

Dec. 2, 1947.

E. L. C. WHITE
 LINE AMPLIFIER FOR HIGH-FREQUENCY ELECTRIC
 SIGNALS SUCH AS TELEVISION SIGNALS
 Filed March 31, 1944

2,431,973

2 Sheets-Sheet 1

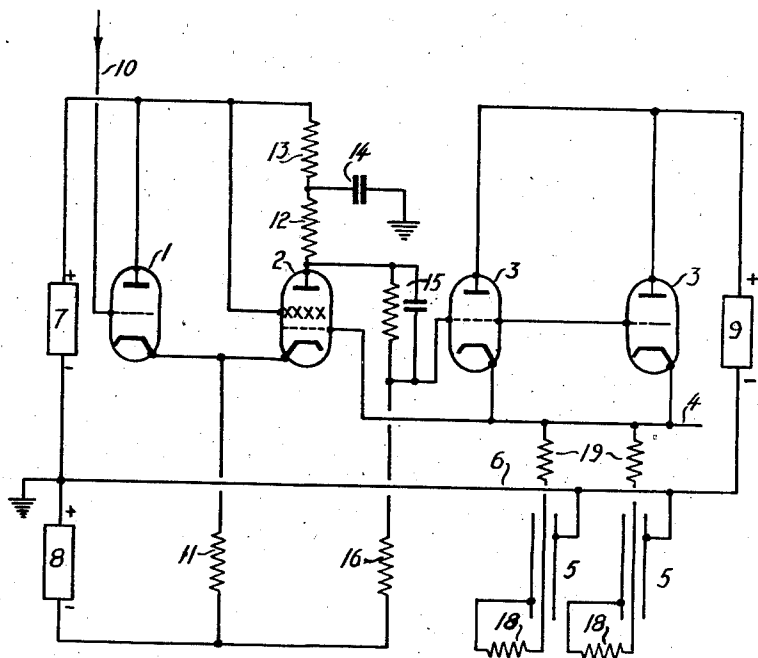


Fig. 1.

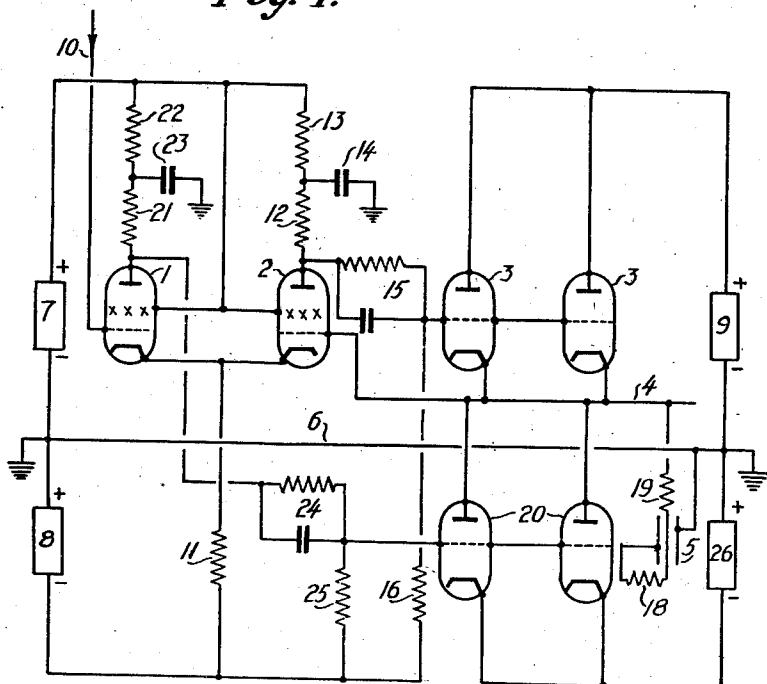


Fig. 2.

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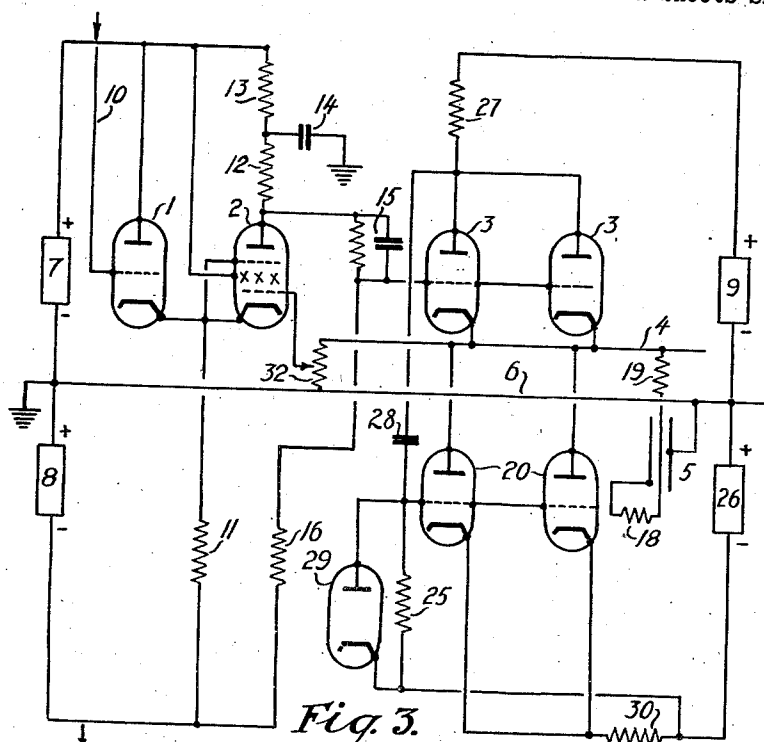


Fig. 3.

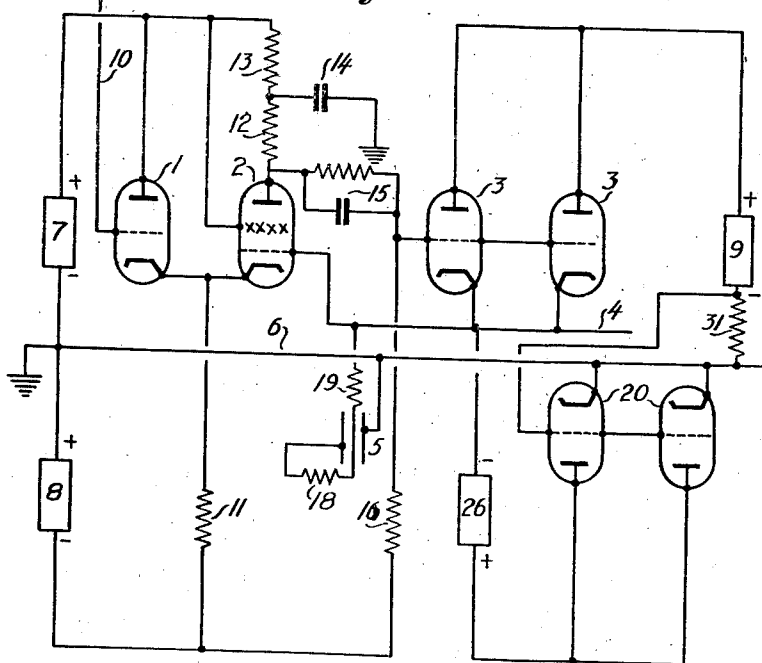


Fig. 4.

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UNITED STATES PATENT OFFICE

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LINE AMPLIFIER FOR HIGH-FREQUENCY
ELECTRIC SIGNALS SUCH AS TELEVISION
SIGNALS

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6 Claims. (Cl. 179—171.)

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The present invention relates to line amplifiers for electric signals such as television signals.

Such an amplifier may be employed, for example, for feeding a plurality of loads such as may be constituted by reproducing apparatuses which are required to be fed from a single input source. For example, the line amplifier may be provided with a single output conductor for feeding the aforesaid loads in parallel, each load being connected to said conductor through a section of transmission line which may be, for example, a concentric conductor cable. In such an arrangement it is required that if any of the sections of transmission line through which the loads are connected to said conductor are open or short-circuited, the effects of reflections caused by the mismatch produced shall not be appreciably transmitted to other loads.

The object of the present invention is to provide a line amplifier for feeding a plurality of loads from a single output conductor with signals which may extend over a wide range of frequencies wherein the arrangement operates with good regulation such that little or no disturbance is produced in the signals supplied to connected loads even when large variations of load occur.

According to the present invention an amplifier is provided comprising two valves with a common cathode impedance arranged to have signals to be amplified applied to the control electrode of the first valve to repeat said signals at the cathode of the second valve, a third valve arranged to be driven from said second valve and to have the load to be fed connected in its cathode circuit, and means for feeding back potentials on to the control electrode of said second valve substantially in phase with potentials applied to the cathode whereof whereby said third valve can be caused to operate with a very low output impedance.

In the case where the signal potentials developed across said load are required to acquire both negative and positive values, for example, as in the case of television signals where light values in the pictures are represented by positive potentials, zero potential may correspond to picture black, and where synchronising signals are represented by negative potentials, the arrangement should preferably be such that the application of said signals to the amplifier can cause the cathode terminal of said load to become at some times positive and at others negative with respect to the other terminal of the load which is usually at ground or other reference potential. Thus the third valve may be arranged to be fed from a high tension source to the negative ter-

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minal of which the cathode terminal of said load is connected through a resistive impedance and to which the other terminal of the load is connected at a point intermediate the ends thereof, whereby a steady negative feed to said load is afforded. In the preferred forms of the invention, however, a further valve is provided for repeating signals at the cathode terminal of said load, said further valve having its anode connected to said cathode terminal and being arranged to have said signals applied to its control electrode in opposite phase to those applied to the control electrode of said third valve.

In one form of the invention said further valve is arranged to be driven by virtue of a connection between its control electrode and the anode of said first valve, said first valve having an anode load impedance for affording the output required for this purpose.

In a further form of the invention the aforesaid further valve is arranged to be driven by virtue of a connection between its control electrode and the anode of said third valve, said third valve being provided with an anode load impedance for affording the required output. In this form of the invention a rectifier may be connected between the control electrode and cathode of said further valve, said rectifier being arranged to maintain the direct current value of the signals fed to said further valve at a desired level.

In a still further form of the invention the aforesaid further valve may have its control electrode connected to the negative pole of the high-tension supply for said third valve included in said output stage, said negative pole being connected to the second mentioned terminal of said load, usually at earth potentials, through a coupling impedance for affording potentials for driving said further valve.

In an arrangement according to the invention which is employed for feeding a load comprising a plurality of devices such as television receiving apparatuses which are required to be fed in parallel, each device is preferably arranged to be connected through a separate section of transmission line having at one end a series resistance having a value substantially equal to the characteristic impedance of the second of transmission line and matched at the other end to the input of said device, whereby the total load on said amplifier with the inputs to all said loads short-circuited can never exceed twice the maximum normal load.

In order that the said invention may be clearly understood and readily carried into effect it will

now be more fully described with reference to the accompanying drawings in which Figures 1 to 4 each illustrate a circuit of an amplifier embodying the invention.

In the various figures of the drawings like parts are indicated by the same reference numerals.

The amplifier shown in Figure 1 of the drawings comprises two electron discharge valves 1 and 2 respectively having a common cathode impedance 11, and a plurality of valves 3, the valves 3 being disposed in parallel with each other, and arranged to be driven from the valve 2. The load to be fed is connected between the output conductor 4 which is connected to the cathodes of valves 3, and to the control electrode of valve 2.

The cables by which two devices which constitute the aforesaid load are connected to the amplifier are indicated at 5 and the earth return conductor for the load circuit is indicated at 6.

The valves 1 and 2 are supplied from a common high-tension source including batteries or other D. C. sources 7 and 8 of which the negative and positive poles respectively are earthed. The high-tension supply for the valves 3 is furnished by a source 9 connected between the anodes of the valves and earth.

Signals to be amplified are applied to the control electrode of valve 1 via conductor 10.

By virtue of the common cathode impedance 11 which is such as to cause the valve 1 to operate as a cathode follower valve signal potentials applied to the valve 1 are repeated at the cathode of valve 2.

The valve 2 constitutes the main amplifier valve of the arrangement and is operated as a non-phase-inverting valve, having an anode load 12 which may be connected to source 7 through a potential dropping resistance 13 having an associated decoupling condenser 14.

The valve 2 drives the valves 3 through a connection from the anode of valve 2 to the control electrodes of valves 3 via the resistance capacity coupling 15 which functions in respect of all signal frequencies and D. C., the grid leak of the valves 3 being indicated at 16.

The devices connected to the cables 5 are represented by resistances 18 and the inner conductor of each cable is shown connected to the conductor 4 through series resistance 19, these resistances being preferably equal to the characteristic impedance of the cable and the impedance of the cable is preferably matched to the input of the devices 18.

With the above arrangement the load formed by the resistances 19, cables 5 and devices 18 connected between the conductors 4 and 6 constitutes a cathode load for the valves 3 so that these valves operate as cathode follower valves and as valves 1 and 2 are both non-phase-inverting valves, signals applied to the control-electrode of valve 1 will appear in the common conductor 4 in the same phase. If valve 2 has a high gain, then due to the feedback between the conductor 4 and the control electrode of the valve 2 there will never be more than a small difference of potential between the potentials appearing in the input conductor 10 of the valve 1 and in the common conductor 4; that is to say, the amplifier will appear to repeat the signals impressed over the conductor 10 at substantially the same level and to present a very small internal impedance and any increase or decrease in the current taken from the output conductors 4, 6, by the devices 18 through the cables 5 and resistances 19 will produce a very little change in potential on the line

4 so that a sudden open or short-circuit occurring in one of the devices 18 cannot cause the production of undesired effects in the other devices. The impedance presented by the amplifier may be, for example, of the order of 1% or less of the total normal load.

The number of valves 3 provided is chosen to deal comfortably with the maximum load expected with something to spare for accidental short-circuits on some of the cables. One valve 3 only may be required in some cases.

If it is desired that the potential of the common conductor 4 shall be negative with respect to earth return conductor 6 for certain portions of the waveform, for example, as is the case when the devices 18 are being fed with television signals in which the light values in the picture are represented by positive potentials with respect to a reference potential, which may conveniently be earth potential, corresponding to picture black, while synchronising signals are represented by negative potentials with respect to the reference potential, the high-tension source 9 may have a tap connected to earth and its negative pole may be connected to the conductor 4 through a suitable resistance enabling a negative potential drop to be produced between the conductor 4 and the conductor 6. Such an arrangement is not shown in the drawings since preferably one of the arrangements shown in Figures 2, 3 and 4 is adopted in which the negative feed to the output conductor 4 is supplied from the anodes of further valves 20, thus reducing the current swing necessary in the valves 3.

In Figure 2 the valves 20 are shown as being fed with signal potentials from the anode of valve 1, this valve being provided with anode load resistance 21, potential dropping resistance 22 and decoupling condenser 23 and the coupling between the anode of valve 1 and the control electrodes of the valves 20 being effected through the resistance capacity coupling 24. Resistance 25 constitutes the grid-leak resistance for the valves 20. The high-tension supply for the valves 20 is indicated at 26, the positive pole of this supply being shown as earthed. Sources 9 and 26 may be constituted by a single source having a tapping connected to earth.

In the arrangement shown in Figure 3 the valves 20 are fed with signal potentials from the anodes of valves 3 which are provided with an anode load 27, the control potentials being applied to the control electrodes of valves 20 through blocking condenser 28. In this case a rectifier 29 shown as a diode may be connected across the grid-leakage resistance 25 for the valves 20 for restoring the D. C. level of the signals impressed on the control electrodes of valves 20 with reference to the peak positive excursions of the potential on said control electrodes as required, for example, in the particular case of a television system in which D. C. reinsertion is effected with reference to the synchronising signals which are positive at this point.

In the arrangement of Figure 3 the valves 20 may be provided with a suitable cathode-loading resistance 30 for biasing purposes.

It may in other cases be more suitable to reverse the diode 29, or to omit it altogether. The function of this diode is only to ensure that the currents in valves 3 and 20 are complementary for the maximum negative and positive excursions of the signal potential which the arrangement is designed to handle. This arrangement gives the greatest freedom from overloading, and even if

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the valves 20 are overloaded, provided that the valves 3 are never overloaded, the output signal will still be a substantially faithful copy of the input signal, including its D. C. value.

Figure 4 shows another arrangement in which the valves 20 are driven from the anode circuit of the valves 3. In this arrangement a resistive load impedance 31 is included between the negative terminal of high-tension source 9 and earth and the negative end of this impedance is connected to the control electrodes of the valves 20 which are arranged with their cathodes directly connected to the earth conductor 6, the anode circuits of the valves including the load constituted by the loads 18 as in the arrangement of Figures 2 and 3, but the anodes of the valves being connected to the common conductor 4 through the high tension source 26. It will be seen that with this arrangement the source 9 "floats" in potential with reference to earth, as also does the source 26.

With all the arrangements shown in the drawing the high degree of stability afforded by the amount of feedback employed enables the valves 3 and 20 to operate satisfactorily without distorting the waveform, even though they have appreciably curved characteristics. Thus these valves can be employed to afford a very large output level without difficulty. Also the regulation of the sources 9 and 26 need not be very good.

It will often be convenient to have the output level on the cable 5 the same as the input level on conductor 10, and under these conditions, if the cables 5 are matched at both ends, the gain between the input on conductor 10 and the common conductor 4 must be 6 decibels. Such gain may be obtained by adjusting the feedback from the conductor 4 on to the control electrode of valve 2, for example, by means of the arrangement indicated in Figure 3, in which the connection between the control-electrode of valve 2 and the output conductor 4 is effected through a tapping on a potentiometer 32 connected between the common conductor 4 and the earth conductor 6. This modification may be introduced in any of the arrangements shown in the drawings.

If the input capacities of the valves 3 and 20, which may be the capacities of several valves in parallel, give too high total capacities compared with the anode resistances of valves 2 and 1 or 3 (according to the circuit used), then stages including cathode-follower valves may be inserted at a point between the valves 2 and 3 and between 1 or 3 and 20 where coupling for all frequencies including D. C. is obtained.

The arrangement described with reference to Figures 2, 3 and 4 of the drawing are most suitable for handling signals which have peak excursions which are equally positive and negative, such as television signals with equal synchronising pulses and picture amplitude and a reference level corresponding to picture black at earth potential. This signal provides a convenient standard to adopt for television signals for various reasons, notably that a gain-control can be fitted at any point where signals have this form and the gain control can be varied without altering the black level.

In an arrangement according to the invention small amounts of frequency distortion in the input signals fed through the conductor 10 may be corrected in the amplifier by putting a similar frequency characteristic in the feedback connection between the output conductor 4 and the control-electrode of valve 2.

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It is to be understood that while the invention has been described as embodied in an unbalanced system in which the output potentials are developed on a single output conductor having an earthed return conductor, the invention may be applied to a balanced arrangement in which output potentials appear in balanced relation on a pair of output conductors which may be fed from two identical amplifiers disposed according to the invention.

What I claim is:

1. An amplifier comprising two valves with a common cathode impedance arranged to have signals to be amplified applied to the control electrode of the first valve to repeat said signals at the cathode of the second valve, a third valve arranged to be driven from said second valve and to have the load to be fed connected in its cathode circuit, and means for feeding back potentials on to the control electrode of said second valve substantially in phase with potentials applied to the cathode thereof whereby said third valve can be caused to operate with a very low output impedance.

2. An amplifier according to claim 1 for developing signals across said load which are required to acquire both negative and positive values comprising a further valve for repeating signals at the cathode terminal of said load, said further valve having its anode connected to said cathode terminal and being arranged to have said signals applied to its control electrode in opposite phase to those applied to the control electrode of said third valve.

3. An arrangement including an amplifier according to claim 1, having a load to be fed comprising a plurality of devices which are arranged to be connected in parallel, each device being arranged to be connected in said cathode circuit through a separate section of transmission line having at one end a series resistance having a value substantially equal to the characteristic impedance to the section of transmission line and matched at the other end to the input of said device, whereby the total load on said amplifier with the inputs to all said loads short circuited can never exceed twice the maximum normal load.

4. An amplifier for affording a low impedance output comprising a first and a second electron discharge tube each including a cathode, a control electrode and an anode, means for coupling the cathodes of said tubes including a common cathode impedance, means to apply signal potentials to the control electrode of said first tube, a first output tube having a cathode, a control electrode and an anode, a cathode load circuit for said output tube, means to apply signal potentials from the anode of said second discharge tube to the control electrode of said output tube, means to feed back potentials from the cathode of said output tube to the control electrode of said second discharge tube, means to maintain the anode of said output tube positive with respect to its associated cathode, a second output tube having a cathode, a control electrode and an anode, means to connect the anode of said second output tube to the cathode of said first output tube, means to maintain the cathode of said second output tube negative with respect to its associated anode, and means to apply signal potentials from the anode of said first discharge tube to the control electrode of said second output tube whereby a low impedance output of signal potentials is available between the cathode of said first output tube and a point of fixed potential.

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5. An amplifier for affording a low impedance output comprising a first and a second electron discharge tube each including a cathode, a control electrode and an anode, means for coupling the cathodes of said tubes including a common cathode impedance, means to apply signal potentials to the control electrode of said first tube, a first output tube having a cathode, a control electrode and an anode, a cathode load circuit for said output tube, means to apply signal potentials from the anode of said second discharge tube to the control electrode of said output tube, means to feed back potentials from the cathode of said output tube to the control electrode of said second discharge tube, means to maintain the anode of said output tube positive with respect to its associated cathode, a second output tube having a cathode, a control electrode and an anode, means to connect the anode of said second output tube to the cathode of said first output tube, means to maintain the cathode of said second output tube negative with respect to

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its associated anode, and means to apply signal potentials from the anode of said first output tube to the control electrode of said second output tube whereby the load circuit for said output tubes is of low impedance.

6. A circuit arrangement as defined in claim 5 wherein a coupling condenser is included in said last named means for applying signal potentials from the anode of said first output tube to the control electrode of said second output tube, and a diode connected between the control electrode and the cathode of said second output tube.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,185,367	Blumlein	Jan. 2, 1940