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RELAXATION OSCILLATOR

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Fig. 1

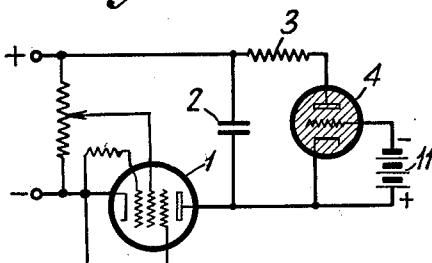


Fig. 2

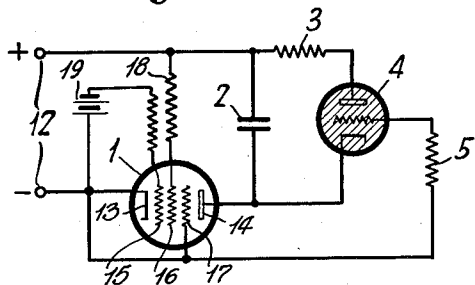


Fig. 3

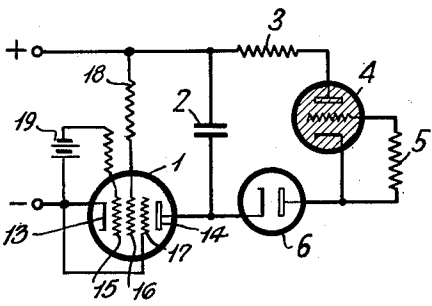


Fig. 4

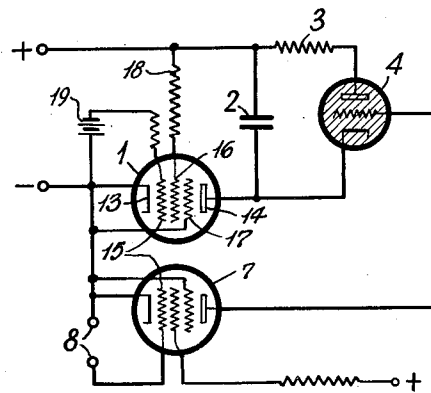


Fig. 6

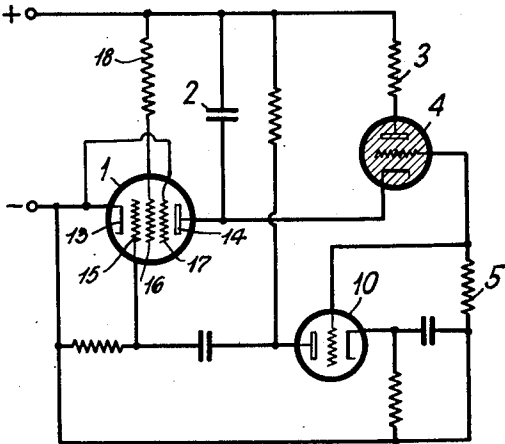
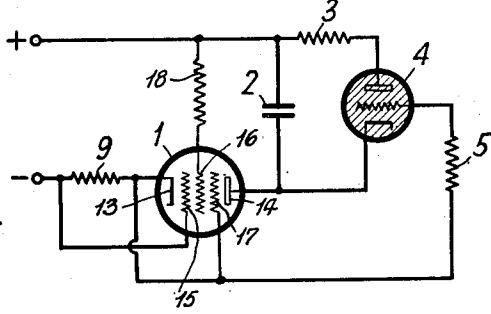


Fig. 5



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RELAXATION OSCILLATOR

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4 Claims. (Cl. 250—36)

This invention relates to arrangements for the production of high-frequency relaxation oscillations.

It is an object of the invention to provide a relaxation oscillator of the type in which gaseous discharge tubes are employed, and in which the limiting frequency can be raised to a value above what would be possible in cases where no provision is made for carrying off a certain excessive accumulation of ions in the discharge path.

The invention will now be described in detail, reference being made to the accompanying drawing wherein

Figure 1 illustrates a known circuit arrangement, this figure being referred to as a basis for explaining the improvements which constitute the invention.

Fig. 2 is a circuit diagram of the improved relaxation oscillator in its simplest form, and

Figs. 3 to 6 inclusive show progressively more complex circuit arrangements by which the invention may be carried out.

A known circuit is shown in Fig. 1. A control tube 1 is provided for charging the relaxation condenser 2 which may then be discharged across a gaseous discharge tube 4. The grid of the gaseous discharge tube 4 has a negative biasing potential applied thereto from the source 11. As is known, the frequency of relaxation oscillations produced by means of such circuit is limited by the finite de-ionization time of the discharge tube 4 and lies below about 70 kilocycles. The relaxation mechanism functions in the following manner:

At the beginning of the discharge a certain excess in ions is produced so that the condenser potential at 2 decreases below the static operating potential of the discharge tube 4; then the ions must be carried off at such speed that the new potential increase at the condenser 2 no longer causes ionization. Hence the discharge is interrupted. This control of the ion supply can be achieved by the known insertion of the outer resistor 3, and furthermore by the choice of the grid biasing potential from the source 11. This grid bias must not be negative to such a high degree that a noticeable lack in ions occurs in the beginning of the discharge, and on the other hand, it should be negative to such an extent that at the end of the discharge the ions can be rapidly carried off. These opposing requirements give the reason for the relatively low limit frequency in the relaxation oscillation operation when using gaseous discharge tubes.

According to the present invention for the

purpose of increasing this limit frequency, means are provided which, at the end of the discharge, produce a sudden and steep rise of the negative potential of the grid of the discharge path such that the grid openings are closed up by space charge layers. The rise of the grid potential, therefore, has the effect that the space charge layers flow together in the grid openings in an abrupt manner.

This desired behavior of gaseous discharge tubes is known as such and has, for instance, the effect that upon sudden application of a negative grid potential an arc can be extinguished. When utilizing this phenomenon in the relaxation oscillation operation, the result is that the requirement to discharge the condenser below the static operating potential can be dispensed with. Then it is only necessary to take care that the grid becomes so negative at the end of the discharge that the arc will be extinguished and the de-ionization period which was necessary, according to Fig. 1, for the entire anode-cathode space will be reduced to the time necessary to confine the ions in the region of the grid mesh alone to form space charge layers.

Such a circuit can be realized in various ways. Thus the grid of the discharge path can be remotely controlled, for instance, by the over-voltage produced when disconnecting an inductance. However, the plate potential may also be so controlled that the pattern of the grid potential is negative, and substantially similar to the pattern of the potential at the relaxation condenser 2. In certain cases the resistance 3 in the plate circuit of the discharge tube 4 may be omitted and the arrangement would still function in the desired manner.

Several circuits, according to the invention, are described in the following in reference to Figs. 2 to 6. A common characteristic of these circuits is that the grid potential of the discharge tube 4 is controlled by the voltage of the relaxation condenser. However, it must be emphasized here that the particular features of the circuits may also be utilized to advantage where such control does not take place, such as, for instance, in the case where the grid is remotely controlled.

Fig. 2 shows a circuit in which the operation is carried out with the "floating" cathode of the discharge tube 4 whereby the grid is connected across a resistance 5, which should not be too high, to the negative terminal of the potential source 12 or to another point having fixed potential relative to the positive plates of the relaxation condenser. In an actual embodiment

of this system a control tube of the pentode type was used together with a gaseous discharge tube of the type having single hole grid and helium filling with a pressure of about 0.6 mm.

The pentode tube as shown in Fig. 2, as well as in Figs. 3 to 6 inclusive, comprises a cathode 13, an anode 14, a control grid 15, a screen grid 16, and a suppressor grid 17. The grids are connected to points of suitable potential in a conventional manner. That is to say, the control grid may be biased by means of the source 19 which interconnects said grid and the cathode. The screen grid is fed from the positive terminal of the potential source 12 through a resistor 18. The suppressor grid 17 is directly connected to the cathode 13. This manner of connecting the grids is well known in the art and is shown, for example, in the RCA Receiving Tube Manual, Technical Series RC13, published 1937. Referring to page 36 and to Fig. 43 thereon, the connections of the pentode tube to an operating potential source is there shown.

The condenser 2 has a value of about 50 micro-microfarads, the resistor 3 about 2000 ohms, and the resistor 5 not higher than 1000 ohms. With this circuit relaxation oscillations of 1 megacycle can be obtained at a charging velocity of 400 volts per microsecond without amplification. As compared with the best relaxation circuits hitherto known which furnish, with an amplification, 500 kilocycles and 200 volts per micro-second at about the same returns in percentage value (20%), this signifies as to frequency as well as amplitude a two-fold improvement, and if the circuit of the prior art is operated without amplification there is obtained in the circuit of the invention a four-fold advantage in the gain factor.

The resistor 5 in the grid circuit of the discharge tube 4 should be as small as possible, since otherwise the space charge layers cannot close in about the grid with the desired rapidity; the resistor may eventually also be dispensed with. At low values of the grid resistance the frequency and the voltage rise at the relaxation condenser show pronounced saturation phenomena, while the latter decrease in the case of high values. There exists likewise an optimum value as regards the size of the plate resistor 3. If this resistor is too large the discharge of the condenser is too slow. Therefore, the grid (as compared with the charging velocity) does not become negative rapidly enough, so that the charging velocity of the condenser must be reduced by decreasing the current. With a very small plate resistor, however, the intensity of the ion current is too high at the end of the discharge, so that in this case the oscillating current should be reduced. There is an optimum value of the resistor 3 between these two cases, this value being substantially as given above for the special case. The optimum resistance can be easily found by varying the other parameters of the circuit. The charging tube 1 need not be a pentode. In place thereof it is possible to use a different tube or combination of tubes, or any other resistor, for instance, an ohmic resistor.

It has been suggested to place the grid tapping of the discharge tube only at a part of the driving potential, it being known to connect it to a part of the charging resistance (German Patent 636,059). On the contrary the present invention proposes (for instance, by the connection with the negative pole of the driving direct potential) to impart to the grid such a negative po-

tential that the desired space charge effect takes place.

In such a relaxation arrangement the influx of ions into the grid of the discharge vessel is obviously very great. Since this ion current enters in part the cathode side and in part also the anode side of the grid, an additional charging of the relaxation condenser takes place on account of the influx at the cathode side, which additional charging tends to destroy the advantages of a saturation tube or of any arrangement for producing a linear potential rise; and causes a non-linear distortion of the condenser voltage. According to a further feature of the present invention, arrangements are provided which eliminate this non-linear distortion.

Fig. 3 shows the use of a high-vacuum tube 6 series connected in the cathode circuit of the gaseous discharge tube 4. The function of the tube 6 is to suppress the ion current at the cathode side. To obtain high frequencies the tube 6 is designed to offer an extremely low anode-cathode capacity.

Fig. 4 shows the use of a high-vacuum tube 7 inserted in the grid circuit of the gaseous discharge tube 4. The working point of the tube 7 is so set that the ion influx at the cathode side of the tube 4 is maintained constant. In some cases it may also be desirable to operate the tube 1, especially a pentode, under a condition of saturation, whereupon the entire ion current of the grid remains constant. In this case it is true that the ion current at the cathode side which influences the condenser charge is not exactly constant, but this error is practically negligible if this current exceeds considerably the current at the anode side, such as is generally the case. The use of a saturation tube has the further advantage that the synchronizing impulses can be applied thereto in a simple manner, for instance, to the control grid at 8.

According to a further feature of the invention this ion current at the side of the cathode may also be utilized to charge the condenser intentionally as fast as possible; since the ion current generally has a higher peak than the current passing through the controlling tube 1. It is only necessary to adjust the circuit constants so that the current will at first be choked somewhat by the control tube and then released again after the ion current of the grid has died down. Such a requirement is satisfied, for instance, by a circuit according to Fig. 5 in which the grid current passes through a cathode resistor 9 of the control tube 1.

An arrangement may also be used according to Fig. 6 in which the grid current controls the tube 1 across an additional auxiliary tube 10. Such an arrangement offers the double advantage, first that of a linear condenser charging, and secondly that of a very rapid condenser charging which is possible especially by utilizing the high grid ion current which is at first of a detrimental nature.

Referring to Fig. 6 in more detail, the positive ion current to the grid of tube 4 (which occurs when this tube breaks down) makes the grid of tube 10 more positive, hence makes the grid of tube 1 more negative. This action blocks the tube 1. The current through tube 1 does not react upon the grid-cathode potential difference of tube 1. Therefore, there is no self-opposing or degenerative action of the tube 1 such as would work against the control voltage applied thereto by the amplifying and phase reversing action of the tube 10. As soon as the ion cur-

rent to the grid of tube 4 ceases, the grid of tube 10 assumes normal bias. Simultaneously the grid of tube 1 assumes such a bias as to render this tube conductive, which permits the condenser 2 to start charging again.

Finally, although as a whole a linear voltage rise at the condenser is aimed at, the discharge tube, in this case, need not be a saturation tube since, in fact, it is not solely the electron current passing through this tube which is decisive. While the arrangement according to Fig. 5 has the advantage of the lesser requirement, the arrangement according to Fig. 6 has the advantage of a more flexible control. In the arrangement according to Fig. 5 there appears on account of the ionic grid current an additional potential drop through the resistor 9 which renders the control grid of tube 1 negative, thereby decreasing the current in the charging tube as desired. But with the decrease of this current the potential drop through the resistor 9 likewise decreases, and hence the control impulses are opposed by the controlled pulses of current through resistor 9. On the other hand, the resistor 5, which should be as small as possible to favor the rapid leading away of the ions, cannot be used for the direct control of the charging tube. Therefore, the arrangement according to Fig. 6 is chosen which also contains in addition an amplifier tube 10 for effecting the necessary amplification of the impulses and also a phase reversal, so that it is possible directly to control the grid of the charging tube 1 without reaction on this control by the current that is controlled. Thus the described partial elimination of the control impulses by the controlled impulses is avoided.

I claim:

1. A relaxation oscillator circuit arrangement comprising a gaseous discharge tube and a vacuum discharge tube, each having an anode, a cathode, and at least one grid, the cathode of the gaseous discharge tube being in circuit with

the vacuum tube, a direct current source having its positive terminal connected through a resistor to the gaseous tube anode and its negative terminal in circuit with the vacuum tube cathode, a capacitor connected between the positive terminal of the source and the vacuum tube anode, impedance means connecting the grid of the gaseous tube to the negative terminal of said source, and means for controlling the potential of the grid of said vacuum tube in accordance with the potential across said impedance means.

2. A circuit arrangement according to claim 1 wherein said impedance means is a resistor.

3. A circuit arrangement according to claim 1 wherein said last mentioned means comprises a third discharge tube, the input of which is coupled to said impedance means and the output of which is coupled to the grid of said vacuum tube.

4. A relaxation oscillator circuit arrangement comprising a gaseous discharge tube, a vacuum discharge tube and an auxiliary control tube, each said tube having an anode, a cathode and at least one grid, a direct current source having its positive terminal connected through a resistor to the gaseous tube anode, and its negative terminal in circuit with the vacuum tube cathode, a connection from the vacuum tube anode to the gaseous tube cathode, a capacitor coupled between said connection and the positive terminal of said source, means for coupling the anode of said auxiliary tube to the grid of said vacuum tube, a direct connection between the grid of said gaseous tube and the grid of said auxiliary tube, an impedance connected between the grid of said gaseous tube and the negative terminal of said source and a connection from the cathode of said auxiliary tube to said impedance whereby the potential of the grid of said vacuum tube is controlled in accordance with the potential across said impedance.

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