May 17, 1949. R. C. MOORE 2,470,573

OSCILLATOR MODULATING SYSTEM

Filed June 10, 1944 2 Sheets-Sheet 1

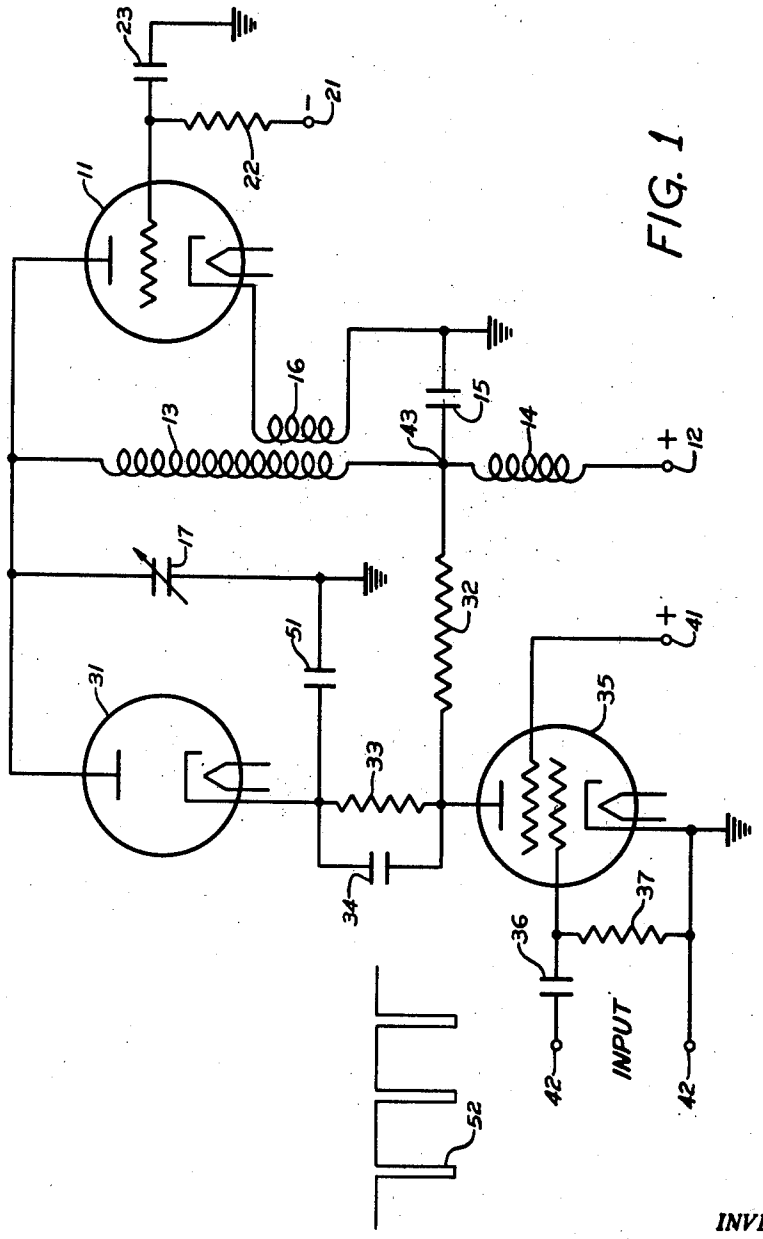


FIG. 1

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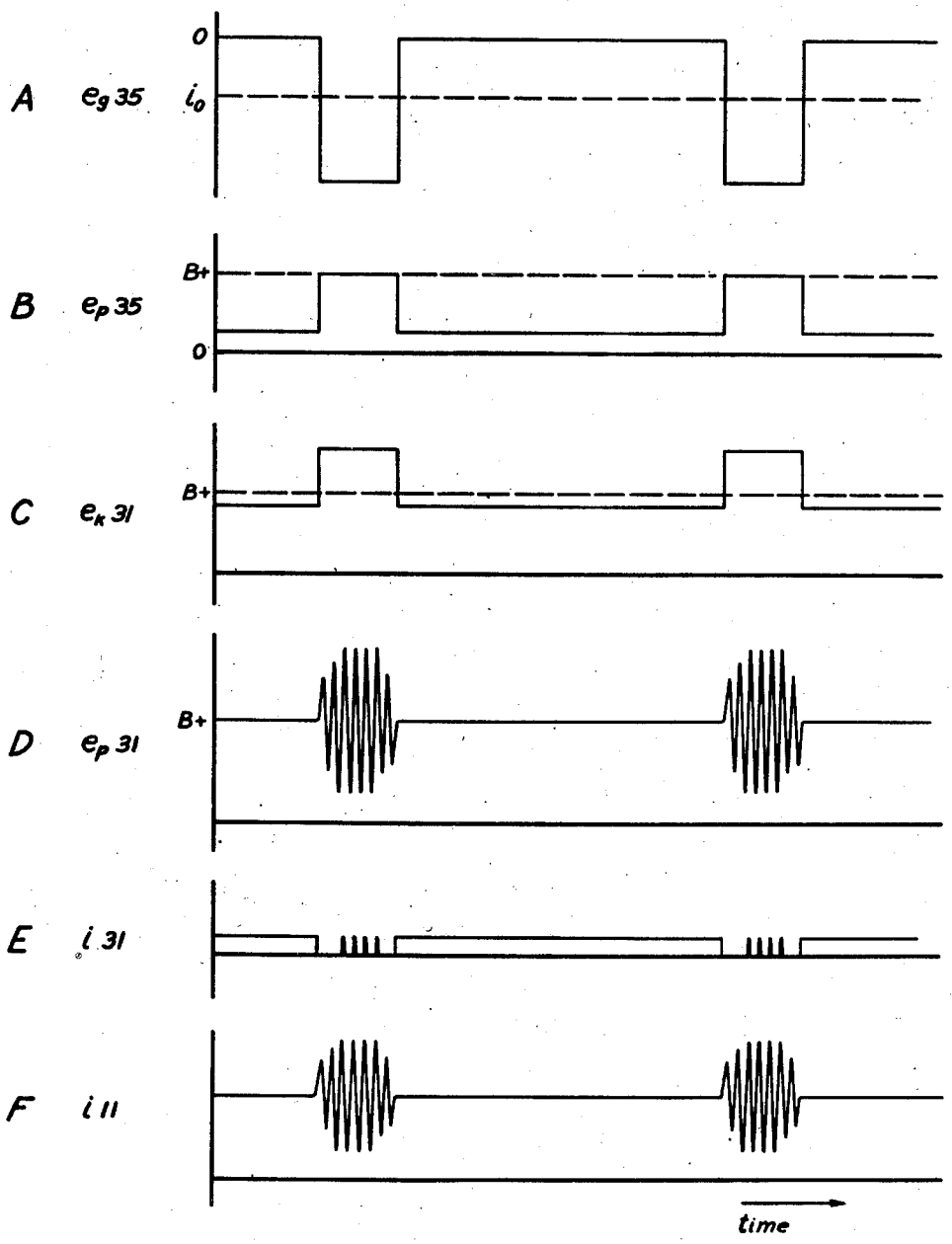


FIG. 2

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UNITED STATES PATENT OFFICE

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OSCILLATOR MODULATING SYSTEM

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12 Claims. (Cl. 332—15)

1

My invention relates in general to the field of signal generation and more specifically concerns a novel high speed pulse modulation system.

In certain signal transmissions, as for example, the present day radio ranging system, it is necessary to transmit properly spaced impulses of ultra high frequency energy. In the transmission equipment, the high frequency carrier is modulated by a series of substantially rectangular impulses so that energy is radiated only during the period of the pulse. No signals are transmitted in the intervals between impulses.

In conventional type circuits, difficulty is encountered in pulse modulation of an oscillator. This difficulty becomes significant if the pulses are of extremely short duration, as the time required for the pulse to reach its peak results in poor modulation with attendant loss of sharpness of the pulse. Further, in conventional type modulation systems, the carrier frequency oscillator is continuously operated and the modulating signals are utilized to correspondingly change the output voltage in a mixing circuit. It is therefore the function of the modulation circuit, if pulse transmission is desired, to provide sufficient voltage swing so as to completely cut off the carrier in the interval between impulses. Generally this requires considerable modulating voltage amplitude and accordingly the additional problem of the amplification of the pulse itself is introduced.

My invention contemplates a pulse modulation system employing a conventional oscillator which will overcome all of the aforementioned problems. In accordance with my invention, an oscillating circuit is adjusted so that all direct currents and voltages are at their normal static operating values, i. e., the D. C. plate current and voltage is normally at full value and the oscillator is ready to operate. The oscillator tuned circuit or tank is shunted by a normally conductive diode rectifier, and is thereby damped beyond that critical point where tube oscillation ceases entirely.

The damping diode shunted across the oscillator tank circuit in my novel impulse modulation system serves as the oscillator control element, and may in turn be controlled by an amplifier circuit energized by the modulating signals.

Summarizing, therefore, the modulating signal, which in this instance consists of a series of spaced impulses, may be applied to a control amplifier. The output circuit of this amplifier controls the effective damping resistance which

2

a diode shunts across an oscillator tank circuit. When no signal is applied to the input of the initial amplifier, the damping diode is conductive such that its effective shunting resistance across the tank circuit is lower than that critical value required to damp out all oscillation.

Upon the application of a modulating impulse to the input amplifier of the circuit, the amplifier output causes the effective diode damping resistance to rise simultaneously with the pulse to a value at which oscillation may take place. Since as previously mentioned, the oscillating circuit is operated at normal static values of current and voltage, the removal of the damping resistance will result in substantially instantaneous oscillation at the natural frequency of the tuned circuit.

The termination of the modulating impulse in the amplifying circuit causes immediate restoration to the initial condition, that is, a diode damping resistance of a value less than the critical value necessary to damp out all oscillation in the tank circuit. Signal generation thus terminates immediately. This process is repeated upon the application of each impulse to the input amplifier.

This novel type of impulse modulation is of extremely rapid operation in that the oscillator is normally inoperative, but in condition to operate upon a suitable increase of the damping resistance. Furthermore, as will be described, the circuits for applying the impulses to the control diode are such that little time delay or distortion are encountered.

It is therefore an object of my invention to provide a novel type of modulation system.

Another object of my invention is to provide an impulse modulator of rapid action.

A further object of my invention is to provide a circuit which permits short time impulse modulation of a conventional oscillator.

Still another object of my present invention is to provide a damping circuit for a conventional type oscillator controllable by a simple amplifier.

These and other objects of this invention will now become apparent from the following detailed specification taken in connection with the accompanying drawing, in which

Figure 1 is a schematic circuit diagram of the impulse modulation system, and

Figure 2 is a graphical representation of the currents and voltages in the elements of the circuit of Figure 1.

Referring now to Figure 1, there is shown a triode oscillator tube 11. The specific tube type

used for the oscillator 11 will of course depend upon the frequency range, and the particular application thereof.

The oscillator is arranged, as is evident from Figure 1, in one form of a Hartley circuit. Thus, the plate of tube 11 is energized from a high voltage direct current source (B) 12 through a tank coil 13. A radio frequency filter comprising a radio frequency choke 14 and a small condenser 15 is utilized to preclude feed-back into the high voltage source 12. Inductively coupled to coil 13 is another coil 16 connected between the cathode of oscillator tube 11 and ground. The inductively coupled coils 13 and 16 thus provide the necessary feed back arrangement between the plate and cathode of the oscillator tube 11.

Individual coils 13 and 16 are used in the plate and cathode circuits respectively in order that coupling condensers need not be used in this part of the circuit. The oscillating circuit is tuned by a variable condenser 17 connected between the plate and ground as shown. This condenser 17 tunes the entire circuit inductance consisting of coupled coils 13 and 16.

The grid of oscillator 11 is maintained at a constant potential by a grid biasing source 21 coupled to the grid itself through a grid protective resistor 22. A small condenser 23 is shunted between the grid and ground of the oscillator 11 and serves as a high frequency filter for the bias supply while completing the radio frequency circuit at the grid. The time constant of the grid leak—grid condenser combination 22—23 should be short compared to the period of the pulse signal 52, and in addition the resistance 22 should be relatively small so that no substantial pulse modulation signal voltage, (to be described hereinafter) will build up across it.

It is therefore evident that excluding other external conditions, the circuit, comprising the triode 11, coils 13 and 16 and tuning condenser 17, will oscillate at a frequency determined by the natural frequency of the tank circuit.

Energy may be removed from the oscillating circuit in any conventional manner and amplified to a suitable level for transmission. The specific utilization of the output of oscillator 11 is no part of the present invention.

As is illustrated in Figure 1, the plate coil 13 is shunted by a rectifying circuit comprising essentially a diode 31 across the tank circuit. The D. C. circuit of the diode is in series with a resistor 32 and a parallel combination of resistor 33 and condenser 34. The plate of diode 31 is directly connected to the plate of the oscillator tube 11. Thus the plate of diode 31 is at the potential of the upper end of coil 13. The potential of the cathode of diode 31 for the signal or D. C. is determined by the voltage drops in resistor 32 and across the parallel combination of resistor and condenser 33 and 34, as will be more completely described in a later paragraph.

Resistor 32 comprises also the plate load resistor of an amplifier tube 35. Tube 35 is connected, as illustrated in Figure 1, with its cathode grounded and an input circuit for the grid comprising a condenser 36 and a shunt resistor 37. The tube 35 is thus operated without grid bias.

The screen grid of tube 35 is connected at 41 to a suitable positive voltage. Under the condition of zero signal input to the terminals 42 of the amplifier 35, a normal plate current flows from the plate supply 12 to resistor 32 and through the tube 35 to ground. The flow of plate current through tube 35 will cause a voltage drop in resistor 32 and hence place the cathode of diode 31 at a lower potential than point 43 of the coil 13. Since the D. C. voltage drop in the coil 13 due to the plate current of oscillator tube 11 is comparatively small, the plate of diode 31 is thus at a higher potential than the cathode of diode 31. Accordingly, the diode 31 conducts and a current flows from the D. C. supply 12 through coil 13, through the diode 31, through resistor 33 and condenser 34, and through the tube 35 to ground. The diode 31 which is shunted across the tank circuit of the oscillator 11 is in this manner effective as a loading resistance across the tank circuit when the tube 35 is operative without signal input. This loading resistance lowers the apparent Q of the oscillating circuit sufficiently to prevent oscillation. The resistance which shunts the tank circuits has no effect upon the normal direct current flowing through the tube 11 since the D. C. resistance of the plate coil 13 is extremely low.

In accordance with my invention, the diode shunting circuit 31 is arranged so that in the absence of signal input to amplifier 35, the effective shunting resistance across the tank circuit of oscillator 11 is less than that critical value required to cut off entirely all oscillations. In this manner the oscillator tube 11 is operated at steady voltages and currents which correspond to those normal values existing during oscillation, but the tank circuit is overloaded by resistance to preclude signal generation. If a negative signal is applied to the grid circuit of the amplifier 35, the plate current of tube 35 decreases substantially instantaneously, and accordingly the voltage drop across resistor 32 becomes small. If the input signal is sufficiently negative, tube cut-off will occur and reduce the voltage drop across resistor 32 to zero. This current change raises the cathode of diode 31 to a potential greater than its plate and thus prevents normal amplitude changes of the diode plate potential from causing diode current flow; steady diode current ceases to flow; and the effects of a tank loading resistance are removed. The tank circuit of oscillator 11 becomes operative at that value of Q determined by the constants of the coils 13 and 16 and the condenser 17, and the tube 11 oscillates at the natural resonant frequency of the tuned circuit.

Oscillations will build to peaks at values where on maximum voltage excursions in the oscillator, the plate of diode 31 exceeds the voltage of the cathode of diode 31. At the peak voltage of the oscillator, the diode conducts again and thus limits the amplitude of oscillations.

Since, as previously mentioned, tube 11 is operated with normal values of steady voltage and current prior to initiation of oscillation, the change in diode current is followed by an immediate oscillation in the tube circuit 11. When the negative signal input at the grid of amplifier tube 35 is removed, current once again flows through resistor 32 and fixes the cathode at a potential below the relatively higher plate potential of diode rectifier 31 so that continuous diode current once more flows and the effective resistance across the tank precludes oscillation.

Since the damping effect of the diode current is considerable, the oscillation in tank circuit 13, 16 and 17 is substantially promptly damped out, and the tube 11 is once more returned to that

point where the applied steady voltages are normal without oscillation.

The value of resistor 33 is predetermined so that the diode current is large enough to damp the tank circuit sufficiently to preclude oscillation thereof. Condenser 51 is shunted between the cathode of diode 31 and ground in order to close the diode R. F. circuit and to preclude feed back of the high frequency oscillation from tube 11. By this circuit arrangement, the cathode of diode 31 is placed substantially at ground potential for R. F.

Since the tube circuit illustrated and described reacts promptly to changes in signal input at the terminals 42, it is well adapted for the transmission of pulses of high frequency energy. For example, if a signal such as is schematically illustrated at 52 and at Figure 2A and comprising a series of negative, sharp, rectangular impulses is applied to the terminals 42, the output energy from oscillator 11 will comprise essentially a series of corresponding pulses of high frequency energy, as at Figure 2F. Thus, in the time interval between the negative pulses 52, the oscillator is sufficiently damped, as previously described, by diode 31 to prevent oscillation. The application of the negative pulse to the grid of modulating tube 35, causes a prompt drop in the voltage across the resistor 32 due to the change in plate current therethrough. This in turn causes the diode to stop conducting and in turn results in the instantaneous initiation of oscillation in the tank circuit 13, 16 and 17.

The effects of voltage variation across resistor 32 upon the plate voltage of tube 35 and upon the diode cathode potential are shown in Figures 2B and 2C respectively. The diode cathode potential rise above that of the B+ source 12 is equal to the voltage developed across resistor 33 and condenser 34 by the average diode current.

The rate of rise of oscillation amplitude is steep in that the tube is normally at the point of incipient oscillation. The sharp reversal of the voltage applied to the grid of modulating tube 35 which occurs at the end of a pulse instantaneously results in the cessation of oscillation. Oscillation ceases rapidly because the diode, when conducting, applies a load across the tank circuit of sufficient magnitude to discharge rapidly the energy stored therein.

The diode plate voltage during pulse modulation is shown in Figure 2D. Although the plate potential follows the voltage variation across the tank circuit during oscillation, diode current is precluded by the corresponding rise of cathode potential shown in Figure 2C for the reasons given above. On the peaks of the oscillating voltage, diode current flows as shown in Figure 2E.

This process of the resistance loading and unloading of the oscillating tank circuit is repeated upon the application of each pulse to the terminals 42. The time constant of the parallel combination of resistor 33 and condenser 34 is prearranged to be larger than the period of the modulating signal 52. Through the use of such a long time constant, the voltage across the condenser 34 will be substantially fixed, so that in practice the circuit, 33—34 will function substantially as if it were a battery and will not be a function of the modulating voltage.

Although the resistor 32 and the condenser 51 are not directly associated as are the elements of the circuit 33—34, some consideration to the time constant of the circuit 32—51 has been given. The product of the resistance 32 and the capacity 51 should be small compared to the period of the modulating signal 52. This is attained by employing a condenser 51 which is no larger than necessary in its function as a radio frequency bypass condenser. The resistance of the load resistor 32 is relatively low, as dictated by conventional video amplifier design practice.

During the oscillation of tube circuit 11 upon the application of a negative signal, at the input terminals 42, the amplitude of the signal generated is determined by the diode 31. Thus the diode 31 serves in addition to limit the peak of the signal since a large peak voltage across coil 13 during oscillation will cause the diode 31 to conduct sufficiently to load the tank circuit slightly and to an extent diminish the amplitude of the oscillations. Therefore, despite the rapidity of action of this pulse modulating system, the pulses of high frequency energy formed in the oscillating circuit are extremely uniform, that is, steep and of constant high frequency amplitude.

Although the rapidity of action of this modulating circuit adapts it best for high speed pulse modulation, it is evident that it could be designed to have a normal modulation characteristic for signals, as speech and the like.

Thus, the circuit illustrated in Figure 1 may be utilized for high speed modulation of a carrier by impulses or for normal modulation of a steady carrier signal. The circuit presents definite advantages over previously used modulation methods in that the response characteristic is extremely rapid and uniform. Of course, various circuit changes may be introduced to the circuit shown without altering the basic modulation concept described.

Accordingly I prefer not to be bound by the above specification, but only by the appended claims.

I claim:

1. In a signalling circuit, an oscillating circuit comprising an oscillator tube and a tank circuit connected thereto including an inductance, a diode, circuit connections from said diode to said oscillator providing a direct current path for the flow of direct current from said diode through said inductance coil while said diode is conductive, said circuit including connections providing a shunt connecton for said dode around said tank circuit, a resistance connected in series with said diode in said direct current circuit, and signalling means connected to said resistance for controlling the current flow in said resistor to vary the relative direct current potential of the cathode of said diode with respect to the anode of said diode for controlling the conductivity of said diode.

2. In a signalling circuit, an oscillating circuit comprising an oscillator tube and a tank circuit connected thereto, a diode connected across said tank circuit, a direct current circuit for said diode and a resistance and a parallel combination resistor and condenser connected in series with said diode in said direct current circuit.

3. In a signalling current, an oscillating circuit comprising an oscillator tube and a tank circuit connected thereto, a diode connected across said tank circuit, a direct current circuit for said diode, a resistance connected in series with said diode in said direct current circuit, an amplifier tube having a plate, said resistance being the plate load resistor of said amplifier tube and an input signalling circuit for said tube.

4. In a signalling circuit, an oscillating circuit comprising an oscillator tube and a tank circuit

connected thereto, a diode connected across said tank circuit, a direct current circuit for said diode, a resistance connected in series with said diode in said direct current circuit, an amplifier tube having a plate, said resistance being the plate load resistor of said amplifier tube and an input circuit for said tube, said amplifier tube operating without bias whereby under zero signalling normal plate current flows through said resistance for placing the cathode of the diode at a lower potential than the anode of the diode and the diode is conductive to damp out oscillations in said oscillator.

5. In a signalling circuit, an oscillating circuit comprising an oscillator tube and a tank circuit connected thereto, a diode connected across said tank circuit, a direct current circuit for said diode and a resistance and a parallel combination resistor and condenser connected in series with said diode in said direct current circuit, said parallel resistor and condenser being operative to raise the cathode potential of the diode above the anode potential of the diode during the non-conductive period of said diode.

6. In a signalling circuit, an oscillating circuit comprising an oscillator tube and a tank circuit connected thereto, a diode connected across said tank circuit, a direct current circuit for said diode, a resistance connected in series with said diode in said direct current circuit, signalling means connected to said resistance for controlling the current flow in said resistor to vary the relative direct current potential of the cathode of said diode with respect to the anode of said diode, and a parallel combination resistor and condenser in said direct current circuit, the time constant of the parallel resistor and condenser being larger than the signal period.

7. In a signalling circuit, an oscillating circuit comprising an oscillating tube, and a tank circuit connected to said tube and containing an inductance coil, the current and voltage condition of said oscillating tube being normally maintained at values to maintain said circuit oscillating; a diode connected across said tank circuit; a resistance in series with the cathode of said diode, a source of direct current for said diode; the anode of said diode being maintained at substantially constant potential, means for controlling the current flow in said series resistance for varying the potential of the cathode of said diode with respect to its anode for controlling the conductivity of said tube and circuit connections from said diode to said oscillator providing a direct current path for the flow of direct current from said diode through said inductance coil while said diode is conductive.

8. In a signalling circuit, an oscillating circuit comprising an oscillating tube, and a tank circuit connected to said tube, the current and voltage condition of said tube being normally maintained at values to maintain said circuit oscillating; a diode connected across said tank circuit; a source of direct current and series resistance for said diode; and an electron tube, said series resistance being the load connected in the output of said electron tube; current flowing in the output of said electron tube when no signal is impressed on the input thereof and current in the output of said electron tube being reduced when a signal is impressed on the input of said electron tube.

9. In a signalling circuit; an oscillating circuit comprising an oscillating tube, and a tank circuit connected to said tube; the current and voltage condition of said tube being normally maintained at values to maintain said circuit oscillating; a diode connected across said tank circuit; a direct current circuit for said diode; a resistance and a parallel resistance and condenser connected in series with said diode in said direct current circuit, and means for impressing signals on said resistance, said parallel resistance and condenser having a large-time constant compared to the period of said signals.

10. In a signalling circuit; an oscillating circuit comprising an oscillating tube, and a tank circuit connected to said tube; the current and voltage condition of said tube being normally maintained at values to maintain said circuit oscillating; a diode connected across said tank circuit; a source of direct current for said diode; a resistance connected in series with said diode and source of direct current; and an electron tube; said series resistance being the load connected in the output of said electron tube; current flowing in the output of said electron tube when no signal is impressed on the input thereof, and current in the output thereof being reduced when a signal is impressed on the input of said electron tube; and a parallel resistance and capacitance connected in series between the cathode of said diode and said load resistance, and having a large-time constant compared to the period of the signals impressed on said electron tube.

11. In a signalling circuit, an oscillatory circuit including an inductance coil, a diode, circuit connections from said diode to said oscillatory circuit providing a direct current path for the flow of direct current from said diode through said inductance coil while said diode is conductive, said circuit connections providing a shunt connection for said diode around said oscillatory circuit, means for rendering said diode conductive to damp said oscillatory circuit beyond the point where oscillations cease and for rendering said diode non-conductive to instantaneously set up oscillations in said oscillatory circuit.

12. In a signalling circuit, a tube, a circuit comprising an inductance coil and other elements connected to said tube and forming therewith an oscillatory circuit, the direct currents and voltages of said tube being maintained at their normal static operating values, a diode, the diode during no signalling being normally conductive so that its effective shunting resistance across the tuned circuit is lower than the critical value required to damp out oscillations, circuit connections from said diode to said oscillatory circuit providing a direct current path for the flow of direct current from said diode through said inductance coil while said diode is conductive, said circuit connections providing a shunt connection for said diode around said oscillatory circuit.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,036,078	Pruden	Mar. 31, 1936
2,257,663	Albrecht	Sept. 30, 1941
2,262,468	Percival	Nov. 11, 1941
2,273,193	Heising	Feb. 17, 1942
2,355,606	Shannon	Aug. 15, 1944