May 13, 1941. B. TREVOR 2,241,937

AUTOMATIC FREQUENCY CONTROL SYSTEM

Filed April 20, 1939

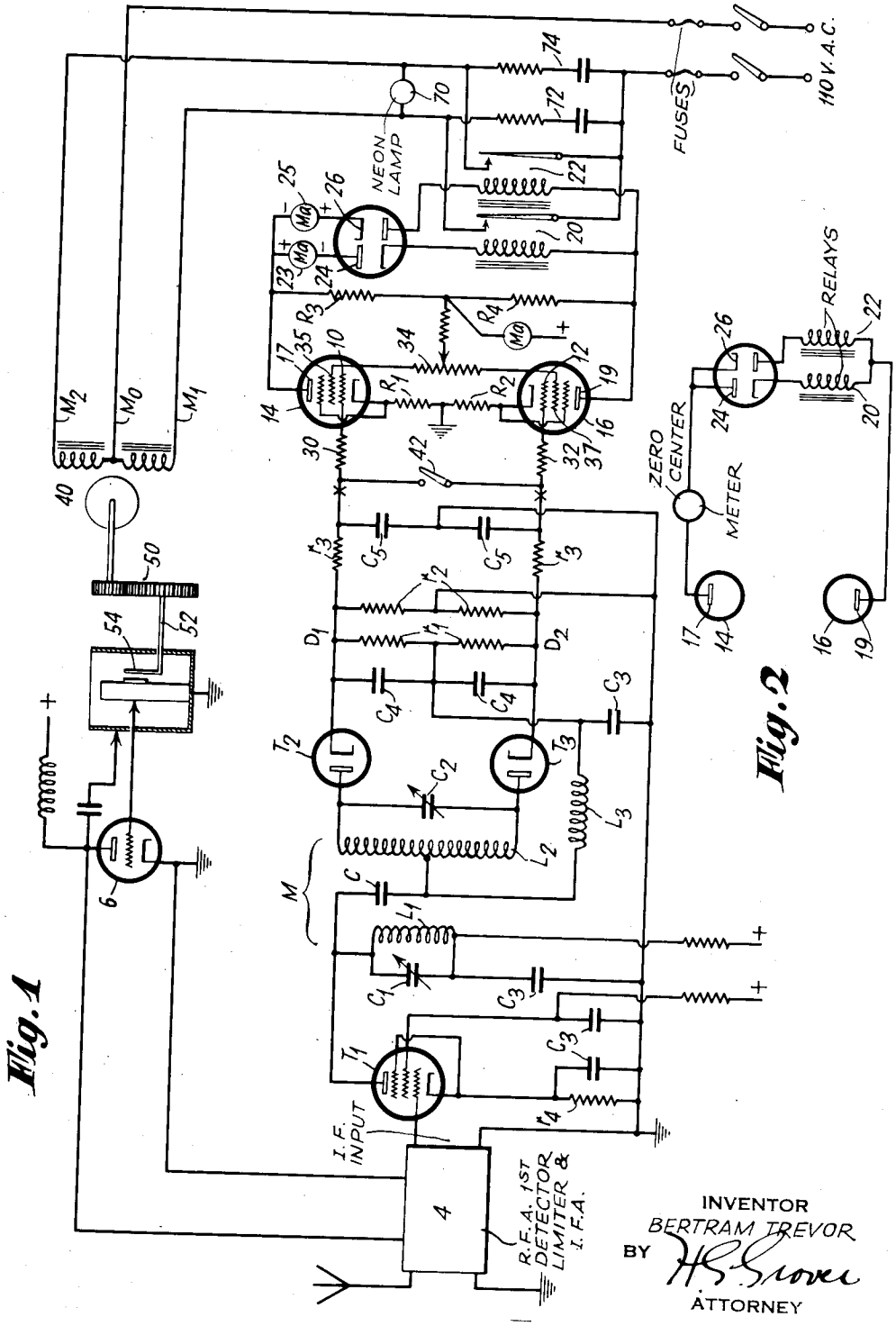


Fig. 1

Fig. 2

Patented May 13, 1941

2,241,937

UNITED STATES PATENT OFFICE

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AUTOMATIC FREQUENCY CONTROL SYSTEM

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Application April 20, 1939, Serial No. 268,871

3 Claims. (Cl. 250—40)

This invention relates to the art of automatically controlling the frequency of the first beating oscillator in a superheterodyne receiver in order to keep the signal accurately tuned to the mid-frequency of the intermediate frequency pass band.

The method to be described uses certain well known features together with novel additions and is particularly adapted for use with ultra high frequency receivers where the electronic method of frequency control does not give satisfactory results. The principle is perfectly well adapted to low frequency as well as high frequency receivers.

Figure 1 shows the essential features of my frequency control system of the present application; while Figure 2 illustrates a modification of the output circuit of tubes **14** and **16** of Figure 1.

Referring to the drawing: wave energy which may be modulated by signals is amplified in **4** and reduced in frequency by beating with oscillations from local oscillator **6**. The wave energy of reduced frequency which may be an intermediate frequency is amplified also in **4** and is fed to the input of tube T_1 the output of which drives the well known network $C_1L_1MCL_2C_2$. The inductance L_2 of this network feeds the wave energy set up in L_2 to two rectifiers T_2 and T_3. The cathodes of the rectifiers T_2 and T_3 are shunted by condensers C_4, resistors r_1 and resistors r_2. Resistor r_3 connects the rectifiers to the control grids **10** and **12** of a pair of coupling and amplifying tubes **14** and **16**. The network $C_1L_1MCL_2C_2$, when properly adjusted, has the property of giving equal and opposite rectified currents through the two diode load resistors r_1 when the input frequency is exactly at mid-band in the intermediate frequency amplifier. This condition hereafter referred to as, "in tune" or "balanced condition," gives a zero potential difference between the points D_1 and D_2. The load circuit of the two diodes T_2 and T_3 is seen to be similar to that of a bridge. The two resistors r_2 in combination with the ground connection between them serve to maintain the mid-point potential between D_1 and D_2 at ground potential regardless of the signal level at the input of T_1. The direct current voltage appearing between D_1 and D_2 rises sharply as the input frequency to T_1 varies either side of balance and the polarity of this voltage is reversed as the signal frequency passes from one side of balance to the other. This voltage is used to control the two direct current amplifier tubes **14** and **16**.

Turning again to the frequency discriminating circuit r_3 and C_5 serve as radio frequency filters, capacitors C_4 serve as radio frequency by-passes, L_3 is a radio frequency choke to return the rectified current from the diodes T_2 and T_3 to the mid-point of L_2, and r_4 is the self-biasing resistor for the tube T_1.

The tubes **14** and **16** comprise a push-pull direct current amplifier stage arranged to drive two motor control relays **20** and **22**. It will be observed that both relays are connected across the output of the direct current amplifier, that is between the plates **17** and **19** of tubes **14** and **16** with diode rectifiers **24** and **26** in series with each relay winding. These diode rectifiers may be separate systems or may be included in a single envelope as is the rectifier designated in the trade as type **6H6**. The polarity of the two diodes **24** and **26** is reversed thus allowing only one relay to operate at a time as the polarity of the voltage difference between the two amplifier plates **17** and **19** reverses with change of the signal frequency. Under the balanced condition there will be no voltage difference between these two plates and consequently, neither relay will draw current.

In this amplifier circuit, the two resistors **30** and **32** in series with the control grids of the amplifier tubes serves to eliminate any tendency for spurious oscillations to develop. The potentiometer resistance **34** connected between the screen grids **35** and **37** allows the amplifier to be balanced (zero voltage between plates) when there exists no voltage difference between the control grids **10** and **12**. The switch **42** between the control grids **10** and **12** is provided to connect these two grids together in order that the balance potentiometer **34** may be properly adjusted. This procedure then assures that there will be no current through either of the relays **20** and **22** when the signal is at mid-band frequency which corresponds to the condition of no voltage difference between points D_1 and D_2.

The two relays **20** and **22** in combination perform the function of a single pole double-throw switch with a definite off position under balanced conditions. The use of a single polarized relay connected across the direct current amplifier output has been used previously but this has the disadvantage of sticking contacts when a relay is used having a neutral off position. The relays shown at **20** and **22** can be the ordinary telephone type giving very positive make and break contacts with no tendency to stick. Furthermore, such relays are inexpensive and rugged.

The terminals $M_1M_0M_2$ of the relays are con-

nected to the windings of a reversible motor 40. The reversible motor may be coupled through suitable reduction gears 50 either direct to the main tuning control of the oscillator 6 or to a vernier condenser, or to a vernier of any sort which produces a frequency change of the controlled oscillator. In the arrangement shown the reduction gearing 50 drives a shaft 52 connected to a conductive plate 54 capacitively coupled to the inner and outer members of a coaxial low loss oscillator circuit controlling the frequency of the oscillator 6 supplying heterodyning oscillations to the first detector in 4. It is, of course, necessary that the motor terminals be polarized properly in order that the system described will bring the signal toward mid-band rather than away from it.

The neon lamp, 70, is provided in order that an operator can easily tell when the tuning motor is running. The lamp lights when the tuning motor runs in either direction. There are two spark suppressor circuits 72 and 74, one across each relay contact, consisting of a .1 μf. capacitor in series with 100 ohms of resistance.

The advantages of the system described are:

1. When the signal is properly tuned to mid-band neither of the relays draws current and the control motor is inoperative.

2. The system is not critical to signal level for normal operation.

3. In case of signal failure the control motor is rendered inoperative and the receiver tuning controls remain fixed until the signal again appears.

4. The system will pick up the signal over a band considerably wider than the band width of the receiver if automatic gain control is used to bring the signal up to a working level to the input of the tube T_1, even though the signal frequency may be outside of the band of the receiver.

5. The working parts of the system are simple and rugged giving trouble-free operation.

6. The accuracy of tuning can be made very great by proper choice of elements in the network $C_1L_1MCL_2C_2$.

It is to be understood that the system described need not be applied only to the first oscillator in a double detection receiver but may be applied to the first and/or second oscillator of a triple detection receiver.

In a modification I make use of a single zero center meter 55 to take the place of the two meters 23 and 25 in the diode circuit shown. In this modification illustrated in Figure 2 one terminal of the single meter 55 is connected to one of the output tube plates, say 17, while the other meter terminal is connected to the plate 24 and cathode 26 of the diodes remote from the coils of relays 20 and 22. The relay coil connection remains unchanged.

What is claimed is:

1. In a system for maintaining the frequency of wave energy substantially constant, wave energy amplifying means including a tunable element which determines the frequency of the wave energy amplified, a pair of rectifier tubes having input and output electrodes, a frequency discriminating circuit connected to the input electrodes of said rectifiers, impedances connecting the output electrodes of said rectifiers in a balanced differential circuit, means for impressing said wave energy on said frequency discriminating circuit, whereby substantially equal differential voltages are produced in said impedances by rectified wave energy when said wave energy impressed on said frequency discriminating circuit is of the proper mean frequency and unequal differential voltages are produced in said impedances when the frequency of said wave energy deviates from said proper frequency, a pair of electron discharge amplifier tubes having input and output electrodes, means coupling said input electrodes to said impedances, a pair of uni-lateral devices connected in parallel, said uni-lateral devices being conductive in different direction, means coupling the said parallel devices to the output electrodes of said amplifier tubes, driving means connected with said tunable element for moving said element in one direction when direct current flows through one of said devices and in the other direction when direct current flows through the other of said devices, and means actuated by current flow in said uni-lateral devices for controlling the operation of said driving means.

2. In a system for maintaining the frequency of wave energy substantially constant, wave energy amplifying means including a tunable element which determines the frequency of the wave energy amplified, a pair of rectifier tubes having input and output electrodes, a frequency discriminating circuit connected to the input electrodes of said rectifiers, impedances connecting the output electrodes of said rectifiers in a balanced differential circuit, means for impressing said wave energy on said frequency discriminating circuit, whereby substantially equal differential voltages are produced in said impedances by rectified wave energy when said wave energy impressed on said frequency discriminating circuit is of the proper mean frequency and unequal differential voltages are produced in said impedances when the frequency of said wave energy deviates from said proper frequency, a pair of electron discharge amplifier tubes having input and output electrodes, means coupling said input electrodes differentially to said impedances, additional impedances in a circuit connected to the output electrodes of said amplifier tubes, means for balancing said last named circuit whereby the voltages in said additional impedances are substantially balanced when the wave energy impressed on said frequency discriminator circuit is of the proper mean frequency, a pair of uni-lateral devices connected in parallel, said uni-lateral devices being conductive in different direction, means connecting the said parallel uni-lateral devices to said last named impedances, driving means connected with said tunable element for moving said element in one direction when direct current flows through one of said devices and in the other direction when direct current flows through the other of said devices, and means actuated by current flow in said uni-lateral devices for controlling the operation of said driving means.

3. In a system for maintaining the frequency of wave energy substantially constant, wave energy amplifying means including a tunable element which determines the frequency of the wave energy amplified, a pair of rectifier tubes having input and output electrodes, a frequency discriminating circuit connecting the input electrodes of said rectifiers in a differential circuit, impedances connecting the output electrodes of said rectifiers in a balanced differential circuit, means for impressing said wave energy on said frequency discriminating circuit, whereby substantially equal differential voltages are produced in said impedances by rectified wave energy when

said wave energy impressed on said frequency discriminating circuit is of the proper mean frequency and unequal differential voltages are produced in said impedances when the frequency of said wave energy deviates from said proper frequency, a pair of electron discharge amplifier tubes having input and output electrodes, means coupling said input electrodes differentially to said impedances, additional impedances coupling the output electrodes of said tubes in a differential circuit, means for balancing said last named differential circuit whereby the differential voltages in said last named impedances are substantially balanced when the wave energy impressed on said frequency discriminator circuit is of the proper mean frequency, a pair of uni-lateral devices connected in parallel, said uni-lateral devices being conductive in different direction, means connecting the said parallel uni-lateral devices in shunt to said last named impedances, a motor connected with said tunable element for moving said element in one direction when direct current flows through one of said devices and in the other direction when direct current flows through the other of said devices, energizing circuits for said motor, normally open contacts in said circuits, and means actuated by current flow in each of said uni-lateral devices for closing a different one of said contacts.

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