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THERMIONIC VALVE AMPLIFIER

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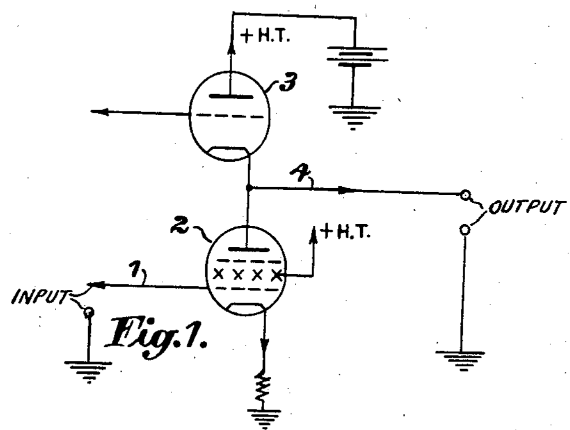

Fig.1.

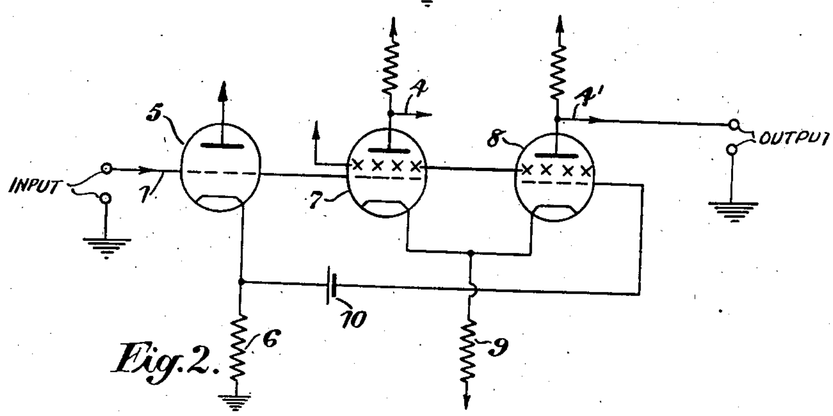

Fig.2.

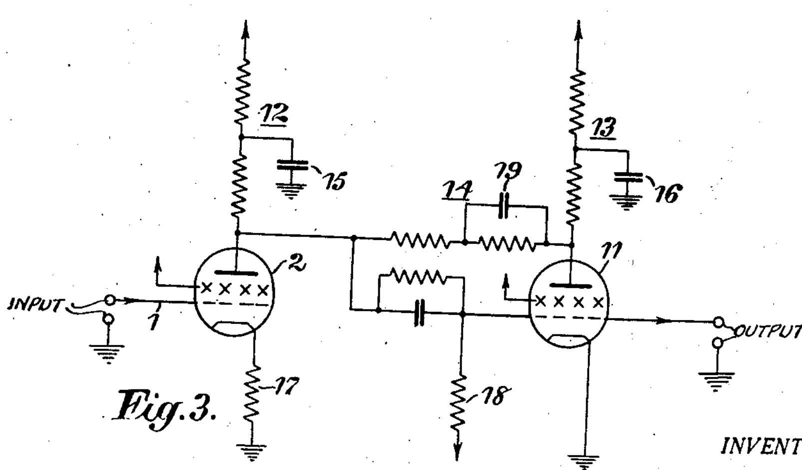

Fig.3.

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THERMIONIC VALVE AMPLIFIER

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7 Claims. (Cl. 250—27)

This invention relates to thermionic valve amplifiers and has particular, although not exclusive, reference to amplifiers employed in television systems in which picture films are transmitted.

It is well known that if the brightness of the image points viewed upon a cinema projection screen are directly proportional to the points of the object from which they are derived, then the picture viewed will appear flat and lack brilliance. It is, therefore, the practice to develop picture films in such a manner that detail in the lighter or less opaque portions of the positive prints is emphasised relatively to the detail in the darker or more opaque portions. A film developed in this manner is said to be developed to a gamma or intensity contrast of value greater than unity and when projected upon a screen the images derived from such a film possess more brilliance and detail than images projected from a film of intensity contrast equal to unity. The gamma or intensity contrast value employed is usually between 1 and 2.

In the case of subjects transmitted directly by television, although the pictures normally require a gamma of between 1.5 and 2.0 so as to produce a pleasing effect, it is usual to transmit television signals at a gamma of approximately unity and to allow the necessary correction to be effected at the receiver, usually by utilising the curved characteristic of the receiving cathode ray tube.

When a picture film is transmitted by means of a camera of the iconoscope type, the transmitting tube, at the high light intensities used, tends to reduce the gamma below unity and thus reduces the intensity contrast of the film so that no correction is required before transmission. When a mechanical or other linearly operating system such as a cathode ray scanning tube and photo-cell is employed, the output from the scanning device will have the same gamma as that of the film which is scanned. As most commercial films have a gamma of between 1.5 and 2.0, some provision must be made for gamma correction unless special films are employed. The required correction represents the introduction of a fractional power conversion law between the input and the output and known forms of circuit arrangement for gamma correction do not provide for the easy operation of such a conversion law. The curvature of the normal valve characteristic is opposite to that required, namely, a power law between 1.5 and 2.0, and the object of the present invention, therefore, is to provide alternative forms of circuit arrangement which enable an approximately fractional power law between input and output to be obtained.

According to the present invention, a circuit arrangement for providing an output representing a fractional power of an input includes a thermionic valve through which current proportional to the input is caused to flow, the connections in the circuit being such that the output is determined by the relative potentials of the grid and cathode of the valve.

In a particular circuit arrangement according to the invention the current fed to the cathode of said valve is arranged to be constant and its control grid is maintained at a fixed potential, the output being taken from the cathode. The operation of the circuit is such that the current through the valve is substantially a linear reproduction of the input, the linearity being ensured by the provision of negative feedback and the output is determined by the relative potentials of the grid and cathode of the valve.

The cathode of the valve may be fed from the anode of a second valve of high anode impedance, said second valve being operated in a substantially linear manner as by the insertion of a resistance in its cathode lead, and the arrangement being such that the current through the first valve is proportional to the input and the departure of the grid-cathode potential from the anode current cut-off value is proportional to a fractional power of the anode current with the result that the output at the cathode of the first valve represents a fractional power of the input.

In another form of circuit arrangement embodying the invention a resistance is connected in the cathode lead of the first-mentioned valve and the output is taken from the cathode to a pair of valves connected in push-pull and having a common cathode resistance so that the differences of potential applied to their grids are amplified and not the absolute potential of the cathode and grid.

In order that the invention may be more clearly understood and readily carried into effect, alternative forms of circuit arrangement embodying the invention will now be described by way of example with reference to Figures 1, 2 and 3 of the accompanying drawing.

Referring to Figure 1 of the drawing, **1** represents an input lead to the control grid of a pentode valve **2**, the anode of which is connected to the cathode of a valve **3**. The grid voltage/anode current characteristic of the valve **3** has a power law greater than 1, and the power law is employed to give an output at the lead **4** which is a fractional power of the input. The leads to the anode of the valve **3** and the screening grid of the valve **2** are connected to suitable sources of high tension supply and the lead to the control grid of the valve **3** is connected to a suitable source of bias potential. It is assumed that the steady potential at the control grid of the valve **2** is maintained at a suitable value by a D. C. coupling from the input source or by reestablishment of the direct current component at the grid.

The valve **2** to which the input signals are applied is made to operate in a linear manner as, for example, by the insertion of a resistance (not shown) in the cathode lead. The current through the valve **3** due to the high impedance of the pentode valve **2** is, therefore, proportional to the input and since the departure of the grid/cathode potential from the cut-off value is proportional to a fractional power of the anode current, the output at the lead **4** will represent a fractional power of the input.

In the arrangement of Figure 1, picture black will be represented by a low current value from the valve **2** and picture white will be represented by a high current value. In order to obtain the complete power law it would be necessary to adjust the bias potential applied to the valve **3** so that it would be at the threshold of anode current cut-off for signals representing picture black. Such an adjustment would, however, necessitate operating at a point in the characteristic curve corresponding to a picture black with a very high impedance facing the output lead **4** with consequent large loss of response at high frequencies. In practice, therefore, it is necessary to operate the valve **3** so that it passes a small current for picture signals representing black.

The operating range for the valve **3** is selected to extend over a part of the characteristic curve of the valve exhibiting the necessary curvature in terms of grid voltage required against anode current supplied. A sharp curvature over the initial portion of the curve can be obtained by operating the valve **3** with as low an anode voltage as possible consistent with the transmission of the necessary signal without undue heating due to the flow of grid current. In practice also it is not possible to operate the valve **2** in a linear manner at zero current and it is, therefore, necessary either to have an initial operating condition with a small standing current, or to connect a resistance between the output lead **4** and a sufficiently highly positive point in a source of high tension supply to cause sufficient standing current to render the output of the valve **2** linear. Alternatively, a diode may be used in place of valve **3**, the anode of the diode replacing the grid and being taken to a fixed potential. In practice, however, diodes tend to give a very rapid curvature followed by a substantially linear characteristic, and are not, therefore, so suitable as valves containing a grid.

Figure 2 shows a system in which negative feedback is utilized to cause the input valve **5** to pass current proportional to the value of the input applied between grid and cathode by means of a high resistance **6** connected in the cathode lead. Assuming an initial operating condition at which a small current is flowing through the valve **5** for picture signals representing black, if the value of the resistance **6** is sufficiently high, positive increments in the input will cause increase in current flowing in the valve **5** proportional to the input signals. As the valve **5** has a power law greater than 1 connecting its anode current and the departure of the grid/cathode potential from the cut-off value, the grid/cathode potential of the valve **5** for linear signal current changes will be a fractional power of the input. The difference of potential is passed to the valves **7** and **8** connected in push-pull and having a common cathode resistance **9** so that they amplify differences of potential applied to their grids but do not amplify on account of the high resistance **9**, the absolute potential of the cathode and grid. The output signal thus appears at the anode of both valves **6** and **7** and can be taken away from the leads **4**, **4'** separately or simultaneously from both in push-pull. A push-pull arrangement of the output is more satisfactory due to the difficulty of completely eliminating the absolute potential of the cathode and grid of valve **5**, as the resistance **9** cannot be made infinite and is always shunted by the capacity of the cathodes of the valves **7** and **8**. The battery **10** indicates a suitable source of bias potential for the control grid.

Figure 3 shows an arrangement in which current is fed from the anode of the valve **11** corresponding with valve **3** in Figure 1 and **5** in Figure 2, back to its control grid. Anode resistances **12** and **13** connected to the valves **2** and **11** respectively and the feedback coupling resistance **14** are made composite with the same ratios of decoupled and undecoupled resistances and the same time constant of condensers **15**, **16**, **19** and resistances which they shunt. These anode connections permit a direct current coupling of the kind described in the specification of British Patent No. 456,450 to be employed between the anode of the input valve **2** and the control grid of valve **11**. The valve **11** is arranged to pass nearly zero standing current at input signal levels representing picture black. The input signals are applied to the lead **1** with signal amplitudes representing white in the negative direction and linear current changes in the valve **2** are produced due to the feedback resistance **17** in the cathode lead. Changes of current at the anode of the valve produce increments of current in the valve **11** and these increments tend to oppose the voltage applied to the grid of the valve **11**. When the feedback from valve **11** to its control grid is sufficiently great, changes of current from the valve **2** are opposed by changes of current from the valve **11** so that as before the current flowing through the valve **11** is approximately a linear replica of the input voltage at **1**. The required condition that the voltage at the grid of the valve **11** shall be a fractional power of the input voltage is, therefore, obtained.

In one circuit arrangement anode resistance **13** is made infinite and the resistance **14** is made zero so that all current from the valve **11** is fed back. Such an arrangement renders rather critical the setting of the exact operating point on the characteristic curve of valve **11**. In an alternative arrangement, therefore, the resistances **13** and **14** may be made about equal so that effectively half the current from the valve **11** is fed back to the anode of valve **2**. The potential at the lower end of the grid leak resistance **18** may be selected so that the standing current in the valve **11** will be near the cut-off value at picture signals representing black. The action tending to lessen the gamma value may be reduced by operating the valve 11 to pass more current at black signal levels and by inserting a resistance between its cathode and earth in order to obtain the same output range for the picture black, to picture white signal input range applied at 1.

I claim:

1. A thermionic amplifier circuit comprising a thermionic tube having a cathode, a control electrode and an anode, a source of signal energy, means to maintain current flow through said tube proportional to the amplitude of said signal energy, means to develop a non-linear potential difference between said control electrode and cathode, said non-linearity being with respect to the amplitude of said signal energy, and means for deriving output energy in accordance with said potential difference.

2. A thermionic amplifier circuit comprising a thermionic tube having a cathode, a control electrode and an anode, a source of signal energy, thermionic means to maintain current flow through said tube proportional to the amplitude of said signal energy, means to develop a non-linear potential difference between said control electrode and cathode, said non-linearity being with respect to the amplitude of said signal energy, and means for deriving output energy in accordance with said potential difference.

3. A thermionic amplifier circuit comprising a thermionic tube having a cathode, a control electrode and an anode, a source of signal energy, means to maintain current flow through said tube proportional to the amplitude of said signal energy, thermionic means to develop a non-linear potential difference between said control electrode and cathode, said non-linearity being with respect to the amplitude of said signal energy, and means for deriving output energy in accordance with said potential difference.

4. A thermionic amplifier circuit comprising a thermionic tube having a cathode, a control electrode and an anode, a source of signal energy, thermionic means to maintain current flow through said tube proportional to the amplitude of said signal energy, thermionic means to develop a non-linear potential difference between said control electrode and cathode, said non-linearity being with respect to the amplitude of said signal energy, and means for deriving output energy in accordance with said potential difference.

5. A thermionic amplifier comprising a power supply, a first thermionic tube having a cathode, a control electrode and an anode, a resistance connected between said power supply and said cathode, a second thermionic tube having a cathode, a control electrode and an anode, means to connect the cathode of said second tube to the anode of said first tube, means to supply energy from said power supply to the anode of said second tube, means to supply signal energy to the control electrode of said first tube, means to maintain the control electrode of said second tube at a substantially constant potential, and means to derive output energy from between said connecting means and the junction point of said power supply and said resistor.

6. An amplifying system comprising a first thermionic tube having a cathode, a control electrode and an anode, the source of energy for energizing said anode, an impedance path connected between said cathode and said source of energy, a source of signal energy connected to said control electrode, a push-pull stage of thermionic tubes, each of said tubes having at least a cathode, a control electrode and an anode, a direct connection from said source of signal energy to the control electrode of one of the said push-pull tubes, a connection from said impedance path to the control electrode of the other of said push-pull tubes, and means to derive output energy from both of the anodes of said push-pull tubes.

7. A thermionic amplifying system comprising a first thermionic tube having at least a cathode, a control electrode and an anode, means to supply signal energy to the control electrode of said tube, means to supply energy to the anode of said tube, an impedance path connected between the cathode and said source of energy, a second thermionic tube having at least a cathode, a control electrode and an anode, coupling means between the anode of said first thermionic tube and the control electrode of said second thermionic tube, further coupling means between the anode of said first thermionic tube and the anode of said second thermionic tube, and means to derive output energy between the control electrode and the cathode of said second thermionic tube.

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