Technical Specification of

100 watts MF, MHF and HF Marine Radio Transmitter

Type A 230

The complete transmitter comprises three R.F. units, a common modulator and operating panel and in AC-installations a power pack with transformers, rectifiers and filters, plus a switchboard with main switch, meter and fuses, built into a common steel cabinet in grey finish. If in special cases extra switches, fuses etc. are placed in the switchboard space for power pack may be too restricted, so power pack is placed outside transmitter. Converters used in DC-installations are always placed outside transmitter.

The three RF units are:

a medium frequency transmitter for telegraphy (in short: MF-transmitter), designated A 231

a medium high frequency transmitter for coastal telephony (in short: MHF-transmitter), designated A 232

a high frequency transmitter for telegraphy and telephony (in short: HF-transmitter) designated A 233.

Frequency range:

MF-transmitter:
8 frequencies in the range 410-512 kHz,
normally 410, 425, 448, 454, 468, 480, 500, 512 kc/s

MHF-transmitter:
a maximum of 23 frequencies, all crystal controlled, in the range 1600-3800 kc/s.
Crystals according to customer's specifications.

HF-transmitter:
arranged for transmitting in the 4, 6, 8, 12, 16 and 22 Mc/s ship's telegraphy and telephony bands. Crystal control throughout. Crystals for one calling and two working frequencies in the telegraphy bands are supplied according to customer's specification. Further a maximum of 20 frequencies in the 4, 8, 12, 16 Mc/s telephony bands and 5 frequencies in the 22 Mc/s telephony band may be available when crystals for the appropriate frequencies are ordered.

Type of emission:

MF-transmitter: A1 (CW), A2 (MCW).

MHF-transmitter: A3 (telephony), A0/A2 (carrier, modulated by a local AF-generator, operated by the key).

HF-transmitter: A1 (CW), A3 (telephony), A0/A2 (carrier, modulated by a local AF-generator, operated by the key).

Output power:

MF-transmitter:
Output to aerial circuit: 175 watts (A1 and A2).
Output measured in artificial aerial (outside transmitter): ranging from 75 watts in 300 pF plus 3,6 ohms to 85 watts in 750 pF plus 1,8 ohms in the range 410 to 512 kc/s.

MHF-transmitter:
Output to aerial circuit: 125 watts (A3, carrier).
Output measured in artificial aerial (outside transmitter): 100 watts in 250 pF plus 6 ohms on the lower frequencies and the same output in 250 pF plus 8 microhenries plus 40 ohms on the higher frequencies.

HF-transmitter:
Output to aerial circuit: 125 watts (A1 and A3 carrier).
Output measured in artificial aerial (outside transmitter): 100 watts in a resistance having a value between 20 and 2000 ohms.

Output power control:

Output may by a switch be lowered to 1/10 of full power.

Frequency stability:

MF-transmitter: $\pm$0,1 %

MHF-transmitter: $\pm$0,02%

HF-transmitter: A1: $\pm$0,02%, A3: $\pm$0,005%.

Modulation:

Modulation takes place in the final stage of the RF-amplifier as combined anode and screen grid modulation, the PA-tubes working in class C. The modulator is switched to the transmitter in question, the modulating power being produced by an AF-amplifier, the final stage of which is working in class AB. Input from modern 50 ohms carbon type microphone. Elaborate vogad (voice operated gain adjusting device) system makes modulation independent of speaking strength and limits modulation to 95%.

Harmonics and spurious frequencies:

All harmonics - and spurious frequencies, if any - will be attenuated at least 40 dbs in relation to the carrier.

Aerial:

A common aerial is used for all 3 transmitters.

No special requirements to length or size are necessary as all 3 transmitters will tune to any aerial likely to be encountered on board a ship (minimum capacity for MF-transmitter yet 290 pF, if all MF-frequencies shall be covered).

Tubes:

| | |
|---|---|
| MF-transmitter: | 6 type QE 05/40 (or American equivalent RCA 6146) |
| MHF-transmitter: | 4 type QE 05/40 (or equivalent) |
| HF-transmitter: | 7 type QE 05/40 (or equivalent)<br>1 type OA2 voltage stabilizer |
| Modulator: | 5 type QE 05/40 (or equivalent)<br>2 type EF 89<br>4 type EL 84<br>1 type ECF 80<br>4 type OA2 voltage stabilizers<br>2 type OB2 voltage stabilizers<br>1 type 90C1 voltage stabilizer. |

Power supply:

According to customer's specification equipped with power pack or converter for one of the following primary supplies:

110 or 220 volts, 50-60 c/s AC, single phase
110 or 220 volts DC (or any other standard DC voltage)
24, 32 or 36 volts DC (battery).

The power pack employed on AC contains filament transformer, rectifier for 24 volts DC and rectifier and filter for 600 volts.

On DC, 110 and 220 volts, the converter supplies 25 volts for filaments and relays and 600 volts for anode supply.

On battery, filaments and relays are supplied directly, and a converter working off the battery supplies 600 volts for anodes.

Power requirements:

The power drain depends to a certain degree on the mode of transmission. The maximum drain is reached on A2 key down and on A3 at full modulation, being

| | |
|---|---|
| on AC about | : 1,0 KVA |
| on DC (including battery operation) | : 1,2 kW. |

Mechanical design:

The welded steel cabinet below contains the switchboard, and terminal strips for connecting cables from outside.

On top of the switchboard 4 drawers fills up the remainder of the cabinet, from below: the modulator-unit, MF-unit, MHF-unit and HF-unit.

Behind the three RF-units are inside the cabinet, on the rear wall of same, mounted three aerial relays, connecting the aerial to the transmitting unit being operated.

All units may be withdrawn for inspections without breaking connecting cables.

Door switches breaks high tension when drawers are withdrawn. Yet door switches may be temporarily locked by hand if high tension is wanted switched in.

Drawers may be completely withdrawn when mechanical stop is released, electrical connections being designed as multicore cables with plugs and sockets.

Dimensions:

Cabinet:

Height: 1370 mm + 70 mm aerial insulator
+ 40 mm shock absorbers.
Width: 540 mm + 20 mm earthing studs on both sides.
Depth: 450 mm (including hand grips) + 40 mm shock absorbers.

Weight: 160 kgs. (120 kgs if power pack is placed outside cabinet).

Power pack: (when not built into the cabinet)

Height: 320 mm
Width: 540 mm
Depth: 340 mm

Weight: 45 kgs.

Converter, including starting relays and radio interference filters:

Height: 380 mm
Width: 490 mm
Depth: 360 mm

Weight: 60 kgs.

Description of

100 Watts MF, MHF and HF Marine Radio Transmitter

Type A 230/A 231/A 232/A 233.

The description covers the following diagrams:

1) Switchboard
2) Internal cabling (in cabinet)
3) Main terminal board connections
4) Rectifier
5) Modulator and operating panel
6) A 231: 100 Watt MF-transmitter
7) A 232: 100 watt MHF-transmitter
8) A 233: 100 watt HF-transmitter.

Switchboard contains mains switch, fuses and voltmeter plus distribution of current for all apparatus such as receivers, autoalarm etc. in the radio cabin, each outlet provided with fuses.

Internal cabling gives a survey of the wiring in the cabinet with terminal numbers, plug pin numbers etc. and shows all connections between the different units of the transmitter.

Main terminal board connections shows all connections to and from the main terminal board.

Rectifier: The rectifier unit contains one transformer supplying 25 volts AC for heating of all filaments of tubes in modulator and transmitting unit being operated.

A full wave selenium rectifier with double filter supplies a maximum of 0,8 amps at 600 volts for anode and screen grid supply of all tubes.

Another full wave selenium rectifier supplies 24 volts DC for relays and via a filter built into the modulator DC for the microphone and auxiliary keying relay.

## Modulator and Operating Panel

## A 230

The modulator and operating panel contains the modulator proper i.e., all transformers, filters, tubes etc. for amplifying the AC-output from the microphone to the level necessary for modulating the power stage of the transmitting units A 231, A 232 and A 233. For the sake of convenience most of the apparatus which likewise are common to the three RF-units, and switches for switching such apparatus between the RF-units, are placed in the modulator and operating panel.

Speech input for the AF-amplifier is produced by the microphone: type: handset, all bakelite, fully sealed carbon type microphone (interchangeable capsule), push button for keying of transmitter and closing of microphone circuit. Earpiece: magnetic, also constructed as an easily interchangeable capsule. The microphone has a nominal resistance of 50 ohms; its characteristic is rising about 20 dbs from 200 c/s to 2000 c/s, substantially flat from 2000 to 3500 c/s and falls off above 3500 c/s. Output of the microphone (at a DC of 60 milliamps): at 2000 c/s about 0,5 volts AC at a sound pressure of 10 dynes per square centimeter.

The microphone is fed with DC from rectifier, converter or battery according to power source, the current being well filtered by a low pass filter before entering the microphone.

The AC output of the microphone is via a low pass filter, cutting off at about 3000 c/s, and a capacitor, fed to one of the primaries of the shielded input transformer. The filter in the input circuit attenuates frequencies below 250 c/s considerably. The total AF-response of the transmitter moreover is so, that the response curve rises some 15 dbs from 250 c/s to 1000 c/s, is substantially flat from 1000 to 2500 c/s, falling off steeply above 3000 c/s: about 15 db down at 3500 c/s and about 35 db down at 5000 c/s.

The 15 db rise in frequency response curve from 250 to 1000 c/s may be reduced to 5 db - if wanted - by simply shorting a capacitor (C10) of the AF-filter.

The symmetrical secondary of the input transformer is connected to the grids of two RF-pentodes EF 89 (with varying slope), working in push pull and via a resistance/capacity network coupled to the driver stage, containing two EL 84 AF-pentodes, which again via a resistance/capacity network drives the grids of the AF-power stage, containing 4 tubes QE 05/40 in parallel - push pull.

Anode and screen grid voltage for the input tubes EF 89 is taken off a voltage divider across 600 volts. Grid bias consists of a fixed, but adjustable, voltage derived through an 2 Megohms resistor R 91 from potentiometer P2: "Sensivitity", which is part of a voltage divider across a stabilized negative voltage of 150 volts.

The setting of potentiometer "Sensitivity" fixes the amplification of the two variable-mu input tubes.

Besides the fixed bias an extra bias is applied to the two input tubes when the input exceeds a certain limit. This bias is derived in the following manner: The pentode section of an ECF 80 (tube no. 4) has its anode connected to the moving contact of potentiometer "Sensitivity" through the above mentioned 2 Megohms resistor R 91 and obtains a voltage between minus 0,5 and minus 11 volts (according to setting of the potentiometer). Its screen grid is connected to zero potential (minus high tension). Its cathode is connected to a point on the above mentioned voltage divider across the negative voltage of 150 volts and adopts a voltage of some 67 volts negative (relative to zero - minus high voltage). At length the control grid of the pentode section of ECF 80 is connected to the moving contact of a potentiometer P 3 inserted in the just mentioned voltage divider and may according to the setting of the said potentiometer - labelled "Max. modulation" - adopt a voltage 122 to 150 volts negative - relative to zero. The anode of the ECF 80 in this way is about 60 volts positive relative to its cathode and the control grid 55 to 83 volts negative relative to its cathode. So the tube is biased well beyond cut-off (will not draw any anode current) and consequently will not affect the grid bias of the two input pentodes EF 89. - From a suitable tapping on a voltage divider across the primary of the modulating transformer (in the AF-output stage) an AC voltage of audio frequency is branched off and via a capacitor C22 led to the control grid of the pentode section of ECF 80. When the peak value of the AC voltage exceeds the grid bias of the tube, the latter will draw anode current during the positive grid voltage peaks. This pulsing anode current passes through the 2 Megohms anode resistor R 91 and is smoothed by capacitor C 42, 0,05 microfarad. The voltage drop across R 91 adds to the fixed bias of the input tubes EF 89 in such a way as to make the grids of the input tubes more negative - lowering the amplification and establishing a momentary balance between input strength of signals and amplification.

At a suitable setting of potentiometer P3, "Max. modulation", the grid bias of the pentodesection of the ECF 80 may be adjusted so, that additional grid bias is developped across R 91 when the depth of modulation exceeds 90 per cent. The control is very effective because a relatively small rise in modulation percentage will cause a large increase in grid

control voltage. In fact, if "Sensitivity" has been adjusted to maximum i.e. so that an input voltage of 30 millivolts will bring about a modulation depth of 90 per cent then an increase in input to 1 volt (an increase of 30 dbs) will cause the modulation depth to increase to only 95-98 per cent. At the same time the distortion within the range stated will not exceed 3 per cent.

On account of the low resistance of the tube ECF 80 charging of the smoothing capacitor C 42 (0,05 microfarad) and filter capacitor C 15 (0,05 microfarad) will occur very quickly, thus immediately an input voltage which would cause overmodulation is applied, the sensitivity is decreased, limiting the depth of modulation to 100 per cent. Discharging of the said capacitors takes place through the 2 Megohms resistor R 91 and lasts a few tenths of a second.

During ordinary speech the grid bias of the input tubes consequently will adjust itself to some average value, giving a very high depth of modulation, and at the same time overmodulation is prevented due to the quick action of the system.

Anode voltage of the driver stage, containing 2 type EL 84 pentodes, is 600 volts (net anode voltage reduced to some 280 volts by anode resistors). Screen grid voltage is taken off a voltage divider across 600 volts. Grid bias is composed of a positive cathode voltage of about 32 volts, caused by the voltage drop of the anode current across a common cathode resistor, and a positive grid bias of some 20 volts derived off the same voltage divider across the modulating transformer primary as above mentioned. The net result is that the grids are about 12 volts negative in relation to the cathodes.

The purpose of feeding a certain AC (and DC) voltage from the final stage back to the grids of the driver tubes is to produce a suitable degree of negative feed back for reducing distortion and making modulating voltages pretty independent of the anode load.

Anode voltage for the four QE 05/40 modulating tubes is 600 volts. Screen grid voltage, 200 volts, is stabilized by two series connected OB 2 stabilizers, fed from plus 600 volts through a resistor. Grid bias is fixed, adjusted by a potentiometer P5, labelled "Grid bias" inserted in a voltage divider across the stabilized negative voltage of 150 volts.

The modulating transformer has two secondaries, one for matching the modulator to the RF-power stages of the transmitting units and another with a nominal impedance of 5 ohms for feeding one or more hailers.

The former secondary is via the transmitter selector control switched to the transmitter being operated, feeding the radio frequency power amplifying stage with modulated anode voltage. The same secondary also provides modulated screen grid voltage for the RF PA via a dropping resistor R 83, 10 kiloohms, the voltage being stabilized by two parallel connected (for the sake of power handling capacity) OA 2 neon stabilizers (tubes nos. 16 and 17) to about 150 volts. In order that the modulation of the screen grid voltage should not be shorted by the stabilizers an AF choke D6 has been inserted in series with the stabilizers. At length for adjusting of modulation of screen grid voltage for the power amplifiers the said choke is shunted by a resistor (R 84).

Lowering Vg2 of the RF PA stage is utilized for transmitting with reduced power. The reduction takes place by the switch "1/1-1/10 power", which in position "1/10" inserts an extra dropping resistor, R 82, in series with the screen grids and at the same time connects a shunting resistor, R 81, from Vg2 to neutral (zero potential). In this way the modulation depth remains fairly unchanged when changing from 1/1 power to 1/10 power.

By the way 1/10 power means roughly 1/3 aerial current, a decrease of about 10 dbs.

When operating A1 the said secondary of the modulating transformer is shorted by a contact of the operating switch.

The 5 ohms secondary of the modulating transformer for feeding hailer may produce a very considerable output, about 150 watts, so an attenuating network generally will have to be interposed between the output winding and the hailer.

As the transmitter has been designed as well for A2 as for A3 transmission two primaries have been fitted to the input transformer of the modulator. An audio frequency oscillator producing a 1000 c/s note is connected to the no. two primary. The tube , no. 8, utilized is the triode section of the ECF 80 tube, and the AF-oscillator is keyed by the transmitters keying relay when transmitting A2 and A0/A2. A potentiometer P1, designated "Modulation A2" controls the modulation percentage when transmitting A2. The vogad system (automatic modulation control) is cut out, when transmitting A2 (by breaking screen grid connection of control tube ECF 80), so having fixed adjustment of potentiometer "Sensitiwity" (which controls sensitivity as well when working A2 as A3) to a value suitable for A3 transmission, potentiometer "Modulation A2" should be set (by means of an oscilloscope) so that the A2 modulation will amount to 75%.

Potentiometer "Sensitivity" should be set as high (turned so far in the clockwise direction) as acoustic noise in the room, where the microphone is placed, allows. If the surroundings are very noisy moderate sensitivity should be used, or else considerable noise will be transmitted as soon as one stops speaking. On the other hand if the transmitter is connected to a voice terminal with extension telephone sets, full advantage of the automatic AF-gain control can be obtained, using a rather "high" setting of "Sensitivity".

The negative voltage of 150 volts utilized in the AF-amplifier and a negative voltage of 90 volts utilized as grid bias in the RF-units and as operating voltage for the automatic grid drive control system described below, is produced by an AF-oscillator employing an QE 05/40 tetrode (tube no. 1) fed off 600 volts high tension. The AC generated, about 1000 c/s, is rectified by a single selicon rectifier OA 211 and the DC smoothed by a capacitor (C 36).

The DC is first led through a safety relay, Rl 3, having 4 change-over contacts. When relay is operated, one contact shorts cathodes of (nearly) all tubes of modulator and RF-units to 600 volts neutral (zero potential). (As long as the aforesaid contact is open all cathodes are connected to a voltage divider across 600 volts, and consequently adopts a positive voltage of some 100 volts. Thus all tubes are completely blocked until relay has operated, which means that all negative grid voltages have been applied). A second contact breaks the mains supply of the direction finder, provided that transmitter selector switch is set to MF, so that the direction finder cannot be operated when transmitter is operated on MF. If direction finder besides MF range also comprises MHF range, mains supply for the direction finder should be broken also in position MHF of transmitter selector switch. In this case strapping of contacts section 5A (02) should be removed during installation of transmitter. A third and fourth set of contacts switches voltage (24 volts) for muting relays in receivers over from emergency transmitter to transmitter 230 - when safety relay operates. (Muting relays operated by the key).

The above mentioned DC next passes a pilot lamp - green - labelled "grid bias on". The pilot lamp will light when the bias generator operates.

In order that the whole transmitter should not be inoperative in case green pilot lamp burns out an NTC resistor is placed in parallel with the lamp and will pass current with moderate voltage drop when pilot lamp is defective.

Finally the DC is through suitable resistors led to two voltage stabilizers, an OA 2, tube no. 14, producing ÷150 volts and an 90 C1, tube no. 13, producing ÷90 volts.

Built into the modulator unit (panel) is the aforementioned automatic grid control device, common to all three RF-units A 231, A 232 and A 233.

Control of the grid drive (excitation) of the RF-power amplifier tubes is brought about by varying the screen grid voltage of the RF-driver tube.

The principle for the rest is: The screen grid of the RF driver tube being operated is fed from plus 600 volts through an 50 kiloohms resistor (R 108), and from the screen grid to neutral (cathode) a pentode, EL 84, tube no. 7 is connected up. When the grid bias of this tube is varied the tube acts as a variable resistance between screen grid of the driver tube and cathode, thus lowering the screen grid voltage according to the grid bias of the EL 84.

The grid bias of the no. 7 tube, EL 84, is - via an DC amplifying stage, also containing an EL 84, tube no. 6 - controlled by the grid current of the RF-power amplifying tubes. The grids of the PA-tubes being operated is via a resistor - a potentiometer P4 - connected to a bias of minus 90 volts. The voltage drop across the potentiometer, caused by the grid current, is via the moving contact of the potentiometer led to the grid of the DC-amplifier, tube no. 6, as grid bias, in such a way, that the higher the grid current, the higher the grid bias of the DC-amplifier becomes, and consequently the smaller the voltage drop across the anode resistor of the DC-amplifier becomes and the smaller the grid bias of the control tube, tube no. 7, and the higher the anode current; that means lowering the screen grid voltage of the driver tube, which was the result wanted, as this will tend to lower the amplification of the driver stage and consequently lower the grid current of the PA-tubes.

By suitable choice of components a balance will occur, and occur immediately on account of the very few and small capacitors involved in the circuit. That means that the grid drive control device easily will follow the fastest hand keying. The balance is adjusted by the above mentioned potentiometer P4 labelled: "PA igl control".

Provided that a certain surplus of grid excitation for the PA-tubes is present with the automatic grid drive control device switched off, it is possible, with the device switched in, to adjust the grid current of the PA-tubes to a value which yields the tubes the very best operating conditions, irrespectively of frequency, class of emission and load, as the grid current will remain practically constant on account of the amplifying effect of the device.

Moreover the automatic grid drive control device will prevent the grid current of the PA-tubes from adopting excessive values, for instance at unloaded PA.

For preventing excessive voltage on the screen grid of the RF-driver tube at key up condition a neon stabilizer OA 2, tube no. 15, is connected between the anode of tube no. 7 (directly connected with and consequently at same voltage as screen grid of RF-driver tube) and neutral (cathodes). The neon tube (stabilizer) strikes (lights) only at key up, and limits the screen grid voltage to 150 volts.

If by some reason the automatic grid drive control device should get out of order, the two EL 84 tubes, nos. 6 and 7, may be removed from the modulator and each filament replaced by an 8 ohms 5 watts resistor (to restore 24 volts filament circuit). The transmitter will still work, as well on A1 as A2 and A3, only the operating conditions of the PA-tubes will be incorrect (grid current will increase above normal) and the output decrease somewhat.

All tubes, except for the A2 oscillator, in modulator will draw anode current as well in key up as in key down condition when the modulator is switched in (at A2, A0/A2 and A3 simplex and duplex). The A2 oscillator is keyed along with the transmitter in question.

A double scale milliammeter (0-15 and 0-150 milliamps) and a switch is placed in the front of the modulator for reading anode current of tubes in modulator.

Likewise a test key and the following switches are placed in the modulator panel: An operating switch, designated "Class of Emission", a power switch and a transmitter selector switch.

The operating switch has the following positions:

1) Off
2) Stand by, Hailer
3) A1: MF, HF
4) A2: MF
5) A3 simplex: MHF, HF
6) A3 duplex: MHF, HF
7) AO/A2: MHF, HF

and will switch any transmitting unit - according to the setting of transmitter selector switch - to the condition of operation indicated on the sign.

At length a keying relay, R1 2, and an auxiliary keying relay, R1 1, have been placed in the modulator panel. The keying relay is operated either directly by the key (24 volts) or by a contact of the auxiliary relay. The keying relay has two contacts: one contact is the keying contact proper, the other one is a spare contact. The auxiliary keying relay is operated by the push button of the handset when working (hailer and) telephony. It is likewise, equipped with two contacts: one contact operates the keying relay proper, starts anode voltage for the modulator when hailer is operated, and switches 24 volts to muting relays in receiver when transmitter is operated on A3 simplex, the other one opens the loud speaker circuit of the receiver used in connection with the transmitter and switches a 5 ohms resistor in as load on the output transformer instead of the loud speaker. In this way the loud speaker is muted whenever the push button of the handset is pressed, no matter if the transmitter is being operated on simplex or duplex.

Operating of hailer:

Set operating switch ("Class of Emission") to "Stand by - Hailer" and press push button of handset after 15 seconds (for heating of filaments).

The five potentiometers placed on chassis (inside the modulator panel)

1) "A2 modulation"
2) "Sensitivity"
3) "Max. modulation"
4) "PA igl control"
5) "Grid bias"

are normally set correctly when the transmitter is leaving the factory.

Resetting of "A2 modulation", "Sensitivity" and "PA igl control" has already been described above. For resetting of "Max. modulation" an oscilloscope must be coupled to the correctly tuned aerial, for instance on MHF, and the modulation envelope examined. An audio frequency oscillator is connected to pins 3 and 5 in microphone socket instead of handset and a 1000 c/s tone, level about 0,5 volts, applied. Adjust potentiometer "Max. modulation" so that the modulation percentage is a trifle below 100 per cent. Lacking on AF-oscillator the handset may be used in emergency, as a moderate whistle in the microphone will produce ample strength for adjusting the potentiometer.

Postentiometer "Grid bias" should be adjusted on A3 simplex, for instance on MHF. The correct setting is the one which will make each of the no. 5 tubes in modulator draw a cathode current of some 10 milliamps (compare "Normal Meter Readings" sheet).

The noise level of the complete transmitter on A3 is about 46 dbs down in relation to 100 per cent modulation, measured by means of a monitor coupled to the aerial.

## MF-Transmitter A 231

### Diagram.

The MF-transmitting unit comprises a master oscillator, a buffer stage and a power amplifier. The master oscillator tube is an QE 05/40 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 at much reduced ratings for reducing heating of electrodes and consequently frequency drift.

The buffer stage also contains an QE 05/40 tube, the anode circuit of which is aperiodic and via a blocking capacitor directly connected to the grids of the power amplifier tubes.

The power amplifier contains 4 parallel connected (with anti parasite ferroxcube pearls in all grids and anodes) QE 05/40 tetrodes. The anode circuit of the PA 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 small trimmer coils connected to taps of the main coil.

The coupling capacitor is made up from a fixed capacitor C 133, and another fixed capacitor C 134, both in parallel with 5 series connected mica capacitors (stacked in a common metal frame and designated C 135); each capacitor is connected to a contact on a switch, the moving contact of which is connected directly to the aerial circuit. Thus the coupling between the tank circuit and the aerial circuit is made variable in 5 steps without affecting tuning of the tank circuit.

For final matching on board an extra capacitor C 132, the value of which is chosen according to the resistance of the ship's aerial, may be connected across the "bottom" capacitor of the 5 series connected capacitors. The extra capacitor is provided with plugs which fits into corresponding sockets.

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 loading coil with taps brought out to a 5-way switch and a continously variable inductance (so called variometer) for tuning in the whole range 410-512 kc/s to aerials having capacities between 300 and 750 pF and at 500 kc/s to aerial having a capacity of but 200 pF.

An artificial aerial with a capacity of 500 pF (two series connected 1000 pF ceramic capacitors) and a resistance of about 3 ohms is incorporated in the transmitter and a switch provided for choosing between artificial and outdoor aerial. A thermocouple ammeter reads the aerial current in both cases. A red warning lamp lights when RF-power is led to the artificial aerial.

A feature which is of invaluable advantage in the high frequency transmitter (described elsewhere): automatic grid current control of the PA tubes, has been employed also in the MF-transmitter since no extra cost is involved. The principle is that the voltage caused by the grid current of the PA-tubes across a resistor, via a DC-amplifier is utilized for controlling the screen grid voltage of the buffer (driver) tube, thus limiting the grid current of the PA-tubes to a value set by a potentiometer, and of course a value giving the very best performance of the PA-stage. (For more details: see paragraph: Modulator).

The transmitter has been constructed for A1 and A2 transmission. Modulation (when transmitting A2) takes place as combined anode and screen grid modulation in the power amplifier, the modulating power being supplied by the common modulator.

Keying takes place by means of a keying relay, placed in the modulator. At key up condition anode current of all tubes in the MF-transmitting unit is cut off by ample grid bias. At key down condition grid bias of the master oscillator is shorted, so the tube may oscillate freely, the amplitude of oscillations being controlled by the grid leak, and all other tubes will draw currents according to the grid excitation and anode load.

## A 231 - Operation.

Close main switch. Set transmitter selector switch in operating panel (modulator) to "MF", set power switch to "1/1", set frequency switch in MF-transmitter to the frequency in question, set "Coupling" to "1", set "Aerial" switch to "Outdoor" and "Aerial coarse" to "1". Turn operating switch in switchboard to "Stand by" for heating of tube filaments. Green pilot lamp in MF-transmitter should now light. After 15 seconds turn lever to "A1". Red pilot lamp in operating panel will now light showing that high tension is on. If filaments have reached operating temperature green pilot lamp in operating panel will light, showing that the transmitter is ready for keying. (No harm will be done to the transmitter or tubes even if operating switch is turned directly to "A1" - without delay - as safety relay in modulator will prevent keying before all voltages are correctly applied).

Press key (or test key) and rotate tuning knob "Aerial fine" until ammeter shows maximum aerial current. If no resonance is obtained using "Aerial coarse" "1", try "2" or one of the following steps, each time rotating "Aerial fine" from minimum to maximum. Cathode current of each of the tubes 103a - 103b - 103c - 103d should amount to some 125 milliamps (total about 500 milliamps). If the total cathode current of the no. 103 tubes is appreciably less than 500 milliamps, choose "Coupling" "2" and repeat tuning procedure. Choose a value of "Coupling" which by proper aerial tuning will make the no. 103 tubes draw a total cathode current of 500 milliamps.

If even at "Coupling" "1" the cathode current of the 103 tubes is higher than 500 milliamps. a capacitor (C 132) must be inserted in the sockets to be found in the right end of the MF-transmitter immediately behind the front plate. (If a capacitor is already placed in the sockets a capacitor having a higher capacity must be inserted).

The value of capacitor C 132 is chosen so that in fair weather (dry and clean aerial insulators) and "Coupling" set to "1" the cathode current of the no. 103 tubes, with correctly tuned aerial circuit, for all frequencies in the range 410 to 512 kc/s in no case exceeds 500 milliamps.

In bad weather when the resistance of the aerial becomes higher, a higher setting of "Coupling" may be used to load the no. 103 tubes to a cathode current of about 500 milliamps.

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. 103 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 value of capacitor C 132.

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

If A2 transmitting is wanted turn operating switch to A2.

A table showing normal meter readings is filled out by the technician who hands over the radio equipment.

If the performance of the transmitter is abnormal close comparison of the actual meter reading with the normal meter readings will be of very great value in tracing faults and should always be stated in correspondance concerning abnormal performance of the transmitter.

## MHF-Transmitter A 232

### Diagram

MHF-transmitter stands for "Medium High Frequency transmitter" colloquially called "Coastal Telephone transmitter".

Crystal control is employed throughout, 23 frequencies in the band 1600-3800 kc/s being available. An QE 05/40 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 (switched in) between grid and chassis (Zero potential), the cathode being connected to a capacitive voltage divider between grid and chassis. The screen grid is decoupled to chassis by a relatively large capacitor and coupling from grid circuit to anode circuit is electronic. The anode circuit consists of a coil (on a ceramic former) with taps, and the interelectrode capacity of the tubes plus a fixed capacitor, 100 pF, made up from two series connected silvered mica capacitors in the range 2500-3800 kc/s; in the range 1600-2500 kc/s an extra capacitor, 150 pF, made up from two series connected 300 pF capacitors, is switched in parallel with the 100 pF capacitor.

The anode circuit of the oscillator is connected directly to the grid circuit of the power amplifier. The power amplifier contains 3 parallel connected (with anti parasite ferroxcube pearls in all grids and anodes) QE 05/40 tetrodes. The tank circuit of the PA has been formed as a pi-filter, consisting of an anode-cathode capacitor, an inductance coil and a coupling capacitor. The anode-cathode capacitor consists - besides stray capacitors - of an 630 pF (two series connected 1260 pF) capacitor in the range 2500-3800 kc/s; in the range 1600-2500 kc/s an extra capacitor, 410 pF, made up from two series connected 820 pF capacitors, is switched in parallel with the 630 pF capacitor. The coupling capacitor consists in the range 2500-3800 kc/s of an 670 pF capacitor, built in 11 sections of different size, and an 350 pF capacitor (actually two series connected 700 pF capacitors) in parallel with the 670 pF capacitor. Each of the 11 sections of the 670 pF capacitor has been 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 relatively constant an extra capacitor, 565 pF (actually two series connected 1130 pF capacitors) is connected in parallel with the coupling capacitor in the range 1600-2500 kc/s.

The aerial circuit consists of the antenna proper and a matching network comprising a variometer (a 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, stacked in a common metal frame and 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 of rotor of variometer). This very elaborate antenna matching system will match the transmitter to any normal aerial encountered on board ships.

For giving the PA-stage the very best operating conditions the principle of automatic grid current control, primarily designed for the HF-transmitter, has been employed also in the MHF-transmitter, since no extra cost is unvolved. The screen grid in this case being controlled is the G2 of the oscillator/buffer tube no. 201.

The transmitter has been constructed for A3 transmission; yet A0/A2 is also available.

Modulation takes place as combined anode and screen grid modulation in the power amplifier, the modulating power being supplied by the common modulator.

Keying takes place by means of the common keying relay, placed in the modulator. At key up condition anode current of all tubes in the MHF-transmitter is cut off by ample grid bias. At key down condition grid bias of the oscillator is shorted, so the tube may oscillate freely. The remaining tubes will draw anode currents according to the grid excitation and anode load.

## A 232 - Operation.

Close main switch. Set transmitter selector switch in operating panel (modulator) to "MHF", set power switch to "1/1", set frequency switch in transmitter to the frequency in question, set "Coupling" to "1", "Aerial coarse" to "1", set "Cathode/grid current" switch to cathode of one of the no. 202 tubes. Turn operating switch in operating panel to "Stand by" for heating of filaments. Green pilot lamp in MHF-transmitter should now light. After 15 seconds turn lever to "A3 simplex". Red pilot lamp in operating panel will now light, showing that high tension is on. If filaments have reached operating temperature green pilot lamp in operating panel will light, showing that the transmitter is ready for keying. (No harm will be done to transmitter or tubes even if operating switch is turned directly to "A3 simplex" - without delay - as safety relay in modulator will prevent keying until all voltages are correctly applied). Pres test key (or push button in handset), rotate tuning knob "Aerial fine" and note aerial ammeter. Tune for maximum aerial current. Note cathode current of tubes nos. 202a, 202b and 202c. The cathode current should increase simultaneously with the aerial current and adopt a value of 100-110 milliamps for each tube when aerial is tuned to true resonance.

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

If cathode current of each of the no. 202 tubes does not reach a value of at least 100 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. 202 tubes adopts a value of 100-110 milliamps.

A good check on tuning being correct is to compare aerial current and cathode current (of the no. 202 tubes) at settings of "Coupling" higher and 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 a coupling as tubes in the latter case will get ruined - and modulation bad.

Note:

If resonance of aerial circuit may be obtained at several settings of knob "Aerial coarse" in the series tuned positions 1-6, always choose the setting with the lowest number, which will tune to resonance, as selection of too high a number of setting means too small a series capacitor and consequently too high voltages in the tuning elements, which might cause flash-over or corona in aerial capacitor or switch.

In order to facilitate future tuning the settings of the knobs "Coupling", "Aerial coarse" and "Aerial fine" should be recorded (in ink or pencil) in the lower part of the white space containing the frequency labelling of the frequency switch.

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

Setting up of channels:

If a new channel, which has not been set up by the factory, is wanted, first procure a crystal for the desired frequency (same as transmitting frequency). It is recommended to order a crystal with a frequency tolerance of not more than ±0,01%. Also when ordering the crystal draw the manufacturer's attention to the fact that the crystal should be calibrated with a total capacity of 50 pF in parallel. Plug in crystal in an idle socket and note the numbering of the socket.

Before connecting the task, turn grid drive control potentiometer in modulator right home in the clockwise direction.

First the plate circuit of the oscillator has to be tuned. If the transmitting frequency is lying in the range 2500-3800 kc/s no extra tuning capacity is needed. If the frequency lies in the range 1600-2500 kc/s an additional 150 pF (two series connected 300 pF capacitors C 211 and C 212) tuning capacitor has to be connected in parallel with the fixed tuning capacitor C 209/C 210. So the capacitor combination C 211/C 212 should be connected to the soldering tag of the contact (in ceramic wafer no. 3, numbered from the front plate) with number corresponding with crystal socket number, by means of a bare tinned copper wire. (If the said capacitor combination already has been connected to one or more soldering tags of the wafer, the soldering tag corresponding with the new frequency is - for convenience - connected to these tags).

The value of inductance of the oscillator plate circuit is selected by wafer no. 2 of the frequency switch. Fix a flexible (insulated) wire to the soldering tag (on wafer no. 2) with number corresponding with the crystal socket number, start transmitter, set power switch to "1/10", set "Cathode/Grid current" switch in MHF-transmitter to "G 202", set "Cathode/Grid current switch in modulator to K 7, set operating switch to "A3 simplex" and press test key in modulator. Clip the other end of the flexible wire to a tap on the coil which one finds reasonable in proportion to the frequency in question (comparing taps utilized for frequencies in the neighbourhood) and note the grid current on the milliammeter. Find the tap which produces maximum grid current. As the correct tap will produce a grid current in excess of the 15 milliamps which corresponds to full deflection of the milliammeter scale, it is necessary to utilize current of another tube for final determination of the coil tap. Cathode current of tube no. 7 in modulator may be used for the purpose. So, having chosen a preliminary coil tap, which will give full deflection of the milliammeter when the latter reads grid current of tubes 202, read cathode current of tube no. 7 in modulator, while turning spindle of grid drive control potentiometer slowly in the anticlockwise direction. Leave potentiometer in a position which will produce a cathode current of tube no. 7 of some 9-10 milliamps (using the preliminary coil tap), and find a tap which - without touching grid drive control potentiometer - will produce maximum current in tube no. 7.

Practically it has shown desireable 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) and the connection is soldered. (Less turns means a coil tap farer-off the front plate).

Next the tank circuit of the RF power stage has to be tuned. Set switch "Coupling" to 0 (Zero) and also set switch "Aerial coarse" to 0 (Zero). If the transmitting frequency is lying between 2500 and 3800 kc/s no additional capacitor should be connected across the tank circuit tuning capacitor or coupling capacitor. If the transmitting frequency lies between 1600 and 2500 kc/s an additional 410 pF(two series connected 820 pF capacitors C 226 and C 227) tuning capacitor has to be connected in parallel with the fixed tuning capacitor C 224/C 225 and an additional 565 pF (two series connected 1170 pF capacitors) capacitor in parallel with the coupling capacitor C 229/230. So the capacitor combination C 226/C 227 should be connected to the soldering tag of the contact (in ceramic wafer no. 5, numbered from the front plate) with number corresponding with the crystal socket number, by means of a bare tinned copper wire - either directly, or by a strap between tags already connected to the capacitor combination and the tag in question. Similarly the extra coupling capacitor C 231/232, 565 pF, should be connected to the soldering tag of the contact (in ceramic wafer no. 4) with number corresponding with the crystal socket number, by means of a bare tinned copper wire - either directly, or by a strap between tags already connected to capacitor C 231/232 and the tag in question. At length a tap on the tank circuit tuning coil has to be selected. A flexible lead is clipped to a tag on one of the two long insulating strips above the tank coil and placed nearest the front plate, viz. the tag which has the same numbering (counting from left) as the crystal socket concerned and which has a wire connection with a contact in ceramic wafer no. 6 corresponding with the crystal socket number. The free end of the flexible lead is clipped to a tap on the tank coil which one finds reasonable in proportion to the frequency in question (comparing taps utilized for frequencies in the neighbourhood). A tap should be selected which will give a distinct drop in cathode current of the no. 202 tubes. If difficulty in finding the correct tap is encountered with transmitter set to reduced power, full power should be employed,provided that the transmitter is keyed but for a very short time. When the correct tap has been found, a 2 mm bare tinned copper wire is drawn between the coil tap and the tag on the rear insulating strip corresponding with the tag on the front strip, where the temporary lead was clipped on.

The wire is carefully soldered at both ends.

Finally the tank circuit is fine-tuned by means of a trimmer coil, the number of turns necessary found by cut and trial. The trimmer coil is placed between the soldering tag just found on the front strip and the corresponding tag on the rear insulating strip.

When the tank circuit is correctly tuned (and unloaded) the cathode current of each of no. 202 tubes will amount to 35-40 milliamps. with the transmitter on full power. The trimmer coil is carefully soldered after checking the cathode current of the no. 202 tubes with the chassis pushed in. The iron cabins 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 tighter will increase the inductance sufficiently for correct tuning of the tank circuit with the chassis pushed in.

At length adjust grid drive control potentiometer in modulator until grid current of the 202 tubes amounts to about 12 milliamps.

If in special cases one "channel" has to be used on two frequencies owing to lack of sufficient number of crystal sockets, it is possible to do this, if the two frequencies does not differ more than 0,5 per cent, and of course separate crystals are available for the two frequencies. The transmitter in this case preferably should be tuned with the crystal having the higher frequency inserted in the (common) socket. No difficulty whatever then will be encountered when the crystal having the lower frequency is inserted instead.

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

Check the values of grid and cathode currents with the values stated in the table "Normal Meter Readings" (attached to the description), operating the transmitter at full power.

## Remarks concerning HF-transmitter A 233 B.

HF-transmitter A 233 B is identical with transmitter A 233 except for the distribution of the crystal frequencies and the width of the frequency bands.

The bands covered by the A 233 B transmitter are:

| | | | |
|---|---|---|---|
| 4094 | - | 4510 | kHz |
| 5892 | - | 6327 | - |
| 8226 | - | 8776 | - |
| 12365 | - | 12654 | - |
| 16495 | - | 16774 | - |
| 22000 | - | 22400 | - |

While in the normal transmitter A 233 crystal sockets 4a/b---- 23a are being used for crystals for telephony frequencies, in A 233 B sockets 4a - 5a - 6a - 7a - 8a are being used for crystals for special telegraphy frequencies. The remaining sockets are partly utilized for crystals for telephony frequencies.

The increased frequency range of the bands has caused change of certain tuning elements. The inductance of the PA tank circuit coil has been increased and the tuning and coupling capacitors of the same circuit decreased, the values being: C 354: 225 pF, C 353: 160 pF, C 352: 90 pF, C 357: 760 pF, C 356: 670 pF, C 355: 420 pF.

## HF-Transmitter A 233

### Diagram

The HF-transmitter covers the following HF-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 QE 05/40 tetrode (tube no. 301) acting as a crystal controlled Pierce-oscillator.

The plate circuit of the oscillator is coupled direct to the grid of the QE 05/40 buffer tube (tube no. 302) the plate circuit of which by means of coil L 301 and capacitors C 308 + C 309 in parallel with trimmer C 310 is tuned to 2 Mc/s when transmitting on 4, 6, 8 and 12 Mc/s, by trimmer C 311 to 4 Mc/s when transmitting on 16 Mc/s and by C 312 to 5,5 Mc/s when transmitting on 22 Mc/s.

The plate circuit of tube no. 302 is for transmitting on 4 and 6 Mc/s connected direct to the grid of tube no. 304, while for transmitting on 8, 12, 16 and 22 Mc/s it is connected to the grid of tube no. 303. On bands 4 and 6 Mc/s the grid of tube no. 303 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. 303 is by means of coil L 302 and trimmers C 319, C 320, C 321, C 322 tuned to 4, 6, 8 and 11 Mc/s.

The plate circuit of tube no. 303 is for transmitting on bands 8, 12, 16 and 22 Mc/s connected to the grid of tube no. 304. The latter consequently is fed with input having the frequencies 2, 2, 4, 6, 8 and 11 Mc/s when transmitting on the frequencies 4, 6, 8, 12, 16 and 22 Mc/s respectively. The plate circuit of tube no. 304 is by means of coil L 303 and trimmers C 328, C 329, C 330, C 331, C 332, C 333 tuned to 4, 6, 8, 12, 16 and 22 Mc/s.

The plate circuit of tube no. 304 is connected direct to the grids of the power amplifier tubes, 3 type QE 05/40 in parallel. In the grid of each tube a resistance/inductance network has been inserted for suppressing parasites. The tubes are working as plain class C amplifiers, their plate circuit being 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 (L 304) and a coupling capacitor. Two sections of the frequency switch take care that suitable fixed capacitors and suitable taps on the coil are cut in on the different bands, while a trimmer C 350 with its shaft brought out on the front panel and provided with knob and scale covers the individual bands. The anode-cathode capacitors are: C 350 (trimmer), C 354: 525 pF (4 Mc/s), C 353: 160 pF (6 Mc/s), C 352: 110 pF (8 Mc/s). On 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 358, 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 capacitor which is common to the tank circuit and the aerial circuit, in this way may be varied between 1730 pF 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 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 capacitives are: C 357: 1150 pF (4 Mc/s), C 356: 667 pF (6 Mc/s), C 355: 412 pF (8 Mc/s).

For matching the aerial circuit to the power amplifier a rather elaborate matching system has been designed. Besides the 11 step variable coupling capacitor the aerial elements consist of a coil L 305 with taps (0-17 microhenries) and a variable capacitor ("Aerial fine", 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), enabling outbalancing of positive or negative reactances within very wide limits, while the variable coupling (in connection with series or parallel connection of the aerial coil and capacitor) will match aerial resistances of any value encountered onboard ships to the PA tank circuit.

As the transmitter covers as well the telegraph as the telephone frequencies on all HF-bands allocated to ships' radio communications certain precautions have been taken to simplify operation within the bands without sacrificing efficiency.

The power amplifier tank circuit is tuned correctly by the trimmer with knob in front. The doubler (tripler) circuits with coils L 301 and L 302 are so bradly tuned (so heavily damped by loading of the grids of the following stage) that they cover the bands without retuning and special precautions. The circuit consisting of coil L 303 and the trimmers (semi fixed) C 328-----C 333 must produce drive of correct amplitude for the grid circuit of the power amplifier on all bands and all frequencies within the bands. A damping resistor is connected across the circuit for lowering the parallel impedance of the circuit on the lower frequencies. But of far superior importance for the correct working of the PA-stage is the automatic grid current control of this stage. The essential thing of the system is that the RF-driver stage - the stage containing tube 304 - even at the borders of the HF-bands will produce ample power for driving the grid circuit of the PA-stage. The principle then is, that the voltage caused by the grid current of the PA-tubes across a resistor - a potentiometer - in the grid circuit, via an DC-amplifier is utilized for controlling the screen grid voltage of the driver tube - 304 - thus controlling the amplification of the driver stage and consequently limiting the grid current of the PA-tubes to a value set by the said potentiometer and which (value) has proven to be the best for correct performance of the PA-stage.

(For details of the DC-amplifier: se paragraph: Modulation).

The transmitter has been constructed for A1 and A3 transmission. Yet also A0/A2 can be utilized.

Modulation takes place as combined anode and screen grid modulation in the power amplifier, the modulating power being supplied by the common modulator.

Keying takes place by means of the common keying relay, placed in the modulator. At key up condition anode current of all tubes in the HF-transmitter is cut off by ample grid bias. At key down condition grid bias of the oscillator tube - 301 - is shorted and of the first doubler tube - 302 - lowered. Thus the oscillator tube may oscillate freely and the first doubler tube operate at a suitable point of its characteristic curve. The remaining tubes will draw anode currents according to the grid excitation and anode load.

To prevent undue strain on the tubes during warming up of the cathodes and in case of incorrect operation, a safety relay has been built into the modulator and connected up to the transmitter being operated in such a manner that the cathodes of all RF-tubes are biassed positively - and anode currents consequently cut off - until the relay operates. As the relay is operated by the grid bias produced by the grid bias generator no tube can draw any anode current before the correct grid bias is applied.

A consequence of the fixed grid bias is that if by some reason no grid drive is present even at key down (no crystal inserted or crystal note oscillating) the RF tubes will not draw any anode current and so no harm is done to the tubes.

The safety relay is common to all three transmitters (MF, MHF and HF), being switched in automatically in the transmitter being operated.

## A 233 - Operation.

Close main switch. Set transmitter selector switch in operating panel (modulator) to "HF", set power switch to 1/10, set band switch in HF-transmitter proper to the correct band, set crystal switch to correct channel (according to table in front plate), set "Coupling" to zero, set cathode/grid current switch to cathode of one of the no. 305 tubes. Turn operating switch in operating panel to "Stand by" for heating of filaments; green pilot lamp in HF-transmitter should now light. After 15 seconds turn lever to "A1". Red pilot lamp in operating panel will now light showing that high tension is on. If filaments have reached operating temperature green pilot lamp in operating panel will light, showing that the transmitter is ready for keying.

(No harm will be done to the transmitter or tubes even if operating switch is turned directly to "A1" - without delay" - as safety relay in modulator will prevent keying before all voltages are correctly applied).

Press key and rotate knob "Trimmer" until minimum cathode current of the no. 305 tubes is obtained. Set power switch to "1/1" and readjust "Trimmer". Cathode current for each 305 tube should then amount to 30-40 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. 305 tubes. If the cathode current of each tube has not reached a value of 100 milliamps, set "Coupling" to "2" and repeat aerial tuning. If necessary proceed to coupling 3, 4 and so on. The cathode current of each tube no. 305 should not exceed 110 milliamps (total for 305a - 305b - 305c: 330 milliamps.)

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

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 PA-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 just described, try to rotate knob "Trimmer" slightly to either side of its original setting and observe if the cathode current of the no. 305 tubes increases; the latter should be the case. - If the cathode current decreases when trimmer is rotated in either direction 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 maximum light in aerial indicator lamp (aerial tuned to correct resonance), but with the difference that the minimum cathode current with loaded amplifier amounts to about 300 milliamps. total, compared with about 100 milliamps, total, unloaded.

Note: If resonance of aerial circuit may be obtained at several settings of knob "Aerial coarse" in the series tuned positions 1-6 always choose the setting with the lowest number which will tune to resonance, as selection of too high number of setting means too high a value of inductance of the loading coil and consequently too high voltages in the tuning elements, which might cause flash-over in aerial capacitor or switch.

In order to facilitate future tuning the settings of the knobs "Trimmer", "Coupling", "Aerial coarse" and "Aerial fine" should be recorded (in ink or pencil) on the calibration dial which appears behind the windows (apertures) immediately above the band switch.

In the upper window marked: "A1: Call, W1, W2. A3" and "Trimmer" the settings of "Trimmer" for the calling frequency and the two working frequencies in the telegraphy band and the setting for the telephone frequencies in the telephony band should be recorded. (The telephone band is so narrow, that the same setting of "Trimmer" generally may be used for all frequencies in the band).

In the lower window (the lower window of the two windows above the band switch) marked "A1, A3" and "Coupling", "A(erial) coarse" and "A(erial) fine" settings of the knobs concerned for telegraphy and telephony respectively should be recorded. (Normally the same settings will hold for all telegraph frequencies and likewise a common set of recordings will hold for all telephone frequencies).

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

Below the band switch two similar windows should be used for recording corresponding settings of the same four knobs in case that an emergency aerial is available.

Placing of the crystals in their sockets may require a small explanation:

Crystal sockets with index "a" should hold 2 Mc/s, crystals and crystal sockets with index "b" should hold 2,7 Mc/s crystals. Sockets 1a/b, 2a/b and 3a/b will hold 2 Mc/s crystals for harmonic frequencies in the 4-6-8-12-16 Mc/s telegraphy bands and 2,7 Mc/s crystals for frequencies in the 22 Mc/s telegraphy band. Sockets 4a---------23a may be used for 2 Mc/s crystals for individual frequencies in the 4-8-12-16 Mc/s telephone bands and sockets 4b--------8b for 2,7 Mc/s crystals for individual frequencies in the 22 Mc/s band.

Trimming:

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

Turn grid drive control potentiometer P4 in modulator, designated: "PA igl control" right home in the clockwise direction.

Set power switch to "1/10", set band switch to "4" (Mc/s), set crystal switch to 2 Mc-crystal with highest frequency (no. 3) set "Cathode/Grid current" switch in A 233 transmitter to K 302 and adjust trimmer C 310, labelled "4-6-8-12" for minimum cathode current (2 Mc/s). Set Cathode/Grid current" switch to "G 304" and readjust C 310 for maximum grid current. Set "Cathode/Grid current" switch to "G 305" and adjust C 328, labelled "4" for maximum grid current (4 Mc/s).

As the correct setting of C 328 will produce a grid current in excess of the 15 milliamps which corresponds to full deflection of the milliammeter scale it is necessary to utilize current of another tube for determination of the correct setting of C 328. Cathode current of tube no. 7 in modulator may be used for the purpose. So, having set C 328 for full deflection of meter reading grid current ("G 305") read cathode current of tube no. 7 in modulator while turning spindle of grid drive control potentiometer slowly in the anti clockwise direction. Leave potentiometer in a position which will produce a cathode current of tube no. 7 of some 8-9 milliamps (using the preliminary setting of C 328) and reset C 328 - without touching grid drive control potentiometer - for maximum current in tube no. 7.

Next set crystal switch to 2 Mc-crystal with lowest frequency (a telephone frequency) and readjust C 310 for maximum grid current "G 304". Shift a couple of times between crystals with highest and lowest 2 Mc-frequency and adjust C 310 for equal grid current "G 304".

Set again crystal switch to 2 Mc-crystal with lowest frequency (a telephone frequency) and readjust trimmer C 328 slightly for increasing current of tube no. 7 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 C 328 for equal current of tube no. 7 on the highest and lowest 4 Mc-frequency. Check setting of trimmer C 310; it might be advantageous to readjust it a trifle to get maximum grid current in the no. 4 tube and consequently also in the no. 5 tubes in both ends of the band (maximum current in tube no. 7).

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 C 310 should not be changed. Set "Cathode/Grid current" switch to "G 305" and adjust C 329, labelled "6", for maximum grid current (6 Mc/s) using current of tube no. 7 in modulator as a make-shift. Shift between crystals with highest and lowest 2 Mc-frequency as above and adjust C 329 for equal grid current in the no. 5 tubes on the lowest and highest 6 Mc-frequency (equal current in tube no. 7).

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 C 310 remains untouched. But now tube no. 3 is switched in. So set "Cathode/Grid current" switch to "G 304" and adjust C 319, labelled "8", for maximum grid current (4 Mc/s). Set "Cathode/Grid current" switch to "G 305" and adjust C 330, labelled "8", for maximum grid current (8 Mc/s) as above, using current of tube no. 7 in modulator as a make-shift. Shift between crystals with highest and lowest 2 Mc-frequency as above and adjust C 330 for equal grid current in the no. 5 tubes on highest and lowest 8 Mc-frequency (equal current in tube no. 7).

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 C 310 remains untouched. Set "Cathode/Grid current" switch to "G 304" and adjust C 320, labelled "12" for maximum grid current (6 Mc/s). Set "Cathode/Grid Current" switch to "G 305" and adjust C 331, labelled "12", for maximum grid current (12 Mc/s) and shift between crystals with highest and lowest frequency as above (using current of tube no. 7 in modulator as a make-shift).

Next set band switch to "16". Set "Cathode/Grid current" switch to "G 303" and adjust trimmer C 311, labelled "16" for maximum grid current (4 Mc/s). Set "Cathode/Grid current" switch to "G 304" and adjust C 321, labelled "16", for maximum grid current (8 Mc/s). Set "Cathode/Grid current" switch to "G 305" and adjust C 332, labelled "16", for maximum grid current (16 Mc/s) and shift between crystals with highest and lowest frequency as above (using current of tube no. 7 in modulator as a make-shift).

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 "G 303" and adjust trimmer C 312, labelled "22" for maximum grid current (5,5 Mc/s). Set "Cathode/Grid current" switch to "G 304" and adjust trimmer C 322, labelled "22", for maximum grid current (11 Mc/s). Set "Cathode/Grid current" switch to "G 305" and adjust C 333, labelled "22" for maximum grid current (22 Mc/s). Shift between crystals with highest and lowest 2,7 Mc-frequency and adjust C 333 for equal grid current in the no. 305 tubes on highest and lowest 22 Mc-frequency (using current of tube no. 7 in modulator as a make-shift.

Adjusting of "Trimmer" in front plate and aerial tuning knobs is described in paragraph: "Operation".

Finally adjust grid drive control potentiometer P4 in modulator until grid current of the no. 305 tubes amounts to 10-12 milliamps. This value, 10-12 milliamps., should hold also for A 231 and A 232.

Check the values of grid and cathode currents with the values stated in the table "Normal Meter Readings" (attached to the description), operating the transmitter at full power.

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 base and its 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 maximum grid current in the succeeding stage.

Care should be taken not to touch the anode of the tube with the metal base when the lamp is held in its base, as the 600 volts 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 idle hand - and finally use a well insulated screwdriver for trimming.

And always check that the door safety switches are working correctly.