May 13, 1941. A. D. BLUMLEIN 2,241,762

THERMIONIC VALVE CIRCUIT, PARTICULARLY FOR USE IN TELEVISION

Filed April 26, 1937 2 Sheets-Sheet 1

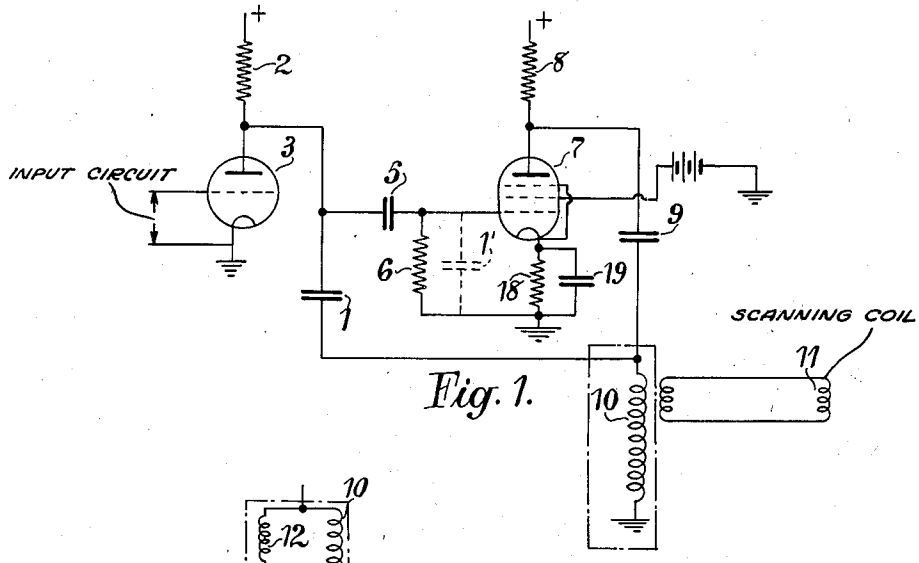


Fig. 1.

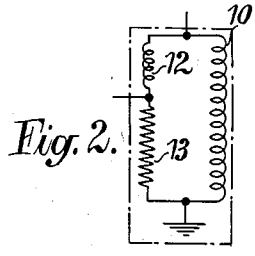


Fig. 2.

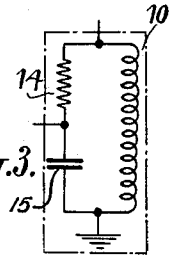


Fig. 3.

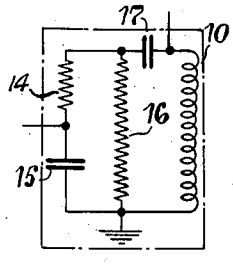


Fig. 4.

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Filed April 26, 1937 2 Sheets-Sheet 2

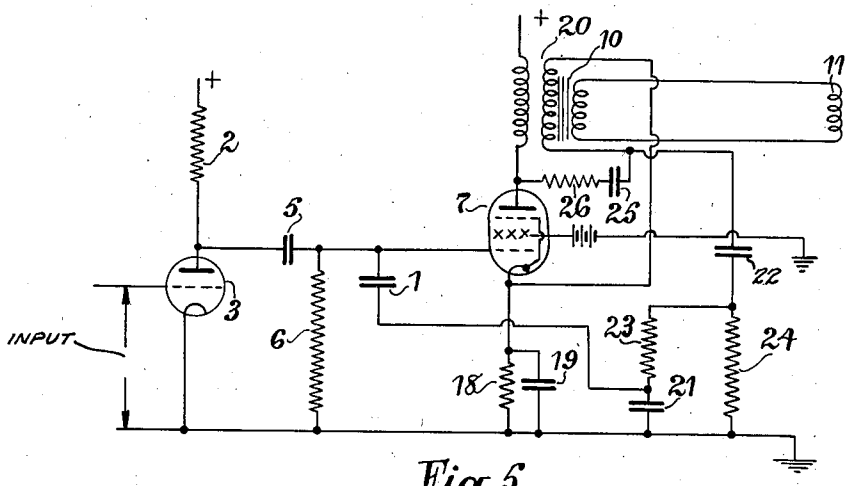


Fig. 5.

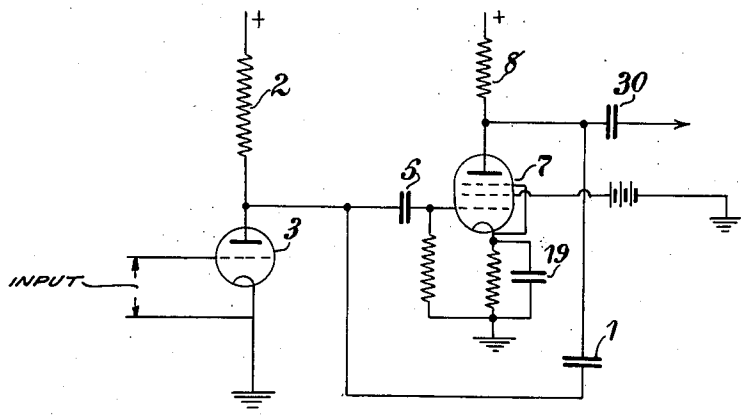


Fig. 6.

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UNITED STATES PATENT OFFICE

2,241,762

THERMIONIC VALVE CIRCUIT, PARTICULARLY FOR USE IN TELEVISION

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Application April 26, 1937, Serial No. 138,951
In Great Britain April 29, 1936

5 Claims. (Cl. 250—36)

This invention relates to thermionic valve circuits particularly for use in television. It is known in television apparatus to employ a thermionic valve to drive a current of substantially saw-tooth wave form through an inductive circuit comprising the scanning coils of a cathode ray tube and in which negative feed-back from the output circuit of the valve to the input circuit thereof is employed to improve the wave form of the saw-tooth current. This negative feed-back is derived from potentials set up across resistances in series with the scanning coils in the output circuit of the valve. This arrangement is to some extent disadvantageous in that, since it is desirable that the feed-back voltage shall be large, the introduction of the resistance in series with the scanning coils from which the feed-back voltage is derived necessitates an increased voltage output from the valve.

Furthermore, such feed-back is effective in increasing the apparent impedance from which the circuit is fed, which has the effect if an output transformer is employed to feed the scanning coils, of increasing distortion due to the finite inductance of the transformer, that is, the valve tends to supply a perfect saw-tooth current to the transformer primary of which some is lost in magnetising current for the transformer, so that the resultant output current to the scanning coils is not a good saw-tooth.

It is the chief object of the present invention to provide an improved thermionic valve circuit employing negative feed-back for the purpose of correcting wave form in which this disadvantage is reduced or avoided.

According to the present invention a thermionic valve circuit is provided comprising a source of potential adapted to feed the input circuit of an amplifying or driving valve, the output circuit of which is adapted to feed saw-tooth current or voltage to a scanning device and a circuit in parallel with said output circuit device arranged to feed-back in the negative sense to the input circuit of the amplifying or driving valve substantially saw-tooth potentials derived from potentials developed across the output circuit. The scanning device may either comprise the coils of an electro-magnetic scanning arrangement or the plates of an electrostatic scanning arrangement. Preferably, the saw-tooth wave form is generated by charging a condenser or condensers which is or are discharged at intervals, the charging or discharging being effected at one side of the condenser or condensers, the other side of the condenser or of some or all of the condensers being fed with potentials derived from potentials across the output circuit as aforesaid. There may be at least two condensers which are charged and discharged at intervals, which are arranged to form a potentiometer in respect of the potentials derived from the potentials developed across the output circuit. When employed for magnetic scanning, the negative feed-back potential applied to the condenser is substantially proportional to the scanning current and in the case of electro-static scanning the negative feed-back potential is proportional to the potential across the electrostatic scanning plates.

Preferably, in connection with electro-magnetic scanning, the output of the amplifying or driving valve is applied to the scanning coils through the medium of an output transformer. Distortion occurs in such cases at low frequencies owing to the inductance of the transformer not being sufficiently high, and this difficulty is avoided in the present invention by employing the negative feed-back to the input of the amplifying valve.

The method of carrying the invention into practice will be readily understood from the accompanying drawings in which:

Fig. 1 is a circuit diagram of an arrangement according to the invention for use with an electrically controlled scanning device,

Figs. 2, 3 and 4 show modifications which may be effected in the circuit arrangement of Fig. 1,

Fig. 5 is a circuit diagram corresponding to Fig. 1, in which a different type of connection is used for deriving the feed-back potential according to the invention, and

Fig. 6 is a circuit diagram of an arrangement according to the invention for use with an electrostatically controlled scanning device.

Referring to Fig. 1, it will be seen that the arrangement therein shown comprises a condenser 1 arranged to be charged over a resistance 2 from a source of positive potential connected to the resistance as indicated by the + sign above it. Connected to one end of the resistance 2 in parallel with condenser 1, is the anode of a discharger valve 3 of which the anode cathode path is made periodically conducting, for example, under the influence of control pulses applied to the control grid. The valve 3 may be arranged in a circuit to function as a blocking oscillator. The anode of the valve 3 is coupled through a condenser 5, and leak resistance 6, to the control grid of the amplifying or output valve 7, shown as a screen grid pentode. The anode circuit of

valve 7 includes resistance 8 which is connected at one end to the positive terminal of a high tension source, and at its other end to condenser 9. Condenser 9, together with condenser 1, is connected to the primary winding of output transformer 10, of which the secondary winding is connected to the scanning coils indicated generally by the inductance 11 of a cathode ray tube television receiver. The lower end of the primary winding of transformer 10 is connected to earth. A suitable biasing resistance 18 with by-pass condenser 19 may be provided in the cathode lead of the valve 7 as shown. It will be seen that in this arrangement, as the condenser 1 is charged and discharged due to the operation of the discharger valve 3, the condenser being charged positively, the increase of current in valve 7 causes the upper end of the primary winding of the transformer, to which the condenser 1 is connected, to assume a negative potential thus neutralising the greater part of the change of voltage across the condenser. So long as the upper end of the transformer primary winding rises uniformly in potential, a saw-tooth input will be applied to the control grid of the output valve 7. If, however, due to the inductance of the transformer 10 the rise of potential at the upper end of the primary winding is less rapid than a true saw-tooth, a relative increase of potential occurs on the anode of the valve 3, with a consequent increase of current from the valve 7 tending to neutralise this departure from a true saw-tooth wave form. A similar effect will occur due to distortion in the valve 7. Since the ambit of potential on the anode of the valve 3 is only the grid swing applied to the valve 7, despite the large voltage accumulated on the condenser 1, the current flow through the resistance in the anode circuit of the valve 3 is nearly uniform whereby a substantially true saw-tooth output is obtained. It will be appreciated from the above description of a circuit in accordance with the invention that a potential derived from potentials developed across the output circuit is fed back in the negative sense to the input of the amplifying valve 7, such potential being derived from a circuit in parallel with the scanning coils.

If desired, the condenser 1 may be supplemented by another condenser connected between the grid of the amplifying valve 7 and earth. This forms, in effect, an additional capacity from which saw-tooth potential is derived, but which does not have the feed-back voltage applied to it. The arrangement comprising condensers 1 and 1' then forms a potentiometer in respect of the feed-back voltage. The condenser 1 might also be replaced by a capacity made up by a number of condensers arranged in any convenient way.

The circuit described is useful for slow scanning speeds where the chief difficulty is introduced by the finite inductance of transformer 10. At slow scanning the secondary circuit of the transformer is substantially resistive and the arrangement shown tends to maintain a saw-tooth potential across the primary of transformer 10. If this primary has low resistance, the magnetising current will not materially affect the saw-tooth output, and the maintenance of a saw-tooth potential across the primary will produce a saw-tooth current in the resistive secondary.

Whilst the circuit described above operates satisfactorily provided the leaking inductance of the transformer 10 and the inductance 11 of the scanning coils is negligible compared with the resistance of the coils and transformer windings, distortion of wave form may occur particularly during the return stroke of the saw-tooth, which, being rapid, causes the inductance of the windings to be effective. In order to overcome this difficulty, the arrangement shown in Fig. 2 may be adopted. In this arrangement the primary winding of transformer 10 is shunted by an inductance 12 and resistance 13 in series, the condenser 1 being connected to the junction between the inductance 12 and resistance 13. By adjusting the ratio of the inductance 12 and resistance 13 to the same order as the ratio of the inductance and resistance of the scanning coils, including any leakage inductance and resistance of the windings of transformer 10, the voltage developed across the resistance 13 is strictly proportional to the current in the scanning coils 11. Under these conditions, the negative feed-back serves to produce a more true representation of the saw-tooth wave form in the scanning coils, providing the output valve 7 is capable of delivering the necessary current. By making the capacity of the condenser 1 very small, it is possible to draw the necessary discharging current of this condenser through the shunt resistance 13 without the shunt resistance and inductance constituting a serious current shunt across the transformer primary winding.

It will be understood that the arrangement of Fig. 2 can be substituted bodily for a portion of the circuit of Fig. 1 and for this purpose there has been enclosed in a broken line the section of Fig. 1 which is replaceable by the arrangement of Fig. 2 or Fig. 3 or Fig. 4, and Figs. 2, 3 and 4 have been enclosed in a broken line to show the part thereof bodily substitutable for the portion of Fig. 1 also enclosed in a broken line.

If desired, instead of employing a shunt inductance and resistance as shown in Fig. 2, the inductance 12 may be replaced by a resistance 14 and the resistance 13 by a condenser 15, as shown in Fig. 3. In this arrangement the time constant of the resistance 14 and condenser 15 is made of the same order as the time constant of the inductance and resistance of the scanning coils 11, including leakage inductance and resistance of the transformer 10.

If the resistance of the primary winding of transformer 10 is relatively high, a further correction for wave form distortion, which may occur particularly at the frame scanning frequency, may be effected with the last-mentioned circuit by inserting as shown in Fig. 4, a shunt resistance 16 across the resistance 14 and condenser 15 in series and by inserting a further series condenser 17 between the upper end of the primary winding of the transformer 10 and the series resistance 14 and condenser 15 and the shunt resistance 16. The shunt resistance 16 represents the shunt inductance of the transformer 10 and the additionally inserted condenser the resistance of the primary winding of the transformer 10.

In Fig. 4 the condenser 17 corresponds to the primary resistance of transformer 10, the resistance 16 corresponds to the primary inductance of transformer 10, the resistance 14, corresponds to the leakage inductance of transformer 10 plus the inductance of the scanning coils and the condenser 15 corresponds to the resistance of transformer 10 plus the resistance of the scanning coils. In order to fix

these values, the resistance and leakage inductance of the secondary and the resistance and inductance of the scanning coils, must be transferred to the primary in well known manner. The impedance representing various transformer and coil impedances described above, are then multiplied by the factor

$$\frac{k}{j\omega}$$

to determine the approximate values of **14**, **15**, **16** and **17**. It will be realised that multiplication by this factor converts inductances into resistances and resistances into condensers. The factor k is a numeric factor to give convenient values to the components and the factor may be determined by fixing condenser **15**. It should be noted in this respect that condenser **1** is in effect almost in parallel with condenser **15**, because the end of condenser **1** remote from **15** executes a comparatively small potential variation as compared with the end of condenser **1** connected to condenser **15**. In making a rough design of the circuit, condenser **1** may therefore be considered as being part of condenser **15** and the nominal value of condenser **15** is rated as the sum of these two condensers in parallel. In practice it has been found convenient to make condenser **1** of the same order as condenser **15**, but wide variations may be made from this ratio and the circuit has been found to operate quite satisfactorily in the absence of condenser **15**, condenser **1** then performing the function of condenser **15**. The size of condenser **1** is usually fixed at a convenient value to be discharged by the discharging valve such as **3** in Fig. 1. Once k has been determined the other component values may be fixed approximately and may later be adjusted to give a good performance. In practice it has been found that adjustment of resistance **14** produces a good "return stroke" or "fly back," and adjustment of resistance **16** allows the forward wave-form to be adjusted to give a good saw-tooth. The resistance **16** and condenser **17** to correct for the primary inductances and resistance of transformer **10** is necessary only for slow scanning circuits such as frame frequency scanning circuits used for television.

Instead of using the arrangement as described above, the feed back according to the invention may be obtained from a third winding on the transformer **10**, for example as shown at **20** in Fig. 5. The arrangement of Fig. 5 comprises a discharger valve **3** arranged similar to the corresponding element of Fig. 1, and also a blocking condenser **5** and coupling resistance **6** in the control grid circuit of valve **7** in the output circuit of which a transformer is arranged. In this figure, however, the condenser **1** of Fig. 1 the charging and discharging of which generates the saw-tooth waveform, is connected on the output side of condenser **5** in place of the input side as in Fig. 1. Since condenser **5** is merely a blocking condenser of a value large enough not to materially affect the operation of the circuit, the choice of this connection is of no importance. Condenser **5**, however, can in the arrangement of Fig. 5 be made small enough to give a certain degree of potentiometer effect between the anode of valve **3** and the grid of valve **7**. Basically this circuit consists of a connection between the end of condenser **1** remote from the grid of **7** and the end of the additional winding in like manner to the connection to the end of the primary shown in Fig. 1. Such a direct connection would produce feed-back which would tend to produce a saw-tooth E. M. F. in the secondary winding of transformer **10**. For use at high scanning frequencies, however, or in order to obtain a good "return" or "fly-back" time, it is necessary to take into account the leakage inductance of the secondary winding and the inductance of the scanning coils **11**. Resistance **23** which corresponds to these inductances and condenser **21** which is effectively in parallel with condenser **1** and corresponds to the resistance of the secondary circuit, have been inserted in like manner to those in the modification shown in Fig. 3. In practice resistance **23** is adjusted to give a good "return" or "fly back." If the inductance of transformer **10** is high, the feed back effect should be sufficient to produce a good forward stroke. If however a very good waveform is required or the inductance of the transformer **10** for reasons of economy and due to the effect of the anode current of the valve passing through it, is not sufficiently high to enable the feed back to correct the effects produced by it, a resistance **24** and condenser **22** may be inserted, whose function is to reduce the feed back for the very low frequencies. This has the effect of increasing the effect of low frequencies at the grid of valve **7**, so correcting any remaining errors of waveform due to the finite inductance of transformer **10**. It has been found with this circuit that if the condenser **19** which decouples the biasing resistance **18** in the cathode, is not made sufficiently large, a very low frequency oscillation is likely to take place, especially in the absence of any controlling signals on the grid of tube **3**. It has been found that returning the earthy end of the tertiary winding **20** direct to the cathode instead of to earth, reduces this unwanted effect. Furthermore it has been found in practice that during the return stroke the capacity between the primary and tertiary winding, together with their leakage inductance has produced an oscillation. This has been prevented by the introduction of condenser **25** and resistance **26**. The values of these components are not critical and satisfactory values are given by making the resistance **26** approximately equal to the sum of the resistances of the primary plus the tertiary winding of the transformer and making the condenser equal to the leakage inductance in the primary and tertiary windings, divided by the square of the value given above for resistance **26**. In applying the invention to the above case, the feed back voltage is usually considerably greater than the voltage applied to the grid of the tube **7**, so that the saw-tooth voltage developed across condenser **1** is quite large compared to the input to the valve. Resistance **2** must therefore be proportioned to provide the necessary current to charge the condenser **1** during a cycle. This however does not tend to produce marked exponential charging of condenser **1**, due to the fact that the end of condenser **1** towards resistance **2** is not subjected to a large voltage variation, so that there is substantially a fixed potential across resistance **2** during the charging of condenser **1**, so that the current through resistance **2** is substantially constant. The value of resistance **2** can be found by trial and error so as to give the required output. A practical cir-

cuit for scanning at 50 cycles was found to have the following values—

Primary inductance of transformer 10	90 henries
Ratio primary to tertiary (winding 20) of transformer 10	1:1
Resistance of primary winding of transformer 10	4000 ohms
Resistance of tertiary winding of transformer 10	7000 ohms
Combined resistance of secondary and scanning coils transferred to primary winding of transformer 10	5000 ohms
Combined secondary leakage inductance and coil inductance transferred to primary winding of transformer 10	7 henries
Condenser 1	.005 micro-farad
Condenser 21	.02 micro-farad
Resistance 23	100,000 ohms maximum (adjustable)
Resistance 24	1 megohm maximum (adjustable)
Condenser 22	.2 micro-farad
Condenser 25	.02 micro-farad
Resistance 26	20,000 ohms
Resistance 2	2 megohms
Resistance 18	250 ohms
Resistance 19	250 micro-farad

(N. B. In designing the circuit the resistance of the tertiary winding 20 should be included with that of resistance 23)

The screen was decoupled from the cathode by a condenser of 8 micro-farads capacity.

The output was controlled by varying the voltage applied to the upper end of resistance 2. In practice it has been found that the valve 3 can be a tetrode, the screen and grid being coupled together through transformer coils, which together with a condenser and leak in the grid circuit, makes the valve 3 perform blocking or relaxation oscillations, so that it is intermittently conducting, thus performing on its anode the necessary charging and discharging of condenser 1. For very rapid scanning circuits, the transformer inductance may be considerably reduced and condensers 22 and 24 omitted. Similarly, smaller values for condenser 1 may be employed. If desired, condenser 1 may be considerably increased and condenser 21 omitted, as explained above in connection with Fig. 4. The value of the components may in practice be found either by calculation or by trial and error.

Where the invention is applied to an electrostatic scanning arrangement, a transformer such as 10 in Fig. 1 is not required and may be omitted together with the capacity such as 9 in Fig. 1, as shown in Fig. 6. In this example, the anode of the amplifying valve 7 is connected to the scanning plates of a cathode ray tube (not shown) through the condenser 30, and to one plate of the condenser 1 as shown. Thus again, the sawtooth potential developed on condenser 1 is applied to the grid of tube 7 and the anode potential of tube 7 is fed back to the condenser. In this case, the capacity of the condenser 1 is made small, to increase its rate of potential rise as described above. Suitable values for the capacity of condenser 1 are 20 $\mu\mu$f. for line frequency and .001 μf. for frame frequency.

Preferably the condenser 1 in Fig. 6 is subdivided and only part of the capacity is included in the anode circuit of the valve 7. To effect the sub-division a further condenser such as 1'', may be added, the capacity of which is preferably greater than that of the condenser at the point indicated by numeral 1 in the drawing. With this arrangement, the whole output voltage of the valve 7 is not used for feed-back purposes.

I claim:

1. Apparatus for producing a serrated wave form comprising a first means for storing electrical energy, a source of uni-directional current, inductive means connected serially with said first means for storing electrical energy, a series circuit including said source of uni-directional current, said first means for storing electrical energy and inductive means, a discharge path for said first means for storing electrical energy, said discharge path being connected substantially in parallel with said first means for storing electrical energy and said inductive means, a second electrical energy storage means connected serially with said inductive means, a source of unidirectional current connected serially with said second electrical storage means and said inductive means, a thermionic tube having an anode, a cathode and at least one control electrode, said second electrical storage means and said inductive means being connected in the anode-cathode circuit of said thermionic tube, and means for impressing variations in the potential of said first electrical storage means onto the control electrode-cathode path of said thermionic tube.

2. Apparatus in accordance with claim 1 wherein there is provided in addition a time constant circuit common to both the anode-cathode and the control electrode-cathode path of said thermionic tube.

3. Apparatus in accordance with claim 1 wherein there is provided in addition resistive means connected serially with said first electrical storage means, said source of uni-directional current and said inductive means.

4. Apparatus in accordance with claim 1 wherein a discharge path connected substantially in parallel with said first electrical storage means and said inductive means comprises the space charge path of a thermionic tube.

5. Apparatus in accordance with claim 1 wherein there is provided in addition a time constant circuit connected in the control electrode-cathode path of said tube.

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