Sept. 21, 1937. W. VAN B. ROBERTS 2,093,781

OSCILLATION CIRCUITS

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Fig. 1

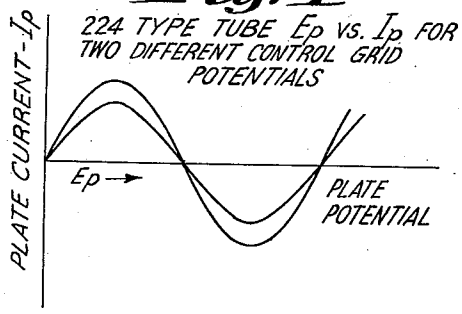


Fig. 2

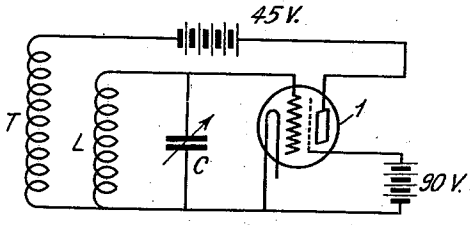


Fig. 3

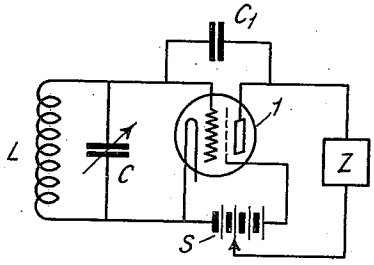


Fig. 4

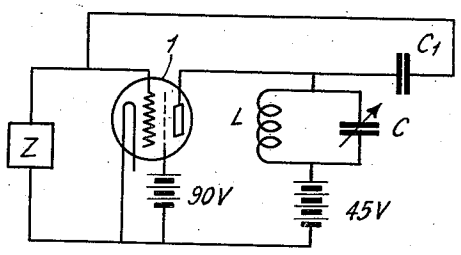


Fig. 5

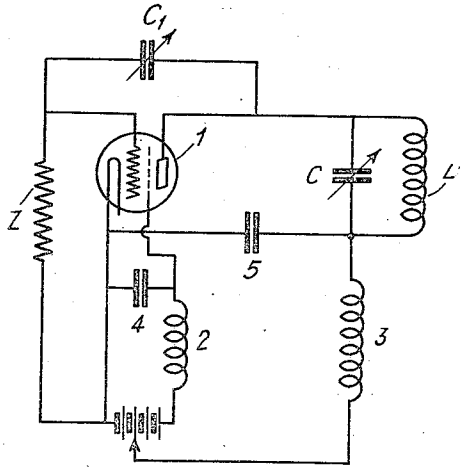
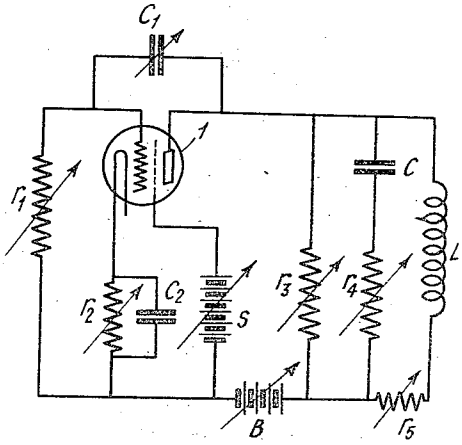


Fig. 6



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Fig. 7

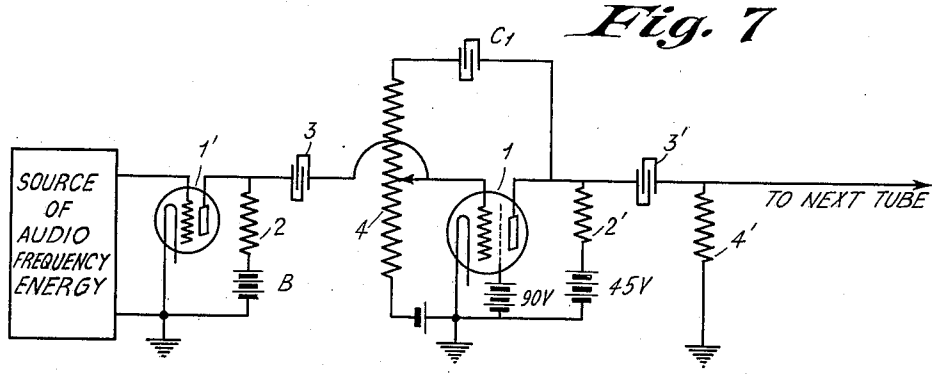


Fig. 8

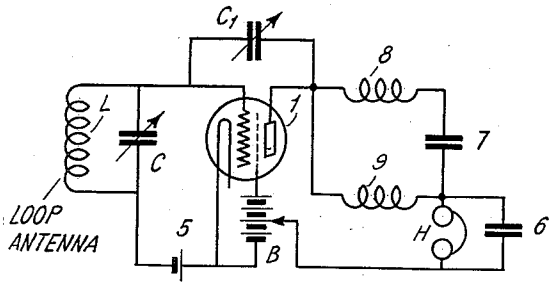


Fig. 9

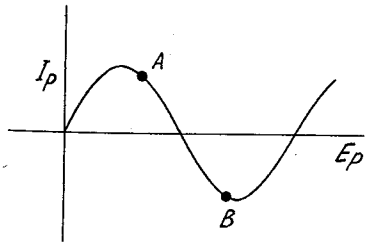


Fig. 10

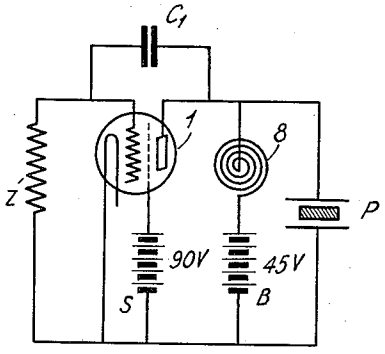
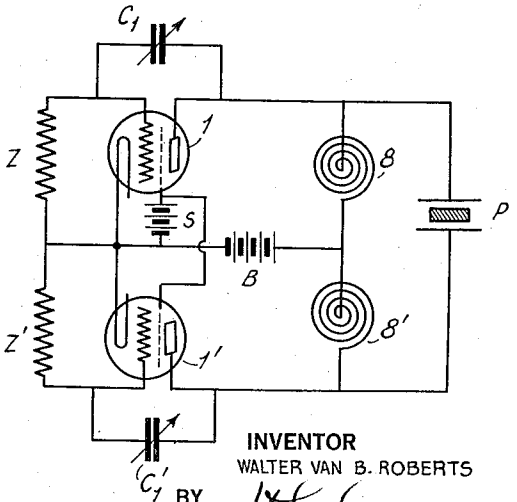


Fig. 11



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2,093,781

OSCILLATION CIRCUIT

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Application November 24, 1931, Serial No. 577,020

2 Claims. (Cl. 250—36)

My present invention relates to regenerative circuit arrangements, and more particularly to a novel method of, and means for producing oscillations in circuits utilizing screen grid tubes.

One of the main objects of my present invention is to provide an oscillation circuit including a screen grid tube, wherein the circuit arrangements are such that there exists a strong oscillation tendency, one of the important features of the arrangement involving the fact that oscillations may be produced at shorter wave lengths than usual with small tubes, or conversely, at ordinary wave lengths oscillations may be produced in circuits having a smaller ratio of inductance to capacity than usual, such circuits, additionally, giving greater constancy of frequency in the face of fluctuations in tube characteristics.

Another important object of the present invention is to provide an oscillator arrangement wherein there are only two connections to the tuned circuit, switching arrangements for multi-range operation involving different coils and/or tuning condenser being thereby greatly simplified.

Another object of the present invention is to provide an oscillator employing a screen grid tube which lends itself in an efficient manner to super-regenerative circuits, the screen grid tube oscillating dynatron fashion as to interruption frequency, with the result that the direction of plate current may be periodically reversed so as to alternately produce regeneration or counter-regeneration in the signal frequency circuits.

Still another object of the present invention is to provide a regenerative circuit whose constants are designed in such a manner that for reinforcement of input voltage on the grid the voltage feed-back from the plate circuit is not altered in phase, thereby permitting relaxation oscillations to be produced conveniently with a single tube, or if the feed-back coupling is made less than necessary for instability, a regeneration independent of frequency may be produced in but a single stage of resistance coupled amplification for audio frequencies.

And still another object of the present invention is to provide a master oscillator circuit wherein a piezo-electric element is disposed in the anode circuit of the oscillator tube, and wherein the oscillator circuit acts simultaneously partly as a dynatron oscillator, and partly as a reversed current feed-back circuit.

And yet another object of the present invention is to provide an oscillation circuit which retains the convenience of switching characteristics of the dynatron oscillator, while increasing the tendency to oscillate substantially five-fold over the dynatron oscillator, the marked strength of oscillation obtained permitting the use of a very soft circuit, which in turn makes the operating frequency less dependent upon variations of tube capacities and other things pertinent to the tube construction which tend to affect frequency.

And still other objects of the invention are to improve generally the simplicity and efficiency of regenerative or oscillator circuits, and to particularly provide an oscillatory or regenerative circuit, employing a screen grid tube, which is readily adapted for use in connection with receiving, transmitting and other high frequency arrangements, and which is additionally reliable in operation and economically constructed.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit arrangements whereby my invention may be carried into effect.

In the drawings,

Fig. 1 graphically shows a pair of characteristics of a 224 type tube,

Fig. 2 diagrammatically shows a circuit embodying the basic principle of the present invention,

Figs. 3, 4, 5 and 6 diagrammatically represent various modifications of the arrangement shown in Fig. 2,

Fig. 7 diagrammatically shows an audio frequency regenerative amplifier embodying the invention,

Fig. 8 shows in diagrammatic manner a super-regenerative receiver embodying the invention,

Fig. 9 is a graphic representation of the operation of the embodiment shown in Fig. 8,

Fig. 10 shows a master oscillator arrangement embodying the present invention, and,

Fig. 11 shows still another form of master oscillator utilizing the present invention.

Referring to the accompanying drawings wherein like characters of reference indicate the same elements in the different figures, Fig. 1 shows the plate current I_p plotted against the plate potential E_p for two different values of control grid potential, the screen potential being fixed at a higher value than any of the plate voltages represented in Fig. 1. It will be observed that in the region of reversed plate current the magnitude of the plate current is controlled by the control grid potential just as in an ordinary tube. That is to say, the more negative the control grid the less becomes the magnitude of plate current. Hence, if a 224 tube is connected in the usual tickler type of feed-back circuit, as shown in Fig. 2, and the plate and screen potentials are adjusted to give reversed plate current, it will be found that the polarity of the coupling between the tickler coil T and the tuned circuit L, C is

opposite to that required with an ordinary tube if oscillations are to be generated.

Since the direction of winding of the tickler coil T and of the coil L is the same, it is not necessary to have a separate tickler coil, and the feed-back may be very well accomplished auto-transformer fashion as indicated in Fig. 3. The feed-back is made by way of the inductance L of the tuned input circuit acting as a one to one auto-transformer. In order to allow the plate battery S to be at cathode potential a shunt feed is provided to the plate. The shunt feed impedance Z may be of any nature that has high impedance to the oscillation frequency. It may be an inductance of relatively low value provided that the inductance in the grid circuit is increased sufficiently to allow the tuning to extend to the desired lowest frequency. A feed-back, or blocking, condenser C_1 is arranged between the anode and control grid of the tube 1, while the impedance Z is connected between the anode and a point on the source S which is some 40 volts positive with respect to the cathode, the screen grid being connected to a point substantially 90 volts positive with respect to the cathode.

An arrangement which is alternative to that of Fig. 3 is shown in Fig. 4, the circuit shown in the latter being essentially similar to that shown in Fig. 3, but it has the advantage that if the impedance Z is made a very high resistance, the control grid of the tube 1 will tend to charge up during oscillations, and thus reduce the magnitude of the steady currents drawn by the various electrodes. This latter action is often made use of in ordinary oscillator circuits. In Fig. 4 the plate circuit is now series fed, which the control grid potential prior to oscillation is made definite by the grid leak resistance, or impedance Z.

An oscillator circuit such as shown in Fig. 4 has been operated with the voltages indicated thereon for screen grid and plate, the impedance Z consisting of 100,000 ohms resistance, L having a value 100 micro-henries, the feed-back or blocking condenser being about 50 mmf., and the tube being an average 224 type tube. This system oscillated so strongly at 760 kilocycles, that it was necessary to insert 100 ohms in the position indicated at r_5 of Fig. 6 in order to stop oscillation. When the circuit of Fig. 4 was changed to a simple dynatron circuit, and the potential sources readjusted for optimum dynatron action, it was found that 14 ohms was sufficient to stop oscillation where 100 had been previously required. This demonstrates how much more strongly the system shown in Fig. 4 tends to oscillate than in a simple dynatron oscillator circuit.

In actual practice, especially at short waves, the refinements shown in Fig. 5 are desirable. Here the condenser C_1 between the plate and control grid of tube 1 is made variable in order to control the amount of feed-back, while the radio frequency chokes 2, 3, and by-pass condensers 4, 5 are used in the circuits from the screen and plate back to the cathode. It is essential that by-pass condensers be used which really function as condensers at the operating frequency. It has been found possible to employ ordinary variable air condensers of readily available capacity (such as .001) for by-passing over a large range of frequencies. With the arrangement shown in Fig. 5, using a 224 type tube with 90 volts on the screen and between 30 and 40 volts on the plate, oscillations of wave lengths as low as 20 or 30 meters are easily obtained even with a tuned circuit that is not at all stiff, that is, having an ordinary broadcast tuning condenser across a very small inductance.

The broadcast wave length oscillations can be produced with coils having a few hundred ohms resistance in series with them. At shorter wave lengths, around 15 meters, there is some difficulty in obtaining oscillation, and it is found that an extremely small inductance (for example, two turns of wire about an inch in diameter) in series with the screen by-pass condenser, results in an increased willingness to operate.

Fig. 6 shows essentially the circuit of Fig. 4 with elements added which can be utilized for controlling the amount of feed-back, and hence, the amount of regeneration and oscillation. All the quantities indicated as variable, or any of them may be used for control of oscillation. Resistors r_1, r_3, r_4 and r_5 act simply as energy absorbing elements. Adjustment of potential sources B or S, or resistor r_2 effects control by varying the electrode potentials. Condenser C_1 controls feed-back by controlling the amount of voltage fed back from plate to control grid.

Due to the fact that for reinforcement of input voltage on the control grid of the oscillator tube of the present invention, the voltage fed back from the plate circuit is not altered in phase, relaxation oscillations may be produced conveniently within a single tube, or if the back coupling is made less than necessary for instability a regeneration, independent of frequency, may be produced in a single stage of resistance coupled amplification for audio frequencies. Fig. 7 shows diagrammatically such a regenerative audio amplifier employing resistance couplings between the output of the screen grid tube 1 and its own input as well as the input of the succeeding tube (not shown).

It will be noted, in connection with Fig. 7, that the source of audio frequency energy is impressed upon the input electrodes of a tube 1', and that the output of the latter is impressed upon the control electrode of tube 1 through a resistor 2 and capacity 3. The condenser C_1 provides the feed-back path between the anode of tube 1 and the control electrode thereof, the impedance Z being in this case a resistor 4, the control grid of tube 1 being adjustably connected to a point on the resistor 4. The output of tube 1 may then be coupled by means of resistor 2', capacity 3' and resistor 4' to the input of the succeeding tube. In case it is desired to regenerate extremely low frequencies, the coupling condenser C_1 should be replaced by a battery of sufficient voltage to maintain the control grid of tube 1 at a proper operating potential, it being understood that equivalent arrangements can readily be employed.

The present type of oscillator lends itself very readily to the design of super-regenerative circuits, since with a single tube operating dynatron fashion as to interruption frequency, the direction of plate current may be periodically reversed so as to alternately produce regeneration or counter-regeneration in the signal frequency circuits. Thus, in Fig. 8 there is shown a dynatron super-regenerative circuit wherein the control electrode and cathode of the tube 1 are connected to a resonant circuit comprising a coil L and a variable tuning condenser C. The coil may be designed as a small loop antenna, since in practice the physical dimensions of a receiver of the type shown in Fig. 8 are very small. For example, the entire receiver could be disposed

within a small box, and the coil L of the antenna comprise a few turns of wire within the cover of the box.

A control grid biasing source 5 may be used to maintain the control grid of tube 1 properly biased, and the adjustable capacity C_1 comprises a condenser of small capacity to give feed-back at radio frequency. The screen grid of tube 1 is connected to the positive terminal of the source B, while the anode of the tube is adjustably connected to a point of less positive potential on the source B through the head-phones H, a radio frequency by-pass condenser 6 being shunted across the head-phones. A network, resonant to the desired interrupting frequency, is disposed in series between the anode and the head-phones H, the network comprising a fixed condenser 7 in parallel with a pair of coils 8, 9, the coils being connected in series with each other. The coils 8 and 9 act as chokes for the radio frequency currents. Briefly, the operation of this circuit may be explained in the following manner:

The battery voltages are so chosen that the normal plate current is very small, or zero. Due to the falling plate current-plate potential characteristic, oscillations are produced at a frequency determined by condenser 7 and coils 8, 9. These oscillations cause the plate potential to vary alternately above and below the normal value, with current in one direction as a result of the plate potential falling below normal but in the other direction when the plate potential is above normal.

Fig. 9 graphically shows the operation of tube 1 in Fig. 8, when plate current is plotted against plate potential. Points A and B designate the extremes of the range of positions of the operating points of the circuit due to interrupting frequency oscillation produced by dynatron action. When the operating point is above the zero axis, then the radio frequency feed back through the capacity C_1 is essentially degenerative. However, when the operating point is below the zero axis then the radio frequency feed-back is regenerative. Thus signal frequency currents are alternately built up and damped out in the circuit LC which is the criterion of super-regeneration.

If the adjustment of plate potential of the present type of screen grid oscillator is made experimentally so as to obtain the maximum tendency to oscillate, the plate potential so chosen will probably not be the potential which gives the maximum value of reversed current, and hence the maximum amount of feed-back action. However, it will be a compromise value which will locate the operating point somewhere between the potential which gives maximum reversed current and that which gives zero plate current, thus making the circuit act simultaneously partly as a dynatron oscillator, and partly as a reversed current feed-back circuit. In other words, by adjusting the relative potentials on screen and plate to make the reversed plate current a maximum, dynatron action is entirely absent. However, a combination of the present method and the ordinary dynatron action may be utilized by adjusting these potentials so that we have a reversed current in the plate circuit somewhat less than its maximum value, and at the same time we have a negative slope for the plate current-plate potential characteristic.

In Fig. 10 there is shown a master oscillator circuit which combines the present method and the ordinary dynatron action. Between the anode and the negative terminal of the 45 volt source B there is disposed a piezo-electric element P, the path consisting of the usual metallic electrodes and quartz crystal. The positive terminal of the source B is connected to the anode through a radio frequency choke 8. The source S, of 90 volts, maintains the screen grid at a higher positive potential than the anode of tube 1. A path including the capacity C_1 provides feed-back path for the radio frequency currents, and it will be noted that the arrangement shown in Fig. 10 essentially comprises the arrangement of Fig. 4.

The impedance Z arranged between the control grid and cathode of tube 1, consists of a resistor. The action of this master oscillator circuit will, in the light of the foregoing explanation, be self-evident when it is considered that a crystal is, in its relations in an electric circuit, equivalent to an anti-resonant circuit in series with a condenser. In any of Figs. 3, 4, 5 or 6 oscillations would be produced equally well if a condenser were inserted in series with the anti-resonant circuit provided that the necessary direct current path were provided around the series condenser. Fig. 10 shows a choke coil 8 for this purpose.

In case a symmetrical system is desired, Fig. 11 may be employed. A feature of this arrangement is that the battery voltage is not impressed across the crystal. Fig. 11 is simply Fig. 10 doubled, except that two crystals are not required since the central plane of the crystal may be considered as connected to the battery, thus dividing the crystal into two fictitious components. The feed-back condensers are shown variable to allow adjustment of tendency to oscillate.

Several particular uses for the present type of oscillatory or regenerative circuit have been shown, such uses comprising regenerative amplification, super-regenerative reception, master oscillator circuit. It is pointed out, however, that various other uses will be apparent from the present disclosure, as for example the use of the present invention in a wave meter.

While I have indicated and described several systems for carrying my invention into effect it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim is:

1. An oscillation generator comprising a pair of electron discharge devices each having a cathode, an anode, a control grid, and a screen grid, a source of potential for maintaining said anodes at a positive potential with respect to said cathodes, a circuit for maintaining said screen grids at higher positive potentials with respect to said cathodes, resonant means connected between said anodes, a circuit interconnecting said control grids, the cathodes of said devices being connected together, and, a condenser connected between the anode and control grid of each of said devices for establishing reactive regenerative feed back from the anode of each of said devices to the control grid of each of said devices.

2. Apparatus as claimed in the preceding claim wherein said resonant means connected between said anodes is in the form of a piezo-electric crystal.

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