# 70 watt Marine Telephone Transmitter A 198 BCV.

## Circuit:

Crystal control is employed throughout, 11 frequencies in the band 1600-3800 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 potential), 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 - besides the inter electrode capacity of the valves - a 120 pF capacitor in the range 2500-3800 kc/s and an extra 150 pF capacitor in the 1600-2500 kc/s range.

In the radio frequency amplifier three tetrodes 807 are connected in parallel, the grids of which are connected to the above mentioned buffer stage while their anodes are connected to a pi-filter circuit, consisting of an anode-cathode capacitor, an inductance and a coupling capacitor. The anode-cathode capacitor in the 2500-3800 kc/s range consists of 522 pF fixed capacitor while in the 1600-2500 kc/s range an extra 348 pF capacitor is engaged. The coupling capacitor consists of a fixed 830 pF capacitor connected in parallel with a 670 pF mica capacitor, built in 11 sections of varying 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 750 pF capacitor is put in parallel to the coupling capacitor in the 1600-2500 kc/s range.

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 flashlamp bulb coupled to the aerial circuit through a small R.F. transformer acts as an aerial current indicator.

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 makes the erecting of a special aerial for medium high frequency unneccessary onboard ships where a medium frequency or high frequency aerial already exists, as the network will match the transmitter to almost any aerial encountered onboard ships. Thus a change-over switch or relay for switching the main aerial to the appropriate transmitter will suffice.

The transmitter is arranged for telephony only. Yet the modulator may be used alone as an audio frequency amplifier with an output of 70 watts (nominally 50 watts) for feeding one or several loudspeakers ("hailer"). Output impedance: 15 ohms, but the load may vary between wide limits as the output voltage is held fairly constant by negative feed back.

The transmitter has a control switch with the following positions:

1) off (afbrudt)
2) stand by (klar) - hailer
3) telephony simplex (skiftetale)
4) telephony duplex (modtale).

The control switch starts the transmitter and makes the necessary switching for operating the transmitter.

Built into the transmitter are also an auxiliary relay and a keying relay. The auxiliary relay is operated by the push button of the handset. It has two contacts. One contact switches receiver output from speaker to an artificial load, muting the speaker whenever the push button of the handset is pressed, thus avoiding acoustic feed back ("howling"). Another contact operates the keying relay and when working "simplex" also a muting relay in the receiver being used in connection with the transmitter. The keying relay has two contacts. One contact keys the transmitter in position "simplex". Another starts the converter in position "hailer", when transmitter is battery operated, and switches in anode voltage when the transmitter is A.C. operated.

When working duplex the transmitter is constantly keyed by a contact in the control switch, but modulation takes place only when the handset push button is pressed, which operation also mutes the loud speaker via the said relays.

With the control switch in position "telephony simplex" 24, 32 or 36 volts from the filament supply is fed to a muting relay in the receiver through the same contact of the auxiliary relay which operates the keying relay; thus when the handset push button is pressed the receiver input is shorted (receiver aerial connected to earth) and no harm is done to the receiver even if transmitting and receiving on the same frequency takes place.

Power output:

70 watts carrier measured in an outdoor (or artificial) aerial with a resistance of 15 ohms. Switch for reducing power to about 7 watts (by lowering the screen grid voltage of the R.F. power amplifiers).

Frequency range:

Maximum 11 crystal controlled frequencies in the range 1600-3800 kc/s.

Stability:

Better than 0,02% according to Atlantic City Conference requirements.

Modulation:

Modulation takes place as combined anode and screen grid modulation of the radio frequency power stage. The modulating power is produced by two 807 valves acting as class A-B audio frequency amplifiers with fixed grid bias (24 volts) plus a certain amount of automatic bias produced by the voltage drop across a cathode resistor, which for stabilizing reasons is bridged by a Zener diode. The modulator is matched to the R.F. power amplifier by a transformer, the secondary of which is passed through by the anode and screen grid current of the R.F. power amplifiers. An extra winding in the transformer with a nominel impedance of 10 ohms will deliver 25 watts of audio power to one or more loudspeakers (matching uncritical because of negative feed back in the amplifier) for hailing, when the control switch is in position "hailer".

The two modulating valves get their grid excitation from a push pull driver stage containing two type EL 84 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 89 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, the midpoint of the said voltage divider being connected to the negative pole of the grid bias supply.

In this way a negative feed back is applied to the amplifier, reducing distortion and making the 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).

The grid bias of the two driver valves, about 11 volts D.C., is derived from the voltage drop across a common 200 ohms resistor in the cathode circuit; the resistor is (when the transmitter is keyed) connected to ÷ HT = zero potential; the cathodes thus adopt a positive voltage of 11 volts. The D.C. potential of the grids will be very nearly zero, being composed of two voltages: a positive voltage of about 24 volts resulting from the D.C. drop across the above mentioned voltage divider and a negative voltage of 24 volts originating from the grid bias supply to which the above mentioned midpoint is connected.

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 Mohm resistor connected to the moving arm of a 5000 ohms variable resistor in the common cathode lead of the variable-mu valves. The setting of the variable resistor determins 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 81 full wave rectifier valve, two 0,1 Mohm 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 300 volts positive relative to chassis, on a voltage divider.

Thus when the peak values of the voltage across each half of the modulation transformer primary exceeds 300 volts (corresponding with a modulation percentage of 85-90%) the rectifier 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 stronger than corresponding with 85-90% modulation appears in the modulation transformer and slowly increase the amplification when the speech intensity falls below the value corresponding with 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. The primary of the input transformer is connected to the microphone through a low pass filter which cuts off at about 3000 c/s. The said 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 2000-35000 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 per square centimetre.

The modulation amplifier requires at the input terminals about 100 millivolts for an 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.

Facilities:

A3 (telephony), simplex and duplex, "hailer".

Power supply:

Using a suitable converter or power pack the transmitter may be operated from a 24, 32 or 36 volts storage battery (accumulator) or from the ship's mains 110 or 220 volts D.C. or from the ship's mains 110, 220, 380 or 440 volts A.C. By linking three pairs of soldering tags by shorting wires or suitable resistors according to voltage, filament, relay and microphone voltage may be matched to 24, 32 or 36 volts supply. Plate voltage, 550 volts 500 milliamps. is supplied by a converter or a rectifier, made for the primary voltage in question. Working off a 24, 32 or 36 volts battery the filament current is supplied directly from the battery. In this case the filament circuit is closed when the control switch is set to "stand by" ("klar"). The converter EO 17 is started when the control switch is turned to "simplex" ("skiftetale") and remains running in the "duplex"("modtale") position. The converter is also started when, with control switch in position "hailer", the handset push button is pressed.

Working off 110 or 220 volts D.C. mains the filament current is supplied from a special 25 volts winding in the armature of the converter EOK 20. (The transmitter consequently must be adjusted for 24 volts operation). Plate voltage 550 volts is delivered from another winding in the armature. In order that the transmitter may be ready for immediate operation when turning the control switch from "stand by" to one of the following positions the converter in this case is started in position "stand by".

Working off A.C. mains the filament current is supplied by a transformer delivering 25 volts A.C. Grid bias and auxiliary voltages (24, 32 or 36 volts) is supplied by a rectifier with filter. Plate voltage 550 volts is supplied by another rectifier with filter. In this case filament and auxiliary voltages are started in position "stand by" while plate voltage is started in the following positions, or when in position "stand by - hailer" the push button of the handset is pressed.

In case the transmitter is installed onboard a ship with several transmitters sharing a common transmitting aerial connected to the transmitters by relays, the relay belonging to the A 198 BCV transmitter is operated when the control switch is set to"stand by", "simplex" or "duplex".

In ships with 24, 32 or 36 volts storage battery one pole of the battery (charging dynamo) is often earthed. The earth contact (no. 3) on the terminal board in this case may be connected to the earthed pole. In case the battery is not earthed, earthing may be accomplished on the terminal board and terminal 3 is then most expediently connected to terminal 1 (which is the positive pole), but earthing of the battery is <u>not necessary</u> for correct working of the transmitter.

<u>Harmonics:</u>

All harmonics radiated from the aerial will be attenuated at least 40 dbs in proportion to the fundamental (as required by the 1947 Atlantic City Conference).

<u>Power drain:</u>

The totel current drawn from the mains amounts to:

| | |
|---|---|
| At 24 volts:(transmitter in position "duplex"): | 20 amps. |
| At 220 volts D,C.: | 2,8 amps. |
| At 220 volts A.C.: | 2,0 amps. |

High voltage:

The plate voltage 550 volts is absolutely dangerous. So all parts carrying this voltage in the converter and the transmitter are shielded or screened in order that accidental contact should be prevented. To warn against the dangerous voltage, which is accessible when the chassis is withdrawn for inspection a neon lamp placed adjacent to the control switch lights as soon as the converter runs or the plate voltage rectifier is started and the fuse in the high tension lead (in the transmitter) is intact. If the fuse blows the neon lamp goes out.

If the high voltage commutator of the converter needs cleaning or polishing always use sand paper fastened to a piece of dry wood. Do not touch the commutator when the machine is running.

Valve complement:

| | | |
|---|---|---|
| 6 | type | QE 06/50 (European type) or 807 (American type) |
| 2 | - | EL 84 or 6 BQ 5 |
| 2 | - | EF 89 or 6 DA 6 |
| 1 | - | EZ 81 or 6 CA 4 |
| 2 | - | OA 2 neon stabilizers |
| 1 | - | flashlight bulb 5 volts 0,2 amp. |
| 1 | - | neon lamp (Edison mignon socket) 220 volts. |

Crystals:

Frequency of crystals same as transmitting frequency (no doubling).

Socket: Two 2,3 mm pins with center distance 12,35 mm (American standard).

Mechanical construction:

The transmitter is built on a 3 mm aluminium chassis with reinforcements, placed in a rustproofed iron cabinet in grey finish. The chassis rests in a sliding mechanism and may be drawn out for inspection when the knurled nuts are removed.

All connections to the transmitter with the exception of aerial and earth are brought out through a 17-pole plug-and-socket. The plug is connected to a multicore cable the opposite end of which is connected to a terminal board screwed to the bulkhead. The connecting cable is of ample length permitting the chassis to be withdrawn without breaking connections.

Aerial connections is made through a spring contact in the top of the transmitter. The earth lead is fastened to a bolt, (one on either side of the cabinet), and connection to the chassis proper is made internally by a very heavy flexible lead.

Cables from the fixed installation are terminated on the terminal board mentioned above.

Dimensions:

| | | |
|---|---|---|
| Height: | 300 mm | + 40 mm shock-absorbers |
| | | + 50 mm aerial insulator |
| Width: | 520 mm | |
| Depth: | 335 mm | + knobs |

Weight: 30 kgs.

As to transmitter and receiver in common cabinet see "Specification".

Typical valve operating conditions:

See special page.

Operating instructions:

To use loud hailer: rotate the control switch to "stand by - hailer" ("klar"). Allow half a minute for heating of filaments. Then press button in handset and speak. Take care that the sound from the loud speaker will not reach the microphone or else "howling" will result.

To communicate by radio rotate the control switch to "simplex" ("skiftetale"), switch: "frequency" ("frekvens") is set to the frequency concerned, set "coupling" ("kobling") to 1, "aerial tuning, coarse" ("antennetrin") to 1, and "aerial tuning, fine" ("antenneafstemning") is rotated slowly from one end of the dial to the other. With the cathode current switch set to 6a, 6b or 6c 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 and note if the aerial indicator lamp lights. If the cathode current does not reach a value of some 90 milliamps. set "coupling" to 2 and repeat aerial tuning. If necessary proceed with coupling 3, 4 and so on. Maximum aerial current is obtained at a cathode current of about 95 milliamps. per valve. It is of no use to make the aerial coupling so tight that the cathode current of the R.F. power valves exeeds 100 mA (each), as the aerial current will decrease and the valves get spoiled.

If there is no point of resonance with switch "aerial tuning, coarse" set to 1 then proceed to 2 and rotate "aerial tuning, fine" again for resonance. If necessary proceed to 3, 4 and so on until a true resonance point has been found - and adjust "coupling" until the correct value of cathode current of the power valves is reached.

It is of vital importance for maximum efficiency that it is a true resonance point which has been found and that the cathode current has not increased because of detuning of the tank circuit caused by too tight aerial coupling. Therefore: always check if the cathode current decreases when "aerial tuning, fine" is rotated to either side of the resonance point.

A practical hint: If resonance can be obtained on two different settings of "aerial tuning, coarse" always choose the setting with the lowest numbering, as this will give the highest aerial current. - Using too high (i.e. numbering higher than necessary for resonance) a setting of "Aerial tuning, coarse" may under certain circumstances give rise to very high voltage in the aerial tuning elements with risk of flash-over in the aerial switch, therefore: always use the setting with the lowest numbering, which will tune to resonance.

The cathode current switch generally will be left in position 6a, 6b or 6c. For checking the modulation set switch to valve 4a or 4b; without speech the cathode current of each of the modulating valves will amount to 40-50 milliamps. A moderate whistling in the microphone will modulate the transmitter 95% and the cathode current of the modulators will increase to about 130 milliamps. (each). With ordinary speech the meter needle will move upwards, reaching a maximum of 130 milliamps. on strong vowels.

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

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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 the 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 calibreted 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 2500-3800 kc/s no extra tuning capacitor is needed. If the frequency lies in the range 1600-2500 kc/s an additional 150 pF tuning capacitor (fixed) has to be connected in parallel with the fixed tuning capacitor.

The "hot" end of the fixed tuning capacitor is connected to the moving contact of wafer no. 3 of the frequency switch, and the 150 pF (extra) capacitor is by a strapping wire connected to all 11 fixed contacts of wafer no. 3 (wafers numbered from the front). So if the frequency is lying in the range 1600-2500 kc/s the extra capacitor is automatically switched in. If the frequency is lying in the range 2500-3800 kc/s the extra capacitor should be disconnected from the fixed contacts of wafer no. 3.

Normally the frequencies (crystals) are disposed in such sequence that the emergency frequency is placed in position 1 and the remaining frequencies placed in positions 2-11 so that increasing frequency designation correspond with increasing position number, that means that crystals having the highest frequencies are inserted in the sockets having the highest number. So if for instance crystals numbered 7 and higher have frequencies in the range 2500-3800 kc/s, the strapping wire connecting the fixed contacts of wafer no. 3 is cut between contact no. 6 and 7. In this way no extra capacitor is connected to the circuit in the positions 7-11.

Wafer no. 2 of the frequency switch selects the coil tap of the same circuit. Connecting leads from the contacts of this no. 2 wafer are taken to the ceramic support mounted horizontally above the coil and numbered accordingly. Clip a short piece of wire to the wire end with the correct number. Set transmitter to reduced power (1/10 power), set cathode current switch to "grid 6" (gitter 6), set control switch to "simplex", press the button in the handset. Clip the other end of the short piece of wire to a tap of the coil which one finds reasonable for the frequency concerned and note the grid current on the milliammeter. When the correct tap has been found the grid current will amount to about 20 milliamps. Practically tuning of the plate circuit of

the oscillator to a frequency slightly higher than resonance has shown desirable; 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 frequencies). This makes the grid current decrease to about 12 milliamps., which is adequate for driving the R.F. power stage. Both ends of the connecting wire are soldered. (Less turns means coil taps 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 2500 and 3800 kc/s no further capacitor should be connected across the tank circuit tuning capacitor (fixed). If the transmitting frequency lies between 1600 and 2500 kc/s an additional 750 pF capacitor has to be connected in parallel with the coupling capacitor (670 pF in 11 sections) and an additional 348 pF capacitor in parallel with the main tuning capacitor (522 pF).

The"hot" ends of the fixed tuning capacitor and the fixed coupling capacitor are connected to the moving contacts of wafers nos. 5 and 4 respectively of the frequency switch and the 348 pF (extra) tuning capacitor and the 750 pF (extra) coupling capacitor are by strapping wires connected to all of the 11 fixed contacts of wafer no. 5 and wafer no. 4 respectively. So if the frequency is lying in the range 1600-2500 kc/s the extra capacitors are automatically switched in. If the frequency is lying in the range 2500-3800 kc/s the extra capacitor should be disconnected from the fixed contacts of wafers nos. 5 and 4. So if - as above - crystals numbered 7 and higher have frequencies in the range 2500-3800 kc/s the strapping wires connecting the fixed contacts of wafers nos. 5 and 4 respectively are cut between contact no. 6 and 7. In this way no extra capacitors is connected to the circuit in positions 7-11.

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 (nearest the front plate) which has the same number (count from left) as the frequency concerned and which has a wire connection with a contact of 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 valves 6a, 6b and 6c. If (especially on the higher frequencies) 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, the tap is linked by a 2 mm tinned copper wire to the tag on the rear insulating strip with the same numbering as the frequency concerned.

The wire is carefully soldered at both ends. Finally the tank circuit is finely tuned by means of a trimmer coil, the number of turns being found by trial. The trimmer coil is placed between opposite soldering tags of the two insulating strips.

When the tank circuit is correctly tuned, the cathode current of each of the no. 6 valves will amount to 30-35 milliamps. with the transmitter set to full power. The trimmer coil is carefully soldered after checking the cathode current of the no. 6 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 coils slightly tighter will increase the inductance sufficiently for correct tuning of the tank circuit with the chassis pushed in.

If a crystal which otherwise is assumed to be alright should refuse oscillating or start very slowly 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" placed below the chassis in the left hand end of the chassis and supplied with a slotted spindle.

Note:

If the amplification is set too high by means of the 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 begims speaking the sensitivity 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 volts 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.

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