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APERIODIC RADIO RECEIVER

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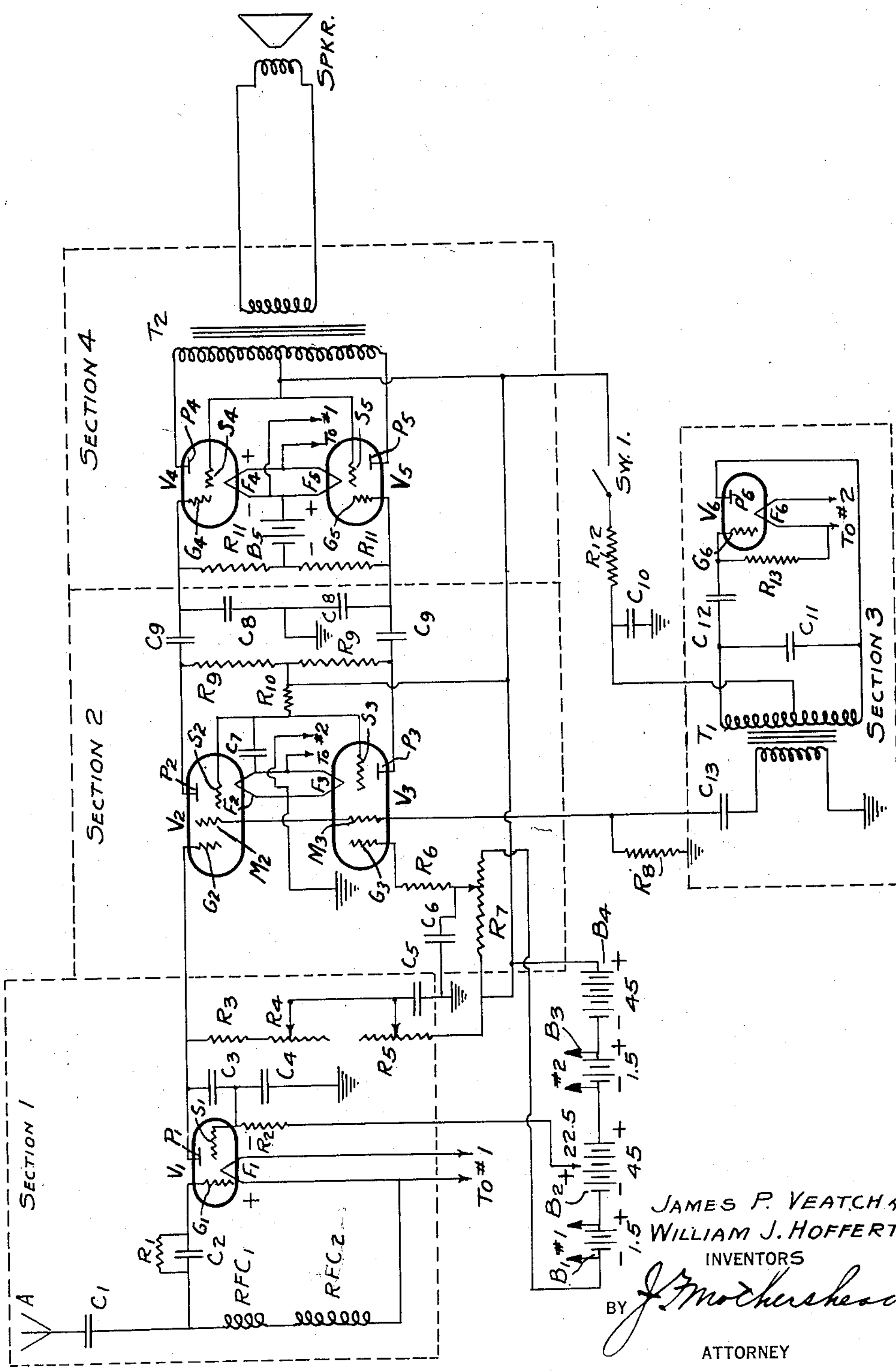

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APERIODIC RADIO RECEIVER

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to us of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to an aperiodic radio receiver and more particularly to a radio receiver capable of responding to transmitted signals through a large frequency range.

It is desirable, in monitoring all radio transmission in a locality, to use a receiver capable of indicating transmission by any of a large number of methods. Law enforcement agencies, in particular, have need of a radio receiver which will detect radio transmission when the time, frequency and type of transmission are unknown. The required receiver must, when placed in a suspected area, give an indication when a relatively strong radio-frequency field is created.

Previous attempts to produce such an aperiodic receiver, in which sensitivity was sought by use of radio-frequency amplifiers, have not been satisfactory because no method has been found which will accomplish the required amplification over a wide range of frequencies.

One object of this invention is to provide a radio receiver capable of responding simultaneously to radio signals transmitted on any of a large range of frequencies.

Another object of this invention is to provide a radio capable of responding to radio communication through a large range of frequencies without the necessity of tuning to a particular frequency or group of frequencies.

Another object of this invention is to provide a radio capable of responding to a wide variety of types of radio transmission.

A further object of this invention is to provide an aperiodic radio receiver capable of responding to keyed continuous wave radio signals.

Other objects will become apparent from the following specification taken in connection with the accompanying drawing which shows a schematic diagram embodying the principles of this invention.

Referring now to the drawing for a general description of the invention, section **1** includes the antenna, input circuit and detector. Section **2** comprises a "push-pull" balanced amplifier. Section **3** is an oscillator capable of producing an audible local frequency. Section **4** includes a "push-pull" balanced amplifier and an output indicator.

In operation, a signal is received and detected in section **1** and supplied to section **2** which is unbalanced thereby. The local frequency produced by section **3** is also applied to section **2** which when unbalanced passes on the local frequency to section **4** where it is further amplified and indicated.

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To explain the invention in further detail, section **1** includes antenna A connected in series with condenser C_1, inductance coils RFC_1 and RFC_2 and thence to filament F_1 of tube V_1. Batteries B_1, B_2, B_3, and B_4 are connected in series, the filament F_1 being connected to leads #**1** from battery B_1. Batteries B_1 and B_3 supply 1.5 volts, while batteries B_2 and B_4 supply 45 volts. Ground is effectively placed between batteries B_3 and B_4 by connections through leads #**2** from battery B_3 to filament F_2 of tube V_2.

The conductor between condenser C_1 and choke RFC_1 is connected through condenser C_2, connected in parallel with resistor R_1, to control grid G_1 of tube V_1. Screen grid S_1 of tube V_1 is connected through resistor R_2 to a central tap on battery B_2. Plate P_1 of tube V_1 is connected through resistor R_3, rheostats R_4 and R_5, and potentiometer R_7 to the negative side of battery B_1. The junction of rheostats R_4 and R_5 is connected to ground through condenser C_5. Plate P_1 is also connected through condensers C_3 and C_4 to ground. The junction of condensers C_3 and C_4 is connected to screen grid S_1 of tube V_1.

The plate P_1 of tube V_1 is also connected in direct current connection to the first control grid G_2 of tube V_2 of section **2**. Tube V_2 is connected in balanced push-pull relation with tube V_3, the filaments F_2 and F_3 being connected in parallel and supplied with current through leads #**2** of battery B_3. One side of filaments F_2—F_3 is grounded. Screen grids S_2 and S_3 of tubes V_2 and V_3, respectively, are connected together and through resistor R_{10} to the junction of equal resistors R_9—R_9 which are connected in series between the plates P_2 and P_3 of tubes V_2 and V_3, respectively. The junction of resistors R_9—R_9 is also connected to the positive side of battery B_4. First control grid G_3 of tube V_3 is connected through resistor R_6 and potentiometer R_7 to the negative side of battery B_1. The junction of resistor R_6 and potentiometer R_7 is connected to ground through condenser C_6.

Section **3**, the local oscillator, includes tube V_6 the filament F_6 of which is connected through leads #**2** to battery B_3. The grid G_6 of tube V_6 is connected through condenser C_{12} to one end of the center-tapped primary of transformer T_1. The other end of said primary is connected to the plate P_6 of tube V_6. Condenser C_{11} is connected across the primary of transformer T_1, the center tap of which is connected through resistor R_{12}, and switch SW_1 to the positive side of battery B_4. Said center tap is also connected to ground through condenser C_{10}. The filament F_6 is connected through resistor R_{13} to grid G_6.

The secondary of transformer T_1 is connected through condenser C_{13} to the second control grids M_2 and M_3 of tubes V_2 and V_3, respectively. Control grids M_2 and M_3 are connected to ground through resistor R_8.

Plate P_2 of tube V_2 is connected through one of the two equal condensers C_9—C_9 to grid G_4 of tube V_4 of section **4**. Plate P_3 of tube V_3 is connected through the other of condensers C_9—C_9 to grid G_5 of tube V_5, also of section **4**. Grids G_4 and G_5 and connected together through condensers C_8—C_8 connected in series and also through resistors R_{11}—R_{11} connected in series. The junction of the two equal condensers C_8—C_8 is connected to ground. Filaments F_4 and F_5 of tubes V_4 and V_5 are connected through leads #1 to battery B_1. The junction of resistors R_{11}—R_{11} is connected through battery B_5 to filament F_4—F_5. Balancing condensers C_8—C_8 are of equal capacitance and have a reactance approximately at the third harmonic of the audio-frequency supplied by section **3**. The reactance of the condensers C_8—C_8 is somewhat less than the resistance of resistor R_9 in order to maintain good balance.

The plates P_4 and P_5 of tubes V_4 and V_5, respectively, are connected to either end of the center-tapped primary of transformer T_2. Plates V_4 and V_5 are connected through the center tap of said primary of transformer T_2 to the positive side of battery B_4. Screen grids S_4 and S_5 of tubes V_4 and V_5, respectively, are connected to the center tap of the primary of transformer T_2. The secondary of transformer T_2 is connected to a speaker.

In operation radio-frequency energy is collected by antenna A causing a voltage to appear across inductances RFC_1 and RFC_2. C_2 is an isolating condenser to prevent any direct potential from entering the receiver. C_2, however, provides a path for the radio-frequency energy. RFC_1 and RFC_2 have a combined series impedance which is high compared to the antenna impedance for all frequencies in the required range.

A wire of infinite length would make the best antenna for the receiver described herein. However, for practical purposes the size of antenna A must be governed by the expected field strength and the space available. Marked variations in response versus frequency will be experienced with short antennas. Relatively large inductance RFC_2 is used to allow low frequencies to be impressed across the grid G_1 and filament F_1 of detector tube V_1. Due to high distributed capacity, high inductance RFC_2 offers a low impedance path to high frequency energy. A separate small inductance RFC_1 is provided to impress high frequencies on the detector.

Tube V_1, a pentode type vacuum tube with low input capacity, acts as a "grid leak detector" performing the dual function of rectification, by diode action of the grid G_1 and filament F_1, and amplification of the direct current voltage produced in case of a continuous unmodulated radio-frequency and the low frequencies of a modulated carrier. Resistor R_1 and condenser C_2 provide a "grid leak and condenser." A voltage appearing across impedances RFC_1 and RFC_2 will cause rectification between grid G_1 and filament F_2 of tube V_2. The resultant current flow will cause a negative voltage to build up on grid G_2 and store in condenser C_2. This negative grid voltage causes a reduction in the plate current of tube V_1 and therefore a reduction in the voltage drop across resistors R_3, R_4 and R_5. If the voltage across impedance RCF_1 and RCF_2 is reduced, the negative voltage on grid G_1 will tend to leak away over resistor R_1.

Resistor R_2 provides the correct voltage for proper operation of screen grid S_1 or tube V_1. C_3 is a by-pass condenser of sufficient size to reduce the amplitude of high frequency voltage appearing on the plate of tube V_1 but not so large that an appreciable attenuation of modulation frequencies will result. Resistors R_3, R_4 and R_5 are a combined series of plate resistors such that the resultant plate potential of tube V_1 will be slightly negative in relation to the negative filament point of V_2 and of equal potential to the equivalent grid G_3 of tube V_3 with no signal, or a selected input signal, impressed upon the receiver. Resistors R_4 and R_5 are variable to allow adjustment of this potential and therefore balance the system. Resistor R_4 is made large with respect to R_5 so that rough and fine adjustment of balance may be made. Condenser C_5 is an audio by-pass for the plate return circuit of tube V_1.

Resistor R_7 is a variable resistor to permit initial adjustment of the bias on tube V_3. The sensitivity may be controlled to some extent by this adjustment. Condenser C_6 is the by-pass for this control. Resistor R_6 simulates the resistance in the circuit of grid G_2 of tube V_2 and allows grid G_3 to operate under the same conditions as grid G_2. Resistor R_{10} provides proper screen voltage for screen grids S_2 and S_3 of tubes V_2 and V_3. Resistor R_{10} is by-passed for audio-frequency by condenser C_7.

In section **3**, the primary of transformer T_1 and condenser C_{11} act as a tank circuit and receive power from the filament-plate circuit of triode T_6 to produce an audible tone. The grid G_6 of triode V_6 is coupled to the tank circuit through condenser C_{12} to give the necessary feedback to produce oscillation in the tank circuit. Resistor R_{13} prevents the voltage of grid G_6 from floating. Resistor R_{12} and condenser C_{10} are used as a filter to prevent the tone produced by section **3** from spreading through the battery to other circuits. Condenser C_{13} is used to couple the audio-tone produced by section **3** to the control grids M_2 and M_3 of tubes V_2 and V_3. Resistor R_8 provides a path for rectified audio-current resulting from the application of a strong audio source to grids M_2 and M_3 which are only slightly biased.

With equal voltages applied to grids M_2 and M_3 of tubes V_2 and V_3, as long as equal voltages are applied to grids G_2 and G_3, equal voltages will appear across resistors R_9—R_9 and be applied through coupling condensers C_9—C_9 to grids G_4 and G_5 of tubes V_4 and V_5. With equal voltages applied to grids G_4 and G_5 equal and opposite currents will flow through the primary of transformer T_2 and no current will be induced in the secondary of transformer T_2 and impressed on the speaker. However, if the voltage on grid G_2 is varied with respect to the voltage on grid G_3, the balance of the system is impaired and an indication will be given at the speaker.

For reception of keyed unmodulated radio-frequency energy, the apparatus is balanced by removing the antenna A, turning the audio-oscillator on by closing switch SW_1 and adjusting resistors R_4 and R_5 until no signal, or until a selected minimum signal, is heard at the speaker. The antenna is then connected. If a radio telegraph station of sufficient intensity is then operated, a signal will be collected by antenna A detected by tube V_1 and impressed on grid G_3 of tube V_2 as explained above. As the original adjustment for balance resulted in equalizing the voltages on grids G_2 and G_3, the change caused by the received signal will unbalance the circuit and cause the audible tone from section **3** to be amplified in section **4** and reproduced by the speaker. If the transmitter is keyed, obviously the tone will appear and disappear in accordance with the keying. For reception of modulated radio signals, it is only necessary to turn off the local oscillator in section **3** by opening switch SW_1 and adjust resistors R_4 and R_5 for the most sensitive position. In this case sections **2** and **4** act simply as audio-amplifiers.

An increase in sensitivity may be obtained by using a separate diode rectifier replacing the grid rectifier and allowing tube V_1 to act purely as a direct current amplifier. Additional direct current amplifiers may be added increasing the sensitivity to the limit set by the noise generated in the input circuit. It will be understood that when keyed, unmodulated radio-frequency energy is being received, a long pulse of continuous wave will result in only direct current flowing through the circuit after detection and before the local oscillation is applied in section **2**. An aperiodic input to the receiver is most readily obtained by using a rectifying element with extremely low input capacity and by using sectionalized inductances to reduce the input capacity. If this input capacity can be kept low in relation to the antenna capacity the response will remain relatively constant through a large range of frequencies. As stated previously, the length of the collector wire will generally be the determining factor.

If the sensitivity of an efficient aperiodic receiver is increased sufficiently many signals will be heard simultaneously. Under such conditions it is possible to reduce the receiver band width, and therefore, the number of stations received, by the use of suitable filters. Such filters may be inserted ahead of the input circuit and may be any of the usual forms, such as band pass, band elimination, or simple resonant circuit. The addition of a simple tuned circuit will increase the sensitivity materially by reducing the detrimental effects of a collector of finite length. A calibrated tuned circuit can be used to determine the approximate frequency of the received signal and aid in locating the exact frequency when using other receiving systems.

In place of the audio reproducer shown in the drawing a visual indicator such as a meter or cathode ray tube may be used to indicate reception of a signal. In this case an indication of the signal intensity may be obtained. Various types of recording systems may be used with the receiver to permit automatic monitoring with the receiving equipment unattended. The indicator could be arranged to show intensity against frequency.

The above specification and drawing describe a preferred embodiment, but many modifications within the scope of the appended claims will occur to those skilled in the art.

What is claimed is:

1. In combination an antenna connected to at least one inductance coil, a first electronic discharge device having at least a plate, control grid, and cathode electrodes, said control grid being connected to one side of said inductance coil through a capacitor shunted by a resistor, said cathode being connected to the other side of said inductance coil, whereby said first electric discharge tube functions as a grid leak detector, a second and third electric discharge device each having at least a plate, cathode, and first and second control grid, the cathode of said first and second electric discharge device being connected together, the first grid of said second electric discharge device being connected directly to the plate of said first electric discharge device, the first grid of said third electric discharge device being connected to an adjustable source of potential whereby the first grid of the third electric discharge device may be adjusted to the normal potential of the first grid of the second electric discharge device, means for producing a local frequency, means for supplying said frequency to the second grids of said second and third electric discharge device, the plates of said second and third electric discharge device being connected in opposition in an output circuit whereby the local frequency does not appear in said output circuit unless radio energy is received by said antenna.

2. An antenna connected to an impedance, a detector connected across said impedance, said detector having an output, first and second vacuum tubes each having first and second control electrodes and an output electrode, said output electrodes being connected in opposition, an oscillator for producing a local frequency, means for applying said local frequency to the second control electrodes of each of said first and second vacuum tubes, a direct connection between the output of said detector and the first control electrode of one of said vacuum tubes, means for applying an adjustable steady potential to the first control electrode of said second vacuum tube equal to that existing on the first control electrode of said first vacuum tube when no radio signal is received by said antenna whereby when a radio signal is received by said antenna the first and second vacuum tubes become unbalanced and produce an output.

3. An antenna connected to an impedance, a grid-leak detector having an input and an output, said input being connected across said impedance, an amplifier stage comprising a first and second vacuum tube each having a first and second input and an output, the output of said detector being directly connected to the first input of said first vacuum tube, the first input of said second vacuum tube being connected to an adjustable source of potential, a device for generating a local frequency, means for supplying said local frequency to the second input of said first and second vacuum tubes, said outputs of said first and second vacuum tubes being connected in opposition, and switching means operable to prevent application of said local frequency to said second inputs.

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