this operation. If a maximum has been found note the value of the cathode current of the no. 5 tubes. If the cathode current does not come up to about 175 milliamps. (each tube, consisting of two parallel connected systems) set "coupling" to "2" and repeat aerial tuning. If necessary proceed to 3, 4 and so on.

At the same time note light in aerial voltage indicator lamp. Maximum light should be obtained simultaneously with maximum cathode current.

Yet the cathode current should never exceed 200 milliamps. (each tube) as too high cathode current will ruin the tubes - and reduce aerial power.

If no point of resonance has been found with switch "aerial coarse" set to "1" then proceed to "2" and rotate "aerial fine" again for resonance (maximum light in aerial voltage indicator lamp). If necessary proceed to "3","4"and so on until a true resonance point has been found, and adjust "coupling" (and readjust "aerial fine") until correct value of cathode current of the power tubes is obtained.

It is a good check on correct tuning of the aerial (tuned to zero reactance) to test if the setting of "trimmer" which has been found with unloaded power amplifier (coupling zero) is unchanged when the amplifier is loaded by the aerial resistance. So, with the aerial tuned as prescribed above, try to rotate knob "trimmer" slightly to either side of its original setting and observe if the cathode current of the no. 5 tubes increases; the latter should be the case. - If the cathode current decreases when "trimmer" is rotated either upwards or downwards a new setting of the aerial tuning elements must be found complying with the instructions given above.

Yet when a very high value of "coupling"-setting (9-10-11) is necessary for correct loading of the tank circuit a small reaction from the aerial may be inevitable. The knob "trimmer" then should be readjusted and

a setting chosen which will give minimum cathode current with aerial tuned to resonance, but with the difference that the minimum cathode current with loaded amplifier amounts to 170-180 milliamps. per tube (compared with 50-60 milliamps. unloaded.)

In order to facilitate future tuning the settings of the levers and knobs "trimmer", "coupling", "aerial coarse" and "aerial fine" for crystal channel no. 1 (crystal 1) should be put down (in ink or pencil) on the calibration dial which appears behind the window immediately above the band switch.

Future adjusting of the said knobs then may take place immediately according to the calibration figures which appear in the window, and the operating switch (in switching panel below) may be rotated directly to the mode of transmission wanted. After a warming up period of 15-20 seconds the transmitter is ready for use.

Please note:

The calibration figures mentioned hold strictly for crystal 1 only. When other crystals are switched in a slight readjustment of "trimmer" may be necessary (adjust to cathode current "dip"). The settings of the remaining levers and knobs will hardly be affected by the small change of frequency within the limits of the ships' transmitting bands.

Placing of the crystals in their holders may require a small explanation.

Sockets with index "a" in the upper two lines should hold 2 Mc crystals, while sockets with index "b" in line three should hold 2,7 Mc crystals. Position 1a and 1b are intended for crystals corresponding with ship's calling frequency (telegraphy) and 2a, 2b and 3a, 3b are intended for ship's working frequencies (telegraphy) in the 4, 6, 8, 12, 16 and 22 Mc bands. Positions 4a-14a are intended for 2 Mc crystals for individual telephony frequencies in the 4, 8, 12 and 16 Mc bands (frequencies not harmonic) while positions 13b, 14b and 15b are intended for 2,7 Mc crystals for telephony frequencies in the 22 Mc band.

Trimming:

The whole transmitter is correctly trimmed when leaving the factory. If for any reason new trimming has to take place proceed as follows:

Set power switch to "1/10" set band switch to "4" set crystal switch to 2 Mc-crystal with highest frequency (no. 3) set "cathode/grid current" switch to "cathode 2" and adjust trimmer C1a, labelled "4-6-8-12" for minimum cathode current (2 Mc/s); set switch "cathode/grid current" to "grid 4" and readjust C1a for maximum grid current. Set "cathode/grid current" switch to "grid 5" and adjust C8 labelled "4" for maximum grid current (4 Mc/s).

Next set crystal switch to 2 Mc-crystal with lowest frequency (a telephone frequency) and readjust trimmer C8 slightly for increasing grid current in the "low" end of the 4 Mc-band. Shift a couple of times between crystals with highest and lowest 2 Mc-frequency and adjust C8 for equal grid current of the no. 5 tubes on the highest and lowest 4 Mc-frequency. Check setting of trimmer C1a; it might be advantageous to readjust it a trifle to get maximum grid current in the no. 4 tubes and consequently also in the no. 5 tubes in both ends of the band.

Next set band switch to "6". As the same anode circuit (2 Mc/s) of tube no. 2 is used on 6 Mc/s as on 4 Mc/s adjustment of C1a should not be changed. Set "cathode/grid current" switch to "grid 5" and adjust C9, labelled "6", for maximum grid current (6 Mc/s). Shift between crystals with highest and lowest 2 Mc-frequency as above and adjust C9 for equal grid current in the no. 5 tubes on the highest and lowest 6 Mc-frequency.

Next set band switch to "8". As the same anode circuit (2 Mc/s) of tube no. 2 is used on 8 Mc/s as on 4 Mc/s C1a remains untouched. Set "cathode/grid current" switch to "grid 4" and adjust C4, labelled "8", for maximum grid current (4 Mc/s). Set "cathode/grid current" switch to "grid 5" and adjust C10, labelled "8", for maximum grid current (8 Mc/s). Shift between crystals with highest and lowest 2 Mc-frequency as above and adjust C10 for equal grid current in the no. 5 tubes on highest and lowest 8 Mc-frequency.

Next set band switch to "12". As the same anode circuit (2 Mc/s) of tube no. 2 is used on 12 Mc/s as on 4 Mc/s C1a remains untouched. Set "cathode/grid current" switch to "grid 4" and adjust C5, labelled "12" for maximum grid current (6 Mc/s). Set "cathode/grid current" switch to "grid 5" and adjust C11, labelled "12", for maximum grid current (12 Mc/s) and shift between crystals with highest and lowest frequency as above.

Next set band switch to "16". Set "cathode/grid current" switch to "grid 3" and adjust trimmer C2, labelled "16", for maximum grid current (4 Mc/s). Set "cathode/grid current" switch to "grid 4" and adjust C6, labelled "16", for maximum grid current (8 Mc/s). Set "cathode/grid current" switch to "grid 5" and adjust C12, labelled "16", for maximum grid current (16 Mc/s) and shift between crystals with highest and lowest frequency as above.

Next set band switch to "22". By doing so 2,7 Mc-crystals are automatically switched into the oscillator circuit instead of 2 Mc-crystals. Set "cathode/grid current" switch to "grid 3" and adjust trimmer C3, labelled "22", for maximum grid current (5,5 Mc/s). Set "cathode/grid current" switch to "grid 4" and adjust trimmer C7, labelled "22", for maximum grid current (11 Mc/s). Set "cathode/grid current" switch to "grid 5" and adjust C13, labelled "22" for maximum grid current (22 Mc/s). Shift between crystals with highest and lowest 2,7 Mc-frequency and adjust C13 for equal grid current in the no. 5 tubes on highest and lowest 22 Mc-frequency.

Trimmer C18, which has its shaft brought out through the front plate and provided with knob and dial must be adjusted for minimum cathode current of the no. 5 tubes for each frequency in each band according to instructions given in section "Operation".

Check the values of grid and cathode currents with the values stated in the "Normal Meter Readings" (attached to the description).

When trimming the transmitter it may be convenient to use a small neon indicator lamp as a tuning indicator. The lamp is held in its brass socket and the glass envelope held against the anode of the tube, the anode circuit of which is being tuned. Maximum light in the neon lamp indicates resonance of the anode circuit, which condition gives rise to maximum grid current in the succeeding stage.

Care should be taken not to touch the anode of the tube with the brass socket of the neon indicator as the 550 volt high tension is dangerous. For safety: Stand on a dry wooden floor or otherwise insulated from ground, and never touch chassis or grounded metal objects with the idle hand - and finally, use a well insulated screwdriver for trimming.

S a f e t y f i r s t.

6/11-1961 HB/lh