

Feb. 14, 1939.

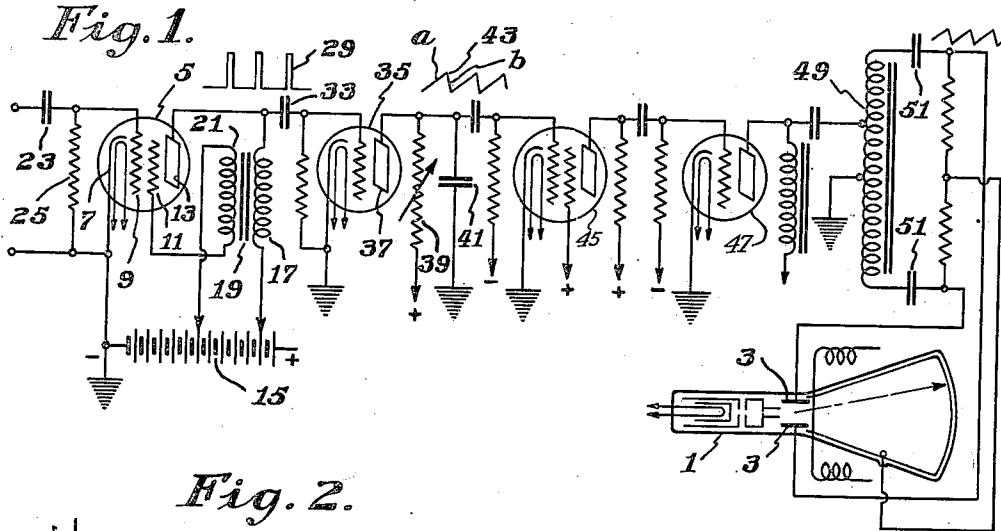
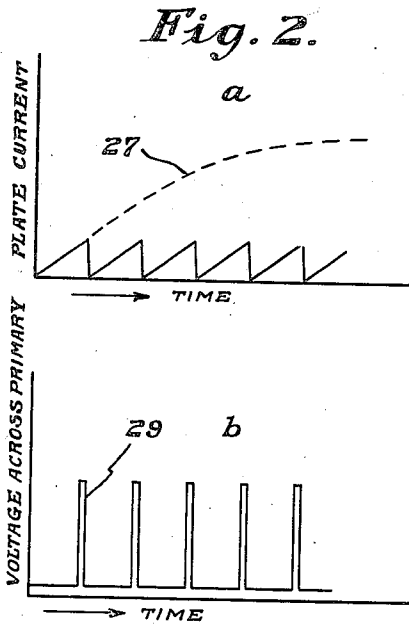
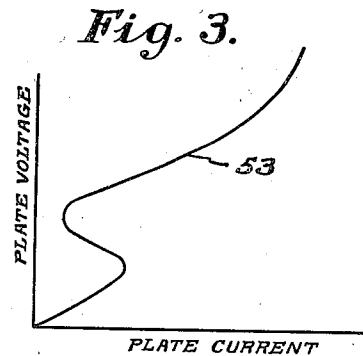
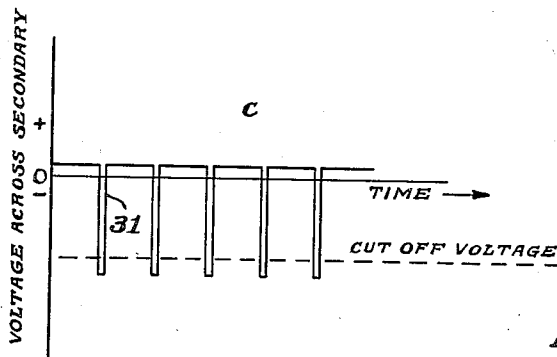
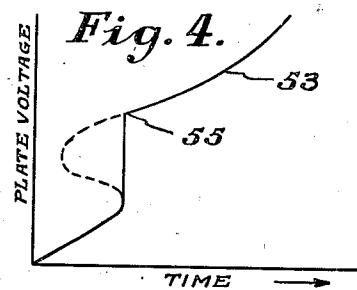
A. C. STOCKER

2,147,114

ELECTRIC DISCHARGE TUBE OSCILLATOR

Filed June 9, 1934

3 Sheets-Sheet 1



INVENTOR  
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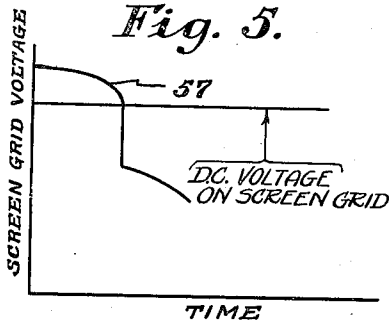
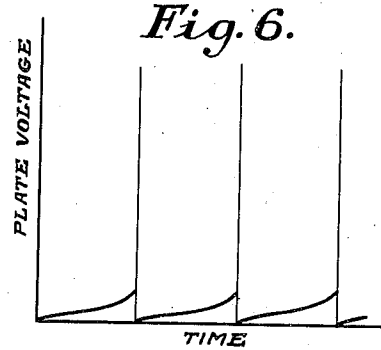
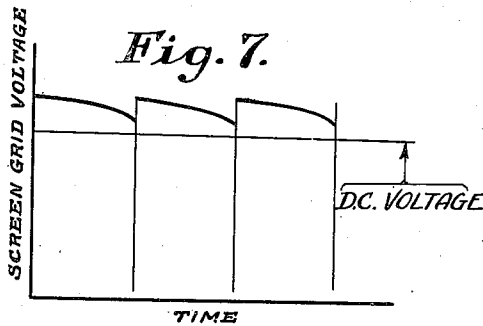
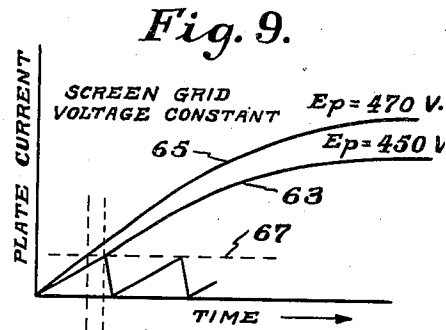
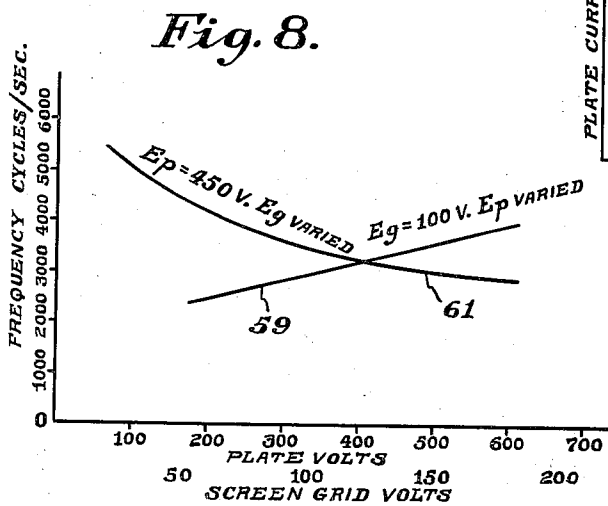
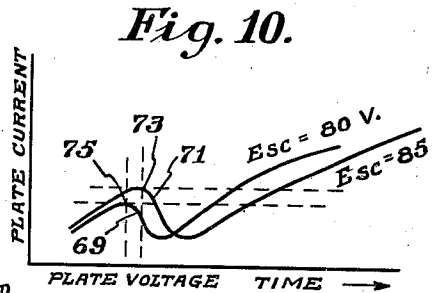
A. C. STOCKER

2,147,114

ELECTRIC DISCHARGE TUBE OSCILLATOR

Filed June 9, 1934

3 Sheets-Sheet 2



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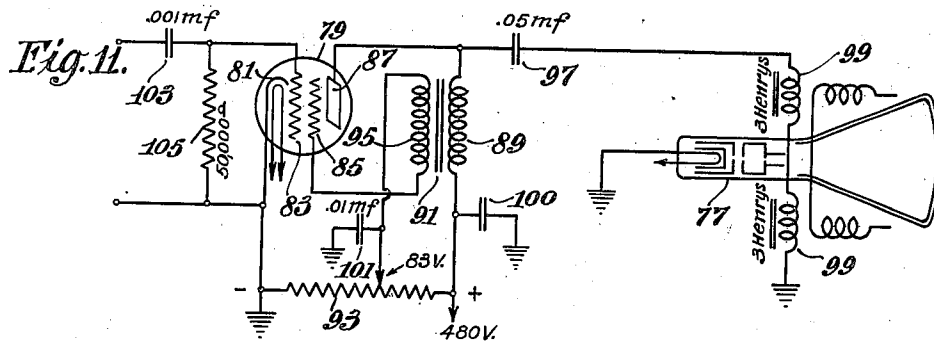
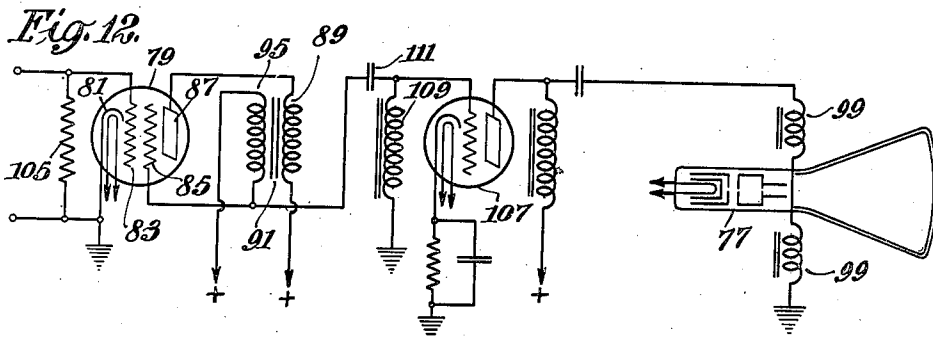
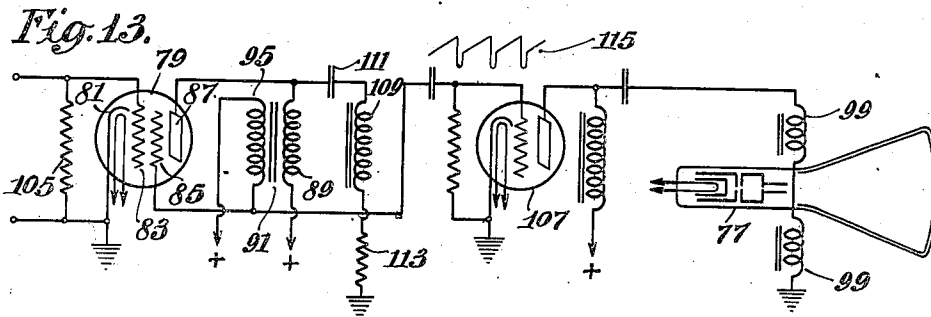
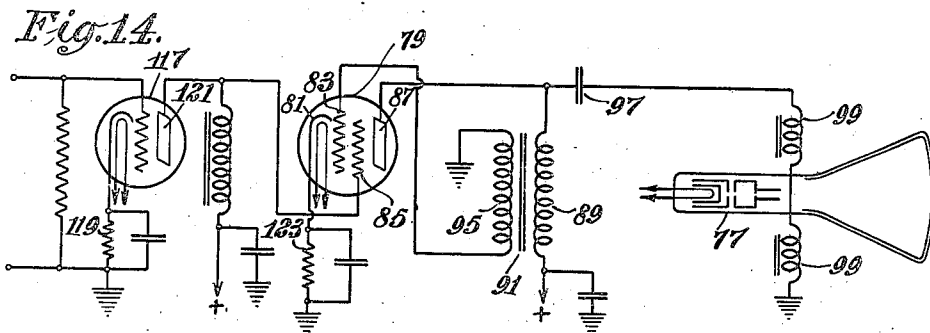
A. C. STOCKER

2,147,114

ELECTRIC DISCHARGE TUBE OSCILLATOR

Filed June 9, 1934

3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,147,114

## ELECTRIC DISCHARGE TUBE OSCILLATOR

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Application June 9, 1934, Serial No. 729,748

7 Claims. (Cl. 250—36)

My invention relates to electric discharge tube oscillators and particularly to oscillators designed to produce voltage impulses periodically for use in television circuits.

In television apparatus of the type utilizing a cathode-ray tube for transmitting or receiving, or for both, means must be provided for deflecting the cathode ray both horizontally and vertically simultaneously in order to scan the view being transmitted and/or the fluorescent screen at the receiver. To obtain undistorted transmission of the view, it is essential that the scanning at the transmitter and at the receiver be maintained in synchronism.

In television systems of the above mentioned type, each cathode-ray tube requires a horizontal deflecting circuit and a vertical deflecting circuit for deflecting the electron beam in the manner described. Each deflecting circuit must supply either voltage or current having a saw-tooth wave shape depending upon whether deflecting plates or deflecting coils are employed. It has been the general practice to generate the saw-tooth wave of voltage or current by generating voltage impulses as by means of the dynatron oscillator and impressing these voltage impulses upon several amplifier tubes connected in cascade for reshaping and amplifying the voltage impulses.

One of the objects of my invention is to provide an improved generator of current or voltage impulses.

More specifically, it is an object of my invention to provide a voltage impulse generator which is stable in operation and which may be readily synchronized.

A further object of my invention is to provide an improved single tube deflecting circuit for a cathode-ray tube.

In a preferred embodiment of my invention, I utilize a screen grid vacuum tube which has a positive direct-current voltage applied to the screen grid, this voltage being somewhat lower than the direct-current voltage applied to the plate as is customary in operating screen grid tubes.

The plate circuit of the tube is made highly inductive whereby an increase in plate current is almost directly proportional to time.

The plate circuit of the tube is coupled to the screen grid through a transformer in such phase that the voltage impulses in the plate circuit which make the plate more positive, induces a voltage impulse into the screen grid circuit to make the screen grid negative and thereby bias the tube to plate current cut-off. This is the equivalent of a sudden break in the plate circuit and the resulting collapse of flux in the plate circuit inductance coil induces an exceedingly high voltage in the plate circuit.

The above mentioned voltage impulse in the plate circuit occurs after the plate current has increased to a certain value because of the negative resistance characteristic of the screen grid tube.

Other objects, features and advantages of my invention will appear from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a circuit diagram of one embodiment of my invention;

Figs. 2a, 2b and 2c are curves showing the plate current and certain voltages appearing in the oscillator circuit shown in Fig. 1;

Fig. 3 is a characteristic curve of a screen grid tube;

Figs. 4, 5, 6 and 7 are curves which are referred to in explaining the operation of the oscillator shown in Fig. 1;

Fig. 8 is a pair of curves showing certain frequency characteristics of my improved oscillator;

Figs. 9 and 10 are curves which are referred to in explaining certain characteristics of my improved oscillator; and

Figs. 11, 12, 13 and 14 are circuit diagrams showing other embodiments of my invention.

Referring to Fig. 1, I have shown one embodiment of my invention applied to a television receiver circuit in which a cathode-ray receiver tube, indicated at 1, is provided with deflecting plates 3 for deflecting the cathode ray horizontally. It will be understood that, in this case, a voltage wave having a saw-tooth shape is required across the deflecting plates 3.

The oscillator of the saw-tooth wave generator comprises a vacuum tube 5 having a cathode 7 which preferably is indirectly heated, a control grid 9, a screen grid 11 and an anode or plate 13. The anode 13 is connected to a point of positive potential such as a positive terminal on a battery 15 through the primary winding 17 of a transformer 19. The screen grid 11 is connected to a point of positive potential such as a point on the battery 15 through the secondary winding 21 of the transformer 19 whereby the screen grid circuit is coupled to the plate circuit.

The positive direct-current voltage applied to the screen grid 11 by the battery 15 or other voltage supply source is ordinarily considerably lower in value than the positive direct-current voltage applied to the plate 13. For example, if the vacuum tube 5 is type 224, the voltage applied to the anode 13 by the battery may be 500 volts, while that applied to the screen grid 11 by the battery may be 90 volts.

In accordance with my invention, the plate circuit of the tube 5 is made highly inductive, this being accomplished in the embodiment being described, by giving the primary winding of the transformer 19 a high value of inductance.

In order to produce the most satisfactory results, the inductance in the plate circuit should be high compared with the total resistance in the plate circuit.

5 In the circuit illustrated, the horizontal synchronizing impulses, which are transmitted from the television transmitter, are impressed upon the control grid 9 of the tube 5 through a coupling condenser 23. The control grid 9 may be  
10 connected to the cathode 7 through a grid leak resistor 25, as shown, or it may be connected to the cathode through a grid leak resistor and a biasing battery (not shown) for applying a negative bias thereto.

15 To explain in general the operation of the oscillator, it will be assumed that voltage has just been applied to the plate 13. Since the plate circuit is almost purely inductive, the increase in plate current will be almost directly proportional to time, as indicated by the dotted line  
20 curve 27 in Fig. 2a. When the plate current reaches a certain definite value, a voltage impulse is produced in the plate circuit in the direction which makes the plate more positive. The reason for this sudden increase in plate  
25 voltage will be explained hereinafter.

This voltage impulse in the plate circuit is impressed upon the screen grid 11 through the transformer 19, the secondary 21 of the trans-  
30 former being so connected to the screen grid that the voltage impulse makes the screen grid less positive. As a result, the plate impedance of the tube is increased to cause a decrease in plate current whereby the screen grid is made still  
35 less positive, or more negative, and the tube is almost instantaneously brought to cut-off by an accumulative action. The result is that the sudden effective opening of the plate circuit causes a sudden collapse of flux in the primary  
40 winding 17 to produce a voltage impulse of great magnitude in the plate circuit, as shown by the curve 29 in Fig. 2b, this voltage impulse appearing in the screen grid circuit as a negative voltage impulse as shown by the curve 31 in Fig. 2c. It will be noted that these negative impulses  
45 have a value exceeding the cut-off voltage of the tube.

Before explaining the operation of the oscillator in more detail, the deflecting circuit shown in Fig. 1 will be described. The voltage impulses  
50 appearing in the oscillator plate circuit are impressed through a coupling condenser 33 upon the input circuit of an amplifier tube 35. The plate 37 of tube 35 is connected through a resistor 39 to a source of positive potential such  
55 as a point on the battery 15 or a point on a voltage divider (not shown). In order to convert the voltage impulses 29 into a voltage having a saw-tooth wave shape, a condenser 41 is connected between the plate 37 and ground whereby  
60 it is charged through the resistor 39. As the condenser is charged, the voltage across it increases in a straight line relation as indicated by the portion "a" of the voltage curve 43. As soon as the positive voltage impulse appears on  
65 the grid of the tube 35, the condenser 41 is caused to discharge through the tube 35 in a very short time, this period of discharge being represented by the portion "b" of the voltage  
70 curve 43. It will be apparent that the voltage appearing across the condenser 41 has a saw-tooth wave shape. The saw-tooth voltage is amplified by amplifiers 45 and 47 connected in cascade whereby a saw-tooth wave of voltage of the  
75 desired value is impressed across the primary sec-

tion of the auto-transformer 49 and, through coupling condensers 51, upon the deflecting plates 3.

The theory of operation of my improved oscillator will now be described more in detail in connection with Figs. 3, 4 and 5. The curve 53  
5 shown in Fig. 3 is the characteristic plate current-plate voltage curve of a screen grid tube, type 224, for example, for the condition where the control grid and screen grid voltages are  
10 held constant. It will be noted that as the plate voltage increases, the plate current increases up to a certain value and then decreases with further increase of plate voltage until it reaches  
15 a certain minimum value where it again begins to increase. The reason for this decrease in plate current, as is well known, is that secondary electrons are emitted from the plate and flow to the screen grid which, at this time, is more  
20 positive than the plate.

In explaining the operation of my oscillator, it is preferred to utilize the characteristic curve 53 to see what happens to the plate voltage as the plate current increases. As previously explained, the increase in plate current, because  
25 of the inductive plate circuit, will be proportional to time. Therefore, the plate current axis is a time axis as well, as indicated in Fig. 4.

Referring to Fig. 4, it will be evident that at a time when the plate current reaches the value  
30 at which it would normally decrease with further increase of plate voltage, the plate voltage suddenly increases to the value indicated by the point 55 on the curve 53. The physical reason for this sudden increase in plate voltage is that,  
35 because of the emission of secondary electrons from the plate, there is a tendency for the plate current to decrease, which tendency is opposed by collapsing lines of flux in the primary winding 17. In other words, the inductance in the plate circuit prevents a sudden decrease in plate current  
40 and it does this by causing an increase in voltage across the primary winding of the transformer 19.

Although the upper portion of the characteristic curve 53 of the screen grid tube has been shown in Fig. 4, the tube operates along this  
45 characteristic only to the point where the plate voltage increases suddenly in value. The reason for this will be seen by referring to Fig. 5 where the curve 57 represents the voltage applied to the screen grid 11. It will be seen, from this  
50 curve that because of the coupling between the screen grid circuit and the plate circuit, the screen grid voltage is reduced as the plate voltage is increased. At the point where the sudden increase in plate voltage occurs, there is a corresponding sudden decrease in screen grid voltage. This sudden decrease in screen grid voltage starts  
55 the accumulative action previously described, whereby the tube is biased to cut-off almost instantaneously. The curves shown in Figs. 6 and 7 show somewhat more accurately than the curves in Figs. 2b and 2c how the plate voltage and the screen grid voltage change as the tube 5 oscillates.

In Fig. 8, the curve 59 shows the frequency of the oscillator output plotted against changes in plate voltage, while the curve 61 shows the frequency of the oscillator output plotted against  
65 changes in screen grid voltage. It will be seen that as the plate voltage is increased, the frequency is increased, assuming that the screen grid voltage remains constant and that, as the screen grid voltage is increased, the frequency is lowered, assuming that the plate voltage remains  
70 75

constant. Since in practice, the plate and the screen grid are supplied with voltages from the same power source, whenever there is an increase in plate voltage, there is a corresponding increase in screen grid voltage. As a result, a tendency for a frequency increase is counter-balanced by a tendency for a frequency decrease, and the frequency of the oscillator output remains substantially constant with a considerable variation in the applied voltages.

The reason for the above described frequency characteristic of the oscillator will be understood by referring to Figs. 9 and 10.

In Fig. 9, the increase in plate current plotted against time for the case of 450 volts on the plate is represented by the curve 63. A similar curve 65 is shown for the case of 470 volts on the plate. As will be understood from the previous description of the oscillator operation, whenever the plate current reaches a value indicated by the dotted line 67, the tube is suddenly biased to cut-off. It will be seen that this value of plate current is reached sooner with the higher voltage on the plate whereby the frequency of oscillation is increased.

Referring to Fig. 10, two plate voltage-plate current characteristic curves of a screen grid tube are shown. The curve 69 shows the characteristic of the tube when the screen grid has 80 volts applied thereto, while the curve 71 shows the characteristic when the screen grid voltage has been increased to 85 volts. As previously explained, the sudden increase in plate voltage, which produces the plate current cut-off, occurs when the plate current increases to a value represented by the peak 73 of the curve 71. This peak in the curve 71 occurs at a later time than does the peak 75 of the curve 69 whereby the frequency of the oscillator output is lower for the higher screen grid voltage.

In Fig. 11, there is shown an embodiment of my invention in which a single tube supplies a saw-tooth wave of current for the deflecting coils of a cathode ray tube indicated at 77. The oscillator preferably comprises a vacuum tube 79 of the screen grid type having a cathode 81, a control grid 83, a screen grid 85 and a plate 87. In one specific embodiment of my invention, a tube was employed having the same general characteristics as the type 224.

The plate 87 is supplied through the primary 89 of a transformer 91 with suitable positive voltage. In the circuit illustrated, the voltage is supplied from a suitable voltage divider 93 connected across a source of rectified and filtered current (not shown). The screen grid 85 is supplied through the secondary 95 of the transformer 91, with a somewhat lower positive voltage, from the voltage divider 93. The screen grid 85 is connected to the plate circuit in the same phase relation as described in connection with Fig. 1.

The plate 87 is coupled through a coupling condenser 97 to the horizontal deflecting coils 99 of the cathode ray tube 77. Preferably, the inductance of the deflecting coils 99 is considerably lower than the inductance of the transformer primary 89, whereby the greater part of the current flow in the plate circuit will be through the deflecting coils and, therefore, be useful current. With this circuit arrangement, the frequency of oscillation is determined mainly by the inductance value of the deflecting coils 99 and by the applied voltages.

The main function of the transformer 91 is not

to make the plate circuit of the tube 79 inductive, but instead merely to transfer the voltage "kick" which occurs in the plate circuit into the screen grid circuit for blocking the tube. It has been found advisable to connect a by-pass condenser 101 between ground and the end of the secondary 95 which is the more remote from the screen grid 85 in order to insure that the tube will oscillate without the reception of synchronizing signals. Otherwise, the plate current would rise to a high value sufficient to injure the tube as soon as synchronizing signals were no longer impressed upon the tube input electrodes. Also, a by-pass condenser 100 may be provided for the plate circuit if desired.

The synchronizing impulses are applied through a coupling condenser 103 to the control grid 83, the control grid being connected to the cathode 81 through a grid leak resistor 105. Certain typical condenser, inductance and voltage values have been indicated on the drawings, but it should be understood that they may be varied within wide limits.

In Fig. 12, a circuit is shown which is similar to the circuit shown in Fig. 11, the main difference being that the voltage impulses supplied by the oscillator tube 79 are applied to a power tube 107 which supplies a saw-tooth current of the proper magnitude for the cathode ray deflecting coils 99. In the two figures, like parts are indicated by the same reference numerals. As in Fig. 11, the main part of the inductance for the plate circuit of the tube 79 is reflected into the primary of the transformer 91, this inductance being provided by the inductance coil 109. Since it is desired that negative voltage impulses be applied to the control grid of the power tube 107, as is well known in the art, for producing the saw-tooth wave of current, the control grid, together with the inductance coil 109, is coupled through a coupling condenser 111 to the screen grid 85 of the oscillator tube. An inspection of Fig. 7 will show that in the screen grid circuit, there are negative voltage impulses of great magnitude.

In Fig. 13, there is shown a slight modification of the circuit shown in Fig. 12. In the two figures, like parts are indicated by the same reference numerals. The main difference between the two figures is that in Fig. 13, the inductance coil 109 has a resistor 113 connected in series therewith, whereby the voltage impulse in the screen grid circuit is given a saw-tooth component. This is due to the fact that a saw-tooth wave of current flows through the inductance coil 109 to produce a saw-tooth voltage wave across the resistor 113, this voltage wave being impressed upon the screen grid circuit through the transformer 119. The shape of the voltage wave applied to the input circuit of the power tube 107 is indicated at 115. As is well known, this is the wave shape desired for producing a perfect saw-tooth wave of current in the deflecting coils 99 since they cannot be made purely inductive.

In Fig. 14, there is shown another form of single tube deflecting circuit. The circuit is the same as the one shown in Fig. 11, except that the secondary 95 of the transformer 91 is connected to the control grid 83 instead of to the screen grid 85, and except that the synchronizing impulses are applied to the screen grid 85 instead of to the control grid. In Figs. 11 and 14, like parts are indicated by the same reference numerals.

The tube 117 shown in Fig. 14 is the one commonly employed in television receiving systems 75

for separating the picture signals from the synchronizing signals. It is biased close to the cut-off point by means of a self-biasing resistor 119 whereby positive synchronizing impulses are passed by the tube while the more negative picture signals are not passed. The plate 121 of the tube 117 is connected to the screen grid 85 of the oscillator tube whereby the plate impedance of the screen grid tube 79 is increased each time a synchronizing impulse appears upon the input circuit of tube 117. The operation of the oscillator shown in Fig. 14, is the same as that of the oscillator shown in the other figures. It will be noted that, in this embodiment of the invention, the control grid 83 is held at a suitable negative bias by means of a self-biasing resistor 123.

My improved oscillator is pulled into step with the synchronizing signals in the same manner whether the synchronizing impulses are applied to the control grid or to the screen grid of the oscillator tube. In either case, a negative synchronizing impulse impressed upon the grid of the oscillator tube causes a sudden increase in the plate impedance of that tube whereby there is produced a voltage impulse in the plate circuit which is transferred into the screen grid circuit (or to the control grid circuit as in Fig. 14), in the proper phase relation to increase the tube impedance still more. This action is accumulative and the tube is rapidly brought to cut-off.

It has also been found that the oscillator may be synchronized by applying positive synchronizing impulses thereto but when synchronized in this manner, the synchronizing impulses must have a considerably greater magnitude than when they have a negative polarity.

From the foregoing description it will be apparent that various other modifications may be made in my invention and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and as are set forth in the appended claims.

I claim as my invention:

1. In combination, a vacuum tube including a cathode, a control grid, a screen grid, and a plate and having a screen grid circuit and a substantially purely inductive plate circuit, means for impressing a positive direct-current potential upon said screen grid, means for impressing a positive direct-current potential upon said plate, and means for so coupling said plate circuit to said screen grid circuit that said screen grid is made negative in response to said plate receiving a positive impulse thereon whereby said tube oscillates at a certain frequency, said screen grid circuit and said plate circuit being non-resonant at said frequency.

2. In combination, a screen grid tube including a control grid, a screen grid and a plate and a substantially purely inductive screen grid circuit and a substantially purely inductive plate circuit, means for applying a positive direct-current voltage to said screen grid, means for applying a positive direct-current voltage to said plate, and means for coupling said plate circuit to said screen grid circuit in such direction that said screen grid is made negative in response to the current in said plate circuit reaching a certain value whereby said tube oscillates at a certain frequency, said screen grid circuit and said plate circuit being non-resonant at said certain frequency.

3. In combination, a vacuum tube including a cathode, a control grid, a screen grid, and a plate and having a substantially purely inductive plate

circuit, means for applying a positive direct-current potential to said screen grid, means for applying a positive direct-current potential to said plate, and a transformer having a primary and a secondary, said primary being included in said plate circuit and said secondary being connected between said cathode and one of said grids in such direction as to make said one grid negative when the current in said plate circuit reaches a certain value whereby said tube oscillates at a certain frequency, said screen grid circuit and said plate circuit being non-resonant at said certain frequency.

4. An oscillator comprising a vacuum tube of the screen grid type having a cathode, a control grid, a screen grid, and a plate, an inductance coil connected between said plate and cathode, means for applying a direct-current voltage to said plate whereby the plate current flow through said coil increases up to a certain value, means for applying a direct-current voltage to said screen grid having a value such that the voltage applied to said plate suddenly increases when said plate current reaches a certain value, and means for applying said voltage increase to said screen grid in reversed phase.

5. In combination, an electric discharge tube having a cathode, a grid, a second grid, and a plate and characterized in that secondary electrons flow from said plate when said second grid has a certain positive voltage applied thereto greater than the voltage on said plate, said tube having a highly inductive plate circuit, a transformer coupling said plate circuit to one of said grids in such direction that said one grid is made less positive in response to said plate being made more positive whereby said tube oscillates at a certain frequency, said plate circuit and said one grid circuit being non-resonant at said certain frequency, and means for applying control voltages to the other of said grids.

6. In combination, an electric discharge tube having a cathode, a grid, a screen grid and a plate, and having a screen grid circuit and a plate circuit, means for applying positive direct-current potentials to said screen grid and to said plate, a transformer having a primary winding and a secondary winding, said primary winding being connected in said plate circuit, said secondary winding being connected in said screen grid circuit in such a direction that said screen grid is made less positive in response to said plate being made more positive, an amplifier tube having input electrodes, an inductance coil having a resistor in series therewith, means for coupling said inductance coil to one of said transformer windings whereby its inductance is reflected into said plate circuit, and means for coupling said amplifier input electrodes to said grid circuit.

7. In combination, an amplifier tube which is selectively responsive to synchronizing signals, said tube having a plate circuit, an oscillator tube having a cathode, a control grid, a screen grid, and a plate, a transformer having a primary and a secondary, said primary being connected between said plate and said cathode, said secondary being connected between said control grid and said cathode in such a direction that said control grid is made less positive in response to said plate being made more positive, and a direct current connection between said amplifier tube plate circuit and said screen grid whereby said screen grid is maintained positive.

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