Oct. 16, 1934. G. E. PRAY 1,977,596

KEYING

Filed Nov. 19, 1930 3 Sheets-Sheet 1

Fig. 1

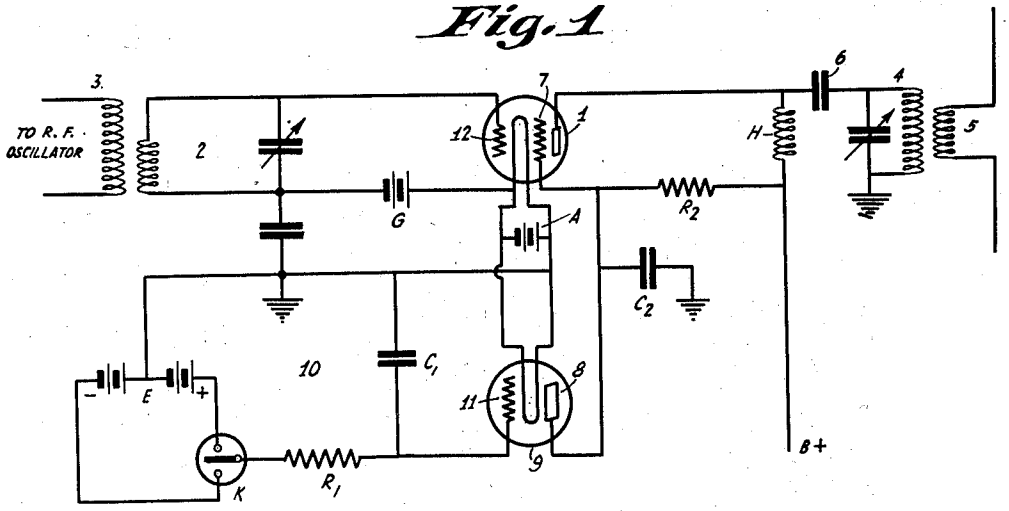
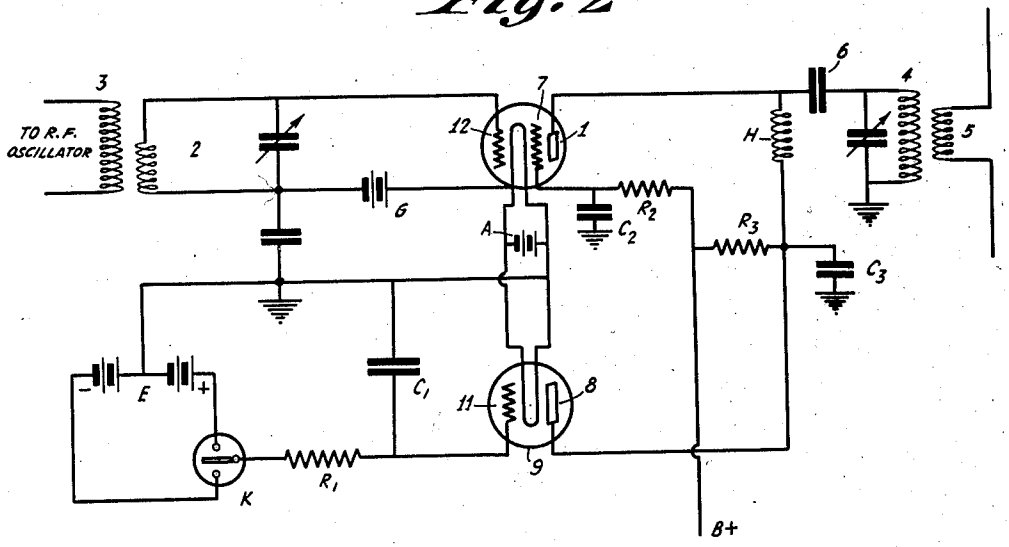


Fig. 2



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Fig. 3

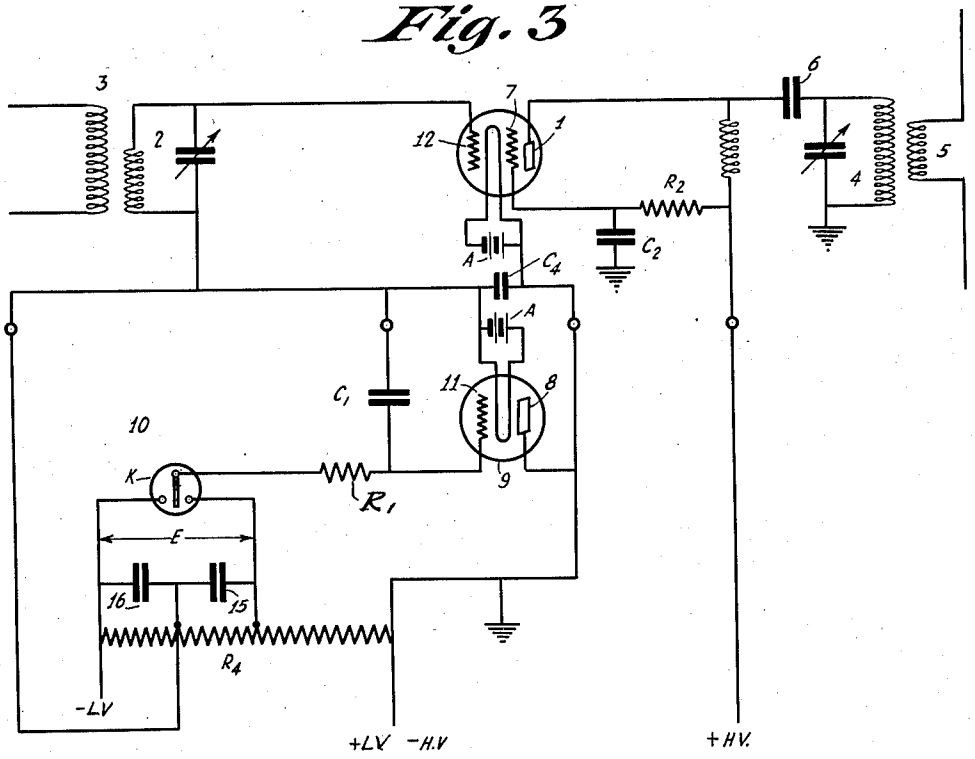
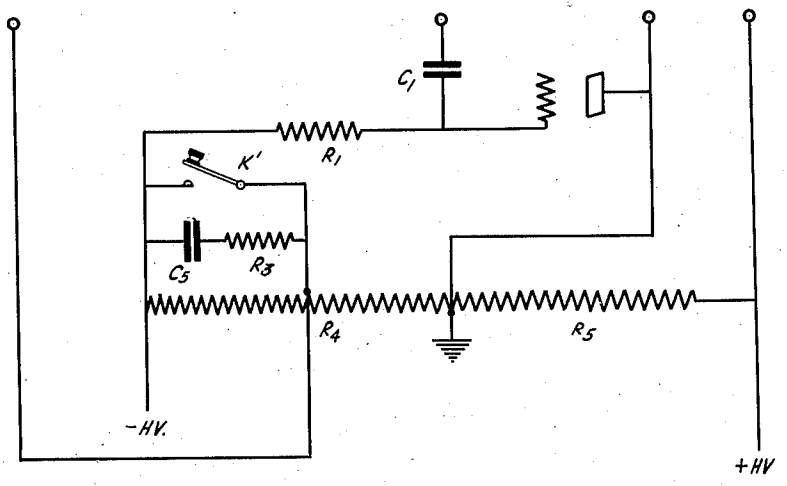


Fig. 3a



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Fig. 4a

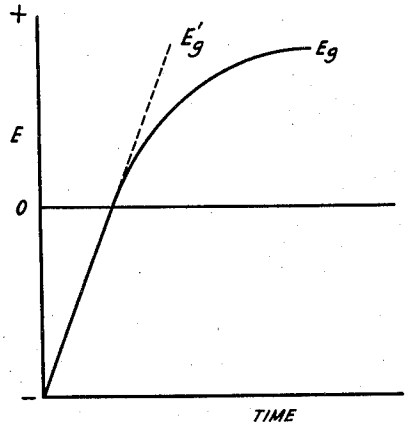


Fig. 4b

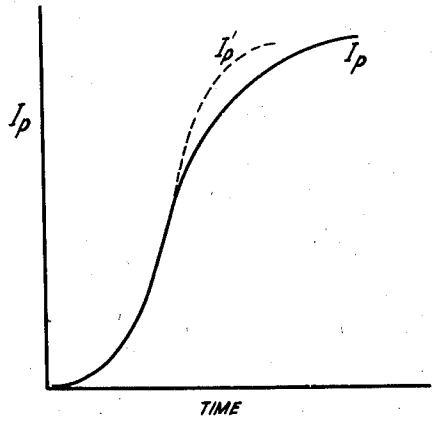


Fig. 4c

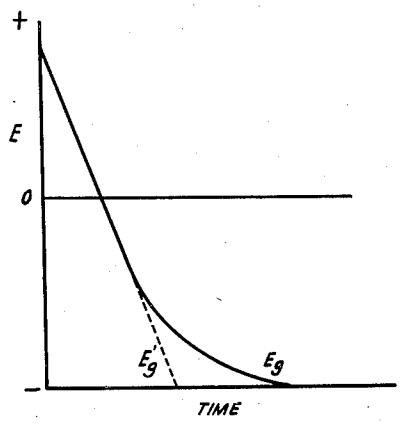
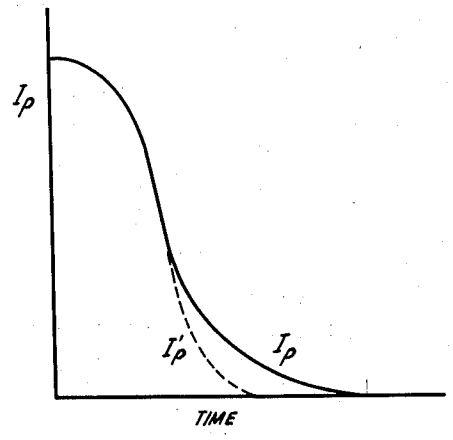


Fig. 4d



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UNITED STATES PATENT OFFICE

1,977,596

KEYING

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Application November 19, 1930, Serial No. 496,622

8 Claims. (Cl. 250—8)

This invention relates to transmitters and in particular to a novel method of and means for keying transmitters including a method of and means for eliminating key shocks heretofore present in transmitters.

It is well known that when a radio receiver or radio receiving equipment is mounted in the vicinity of a transmitter the reception of signals in said receiver is interfered with more or less by disturbances originating in the transmitter. In each keying operation of the transmitter the rise and fall of the signal current in the circuits thereof is audible in a receiver adjacent thereto in the form of a cracking noise known in the art as key clicks or key shocks. The nearer the transmitter is to the receiver the greater is the interference caused by the transmitter in the received signals. If the transmitter is located in the same room or close to the receiver then reception of signals in the receiver becomes practically impossible during the time in which the transmitter is operating.

Attempts have been made heretofore to eliminate disturbances in receiving circuits which originate in a transmitter located adjacent thereto. One method used heretofore to eliminate such disturbances in the receivers involves the use of shielding for the receiver and/or for the transmitter. Another method contemplates the use of radio frequency choke coils in the receiver and/or transmitter circuits. Generally such attempts have been more or less unsuccessful due to the fact that when the first method is used the shielding effect is not complete and when the second method is used complete elimination is not obtained since the initial stage of the oscillations in the transmitter due to keying contains a practically continuous frequency band or spectrum. Choke coils used for this purpose would block out a single frequency or a narrow band of frequencies. Oscillations of other frequencies would enter the radio receiving circuits and cause disturbances therein.

The object of the present invention is to provide a novel method of and means for eliminating at the source, that is in the transmitter, disturbances which may affect radio receiving apparatus and which are due to keying operations of the transmitter.

Another object of the present invention is to provide a novel method of and means for eliminating keying disturbances at the source, that is in the transmitter, in which the keying apparatus operates at a low potential whereby the disturbances to be eliminated are of low amplitude.

Numerous other objects will become apparent from a reading of the specification.

Briefly and broadly the above objects are obtained by the use of a keying system for transmitters which includes means to prevent the sudden rising of the keying current at the start of the keying operation and the abrupt falling off thereof at the termination of the keying operation. This results in key signals, the sharp edges of which are, as it were, rounded off.

In one modification of the invention the keying means involves the use of a keying tube having its anode connected to the screen grid electrode of one of the tubes in the high frequency generator, and its input circuit connected in a novel manner to a source of potential through a filter network, the elements of which are proportioned to retard a change in the input current due to sudden changes of potential on the grid of the keying tube and consequently retard the initial and final changes in the keying current and potential appearing on the anode of said keying tube.

A further modification involves an arrangement in which the input circuit of the keying tube including the filter network is somewhat similar to the input circuit and filter network of the keying tube described above but in which the anode circuit of the keying tube is connected to the anode circuit of one of the tubes of the transmitter in such a manner that the keying potentials, the corners of which are rounded off as hereinbefore described, are applied to the anode of said transmitter to modulate the frequencies generated or amplified therein.

In the above described modifications the keying potential for the input of the keying tube is obtained by the use of a battery having opposed terminals connected together and to the filament of the keying tube while the other terminals thereof are connected to contacts cooperating with the key in such a manner that negative and positive potentials may be alternately applied to the control electrode of the keying tube.

Still another arrangement is provided wherein the keying impulses which are applied to the control electrode of one of the transmitter tubes, are obtained by a keying tube, the input circuit of which is connected with a resistance supplied with potential from any source, which resistance supplies the anode cathode and control electrode potential for the keying tube, and the control electrode potential for the transmitter tube. A second

source of potential supplies the anode potential and screen grid potential for the transmitter tubes.

Provision has also been made whereby the last referred to embodiment may be entirely supplied with current from a single source.

The novel features of applicant's invention will be pointed out specifically in the claims attached hereto. A better understanding of the invention and the operation thereof will be had from the following detailed description thereof and therefrom when read in connection with the attached drawings throughout which like reference numerals indicate like parts.

Figure 1 shows one embodiment of applicant's novel keying means and its application to a transmitter;

Figures 2 and 3 show modifications of the arrangement of Figure 1;

Figure 3*a* shows novel means whereby the arrangement of Figure 3 may be energized by a single source; while

Figure 4 shows curves characteristic of the currents flowing in certain ones of the circuits of the hereinbefore described arrangement.

Referring to the drawings and in particular to Figure 1 thereof, 1 is a thermionic amplifier or oscillation generator having its input circuit 2 connected to a source of oscillation 3 and its output tank circuit 4 connected to a load circuit 5. The oscillation generator or amplifier in itself forms no part of the present invention. A detailed description thereof is deemed unnecessary except to state that the frequency of the input circuit 2 may be determined by the tuning capacity shown therein while the output circuit of 1 includes a blocking condenser 6, and a tuned tank circuit 4, as shown. Potential is supplied to the screen grid and the anode of thermionic tube 1 from a source B+ (not shown) through resistance R_2 and choke coil H respectively. The purpose of resistance R_2 is to reduce the potential reaching screen grid 7 while the purpose of the choke coil H is to prevent high frequency oscillations appearing on the anode of 1 from reaching the source B+.

In order that the oscillations appearing in the anode circuit of 1 may be modulated at signal frequency the screen grid electrode 7 of tube 1 is connected to the anode 8 of the keying tube 9 in such a manner that potential from B through R_2 supplies the anode cathode circuit of tube 9, as well as the screen grid 7 of tube 1. The potential of the anode 8 and the direct current flowing in the anode cathode circuit of tube 9 will vary at signal frequency as will appear in detail hereinafter. This variation will be utilized to key thermionic tube 1. The variations will start and terminate slowly in accordance with the present invention, thereby eliminating key clicks heretofore present in transmitters of this type.

In order that the potential appearing at 8 and the current flowing in the anode circuit of 9 may vary at signal frequency the input circuit 10 of tube 9 includes a key K adapted to connect the grid 11 of tube 9 through a resistance R_1 either to the negative or positive terminal of battery E, the midpoint of which is connected, as indicated, to the filaments of tubes 1 and 9, whereby manipulation of the key K will apply to the grid 11 a potential either negative or positive with respect to the filament of the tube 9. When the key K connects the grid 11 of 9 to the negative terminal of battery E the tube 9 is nonconducting and since no current can flow between the anode 8 of tube 9 and the cathode a high potential is applied to the screen grid 7 of tube 1. This is due to the fact that the anode cathode circuit of tube 9 and the screen grid cathode circuit of tube 1 are supplied with direct current through a common circuit R_2, B+. When the control grid of tube 9 is connected to the positive terminal of the battery E tube 9 becomes conductive and anode cathode current flows therein. This absorbs current from the screen grid cathode circuit of tube 1. This tends to decrease the potential at 7.

Up to this point applicant has described a novel and efficient keying method in which reverse keying is obtained and in which keying shocks and key clicks are substantially reduced due to the inherent characteristics of the circuit. However, in order to further insure that the keying potentials on the anode 8 do not rise and fall at too rapid a rate the electrical inertia is applied in accordance with the present invention to the input circuit of tube 9 and to the output circuit thereof in the form of a resistance R_1, a condenser C_1, a resistance R_2 and a condenser C_2. In actual practice it has been found that the condenser C_1 may, and often does, comprise the capacity between the control electrode and cathode of tube 9. Filament heating current is supplied to the filaments of tubes 1 and 9 from a common source of potential A, as shown, while negative potential is supplied to the grid of 1 from a source G.

The arrangement shown in Figure 2 is somewhat similar to the arrangement of Figure 1. The arrangement of Figure 2 differs from the arrangement of Figure 1 in several respects. In Figure 2 the anode cathode circuit of keying tube 9 derives its current and potential from the same circuit which supplies current and potential to the anode and cathode circuit of tube 1, thereby producing anode modulation at signal frequency, which is reversed with respect to the keying operations while the inertia necessary to round off the sharp corners of the keying modulation is obtained by resistance R_1, condenser C_1 and resistance R_3 and condenser C_3.

In order that the keying potential may be applied to the control electrode of one of the tubes of the transmitter, the arrangement of Figure 3 has been provided. In this arrangement the biasing potential for the control electrode of tube 1, and the anode potential and the control grid electrode potential for the keying tube 9 are supplied from a single resistance, which may be connected across any source of direct current potential LV. The anode cathode and screen grid cathode potential for the amplifier 1 is supplied from a separate high voltage source HV. In this arrangement the potential of the control electrode 12 of tube 1 is determined by the current which flows in the anode cathode circuit of the keying tube 9 since the anode cathode current in the tube 9 is made up of the rectified current in the grid cathode circuit of 1 and of the current due to the voltage dropped across R_4. When the key K supplies a negative potential to the control grid 11 through R_1 the tube 9 is nonconducting and since no current can flow in the anode cathode circuit thereof the potential applied to 12 is negative, that is, more negative than normal, and the oscillations generated or amplified in 1 are cut off. When the key K connects the control grid 11 to a positive point on resistance R_4, that is, a point more positive than normal, the keying tube becomes conductive and current flows in the anode cathode circuit thereof. This permits rectified current to flow in the grid cathode circuit of tube 1, causing the

potential applied to the grid 12 of tube 1 to become less negative, making the tube conductive, and allowing current to flow in the anode cathode circuit thereof. In this modification the keying operation is simultaneous in the keying and in the keyed circuits. The current in the radio frequency circuit, that is, the output circuit of tube 1, will follow the same curves as that of the keying circuit 10 and in the input circuit of the keying tube 9. In the apparatus, as arranged in accordance with applicant's novel invention shown in Figure 3, the current flowing in the output of 8 and in the input circuit of 1 will lag the keying operations due to the inherent nature of the circuits. This in itself will tend to round off the corners of the keying current, thereby eliminating key shocks and key clicks from being produced by the circuits. In order to further insure that the current due to keying does not rise or fall too rapidly additional time lag characteristics are obtained by providing additional inertia in the form of resistance R_1, condenser C_1 and resistance R_4 and condenser C_4. The condensers 15 and 16 tend to eliminate any potential variations appearing in R_4 at audio frequency and preventing such variations from affecting the signals to be transmitted. It will be noted in this modification that separate sources of potential are required for the filaments of 1 and 9 in order that the keying currents therein be confined to the proper circuits so that the anode cathode circuit of tube 9 will carry the rectified current flowing in the grid cathode circuit of 1 in addition to current flowing therein due to potential drop across resistance R_4.

In Figure 3*a* is shown a keying arrangement which may be applied to the input circuit of keying tube 9 and which permits the use of a single source of potential to operate both tubes. In this arrangement, the potential necessary for the entire operation of the apparatus including the radio frequency tubes and the keying tube 9 is obtained from a resistance R_4, R_5 adapted to be connected across a source of high potential HV not shown. Keying potential for the control grid 11 of keying tube 9 is supplied through a resistance R_1 connecting said grid when the keying K' is in the open position to the negative terminal of the resistance R_4 and when the key K' is close to a predetermined point on R_4, which is positive with respect to the negative terminal of R_4. In this manner the keying tube 9 can be rendered conductive or nonconductive by manipulation of the key K_1. The control electrode of radio frequency tube 1 is connected as in Figure 3 to a point on resistance R_4 so that the potential applied to the grid 12 of 1 may be varied at signal frequency in a manner somewhat similar to that in which it is varied in the modification shown in Figure 3. In this arrangement manipulation of K_1 varies the bias applied to the grids of tubes 9 and 1 between the limits of some predetermined negative values of voltage. The anode cathode current flowing in the keying tube 9 is, as in Figure 3, the sum of the rectified grid current flowing in tube 7 and the current flowing due to the potential drop across R_4. Since the current which could flow in the anode cathode circuit of the keying tube 9 depends on the conductivity of the tube the potential applied to the grid 12 will depend upon the position of key K_1. It will be noted in this modification that the keying tube 9 carries a large portion of the anode cathode current for the radio frequency tube. This condition occurs due to the fact that keying tube 9 offers a relatively low resistance path for the return of anode cathode current from the cathode of tube 1 to the negative side of the high voltage. This results in no serious disadvantage but does result in a change in the form of the keying wave.

In connection with Figures 1 and 2, it will be understood that although separate sources of potential have been shown to energize the elements of the several tubes, all of the elements of the tubes may be energized from a single source. In the arrangements of Figures 3 and 3*a*, separate sources of potential are used for the filaments of tubes 1 and 9.

In explaining the operation of the several modifications reference will be had to Figure 4 of the drawings in which curves are shown representative of the current flowing in various circuits of the tubes plotted with reference to time. The operation of the keying circuits shown in Figures 1, 2 and 3 is the same, and a statement of the operation of Figure 1 will be sufficient to explain the operation of all of these modifications. Referring to Figures 1, 2 and 3, and the curves of Figure 4, assume that the keying relay K connects the negative terminal of the battery E to the grid 11 of keying tube 9 so that a sufficiently negative voltage is supplied to the grid 11 of keying tube 9 to prevent the flow of any current between the anode and cathode of 9. If the grid bias could now be varied as a straight line to the proper positive value, as indicated by the dotted line Eg_1, curve *a* of Figure 4, the anode cathode current of 9 would then follow the curved dotted line $I'p$ as shown by the dotted line in curve *b* of Figure 4. No practical scheme, however, has yet been devised to permit variation of the grid bias in a straight line to obtain the desirable result indicated in curve *b* of Figure 4. The next best solution which has been devised in accordance with the present invention is to use filter circuits to introduce sufficient lag in the circuits to accomplish the above result. These circuits have been found to give very good results. While the keying relay K is in the position indicated above C_1 receives a negative charge. If the relay K now moves to its other position wherein the battery E tends to apply a positive potential to the grid 11, C_1 starts to discharge through R_1 and after it has discharged starts to charge positively through R_1 and then the grid 11 receives a positive bias. The grid voltage curve obtained by the use of this filter network is shown by the full line curve Eg in *a* of Figure 4. The resulting anode cathode current appearing in keying tube 9 is shown by the full line curve Ip in *b* of Figure 4.

When the keying relay K returns to its first position connecting the grid 11 through resistance R_1 to the negative terminal of battery E, C_1 discharges through the tube and through R_1 and then charges negatively through R_1 and allows the grid 11 of tube 9 to receive a negative bias. The curve $E'g$ of C shows the fall of potential of the grid 11 of tube 9 when K connects said grid to the negative terminal of the battery E, which would result if the potential could be caused to fall as a straight line. The actual fall of the current on the grid Eg, as obtained by the use of applicant's filter network or lag introducing circuit, is shown by the full line curve Eg of curve C of Figure 4. The anode cathode current which would appear in the output circuit of tube 9 if the potential on the grid thereof could be controlled in accordance with

E'g of curve C, is indicated at I'p of curve d of Figure 4, while the current actually obtained in the anode cathode circuit of tube 9 is indicated by the full line Ip in curve d of Figure 4.

In the arrangement shown in Figure 3a, the keying relay K' varies the bias on grid 11 between the limits of some predetermined negative values of voltage, limiting the maximum value of Ip to some point on the straight line portion of the Ip curve. This reduces the time factor due to the upper portion of Ip of curve b of Figure 4 and causes this curve to flatten out sooner, thereby giving lower maximum but more abrupt curves at the top corners of the keying wave. This is likewise a characteristic to a lesser extent of the modification shown in Figures 1, 2 and 3, especially if the keying relays were to be replaced by one similar to K' of Figure 3a.

Having now described my invention and the operation thereof, what I desire to protect by Letters Patent is:

1. Signalling means comprising a thermionic tube having input and output circuits tuned to radio frequency oscillations, a circuit for modulating said oscillations at signal frequency including a second thermionic tube having its output electrodes connected in series with the output electrodes in said first named tube and in parallel with a common potential source, a circuit connected with the input electrodes of said second named tube and adapted to vary the internal impedance of said tube at signal frequency, whereby the energy taken from said common source by said last named tube varies at signal frequency, and a capacitive impedance and a resistance in said circuit whereby said variations in impedance of said tube at signal frequency are gradual.

2. In combination with a high frequency thermionic tube relay and a thermionic modulating tube, a circuit for connecting the internal impedance of said modulator tube in series with the internal impedance of said relay tube, said tube impedances being connected in parallel with a source of potential, a keying circuit connected with the input electrodes of said modulator tube, and a filter network comprising series resistance and parallel capacity interposed between said keying circuit and the input electrodes of said modulator tube.

3. The combination as recited in claim 2 in which the thermionic relay is of the screen grid type and in which the screen grid to cathode impedance of said tube is connected in parallel with the anode to cathode impedance of said tube.

4. Signalling means comprising, a high frequency relay circuit including a thermionic tube of the screen grid type, means for applying oscillations to be relayed to the input circuit of said tube and a repeater circuit connected with the anode of said tube, a connection between the anode of said tube and the positive terminal of a source of potential, a resistance connecting the positive terminal of said source to the screen grid electrode of said tube, a modulating tube having its anode to cathode impedance connected in shunt to the screen grid to cathode impedance of said relay tube, and a source of modulating potentials connected by a filter circuit with the input electrodes of said modulating tube for varying the impedance of said modulating tube at signal frequency.

5. Signalling means comprising, a high frequency relay circuit including a thermionic tube of the screen grid type, means for applying oscillations to be relayed to the input circuit of said tube and a repeater circuit connected with the anode of said tube, a connection between the anode of said tube and the positive terminal of a source of potential, a resistance connecting the positive terminal of said source to the screen grid electrode of said tube, a keying tube having its anode to cathode impedance connected in shunt to the screen grid to cathode impedance of said relay tube, a source of signal potential, and a filter circuit including a capacity and a resistance connecting said source of signal potential to the input electrodes of said keying tube.

6. High frequency relaying and modulating means comprising, a thermionic tube of the screen grid type, means for impressing high frequency oscillations to be repeated on said tube comprising, an inductance and a variable capacity connecting the control electrodes of said tube to the cathode of said tube, a circuit adapted to repeat the oscillations relayed in said tube comprising, an inductance and a capacity connected between the anode and cathode of said tube, a keying tube having its cathode connected to the cathode of said first named tube and its anode connected to the screen grid electrode of said first named tube by way of a resistance and to the anode of said first named tube by way of an inductance means for connecting said resistance and said inductance to the positive terminal of a source of potential, a capacity connected between the control grid electrode and cathode of said keying tube, and a source of potential and a resistance connected by way of a key in parallel with said capacity.

7. In combination, with a high frequency thermionic tube relay and a thermionic modulating tube, a circuit connecting the anode to cathode impedance of said modulating tube in series with the anode to cathode impedance of said relay tube, said tube impedances being connected in parallel with a common source of potential, a keying circuit connected with the input electrodes of said modulating tube, and a filter network comprising series resistance and parallel capacity interposed between said keying circuit and the input electrodes of said modulator tube.

8. The combination as recited in claim 7 in which the thermionic relay is of the screen grid type and in which the screen grid to cathode impedance of said tube is connected in parallel with the anode to cathode impedance of said tube.

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