

TRANSMITTER 4T

FREQUENCY MULTIPLIER UNIT

Note:- The identity numbers of components used in these notes are the same as those used in Section RS pages 2 - 19 to which reference should be made for details not given here.

1. INTRODUCTION.

Transmitter 4T has been modified by the addition of a Patt. W6260 Frequency Multiplier Unit. This unit has been designed to meet the requirements for Crystal Frequency Control of Transmitter 4T on the higher frequencies and to obviate the use of crystals cut to frequencies higher than 7,000 kc/s.

The unit is capable of operating in three alternative modes:-

- I. Variable frequency control over the whole frequency range of Transmitter 4T (100 - 17,000 kc/s).
- II. Fundamental crystal frequency control between 1930 and 7,000 kc/s.
- III. Doubling or trebling (up to 17,000 kc/s) the frequency of a crystal having a fundamental frequency between 2,400 and 7,000 kc/s).

The output power of the Transmitter 4T remains approximately the same for V.F.O. crystal fundamental and crystal doubling, but some slight reduction of power will be experienced when trebling the crystal frequency.

2. CONSTRUCTION.

The Frequency Multiplier Unit is fitted on the front of the Transmitter 4T, replacing the door of the valve compartment. Access to the master valve is now obtained by removing the cover of the unit. While the remaining valves are accessible by swinging the unit down on its hinges. The safety interlock arrangements formerly fitted to the valve access door of Transmitter 4T, which ensures that this door could not be opened unless the H.T. supply was broken, are not fitted to the frequency multiplier unit and in consequence it is IMPORTANT to ensure that the MAIN SWITCH IS BROKEN BEFORE THE COVER OF THE UNIT IS REMOVED OR THE UNIT IS SWUNG DOWN ON ITS HINGES.

In addition it should be noted that in cases where the transmitter is fed from an A.C. supply, if the unit be removed or hinged downward with the filament supplies "ON", the filament voltage on the remaining valves in the transmitter will rise to about 6 volts, instead of the correct value of 4 volts.

Connections between the unit and the existing circuit of the Transmitter 4T are made by means of five knife contacts at the rear of the unit, which engage with sockets mounted at the front of the space in which the master valve was previously fitted. A four-pin adaptor is placed in the old master valve socket and connections are made from this to the knife contacts and to earth.

3. CIRCUITS.

The Frequency Multiplier Unit contains an indirectly heated beam tetrode, NT75B with its beam plates externally connected to the screen. The heater takes approximately 30 seconds to warm up and this time should be allowed to elapse after switching on before pressing the morse key.

This valve acts as the master oscillator of the Transmitter 4T and as it takes more current than the old master valve, an additional 20,000 ohm resistance (200) is fitted in parallel with the H.T. dropping resistance (32), in order to obtain the correct operating voltages.

The valve may operate as a normal variable frequency oscillator, as a crystal-controlled oscillator working on the fundamental crystal frequency, or as a crystal controlled oscillator working on the second or third harmonic of the crystal frequency i.e. a frequency doubler or trebler.

The conditions of operation are chosen by means of a switch (201) having five positions, V.F.O., crystal fundamental and three different frequency bands of crystal controlled frequency multiplying.

The unit has only two controls, the switch mentioned above and a cathode tuning condenser (214). This latter control is only operative when frequency multiplication is being used, i.e., when the switch is in position 3, 4 or 5.

The complete circuit of the multiplier unit is shown in Fig. 4, while Figs. U, V and W are simplified diagrams of the circuit in the V.F.O., crystal fundamental and frequency multiplying conditions. Fig. Y is a simplified diagram of the keying circuit.

The circuit of the master oscillator valve (213) is controlled by means of a four-pole, five-way switch (201). The five positions of this switch are:-

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SIMPLIFIED DIAGRAMS

VARIABLE FREQUENCY CONTROL

SWITCH POSITION 1.

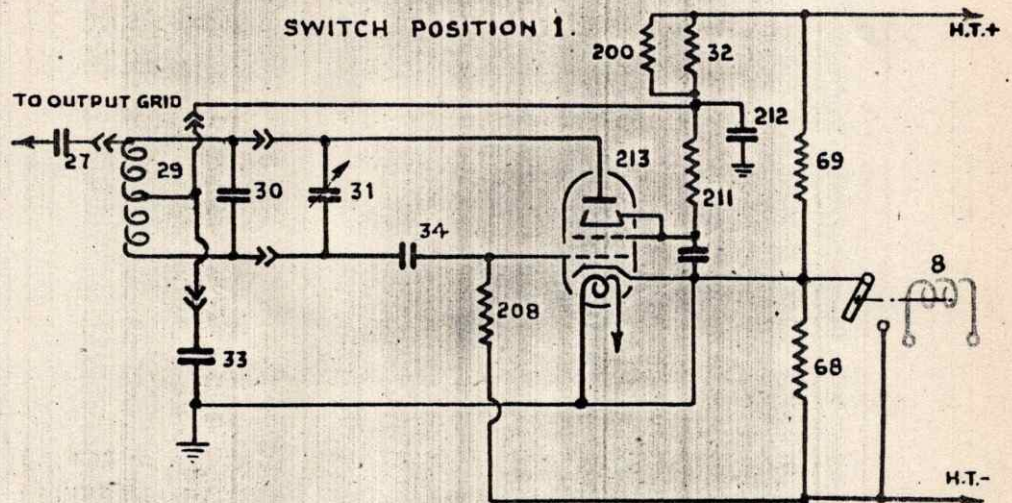


FIG. u.

FUNDAMENTAL CRYSTAL CONTROL

SWITCH POSITION 2.

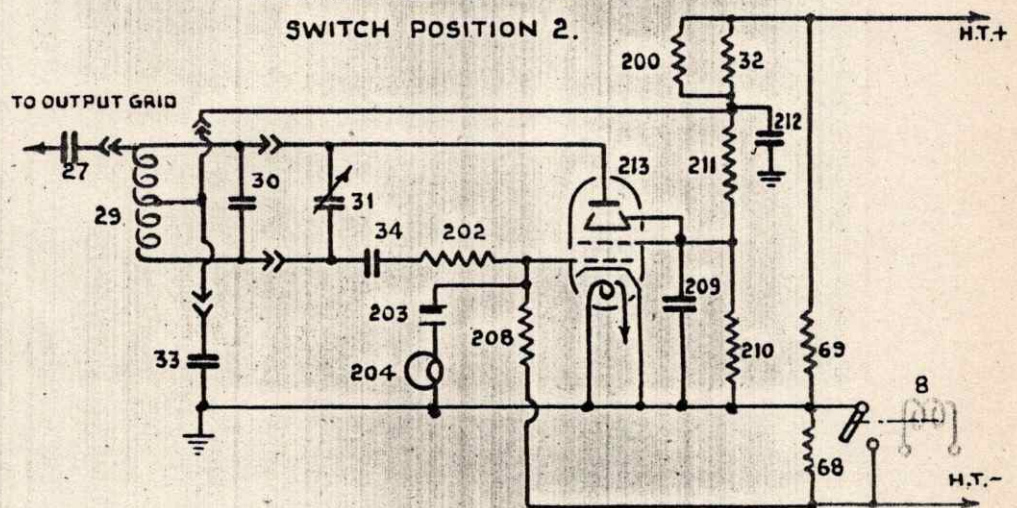


FIG. v.

CRYSTAL DOUBLE OR TREBLE

SWITCH POSITIONS 3, 4 & 5.

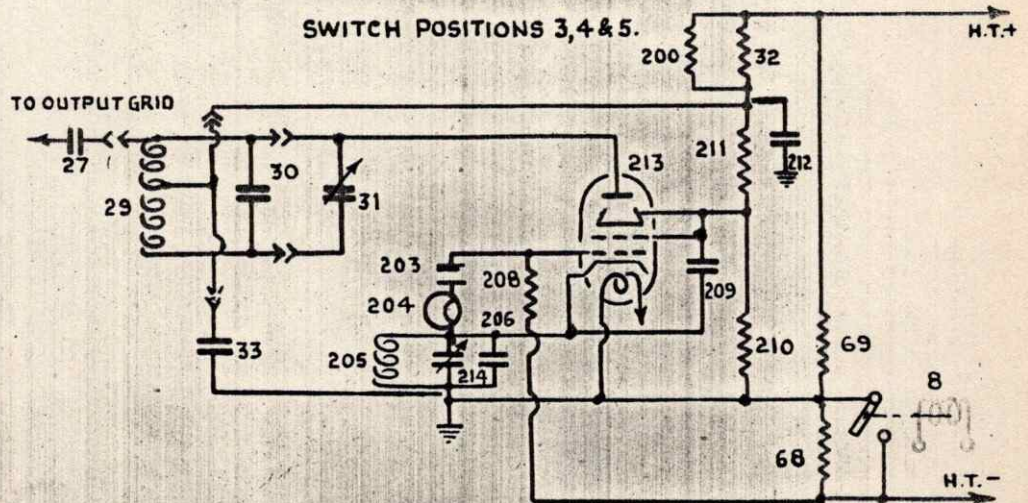


FIG. w.

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1. Variable frequency control. Master valve connected in normal Hartley oscillator circuit and tuned by the normal master oscillator tuned circuit in the range unit. (See Admiralty Handbook of W/T (1938) Vol. II, Para. K7).
2. Crystal fundamental. The grid of the master valve is connected to the cathode of the valve via the crystal and to the tuned circuit through a resistance (202).
- 3.) Crystal Doubling or Trebling. For frequency multiplication the master valve has a tuned circuit connected
- 4.) between the cathode and earth, while the crystal is connected between the grid and cathode in series
- 5.) with its indicating lamp. The only difference between the three positions of the switch marked "Crystal Doubling and Trebling" is the amount of cathode tuning inductance (205) in circuit.

4. CRYSTAL.

The crystals employed are contained in plug-in holders which fit into a socket at the top of the multiplier unit. A 4-volt 0.5 watt lamp (204) is connected in series with the crystal (203) and indicates when an excessive current is passing through the crystal.

This lamp is provided both as a fuse and an indicating device. When using the crystal on the fundamental frequency the crystal current is so small that the lamp does not glow. The crystal current increases when doubling or trebling and the lamp will glow fairly brightly on the higher frequencies when the cathode circuit is tuned to the crystal frequency. If the crystal current is too high the cathode circuit should be detuned towards a higher frequency (clockwise) until the lamp barely glows. The aim should be to maintain effective control by the crystal with a minimum of crystal current.

Under certain conditions the lamp will glow when the crystal is not oscillating and for this reason the lamp should NOT be used as a Cathode tuning indicator.

Both the crystal and the indicating lamp must be removed before the cover of the multiplier unit is removed.

5. VARIABLE FREQUENCY CONTROL CIRCUIT.

When the master oscillator switch (201) is set to position 1 the master oscillator valve (213) is connected as a normal Hartley oscillator as shown in Fig. U.

The cathode of the VT75B master oscillator valve is earthed through one contact of the switch (201). Another contact of the switch disconnects the lower end of the screen potentiometer resistance (210) from earth, thus raising the screen voltage to the value required for satisfactory operation.

Owing to the additional length of lead to the anode of the master oscillator valve, a small capacity has, in effect, been added in parallel with the tuned circuit capacity. The effect of this is not appreciable on frequencies covered by range units 0 to 6 and makes very little difference on the lower frequencies of the remaining ranges. Range Units 7 and 8 will still cover their nominal frequency bands, but Range Unit 9 now has an upper limit of 17,000 kc/s, when using variable frequency control, although 17,200 kc/s, can still be reached when using the crystal multiplier.

6. CRYSTAL FUNDAMENTAL CIRCUIT.

When the switch (201) is set to position 2 the master oscillator valve is connected to operate as a crystal-controlled oscillator operating at the fundamental frequency of the crystal. The circuit is shown in Fig. V.

The grid of the master oscillator valve (213) is now connected to the master tuned circuit via a 20,000 ohm resistance (202) and the condenser (34) in the normal Transmitter 4T circuit. The crystal is connected between the grid of the valve and the cathode which is earthed. The resistance (202) prevents the circuit becoming self-oscillatory and at the same time permits sufficient potential to reach the grid to energise the crystal and so set the tuned circuit (29)(30)(31) into oscillation when it is brought into resonance with the crystal.

The voltage on the screen of the valve is maintained at approximately the same value as for V.F.O. control by one contact of the switch (201), which earths the lower end of the screen potentiometer resistance (210).

The value of the resistance (202) which is connected between the grid of the master oscillator valve (213) and the isolating condenser (34) is chosen to give satisfactory operation with crystals having frequencies between 1930 and 7000 kc/s. Should it become necessary to employ crystals having frequencies below 1930 kc/s, the value of this resistance may have to be increased to prevent the circuit becoming self-oscillatory at some frequency other than that to which the crystal is cut.

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7. CRYSTAL DOUBLING OR TREBLING CIRCUIT.

When the switch (201) is set to position 3, 4 or 5 the circuit is arranged for multiplication of the crystal frequency. The only difference in the circuit given by the three positions is that in positions 4 and 5 increasing portions of the cathode circuit inductance are short-circuited. (Fig. W).

When the switch is in any of these positions the following circuit changes are effected:-

- The grid of the master valve (213) is disconnected from the condenser (34).
- A circuit tuned to the fundamental frequency of the crystal is inserted in the cathode lead of the valve.
- The crystal is connected between grid and cathode.
- The lower end of the screen grid potentiometer resistance (210) is connected to earth.

Excitation of the crystal is obtained by tuning the cathode circuit to the same frequency as that of the crystal. The master circuit is then tuned to the second or third harmonic of the crystal frequency giving a transmitted frequency of twice or three times that of the crystal.

The cathode circuit comprises a small coil (205), the whole of which is in circuit when the switch (201) is in position 3. When the switch is in positions 4 or 5 portions of the coil are short-circuited. The coil is tuned to the crystal frequency by a small variable condenser (214), of 160 mmfd. maximum capacity, in parallel with which is connected to a fixed condenser (206) of 100 mmfd. capacity. This latter condenser is provided to ensure that the L/C ratio of the tuned circuit does not become unduly high and thus cause an excessive crystal current.

The frequency bands covered by the cathode circuit when frequency doubling are indicated on the front of the multiplier unit. When trebling, the bands will shift slightly downwards, e.g. when doubling, the cathode circuit will tune to 3000 kc/s on ranges 3 and 4, but when trebling this frequency can be obtained only on range 3. When it is possible to tune the circuit to a crystal frequency on either of two ranges, the higher range should be chosen; this will result in a lower crystal current.

When doubling or trebling the crystal frequency, receivers in the same compartment as the Transmitter 4T will be able to receive the fundamental frequency at some strength while the key is pressed, depending upon the screening of the receiver and its aerial connection.

8. KEYING CIRCUIT.

The keying of the Transmitter 4T is unchanged. The grids of the output and master valves are connected to H.T. negative and the operation of the magnetic key connects H.T. negative to filament negative. The keying circuit is shown in Fig. Y. (Page RS27).

For convenience in wiring the cathode of the master valve (213) is connected to earth and the H.T. return circuit is completed by a lead from the filament negative pin of the adaptor in the old master valve holder to earth.

During "spacing" conditions the grids of the master and output valves are about 250 volts negative with respect to cathode and filament respectively and the valves are completely "shut down". When the morse key is pressed the grids are returned to earth and the valves operate normally.

As the keying bias of 250 volts is applied to one socket of the crystal holder during "spacing", when the switch (201) is in any position but "1", the safety switch on the front of the Transmitter 4T should be broken before changing crystals.

OPERATION.

9. PRECAUTIONS TO BE OBSERVED WHEN USING THE FREQUENCY MULTIPLIER UNIT.

IT IS MOST IMPORTANT THAT THE FOLLOWING PRECAUTIONS BE OBSERVED WHEN OPERATING A TRANSMITTER 4T FITTED WITH A FREQUENCY-MULTIPLIER UNIT.

- ALWAYS BREAK THE SUPPLIES TO THE TRANSMITTER BEFORE REMOVING THE COVER OF THE MULTIPLIER UNIT OR LOWERING THE UNIT ON ITS HINGES TO GAIN ACCESS TO THE VALVES.
- ALWAYS BREAK THE H.T. SUPPLY BY MEANS OF THE SAFETY SWITCH BEFORE CHANGING CRYSTALS.
- ALL TUNING SHOULD BE CARRIED OUT ON M.C.W. SINCE, IF THE OUTPUT CIRCUIT IS NOT IN TUNE, THE FEED CURRENT ON C.W. MAY BECOME HIGH ENOUGH TO DAMAGE THE OUTPUT VALVES.

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10. TUNING - VARIABLE FREQUENCY CONTROL.

The procedure for tuning the Transmitter 4T using variable frequency control is as follows:-

- (a) See that the safety switch (106) is set to "OFF".
- (b) Set the modulation control switch (74) to "M.C.W."
- (c) Set the switch (201) on the Multiplier Unit to position "1".
- (d) Insert the appropriate range unit for the desired frequency in the transmitter. See that the latches are vertical.
- (e) Set the aerial coupling control on the range unit to "0".
- (f) Set the safety switch to "ON".
- (g) Press the morse key and tune the master circuit to the required frequency by wavemeter.
- (h) Adjust the output tuning control (20) to give minimum reading on the output valve anode milliammeter (36).
- (j) Adjust aerial tuning for a rise in the reading of the output valve anode milliammeter. This should coincide with a reading on the aerial ammeter.
- (k) Increase the aerial coupling and readjust aerial fine tuning until maximum aerial current is reached.

11. TUNING - CRYSTAL FUNDAMENTAL CONTROL.

The procedure for tuning the transmitter when fundamental crystal control is to be used is as follows:-

- (a) See that the safety switch (106) is set to "OFF".
- (b) Set the modulation control switch (74) to "M.C.W."
- (c) Set the switch (201) on the multiplier unit to position "2".
- (d) Plug the crystal to be used into the socket at the rear of the top of the multiplier unit.
- (e) Insert in the transmitter the range unit covering the crystal frequency.
- (f) Set the coupling control on the front of the range unit to "0".
- (g) Set the safety switch to "ON".
- (h) Press the morse key and tune the master circuit for a slight decrease in the reading of the anode current ammeter (36). (The approximate position at which the dip should occur may be found by reference to the book of "Typical Master Tuning Curves" supplied with Transmitter 4T).
- (j) Adjust output tuning control for minimum reading of the anode meter (36).
- (k) Adjust aerial circuit for a rise in the reading of the anode current meter, which should coincide with a reading on the aerial ammeter.
- (l) Increase the aerial coupling and readjust aerial fine tuning control until maximum aerial current is obtained.
- (m) Readjust master tuning condenser for maximum aerial current, taking care not to approach too closely to the point at which the crystal stops oscillating.
- (n) Set the modulation switch to the type of modulation required.

12. TUNING - DOUBLING OF TREBLING CRYSTAL FREQUENCY.

The procedure to be followed when tuning to a multiple of the crystal frequency is as follows:-

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- (a) See that the safety switch (106) is set to "OFF".
- (b) Set the switch (201) on the multiplier unit to position "3", "4" or "5", according to the frequency of the crystal to be used:-

<u>Crystal Frequency.</u>	<u>Switch Position.</u>
2400 - 3000 kc/s.	3
3400 - 4740 kc/s.	4
4740 - 7000 kc/s.	5

- (c) Plug the crystal into the sockets on top of the multiplier unit.
- (d) Insert in the transmitter the range unit which will cover the required frequency i.e., twice or three times the crystal frequency.
- (e) Set the master and output tuning condensers to the approximate frequency.
- (f) Set the safety switch to "ON".
- (g) Press the morse key and adjust the cathode tuning condenser (214) for minimum reading on the anode meter (36).
- (h) Tune the master circuit for minimum anode current in anode meter (36).
- (j) Adjust output tuning condenser for minimum anode current in anode meter (36).
- (k) Adjust aerial tuning for a rise in anode current, which should coincide with a reading on the aerial ammeter.
- (l) Increase aerial coupling and adjust aerial fine tuning control for maximum aerial current.
- (m) Readjust cathode tuning condenser for maximum aerial current consistent with low crystal current (indicated by lamp on multiplier unit).

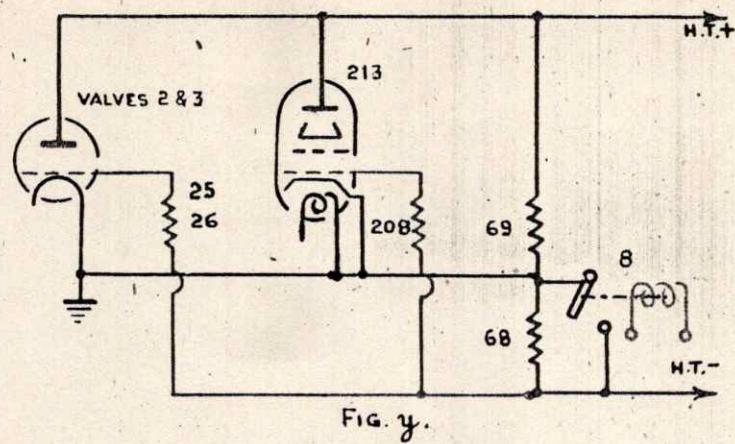
NOTE 1: On no account must the master circuit be tuned to the fundamental crystal frequency when the switch (201) is in positions "3", "4" or "5", as this will produce an excessive crystal current.

NOTE 2: If the decrease in anode current when tuning the cathode circuit is not visible, set the cathode tuning condenser (214) a few divisions higher than the setting shown in the typical tuning sheet and proceed with the next operation.

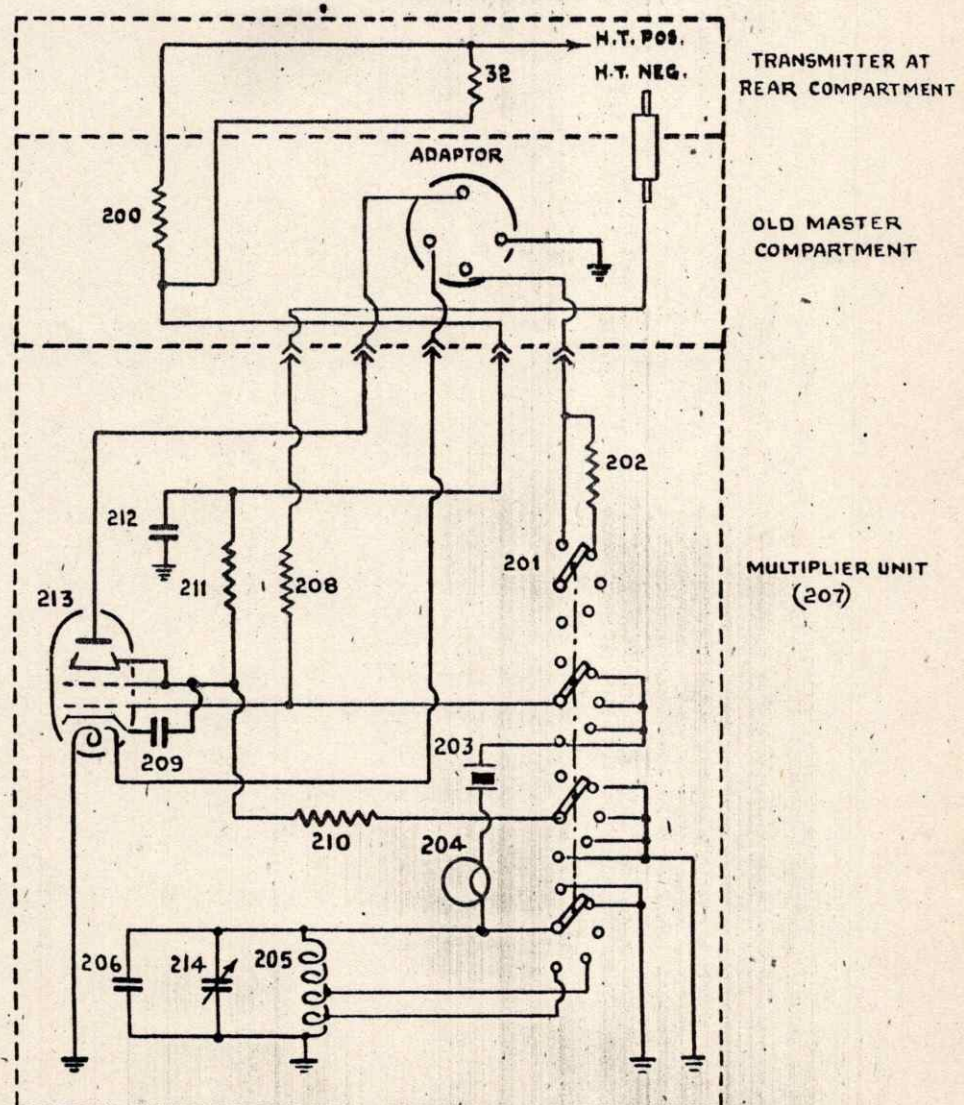
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KEYING CIRCUIT - SIMPLIFIED DIAGRAM



MULTIPLIER UNIT - COMPLETE CIRCUIT DIAGRAM



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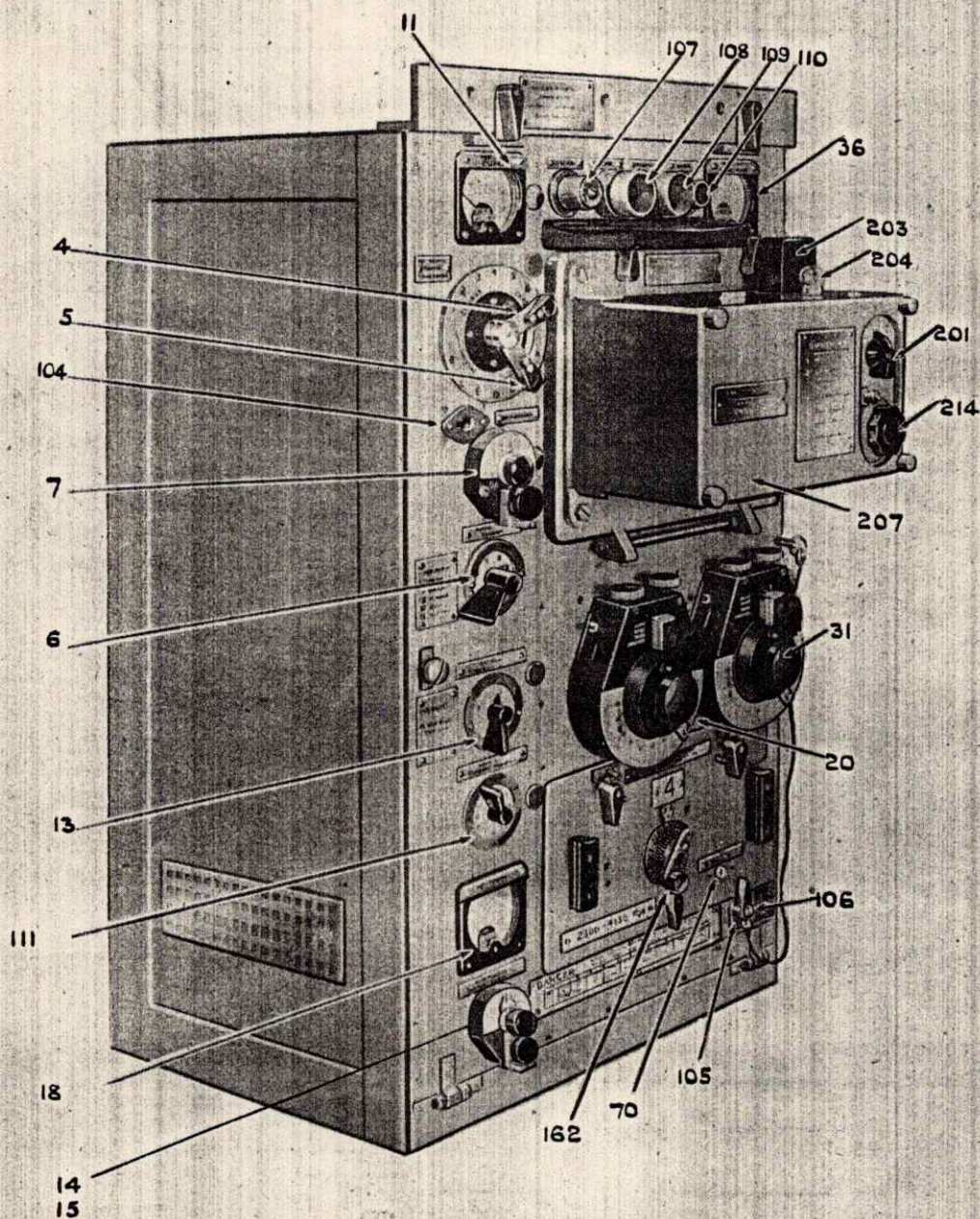


FIG. X