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G. S. P. SCANTLEBURY

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THERMIONIC VALVE AMPLIFIER CIRCUIT ARRANGEMENT

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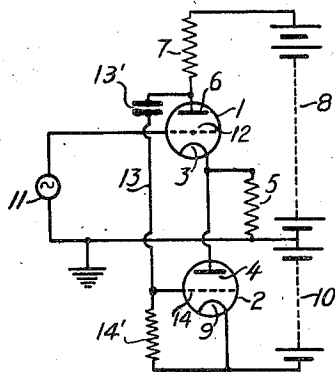


Fig. 1.

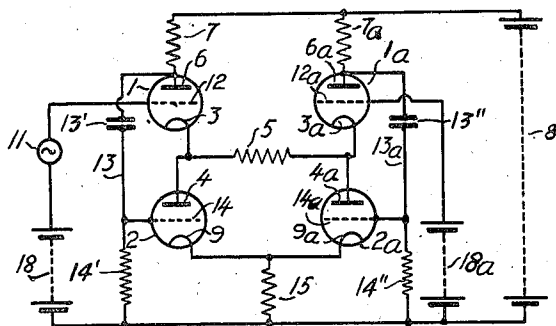


Fig. 2.

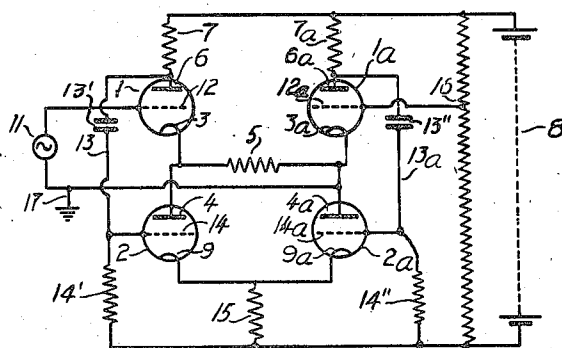


Fig. 3.

INVENTOR.
GORDON S. P. SCANTLEBURY.

BY

H. S. Snover

ATTORNEY.

UNITED STATES PATENT OFFICE

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THERMIONIC VALVE AMPLIFIER CIRCUIT
ARRANGEMENT

Gordon Sidney Pengelly Scantlebury, Ealing,
London, England, assignor to Electric & Musical
Industries Limited, Hayes, Middlesex, Eng-
land, a company of Great Britain

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This invention relates to thermionic valve amplifier circuit arrangements and more particularly to improvements in or modifications of the circuit arrangements claimed in U. S. Patent No. 2,358,428, granted to E. L. C. White, Sept. 19, 1944.

In said patent there is claimed a circuit arrangement comprising a thermionic valve and a load arranged in a cathode follower circuit, means for applying signals to the control electrode of said valve, a further valve having its output circuit arranged to feed current to said load in opposite sense to the current fed thereto by said first-mentioned valve, said further valve also being arranged to be controlled by said signals, the arrangement being such that if the current flowing through said load under the control of said first-mentioned valve is caused to increase on the application of said signals, the current flowing through said load under the control of said further valve is caused to decrease and vice versa.

Arrangements of this kind have the practical disadvantage that either separate sources of anode power have to be provided for the two valves, or alternatively, a single source of power with a low impedance tapping has to be provided.

The object of the present invention is to provide an improvement in or modification of the cathode follower circuit claimed in the patent in which a single source of anode current power without a low impedance tapping point can be used.

According to the invention there is provided a circuit arrangement comprising a first and a second pair of similar valves, the anode to cathode paths of the valves of each pair being arranged in series in the same sense across a single source of anode voltage, a load circuit arranged to receive current in opposite senses from the valves of each of said pairs of valves and means for applying signals to said valves so that the valves of each pair are excited in opposite phase and the contributions of all said valves to the signal current through said load are additive.

In order that the invention may be more fully understood it will now be described, by way of example, with reference to the accompanying drawing in which:

Figure 1 shows a cathode follower circuit arrangement forming the subject matter of the patent above referred to,

Figure 2 shows a circuit arrangement of one form of the present invention, and

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Figure 3 shows an alternative circuit arrangement according to the present invention.

In each of these figures some elements, such as blocking condensers and leak resistances, which are not necessary to an understanding of the invention have been omitted for simplicity.

Referring now to Figure 1, it will be seen that the arrangement comprises valves 1 and 2, the cathode 3 of valve 1, the anode 4 of valve 2 and one terminal of the load 5 being connected to a common point and the other terminal of said load 5 is earthed. The anode 6 of valve 1 is connected through resistance 7 to the positive pole of a source of anode potential 8, the negative pole of which is earthed. The cathode 9 of valve 2 is connected to the negative pole of the source of anode potential 10, the positive pole of which is earthed. The signals to be amplified, provided by a source of signals shown diagrammatically at 11, are fed to the grid 12 of valve 1 and similar signals reversed in phase which appear at the anode 6 are fed by condenser 13' and the conductor 13 to the grid 14 of valve 2 so that valves 1 and 2 are excited in opposite phase. The grid 14 is returned to cathode 9 through grid leak resistor 14', as shown in the aforesaid patent. As explained in the patent referred to, this circuit arrangement presents to the load 5 a lower impedance than would be presented by valve 1 or valve 2 in the usual cathode follower circuit.

It will be observed, however, that the circuit arrangement shown in Figure 1 requires two separate sources of anode voltage 8 and 10, which is inconvenient in practice. If a single source of anode voltage having an intermediate tapping point were to be used, considerable currents would flow in operation to and from the tapping point, and the arrangement would have to be such as to provide a low effective impedance at the tapping point as otherwise undesirable changes in anode voltage applied to valves 1 and 2 would occur. Although such a single source of anode voltage with a low impedance intermediate tapping point might be devised, it would be complicated and expensive.

This difficulty of anode power supply may, however, be overcome according to the present invention by adopting the circuit arrangement shown in Figure 2, in which elements corresponding to elements of Figure 1 having been given similar reference numerals. It will be seen that this circuit consists of two pairs of valves 1, 2, 1a, 2a each pair similarly arranged substantially in accordance with the arrangement of Figure 1 except that the terminal of the load 5 which was

formerly earthed is now connected to the common point of the cathode 3a and anode 4a of valves 1a, 2a respectively, and further, that a resistance 15 is connected in the cathode leads of valves 2, 2a between the cathodes 9, 9a and the negative poles of the batteries 18, 18a. It should also be observed that the negative pole of the source of anode voltage 8 is no longer connected to the load, but is instead connected to the end of resistance 15 remote from the cathodes 9, 9a, so that the anode to cathode paths of each pair of valves are arranged in series in the same sense across said source 8. Each of grids 14 and 14a is connected to the negative end of current source 8 through respective grid leak resistors 14' and 14''. Condensers 13' and 13'' are inserted in respective leads 13 and 13a.

With this arrangement, the signals applied to the grid 12 of valve 1 by the source of signals 11 excite the valve 2 in opposite phase as described with reference to Figure 1. The resultant currents fed by valves 1 and 2 through the load 5 flow through the effective cathode impedance of valve 1a with its associated valve 2a, and the voltage drop of the signal currents across this impedance causes changes of potential of the cathode 3a with respect to the negative pole of the voltage sources 8 and 18a. As the grid 12a of valve 1a is connected via source 18a to source 8 so that its potential with respect to the source 8 is fixed, its potential does not vary with signals. Thus, the potential variations of the cathode 3a due to signals are effectively applied between said cathode 3a and grid 12a, thereby causing changes in the anode current of valve 1a and, due to the coupling between anode 6a and grid 14a, changes in the anode current of valve 2a in the opposite sense. It is easily seen that the contributions of each of the valves 1, 2, 1a, 2a to the signal currents through the load 5 are additive.

The cathode resistance 15 is provided to assist in maintaining symmetrical operation. It will be appreciated that if, for example, the signal current variations of valve 2 tend to be greater than those of valve 2a, a signal voltage will be developed across resistance 15 which will tend to equalise the current variations of these two valves.

Due to the addition of the contributions of all the valves, the impedance seen by the load 5 is very low and can be shown to be approximately equal to

$$\frac{1}{g\left(\frac{R}{2}+1\right)}$$

where g is the conductance of the valves 1, 1a, 2, 2a, which are all assumed to be equal and R is the value of the resistance of 7 and 7a, which are assumed to be equal.

It will be appreciated that although the currents in the valves 1, 1a, 2, 2a vary with the applied signals, the current drawn from the source of anode voltage 8 is substantially constant due to the balanced circuit arrangement, and consequently the source 8 may have relatively poor regulation without adversely affecting the operation of the arrangement. Further, the sources 18, 18a, are not required to provide any current and may therefore take the form of low capacity batteries or a high resistance potential divider across the source of voltage 8. An arrangement of this kind is shown in Figure 3 in which elements corresponding to those of Figure 2 have been given the same reference numerals. It will

be seen that the sources of voltage 18, 18a have been eliminated, and the potential of grid 12a has been held fixed with respect to the source of voltage 8 by connecting it to a tapping point 16 on a potential divider across said source. The terminal of the source of signals 11 which was formerly connected to one pole of the source 18 is now connected to the common point of the cathode 3a, anode 4a and load 5, which brings the grid 12 to a suitable operating potential. This arrangement has a further advantage that an earth may be applied as shown at 17 to one terminal of the source of signals and to one terminal of the output load.

Although in the circuit arrangements above referred to the contributions of each of the valves to the signal current in the load have been assumed to be substantially equal, the invention is not limited to arrangements of this kind. Thus, for example, it is sometimes desirable to feed pulses of current with a very high rate of rise and fall to a load circuit and in such cases the two valves which give increased current through the load may be excited to a greater extent than the other two valves which give decreased current through the load or vice versa. This may be accomplished by omitting the cathode resistance 15 or by connecting a sufficiently large bypass capacity across it. If screen grid or pentode valves are used it is desirable in such cases to decouple the screen of each valve directly to its associated cathode.

It will be seen that in the arrangement shown in Figure 3, the source of anode voltage 8 is not directly earthed. If, as will usually be the case, the source 8 takes the form of a mains rectifier and smoothing circuit, two equal condensers connected in series should preferably be connected across the D. C. voltage supply leads and the common point of said condensers connected to the line which is earthed at 17. If valves 1, 2, 1a, 2a are screen grid valves, the voltage supplies for their screen grids may be obtained from the source of anode voltage in known manner through dropping resistances, some of which may, if desired, be common to the screen grids of corresponding valves of each pair. Further, the effective bias on the valve 1 may be adjusted if desired by introducing a dropping resistance between the cathode 3 and the anode 4.

In order to ensure that the signals derived from the incoming signals and applied to the input circuits of valves 2, 1a and 2a shall be substantially identical in waveform with the applied signals, the couplings between the anode 6 and grid 14 and between anode 6a and grid 14a should be arranged, for example, by the insertion of suitable networks between these electrodes in known manner, so that as little amplitude and phase distortion as possible will arise. The effective output impedance of the arrangement is dependent upon the values of the coupling resistance 7 and 7a and the output impedance may, for example, be reduced by increasing the values of resistance 7, 7a, although such increase will limit the frequency band over which phase and amplitude distortion can be avoided.

Although the invention has been described with reference to two pairs of valves, it will of course be understood that each valve of each pair may, if desired, be replaced by a number of valves in parallel.

I claim as my invention:

1. A circuit arrangement comprising a first and a second pair of similar valves, the anode to

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cathode paths of the valves of each pair being arranged in series in the same sense across a single source of anode voltage, a load impedance having one end thereof connected to a point common to the respective cathode and anode of the first pair of valves, the opposite end of said load impedance being connected to a point common to the respective cathode and anode of the second pair of valves whereby the load impedance is adapted to receive current in opposite senses from the valves of each of said pairs of valves, means for applying signals to said valves so that the valves of each pair are excited in opposite phase, additional connections whereby corresponding valves of the two pairs are also excited in opposite phase and the contributions of all said valves to the signal current through said load impedance being additive.

2. A circuit arrangement according to claim 1 in which said means for applying signals comprises an impedance which is arranged so that the output current of a first valve of said first pair flows therethrough and which is coupled to the input circuit of the second valve of said first pair so as to excite said second valve in opposite phase to said first valve and a further impedance similarly arranged and coupled to said second pair of valves so as to excite a first valve of said second pair in opposite phase to the second valve of said second pair.

3. A circuit arrangement according to claim 1

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in which impedances are arranged between the positive terminal of said source of anode voltage and the anodes of said first valves of each of said pairs respectively, and in which a coupling is provided between the control electrode of said first valve of said second pair and said source of anode voltage for preventing change of potential between said last-mentioned control electrode and said source of anode voltage so that if signals are applied to the control grid of said first valve of said first pair, signals will be developed between the cathode and control electrode of said first valve of said second pair.

4. A circuit arrangement according to claim 1 in which an impedance is included between the cathode of the second valves of each of said pairs and the negative terminal of said source of anode voltage.

GORDON SIDNEY

PENGELLY SCANTLEBURY.

REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
2,358,428	White	Sept. 19, 1944
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