Jan. 19, 1954 W. T. CHAPIN 2,666,815

CATHODE-FOLLOWER IMPEDANCE MATCHING DEVICE

Filed March 1, 1950

Fig. 1.

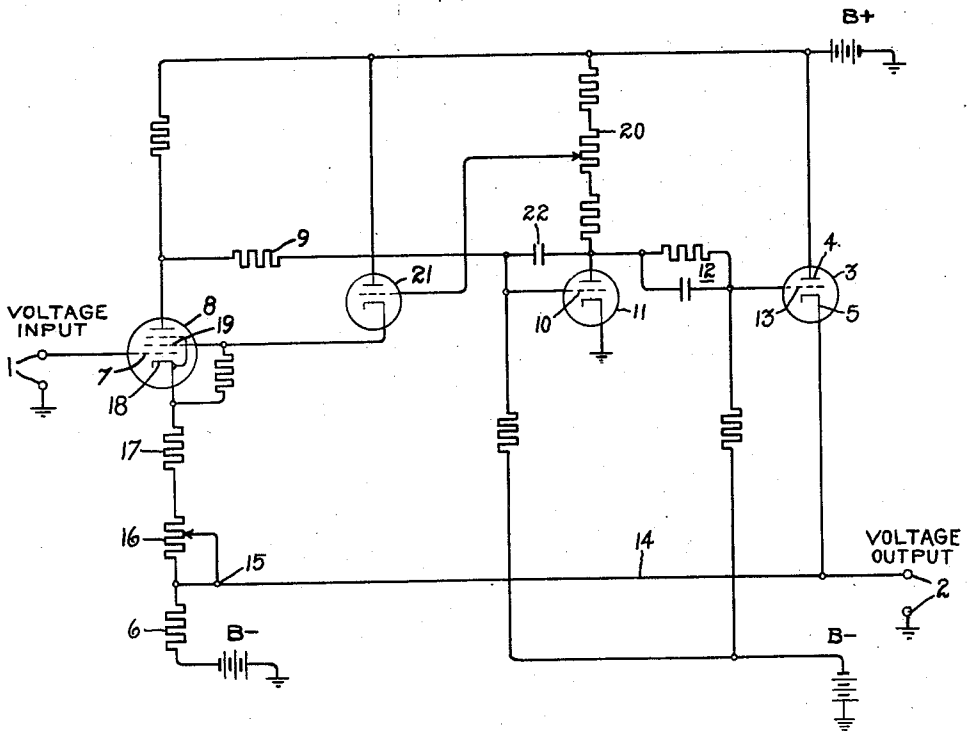
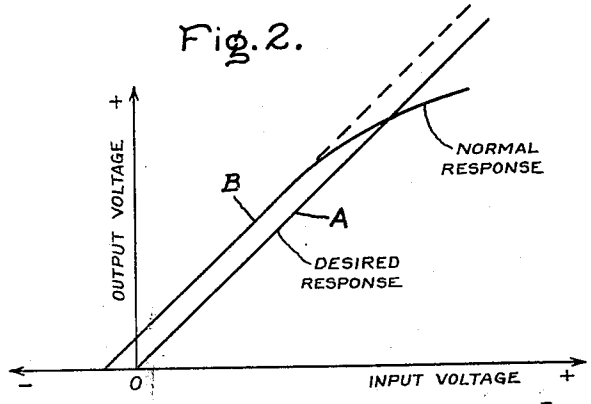


Fig. 2.



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CATHODE-FOLLOWER IMPEDANCE MATCHING DEVICE

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2 Claims. (Cl. 179—171)

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This invention relates to an impedance matching arrangement particularly applicable for communicating electrical signals between two circuits.

In the electrical signal transmission field, the problem often arises for communicating electrical signals between unbalanced impedance circuits, for example, supplying a low impedance load from a high impedance source. The cathode follower type circuit has been a common device for achieving this result. This circuit is essentially an impedance lowering device having less than unity voltage gain but capable of producing power gain. The output voltage of a cathode follower circuit has good regulation because of its low impedance while the input voltage may have a high impedance and relatively poor regulation. However, the normal cathode follower circuit suffers from the fact that a given amount of no-signal bias is developed across its output. That is, for zero signal applied to the input circuit of the cathode follower, there is a certain amount of space current flow, resulting in a signal being developed across its output. Also, the variation of input signal over a given intensity range produces a plate current variation through the normal cathode load resistor which reduces the effectiveness of the input signal. These prove to be undesirable if the output signal is to follow the input signal identically over a range including zero input voltage.

An object of my invention is to provide an improved impedance matching arrangement.

A further object of my invention is to provide an improved arrangement for effecting communication of signals, variable over a given range of intensities, between circuits of different impedance at unity gain.

A still further object of my invention is to provide an improved cathode follower circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawings wherein Fig. 1 shows a circuit diagram of an embodiment of my invention, and Fig. 2 shows response curves employed in describing the invention.

Briefly, an embodiment of my invention comprises an improved cathode follower circuit arrangement for supplying a voltage, variable over

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a range of intensities including zero volts, from a high impedance source to a relatively low impedance load. The signals are applied through a coupling amplifier to a cathode follower circuit whose output circuit is coupled to the load circuit and also comprises a portion of the cathode load circuit of the coupling device. The coupling device is provided with a feedback path to compensate for the effectively reduced input signals due to plate current variations in the output circuit.

Fig. 2 illustrates certain characteristics showing the operation and certain of the advantages of my invention. In Fig. 2 the curve A bearing the legend "Desired response" shows the relationship between the voltages at the output terminals 2 of the apparatus illustrated in Fig. 1 plotted as ordinates and the voltages at the input terminals 1 of that apparatus plotted as abscissae. It will be observed that the origin of this curve A is zero and that the output voltage at terminals 2 varies linearly from zero with variation in voltage at terminals 1.

The relationship of this curve A to curve B of Fig. 2 illustrates the advantage of my invention over that of the usual cathode follower circuit. Curve B represents the corresponding characteristics of the usual cathode follower circuit not employing my invention. It is observed that at zero input voltage a considerable output voltage appears and that this voltage increases substantially linearly only over a range considerably less than the range of linear response of my invention.

Referring to the Fig. 1, positive and negative going voltages with respect to ground and available across terminals 1 from a high impedance source, not shown, are to be supplied to the output terminals 2 associated with a relatively low impedance load, also not shown. To achieve this result, a main cathode follower circuit comprising a triode 3 having its anode 4 directly coupled to a source of B+ voltage and its cathode electrode 5 coupled by the cathode load impedance 6 to a source of B— voltage. Under the normal cathode follower operation, the output developed across 6 would be applied to the output terminals 2. In the present arrangement, the signals available at 1 are applied between an effective intermediate point on 16 and the control electrode 7 of pentode 8, operating as a coupling amplifier, which in turn supplies the signals in amplified form over coupling resistor 9 to the control electrode 10 of triode 11 operating as a phase inverter. The inverted, amplified signals are coupled from the

output of 11 by means of coupling circuit 12 to the control electrode 13 of tube 3. The output of tube 3, available across 6, is thereupon supplied to terminals 2 by lead 14 connected to point 15. Thus any variation in the input voltage available at 1, results in an output voltage variation available across terminals 2.

In order to compensate for the no-signal bias the output of tube 3 is included in the voltage divider circuit comprising pentode 8, thereby permitting cathode 5 to be operated at ground level. Thus for zero input voltage available at 1, the tap on potentiometer 16 is adjusted to provide zero or ground level voltage across output terminals 2. Thus a positive or negative going voltage with respect to ground at terminal 1 results in a corresponding positive or negative going voltage respectively, properly referenced with respect to ground, being available at terminals 2. As the input voltage is increased, the output also increases by virtue of increased current flowing through 6. Most of this increased current is supplied by tube 3, resulting in a decreased grid to cathode bias of tube 3. This change in bias is produced by a change in the grid of cathode bias of tube 8 amplified by the gain of the circuit. Also, the increased current flowing through the cathode load of tube 8 comprising resistances 16 and 17 causes an increase in the voltage drop from cathode 18 to the output terminal 2. The change in bias of tube 8 and the increased drop across 16 and 17 both cause the output voltage available across terminals 2 to be less than the input voltage.

To compensate for this non-linearity in transfer of signals from terminals 1 to terminals 2, the voltage of screen 19 of tube 8 is arranged to be increased with increased input, hence increasing the plate current through tube 8 and the output resistance 6, thereby raising point 15 to its required level. This screen voltage variation is effected by a feedback arrangement coupling a portion of the output of the phase inverter 11 available across the anode load potentiometer 20 through device 21 to the screen grid 19. Device 21 is arranged with its anode electrode coupled directly to B+ and its cathode electrode coupled directly to the screen electrode 19 with the output signals available across 20 being applied to its control grid. The rate at which the screen to cathode voltage of device 8 is increased is controllable by adjusting the tap on potentiometer 20. With the proper adjustment of the tap of potentiometer 20, the current through tube 8 is caused to increase even with a decrease in grid to cathode bias of tube 8. The increase in current through tube 8, as previously mentioned, compensates for the decrease in cathode to output voltage of tube 8.

Recapitulating the series of events, the output of tube 8 is applied through the phase inverter tube 11 to the input of cathode follower tube 3 resulting in a corresponding current change through load impedance 6. For a zero input signal to tube 8, potentiometer 16 is adjusted to provide a zero signal output across terminals 2. If the input voltage to tube 8 is varied in a positive going direction, a corresponding positive going variation is experienced across terminals 2. However, it is found that the unity gain requirement is no longer obtained being due primarily to the fact that the variation in current through load resistor 6 controls the effectiveness of the input signal. To compensate for this, a feedback arrangement comprising tube 21 is provided to vary the screen grid voltage, thereby adjusting the plate current flow through tube 8, and hence compensating for the variation in effective bias.

To prevent instability in the arrangement shown by the single figure, tube 8 is arranged as a wide-band amplifier. Tube 11 has a capacitor 22 coupled between its plate and grid electrodes to reduce its bandwith relative to tube 8 such that the loop gain-phase shift characteristic never approaches the oscillatory state.

Applicant's arrangement provides a stable, unity gain coupling arrangement for feeding signals between different impedance stages. However, applicant's arrangement lends itself readily to other gain requirements by merely adjusting the rate at which the space discharge current of tube 8 is to be increased in response to a given output current variation thereof. The manner in which the feedback signal is derived and used to control the space discharge current may be varied in accordance with the particular circuit requirements, although the use of a phase inverter 11 and coupling device 17 has produced satisfactory results. The point of coupling of the load circuit to the cathode load resistance of tube 8 may also be varied to obtain a required input to output signal relationship.

While I have shown only a certain preferred embodiment of my invention by way of illustration, many modifications will occur to those skilled in the art and I therefore wish to have it understood that I intend, in the appended claims, to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An arrangement for applying a signal variable over a range of intensities from a high impedance source of a low impedance load comprising an electron discharge device including a cathode, a control grid, a screen grid, and an anode, a source of unidirectional operating potential including a positive and a negative terminal, a cathode resistance connected between said cathode and said negative terminal, means for applying said signal in circuit with said control electrode and said cathode resistance, an anode resistance connected between said anode and said positive terminal, a second electron discharge device including an input circuit, the electron discharge path of said second device being coupled across said potential source and including a portion of said cathode impedance, means for coupling voltage variations across said anode impedance to the input circuit of said second device, amplifier means including a portion of said signal coupling means and coupled between the anode and the screen electrode of said first device for feeding back voltage to said screen electrode in a manner to increase the potential difference between the cathode and said screen electrode of said first device as said signal voltage increases, whereby the current flow through said cathode resistance varies in correspondence with signal variations on said first control electrode, and means for coupling said low impedance load between an intermediate point of said cathode resistance and an intermediate point of said source.

2. An arrangement for supplying a signal, variable over a range of intensities, from a high impedance source to a low impedance load comprising a first electron discharge device, a plurality of input circuits for said device, a cathode load impedance and an anode load impedance, means applying said signal to one of said input circuits, a source of unidirectional voltage, said load im-

pedances coupling the electron discharge path of said device across said voltage source, a second electron discharge device comprising an input circuit, means coupling the electron discharge path of said second device through a portion of said cathode impedance across said voltage source, signal coupling means coupled between said anode load impedance and the input circuit of said second device, amplifier means including a portion of said signal coupling means and coupled between said anode load impedance and another input circuit of said first device for feeding back a signal to said other input circuit of said first device to compensate for reduction in effectiveness of said input signal due to electron discharge current flow through said cathode impedance to an extent to cause said current flow to vary in correspondence with said signal, and means for coupling said low impedance load between an intermediate point of said cathode impedance and an intermediate potential point of said source of unidirectional voltage.

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