

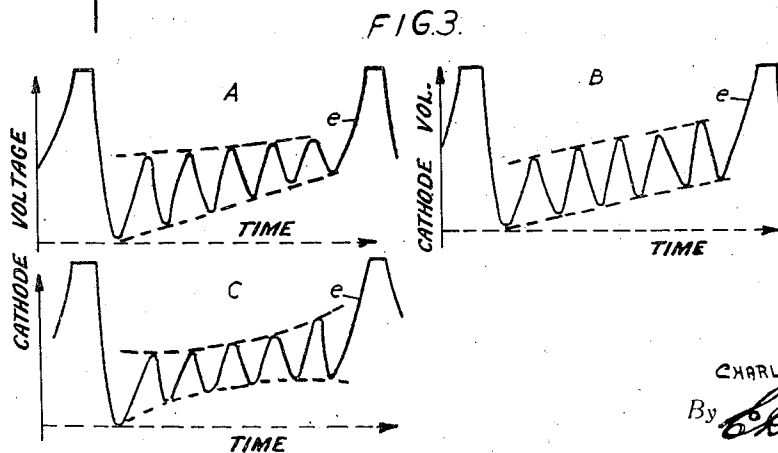
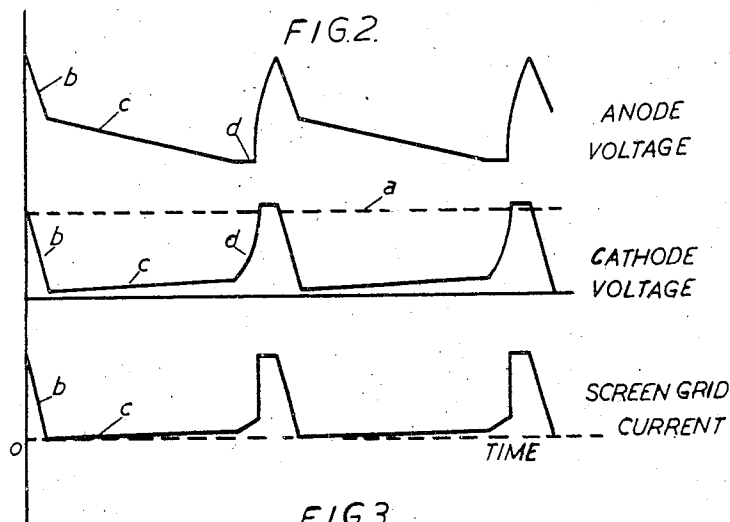
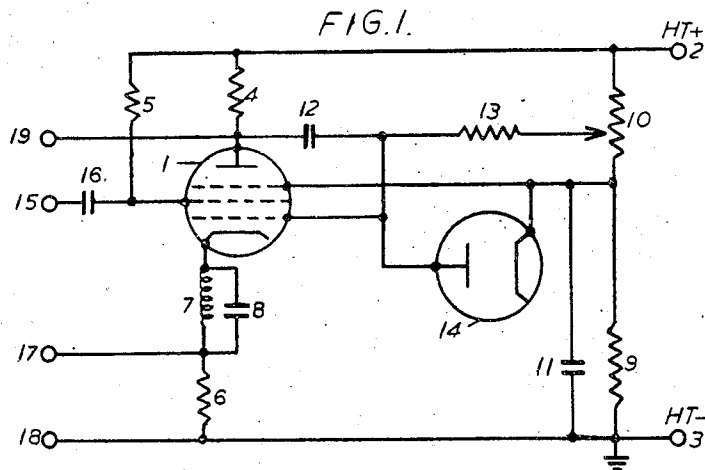
Feb. 22, 1949.

C. W. EARP
OSCILLATION GENERATOR

2,462,078

Filed Sept. 10, 1945

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 4

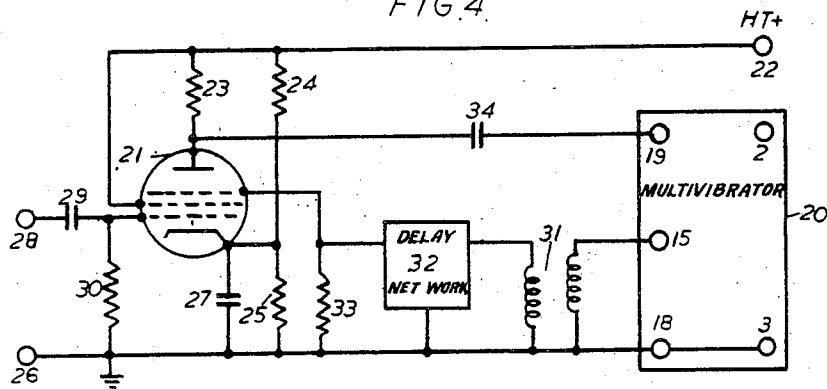
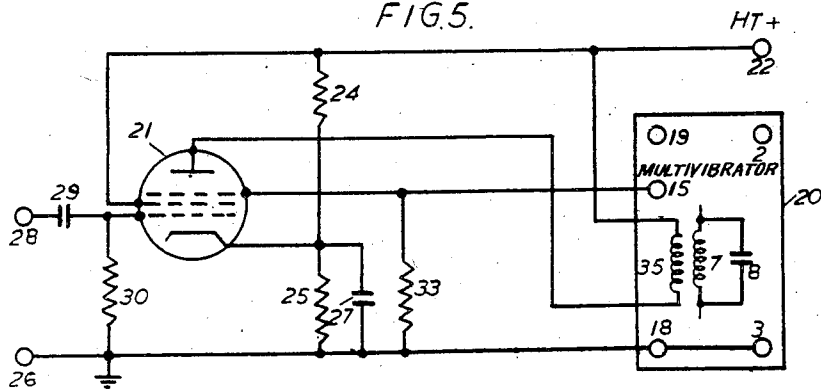


FIG. 5



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2,462,078

OSCILLATION GENERATOR

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Application September 10, 1945, Serial No. 615,417
In Great Britain September 15, 1944

11 Claims. (Cl. 250—36)

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The present invention relates to oscillation generators of the electrical multivibrator type, utilising a single multi-grid electron discharge device or valve having the electrodes intercoupled to perform the function of the two valves normally present in the well known orthodox multivibrator circuit.

In the circuits of the type specified the circuit arrangement oscillates between two conditions in which the relative potential differences of two electrodes are reversed the one with respect to the other, the reversal being brought about by the application to an electrode of a voltage of opposite polarity to the biasing voltage already existing on that electrode. Such an applied voltage may take the form of a voltage pulse generated in another part of the circuit so that the circuit functions continuously as an oscillator. Such an oscillator may be synchronised to a train of pulses of suitable voltage polarity applied to an electrode so as to switch the circuit from one condition to the other, the timing of the synchronising pulse and of the generated pulse being suitably chosen.

The single valve type of multivibrator is inherently more stable in frequency than the plural valve version, particularly with regard to power supply fluctuations, but for certain purposes such as for producing pulses which are employed for opening a gating circuit, for example, for the selection of a particularly desired pulse train in a received signal to the exclusion of other pulse trains of the same or different frequencies and interferences, or for frequency dividing, the stability of the single valve type is still not sufficiently good. It is the object of this invention to increase the stability of a single valve continuously running multivibrator circuit of the type specified.

This object is attained in accordance with this invention by providing a stabilised electric multivibrator comprising a thermionic valve having in the order named, a cathode, first, second and third grid electrodes and an anode; an operating source therefore having a substantially constant unidirectional potential; first and second resistances connecting the positive terminal of the said source to the anode and first grid electrodes, respectively; a third resistance connecting the cathode to the negative terminal of the said source; a condenser connecting the anode to the first grid electrode; means for applying a constant positive potential to the third grid electrode with respect to the negative terminal of the said source; a resonant circuit connected in series

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with the cathode; and means for deriving output pulses from the second grid electrode.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 shows a schematic circuit diagram of a multivibrator according to the invention;

Figs. 2 and 3 show waveform diagrams used in explaining the action of Fig. 1; and

Figs. 4 and 5 show respectively two examples of self-gated multivibrators according to the invention.

The multivibrator according to the invention shown in Fig. 1 comprises a pentode valve 1 energised by a high tension source intended to be connected to the terminals 2 and 3, the latter being the negative terminal which is preferably connected to ground. The anode and screen grid of the valve 1 are connected to the positive terminal 2 through resistances 4 and 5 respectively. The cathode is connected to ground through a resistance 6 and a parallel resonant circuit consisting of an inductance 7 and a condenser 8.

A resistance 9 is connected in series with a resistance potentiometer 10 between the terminals 2 and 3, and a by-pass condenser 11 shunts the resistance 9. The suppressor grid of the valve 1 is connected directly to the junction point of the resistances 9 and 10. The control grid is connected to the anode through a condenser 12 and to the moving contact of the potentiometer 10 through a resistance 13. It is also connected to the anode of a diode 14, the cathode of which is connected to the junction point of elements 9 and 10. An output terminal 15 is connected to the screen grid through a condenser 16, and an input terminal 17 is connected to the junction point of the elements 6 and 7 for applying synchronising pulses. 18 is an additional ground terminal which may be used with 15 or 17. A terminal 19 connected to the anode is provided to enable synchronising pulses to be applied, if desired, to the anode instead of to the cathode.

The circuit as described without the elements 7 and 8 (the cathode being connected directly to the resistance 6) is a known arrangement which generates regularly repeated short duration pulses which may be obtained from the terminals 15 and 18. It is found to be very stable in operation, the frequency being only slightly effected by variation of the high tension voltage. The arrangement is particularly suitable for low repetition frequencies. In certain applications an exceedingly stable generator is required, and for this reason the resonant circuit 7, 8 is introduced according to the present invention.

In order to make the operation clear, a specific example of the circuit of Fig. 1 will be taken, adapted for generating short pulses with a repetition frequency of about 100 pulses per second. The circuit elements had the following values:

Element	Resistance, Ohms	Element	Capacity, Mfds.
4	150,000	11	0.1
5	25,000	12	0.001
6	5,000	16	0.1
9	100,000	8	0.1
10	500,000		
		Element	Inductance, Henry
13	2×10^6	7	0.5

H. T. Voltage 200.

It will be noted that the suppressor grid potential is maintained constant at about 33 volts and that the control grid potential is prevented by the diode 14 from exceeding this value.

The action of the circuit is rather complicated and will not be described in detail. The main features are however exhibited in the curves of Fig. 2.

The action starts at zero time, when the screen current is large, and the anode voltage has its maximum value. Since the resistance 4 is several times larger than the resistance 5, the anode current will be small compared with the screen current, and the potential of the cathode will be determined mainly by the screen current. This cathode potential should be a little higher than the suppressor grid potential, which is indicated by the dotted line *a* in Fig. 2. This results in the anode current being nearly but not quite cut off. At zero time, the control grid voltage will be approximately the same as the suppressor grid voltage, and will subsequently follow the cathode voltage owing to the feed-back action of the resistance 6, remaining always slightly lower.

At zero time, the anode potential having reached a relatively high value, and the suppressor grid being only slightly negative to the cathode, a small anode current begins to flow, with a resulting drop in anode voltage which is immediately communicated to the control grid through the condenser 12. The cathode voltage falls with that of the control grid, and this increases the anode current because the suppressor grid becomes more positive to the cathode. The change is fed round again and the anode voltage falls steeply so that the cathode voltage is driven rapidly nearly to zero, and the control grid voltage goes with it so that the space circuit of the valve is nearly but not quite cut off. The screen current therefore falls nearly to zero. This general fall in potential of the valve electrodes is indicated by the parts *b* of the three curves.

The condenser 12 now charges up slowly through the high resistance 13 in such manner that the control grid potential rises slowly. A similar rise occurs in the cathode potential, and the anode potential falls further due to the slight increase in the anode current. The anode potential fall is practically linear due to the feed-back action, and this effect continues for a relatively long period, as indicated by the portion *c* of the curves. When the anode potential has nearly reached that of the cathode, a short period *d* occurs when the anode current becomes constant, and then the feed-back from the anode

ceases to operate so that the cathode and control grid potentials both begin to rise much more rapidly and in an exponential manner, until the cathode potential reaches the suppressor grid potential, when the anode current is nearly cut off and the anode potential rises sharply at first and then more slowly and exponentially to the maximum value, when a new cycle commences.

During the period *c* there is a small increase in the screen current, and afterwards a sharp increase to the maximum during the period *d*. While the anode voltage is rising exponentially to the maximum value, the screen current and cathode potentials remain constant owing to the action of the diode 14, which prevents the control grid voltage from rising above the suppressor grid voltage.

The suppressor grid voltage variation will clearly be similar to the screen current curve, but inverted. Thus short negative pulses with steep sides will be obtained for the terminal 15.

Now when according to the invention the resonant circuit 7, 8 is included in series with the cathode, the sharp down strokes *b* of the cathode potential will excite the resonant circuit and will cause it to "ring." The natural frequency of the resonant circuit should preferably be from five to ten times the frequency of repetition desired for the pulses. An alternating voltage will be superposed on the cathode voltage as shown in Fig. 3. Then the time at which the cathode voltage exceeds the suppressor grid voltage at the end of the cycle is precisely determined by the steep up-stroke at *e* in Fig. 3 of the superposed alternating voltage wave, and this accurately fixes the commencement of the new cycle. During the periods of the cathode pulses the resonant circuit is heavily damped by the low cathode impedance of the valve. These pulses should preferably be made of very short duration, by making the ratio of the resistance of element 4 to that of element 13 small. In the example given above this ratio is about 0.075. At the end of the cathode pulse the valve is nearly cut off so that the damping is small and the circuit continues to ring throughout the periods between the cathode pulses. As the cathode current gradually increases, a certain amount of negative resistance is introduced, and the amplitude of the superposed waves therefore does not necessarily decrease, as shown at A, Fig. 3. It may remain substantially constant, or it may decrease and then increase. Examples of these possibilities are shown in Fig. 3, at B and C.

The time interval between the cathode pulses is very accurately determined by the resonant circuit 7, 8 and if the circuit constants are chosen so that a very short cathode pulse is produced a very stable oscillation is obtained.

As already explained, the output pulses are preferably derived from the screen grid, and if very short pulses are required, the pulses from the screen grid may be differentiated in known manner. The potentiometer 10 provides a convenient fine adjustment of the multivibrator frequency.

The circuit of Fig. 1 may be easily synchronised by a pulse train having substantially the same repetition frequency as that of the circuit; and this may be done in a number of different modes and by several methods of signal injection. The synchronising pulses may be used either to advance or retard the emission of the pulses, at instants corresponding to either the leading or the trailing edges of the cathode pulses. The

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various possible methods of applying the synchronising pulses in either sense to any suitable valve electrode will be understood by those skilled in the art; but the preferred method is to apply the synchronising pulses in positive sense to terminal 17 and thence to the cathode. The synchronising pulses do not appreciably excite the resonant circuit, and if the repetition frequency of the oscillation when controlled is slightly lower than that of the synchronising pulse train, synchronisation takes place by the exact determination of the leading edges of the cathode pulses, the timing being slightly advanced.

This arrangement is found to be quite satisfactory even when the synchronising pulse train contains interfering pulses of waves so long as they are not strong enough to be capable of causing the emission of a cathode pulse too soon by one or more cycles of the superposed alternating current wave. Other embodiments of the invention to be described presently permit satisfactory operation even with strong interference.

An oscillator according to Fig. 1 may be used to remove moderate interference from a particular signal pulse train by adding a gating pentode valve to the suppressor grid to which are applied in positive sense short gating pulses derived by differentiation from the screen grid of the valve 1 in Fig. 1. The signal pulse train is applied to terminal 17 of Fig. 1 and also to the control grid of the gating pentode, which will be opened only at the instants when the signal pulses are due to arrive. In this way the interference will be cut off. Preferably the signal pulses are applied to the gating valve after a slight delay in order to ensure that the gate will always open in time. The duration of the gating pulse may be adjusted by known methods so that the signal pulses will not be curtailed.

Fig. 4 shows a multivibrator of the kind described with reference to Figs. 1 to 3 to which has been added a self-gating arrangement by means of which false operation due to strong interference accompanying the synchronising pulses may be prevented. The multivibrator is shown by the block 20 which comprises the elements shown in Fig. 1. Only the terminals which are used for connection to the gating circuit are shown, and are given the same designations as in Fig. 1. A gating valve 21 has its anode connected to the positive high tension terminal 22 through an anode load resistance 23. It will be understood, of course, that a common high tension supply may be used, if desired, for the valve 21 and for the multivibrator 20. The screen grid is connected directly to the terminal 22, and the cathode is suitably biased positively by connection to the junction point of two resistances 24 and 25 connected in series between terminal 22 and the earth terminal 26. A cathode by-pass condenser 27 shunts the resistance 25. The synchronising pulses are applied to the input terminal 28 and thence through a blocking condenser 29 to the control grid of the valve 21, the usual grid resistance 30 being provided.

The pulses from the screen grid of the valve 1 of the multivibrator 20 (see Fig. 1) are applied through the terminal 15 and through a transformer 31 to a delay network 32 of any suitable type (such as a transmission line consisting of series inductances and shunt condensers) to the suppressor grid of the valve 21. A suitable terminating resistance 33 is provided. Finally, the

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anode of the valve 21 is connected through a blocking condenser 34 and terminal 19 to the anode of the valve 1 of the multivibrator 20 (see Fig. 1).

The elements 5 and 16 (Fig. 1) should be chosen to produce suitable short differentiated pulses which are inverted by the transformer 31 (Fig. 4). Short positive pulses of which the leading edges coincide with the leading edges of the corresponding negative screen grid pulses will be obtained, followed by short negative pulses which have no effect. The positive pulses are suitably delayed (for example by about 100 microseconds) and are applied to the suppressor grid of the valve 21.

Positive synchronising signals applied at the terminal 28 are amplified and inverted by the valve 21 and are applied negatively to the anode of the valve 1 (Fig. 1) about 10 microseconds before the circuit would normally emit a pulse when uncontrolled, thus synchronising the multivibrator. The valve 21 is biased so that it is normally blocked, but is unblocked by the pulses derived from the multivibrator itself. The delay introduced by the network 32 should be such that when a synchronising pulse is due to arrive, the valve 21 is just unblocked in time by a pulse derived from the preceding synchronising pulse. Thus the valve 1 (Fig. 1) cannot be affected by pulses or by any interfering signals except during the specified 10 microseconds interval. In this way interfering signals of large amplitude are practically prevented from producing false operation and accurate synchronisation by the desired pulse train is ensured.

The modification of Fig. 4 which is shown in Fig. 5 is adapted for synchronising the multivibrator to a train of pulses, or for selecting a given train of pulses from other trains by automatic frequency control without directly controlling the times of emission of the generated pulses. Those elements of Fig. 5 which are the same as elements of Fig. 4 have been given the same designation numbers and will not be again described. The transformer 31 and the delay network 32 are not required in the case of Fig. 5 and have been omitted, the output terminal 15 of the multivibrator 20 being connected directly to the suppressor grid of the valve 21. The anode is connected to the terminal 22 through a winding 35 which is inductively coupled with the inductance element 7 of the multivibrator 20 as indicated in Fig. 5. Thus the stabilising resonant circuit is in this case a tuned transformer. It will be understood, of course, that the elements 7 and 8 may be connected in the same way as in Fig. 1. The elements 23 and 34 of Fig. 1 are of course not required in Fig. 5 and have been omitted.

As in the case of Fig. 4, the output pulses from the multivibrator are preferably differentiated to produce short positive pulses alternately with negative pulses which are not used. The positive pulses applied to the suppressor grid of the valve 21 unblock the valve for the duration of the input pulses which are applied at terminal 28 as before, together with any interfering signals which may be mixed therewith. Pulses which coincide with the unblocking pulses appear in the anode circuit and are applied to the tuned transformer 7, 35. According to the manner in which the connections to the windings have been poled, these will advance or retard the phase of the ringing of the resonant circuit, so synchronising the multivibrator to the applied pulse train.

It will be seen that since the unblocking pulses

are positive, they will correspond with the trailing edges of the pulses generated by the suppressor grid of the valve 1 in the multivibrator 20, and therefore with the trailing edges of the cathode pulses. These trailing edges correspond in time with the extreme negative peaks of the ringing voltage waves of the resonant circuit 7, 8. By suitable choice of the natural period of this circuit, the trailing edges of the gating pulses can be made to correspond closely with the initial instants of zero voltage of the ringing oscillations, so that pulses arriving from the valve 21 at such instants cause a quadrature drive to the ringing circuit, and therefore they exert a phase advancing or retarding influence. If the repetition frequency of the pulses generated by the multivibrator when uncontrolled is supposed to be slightly lower than that of the synchronising pulse trains, then the transformer 7, 35 should be poled so that when such synchronising pulse rides on the sloping trailing edge of the corresponding unblocking pulse, a quadrature phase advancing drive is applied to the ringing circuit and therefore the oscillation period will be slightly shortened to maintain the synchronism.

If it is desired to synchronise to a pulse train of slightly lower repetition frequency than that of the multivibrator, one of the transformer windings should be reversed in order that the gated pulses may retard the phase of the ringing circuit.

For actually selecting the desired pulse train a second gating valve (not shown) is preferably provided with the gating pulses applied to the suppressor grid through a network including a suitable delay so that the gate may be fully opened for the whole periods of the pulses.

What is claimed is:

1. A stabilised electric multivibrator comprising a thermionic valve having in the order named, a cathode, first, second, and third grid electrodes and an anode; an operating source therefor having a substantially constant unidirectional potential; first and second resistances connecting the positive terminal of the said source to the anode and first grid electrode respectively; a third resistance connecting the cathode to the negative terminal of the said source; a condenser connecting the anode to the first grid electrode; means for applying a constant positive potential to the third grid electrode with reference to the negative terminal of the said source; a resonant circuit connected in series with the cathode; and means for deriving output pulses from the second grid electrode.

2. A multivibrator according to claim 1, in which the resonant circuit comprises an inductance shunted by a condenser.

3. A multivibrator according to claim 1 in which the resonance frequency of the resonant circuit is selected to be between five and ten times the repetition frequency of the pulses generated by the multivibrator.

4. A multivibrator according to claim 1 comprising means for preventing the potential of the first grid electrode from becoming positive with respect to that of the third grid electrode.

5. A multivibrator according to claim 4 in which the said means comprises a diode having its anode connected to the first grid electrode and its cathode connected to the third grid electrode.

6. A multivibrator according to claim 1 comprising means for applying synchronising pulses to the cathode circuit.

7. A multivibrator according to claim 1 including an inductive winding coupled to the said inductance, and means for applying synchronising pulses to the inductive winding.

8. A multivibrator according to claim 1 including means for applying synchronising pulses to the anode.

9. A multivibrator according to claim 1 including a gating valve having a cathode, anode, control grid and suppressor grid, means for applying a blocking bias to the said gating valve, means for applying a train of input pulses to the control grid of the gating valve, means for applying output pulses from the gating valve to synchronise the multivibrator, and means for applying output pulses from the multivibrator to unblock the gating valve to enable it to admit each input pulse when it is due to arrive.

10. A multivibrator according to claim 9 in which the means for applying the output pulses from the gating valve comprises means for connecting the anodes of the multivibrator and gating valves, and in which the means for applying pulses to unblock the gating valve comprises a delay network connected between the second grid electrode of the multivibrator valve and the suppressor grid of the gating valve.

11. A multivibrator according to claim 9 in which the means for applying the output pulses from the gating valve comprises means for inductively coupling the anode of the gating valve to the said resonant circuit, and in which the means for applying pulses to unblock the gating valve comprises means for connecting the second grid electrode of the multivibrator valve to the suppressor grid of the gating valve.

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