March 5, 1929. R. W. CAMFIELD 1,704,497

RADIO DETECTOR SYSTEM

Filed July 3, 1924

FIG. 1.

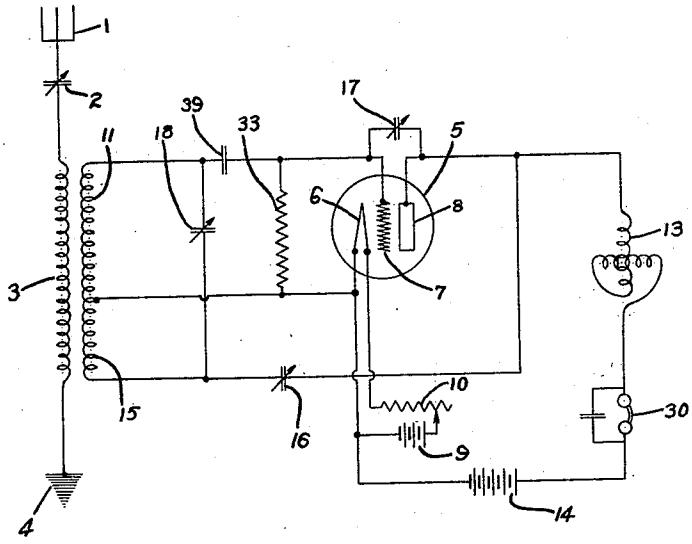
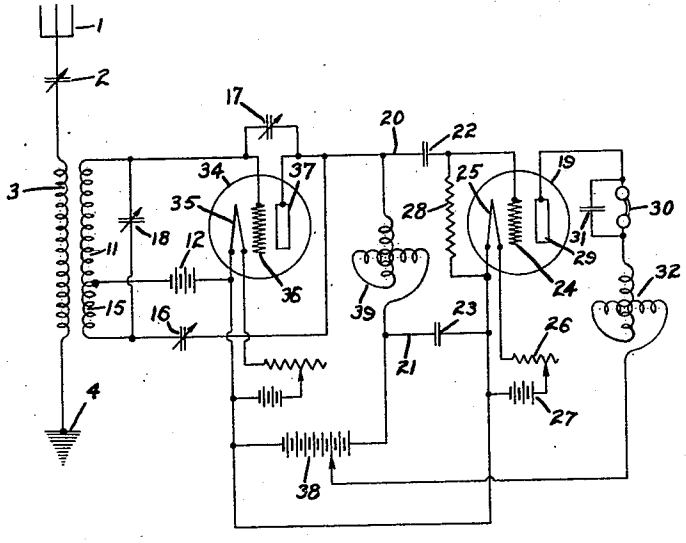


FIG. 2.



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UNITED STATES PATENT OFFICE.

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RADIO DETECTOR SYSTEM.

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This invention relates to a system for detecting signals transmitted by radio waves by the aid of one or more electronic tubes, and more particularly to such a system in which at least some of the electronic tubes are used to regenerate the radio frequency energy received, whereby the amplitude of the signal is increased materially.

Such systems have been proposed in the past, but have not been very satisfactory, due to the fact that the adjustment necessary to produce regeneration without producing disturbing oscillations by the tube is very critical; and even when so adjusted, slight incidental changes in conditions may destroy the efficacy of the adjustment or render the entire system oscillatory to an objectionable extent, and thereby make interfering reradiation possible. Such reradiation is very undesirable, causing as it does, annoying interference in nearby receivers.

It is therefore one of the objects of my invention to make it possible to secure regeneration without oscillations, and without disturbing reradiation by the aid of stable adjustments.

My invention possesses other advantageous features, some of which, with the foregoing, will be set forth at length in the following description, where I shall outline in full that form of the invention which I have selected for illustration in the drawings, accompanying and forming part of the present application. Although I have shown in the drawings but one embodiment of my invention, I do not desire to be limited thereto, since the invention as expressed in the claims may be embodied in other forms also.

Referring to the drawings:

Figure 1 is a wiring diagram of one form of my invention, used in connection with a single tube receiver; and

Fig. 2 is a modification, in which two tubes are used.

In Fig. 1, I show a conventional type of circuit, such as antenna 1, condenser 2, loading coil 3, and ground 4, for absorbing electromagnetic radiations. The energy received in this circuit is caused to affect an electronic tube 5, which is shown as of the usual thermionic type, and has a heated filament or electron emitting electrode 6, a grid or control electrode 7, and a plate or anode 8. The filament 6 is heated by current supplied from a source, such as battery 9, and the degree of heat is controlled by a variable resistance 10 in series with filament 6 and source 9. In practicing my invention, it is possible to arrange tube 5 either as a radio frequency amplifier or as a detector. In the present instance I show it as a detector. The filament 6 and grid 7 are subjected to the varying differences in potential induced in a coil 11 coupled to coil 3. These potential differences occur in accordance with the signaling energy received by the absorbing circuit, and conform to the modulations carried by the radio frequency waves forming the signal. To improve the detector action, I show the usual grid leak resistance 33 between the filament 6 and grid 7, and a grid condenser 39. All this is well understood at the present time, and needs no further explanation.

The input circuit of tube 5 includes the grid 7, condenser 39, coil 11 coupled to coil 3, and filament 6. In the present instance, the output circuit of the tube 5 includes a variable inductance, such as a variometer 13, a source of potential, such as a battery 14, to maintain the potential of plate 8 positive with respect to the filament 6, and thus to cause a flow of electrons between these two electrodes, the volume of which is controlled by the variation in potential of the grid 7; and a telephone 30 or other form of translating device.

As thus far described, the circuit is entirely analagous to the usual single tube detector system. It has been also found that by properly tuning the plate circuit, as by adjustment of the variometer 13, it is possible to pass some of the amplified energy back to the input circuit, and to cause a reamplification of this portion. This effect has been explained on the ground that the capacitive coupling between the grid 7 and plate 8 in the evacuated tube 5 permits such a transfer to take place, especially when the plate or output circuit is accurately adjusted for this effect. It is thus evident that in such regenerative schemes, which produce a higher degree of amplification, the capacitive coupling between the electrodes is a useful and necessary factor. The difficulty comes in that the adjustment for efficient regeneration is critical, and such regeneration is very apt to become highly unstable and to cause the tube circuits to sustain independent oscillations. Such oscillations interfere materially with the quality of the reception, as well as distort the signals to some extent. The most objectiona-

ble feature, however, is that reradiation is produced, with all its attendant evils, such as interference with nearby receivers.

In order to prevent the circuit reradiating, and thus to overcome these objections, I provide a neutralizing coil 15, inductively coupled to coil 11 and connected to one terminal thereof, and which forms one element of a circuit providing for an adjustable amount of energy interchange between the input and output circuits. To make this interchange of the proper direction, coils 11 and 15 are wound as if they were a single continuous helix. The bottom terminal of the coil 15 is connected to a point in the output circuit in this case, through an adjustable condenser 16. The point in the output circuit chosen for this connection is adjacent the plate electrode 8. The amount of energy interchange between the input and output circuits may be so adjusted by the aid of condenser 16 that the tube 5 may be maintained at a regenerative stage, yet without any tendency to oscillate. This effect may be increased, and adjustments of condenser 16 rendered still less critical, by providing an additional capacitive coupling 17 between the plate 8 and grid 7, which assists the inherent coupling that exists between them. This coupling 17 may be adjustable also. Furthermore, in order to secure the maximum effect of the incoming signals, it is advisable to bridge coils 11, 15 with a variable condenser 18, which tunes the closed circuit 11, 15, 18 to the incoming radio frequency.

The operation of the system and its adjustment are relatively simple. If condenser 17 is used, it may be set at an intermediate position. Condenser 16 may be placed to provide minimum capacity, and circuit 11—15—18 may be tuned to the frequency of reception. Then variometer 13 is carefully adjusted to secure regeneration, or even oscillation. To prevent reradiation, condenser 16 is varied until oscillations just cease. If such an adjustment is found too critical, the capacity of condenser 17 may be increased, and the process repeated. Once the proper setting of these two condensers is obtained, there will be little occasion for readjustment, even for a variation of material amount of the frequency of the radiant energy received.

In Fig. 2, I illustrate a receiving system in which there is one stage of radio frequency amplification, secured by the aid of a tube 34, having filament 35, grid 36 and plate 37. This tube has its input circuit connected substantially as in Fig. 1, to be sensitive to energy received in the absorbing circuit 1—2—3—4. A grid biasing battery 12 is however included in the input circuit to prevent distortion, as is well understood; furthermore, no grid leak is provided. The output circuit includes the variometer 39 or other variable impedance, as well as a plate battery 38. The prevention of oscillation or instability is secured as in the former instance, by the aid of coil 15 and condensers 16 and 17, and the mode of operation is identical.

In this instance however, the adjustments are performed by listening in the phones 30, which are in the output circuit of the detector tube 19, the input circuit of which is connected to the amplifier stage in a manner now to be described. This tube I prefer to couple to the preceding amplifier by conductive connections 20 and 21 across the terminals of variometer 39. These connections include fixed condensers 22 and 23 serving as stopping condensers. In this manner the amplified voltage variations existing across the variable inductance 39 are impressed across the input electrodes of tube 19, comprising the grid or control electrode 24, and the filament or electron emitting electrode 25. The temperature of this filament is controlled by the variable resistance 26, in series with the heating current battery 27. As is usual, a high resistance grid leak 28 may also be provided between these two electrodes, for improving the operation of the tube 19 as a detector.

The output circuit for tube 19 includes the plate 29, the translating device 30, at least a portion of battery 38, and filament 25. In case one or more stages of audio frequency amplification is desired, the translating device 30 may be arranged to transmit the detected impulses to these amplifiers. But since such an arrangement is now well-known, it is considered unnecessary to show them. Instead, the translating device 30 is shown as a pair of phones that are used for directly producing the sound waves. A small fixed condenser 31 is shown, shunting the phones 30 and serving to by-pass the radio frequency component of the rectified or detected signals.

One of the important features of my invention resides in the fact that it is possible for me to secure reamplification or regeneration in the detector tube 19 as well as in the amplifier tube 34, without danger of producing oscillations and consequent reradiation. In other words, the adjustment of condensers 16 and 17 in the amplifier stage serves also to stabilize the detector stage, when that stage is conductively coupled as indicated to the amplifier tube. It is therefore quite feasible to tune the plate or output circuit of tube 19 and take advantage of this effect. For this purpose I include a variable inductance 32 in the form of a variometer, in the output circuit. By careful adjustment of this variometer, the desired regenerative effects may be readily obtained, and due to the stabilization in the amplifier stage, the detector circuit is also stable against oscillations. Although I am not prepared at this time to set forth in detail the reason for this behavior, nevertheless I have verified it by proper experiment.

The system as disclosed is particularly well adapted for reception of broadcasted speech or music, as well as for other high frequency signals.

I claim:

1. In a high frequency system, a tube having an electron emitting electrode, a control electrode, and an anode, means forming an input circuit for said tube, connected between the electron emitting electrode and the control electrode, means forming an output circuit between the anode and the electron emitting electrode, said means including a tuning device whereby regeneration may be secured, and means for preventing the tube from producing oscillations, comprising a neutralizing circuit connected between the electron emitting electrode and the anode, including an inductance coil coupling the two circuits, and a variable capacitance, so adjusted as to produce an energy interchange between the two circuits of such character that regeneration is secured but local oscillations are neutralized.

2. In a relay system for currents of radio frequency, an electron relay tube having selectably tunable input and output circuits, a reactive element in addition to the inherent relay capacitance for effecting positive feed back of energy from the output to the input circuit, and separate reactive means for effecting reverse feed back of energy from the output to the input circuit whereby the relay system is prevented from oscillating but will operate regeneratively, the reactances of said element and said reverse feed back means being so arranged and proportioned that the system will not oscillate but will remain in regenerating condition for a substantial variation in the frequency of received energy.

3. In a relay system for currents of radio frequency, an electron relay having grid, plate and cathode elements, selectively tunable input and output circuits, means for effecting positive feed back of energy between said circuits comprising an external condenser connected across the grid and plate of said relay, and means for effecting reverse feed back of energy between said circuits comprising an inductance coupled to one of said circuits, and connected to the other one of said circuits thru a series condenser, said condensers having their reactances so adjusted and proportioned that the system will not oscillate but will effect regeneration of repeated energy over a wide range of radio frequencies without effecting further adjustment of said condensers.

In testimony whereof, I have hereunto set my hand.

RUSSELL W. CAMFIELD.