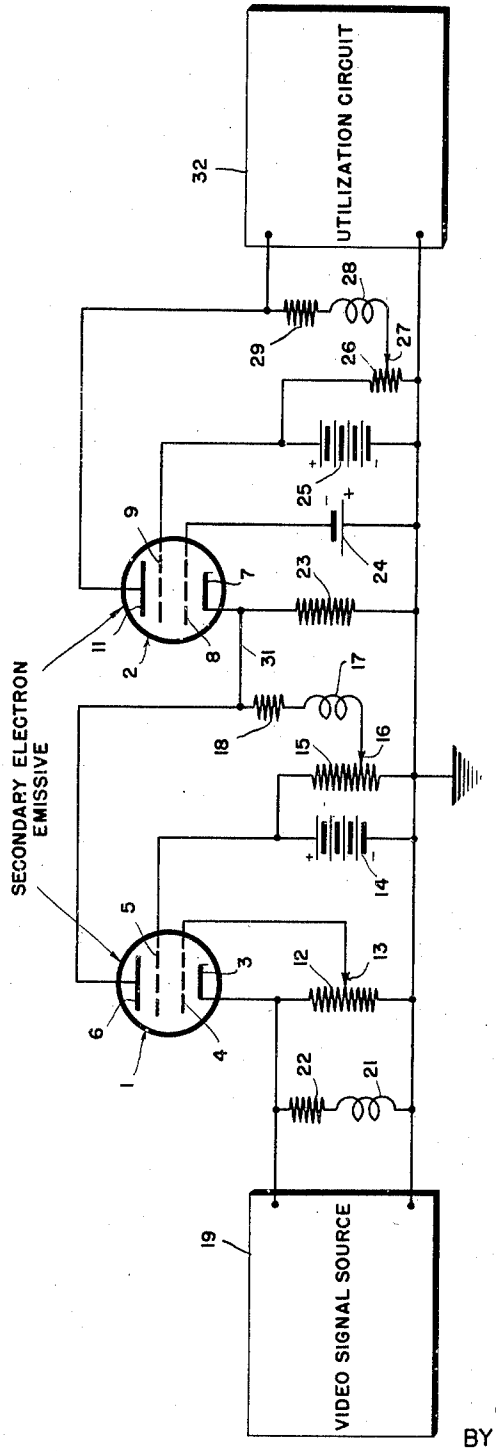
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CATHODE-COUPLED AMPLIFIER

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CATHODE-COUPLED AMPLIFIER

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1

This invention relates to amplifiers and particularly to apparatus of this character capable of amplifying relatively high frequency signals such as the video signals in a television system.

The picture intelligence is conveyed, in a television system, by means of video signals. These signals comprise two components. One component of relatively high frequency represents the light values of elemental areas of the television picture. The other component of relatively low frequency represents the average illumination of the television subject. In a system where a tube of the dissector type is employed to generate the video signals, both components are derived from the output of the tube. In order for such a system to operate efficiently it is desirable that both components be preserved during the subsequent amplification of the video signals which is required to modulate a transmitter. It also is desirable at the receiver to provide an amplifier which is capable of passing both components of the video signals.

In a conventional amplifier it is customary to impress the intelligence signals upon the control grid and to derive the amplified signals from the plate circuit of the tube. In order to effect the desired degree of amplification it generally is necessary to use a cascade arrangement of a plurality of vacuum tubes. The coupling between successive amplifier tubes usually is accomplished by using either an inductive or a capacitive coupling between the plate circuit of one tube and the control grid circuit of the succeeding tube. Such an arrangement is necessary in order to isolate the control grid of the succeeding tube from the relatively high plate voltage of the preceding tube. It is well known that both of these types of couplings will pass only the relatively high frequency component of a video signal with the result that the relatively low frequency component, if present, is not amplified by any of the vacuum tubes except possibly the first one. It also is well known that, by using the conventional grid excitation of a vacuum tube amplifier, the efficiency of such a device decreases as the frequency of the signals to be amplified increases. Such an effect is due to the shunting or short circuiting action of the inherent interelectrode capacity within the tube between the control grid and the cathode.

One way in which such an amplifier may be operated theoretically to avoid losing the relatively low frequency component is to employ a conductive coupling between the plate circuit of one

2

tube and the cathode circuit of the succeeding tube. In other words, cathode excitation of the vacuum tubes is substituted for the more conventional grid excitation. However, such an expedient ordinarily is not practical for the reason that the high plate voltage which thereby is impressed upon the cathode of a succeeding tube is greater than that which the insulation between the cathode and its heater element can withstand. About the only way in which such an amplifier can be made to function successfully is by the use of specially constructed tubes wherein there is provided materially increased insulation between the cathode and the heater element.

It, therefore, is an object of the present invention to provide a novel amplifier, adapted particularly to amplify relatively high frequency signals, wherein any relatively low frequency component of the signal also is amplified without discrimination.

Another object of the invention is to provide a television video signal amplifier which may consist of a plurality of cascaded stages wherein cathode excitation by direct coupling to an anode circuit may be employed without exceeding the break-down voltage of the insulation provided between the cathode and its associated heater element.

A further object of the invention is to provide a television video signal amplifier capable of amplifying both the relatively high frequency and the relatively low frequency components indiscriminately and in which there is eliminated from the coupling circuits the interelectrode capacity between the control grid and cathode of a vacuum tube without, at the same time, exceeding the break-down voltage of the insulation between the cathode and its associated heater of the tube.

In accordance with the invention, there is provided an amplifier which is particularly adapted to faithfully amplify intelligence signals of all frequencies up to a frequency of the order of several megacycles per second. Such an amplifier is well suited for use as a video signal amplifier in a television system. It may comprise any desired number of stages, each of which preferably, but not necessarily, is substantially similar to the others. One stage of such an amplifier embodying the present invention comprises a vacuum tube having an electrode capable of emitting primary electrons, an electrode to control the primary electron emission, an electrode to accelerate and collect electrons and an electrode capable of emitting secondary electrons upon the bombardment thereof with primary electrons. A

source of intelligence signals which may vary in frequency from a few cycles per second to several megacycles per second is coupled to the vacuum tube in such a manner that the primary electron emissive electrode is excited by the intelligence signals. Means are provided for biasing the control electrode with respect to the primary electron emissive electrode. Potentials which are of positive polarity relative to the primary electron emissive electrode are impressed upon the electron accelerating electrode and also upon the secondary electron emissive electrode. In accordance with one of the main features of this invention, the positive voltage which is impressed upon the secondary electron emissive electrode is small as compared to the positive voltage impressed upon the electron accelerating and collecting electrode. A utilization circuit for the amplifier is conductively coupled to the secondary electron emissive electrode. Inasmuch as the voltage impressed upon this electrode is relatively small, the utilization circuit, if desired, may comprise a second amplifier stage arranged substantially as in the manner described. Inasmuch as the output circuit voltage is not great it may be impressed upon the primary electron emissive electrode of the second stage without endangering the insulation between this electrode and whatever element is associated therewith to condition it for electron emission.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

The single figure of the accompanying drawing is a schematic circuit diagram of a two-stage amplifier embodying the present invention.

Referring now to the drawing, there is shown a two-stage video signal amplifier employing respectively two vacuum tubes 1 and 2. Each of these tubes is a tetrode consisting, in the case of tube 1, of a primary electron emissive electrode such as an indirectly heated cathode 3, an electrode to control the primary electron emission from the cathode, which electrode may be in the form of a grid 4, an electrode for accelerating and collecting electrons which also may be in the form of a grid 5 and an electrode such as a plate 6 capable of copious secondary electron emission upon the bombardment thereof with primary electrons. Similarly, the tube 2 is provided with a cathode 7, a control grid 8, a screen grid 9 and a secondary electron emissive plate 11.

The cathode 3 of the tube 1 is connected through an impedance device such as a resistor 12 to ground and the control grid 4 of this tube is connected to a sliding contact 13 adapted to engage the resistor 12. The screen grid 5 is connected to the positive terminal of a source of relatively high voltage direct current energy such as a battery 14, the negative terminal of which is connected to ground. A resistor 15 is connected across the terminals of the battery and there is provided a sliding contact 16 for engagement with this resistor. This contact is connected through a suitable load circuit to the plate 6 of the tube 1. In the present instance this load circuit comprises a coil 17 connected in series with a damping resistor 18. The coil 17 is known as a peaking coil, the inductance of which is so chosen that the circuit is tuned by means of the stray capacity of the circuit. The resistor

18 serves as a damping resistor to render the amplifier response characteristic substantially flat over a considerable range of frequencies which, in the case of television video signals, is from zero to frequencies of the order of several megacycles per second.

The video signals to be amplified by such a system may be derived from any convenient source 19. In the case where the source 19 includes a dissector tube, in addition to the relatively high frequency component of the video signal representative of the light values of elemental areas of the television subject, there is present in the signal a relatively low frequency component representative of the average illumination of the subject. However, as is well known, when using other types of pickup tubes it is necessary to develop the relatively low frequency component of the signal independently and to incorporate it subsequently with the transmitted video signals. However, when using an amplifier in accordance with the present invention, both the high and the low frequency components of the video signals may be impressed upon the amplifier for concurrent amplification. For the present description, therefore, it will be considered that the video signals derived from the diagrammatically illustrated source 19 contain both the high and the low frequency components. It, nevertheless, will be appreciated that the amplifier in accordance with this invention also is susceptible of use to advantage in amplifying only the relatively high frequency video signal component. There is connected in parallel with the terminals of the video signal source 19 a peaking coil 21 and a damping resistor 22. Also, the terminals of the source 19 are connected across the cathode resistor 12 of the amplifier tube 1.

In like manner, the cathode 7 of the tube 2 is connected to ground through a resistor 23. The control grid 8, in this case, is connected to ground through a negative biasing battery 24. The screen grid 9 is connected to the relatively high voltage positive terminal of a battery 25, the negative terminal of which is connected to ground. A resistor 26 connected across the battery 25 is provided with a sliding contact 27 which is connected through a peaking coil 28 and an associated damping resistor 29 to the plate 11 of the second stage amplifier tube 2.

The output circuit of the tube 1 is derived from the circuit connected to the plate 6. This output circuit is conductively coupled by means of a conductor 31 to the cathode 7 of the tube 2. In like manner the output circuit of the tube 2 is derived from the circuit connected to the plate 11. This circuit is conductively coupled to the terminals of a utilization circuit 32. The utilization circuit, for example, may comprise additional amplifier stages similar to those illustrated in detail, or the modulation circuit of a transmitter or the electron beam intensity control circuit of a cathode ray reproducing tube in the case of a television receiver.

Referring now to the operation of the two-stage amplifier embodying the invention, the video signals derived from the source 19 excite the amplifier tube 1 by means of varying the voltage of the cathode 3 with respect to the control grid 4 while the potential of this grid is maintained at a relatively fixed value. To accomplish this the terminals of the source 19 are connected directly across the cathode resistor 12. It is seen, therefore, that the interelectrode capacity between the control grid 4 and the associated cathode 3 can

have no effect upon the strength of the video signals available for exciting the amplifier tube 1. In the case of a conventional prior art circuit for exciting a vacuum tube the signal source is connected between the control grid and the cathode where the interelectrode capacity between these two tube elements is in parallel with the signal source. Inasmuch as the impedance of the interelectrode capacity decreases as the frequency of the signals increases, it acts to partially short circuit a source of relatively high frequency signals. It is assumed that the voltage of the video signals derived from the source 19 is small with respect to ground so that it may be impressed upon the cathode circuit as shown. The coupling between the source 19 and the cathode resistor 12 is entirely conductive so that both the high and the low frequency components of the video signals are employed to excite the tube 1.

The negative biasing of the control grid 4 by means of the described connection to the cathode-coupled resistor 12 will vary with variations of the video signal voltage and, therefore, will have some degenerative effect upon the performance of this stage of the amplifier. However, when operating in a non-linear region of the tube characteristic, an adjustment of the point of contact of the slider 13 with the resistor 12 provides a facility for effecting a level control of the video signals.

By means of the relatively high positive potential relative to the cathode 3 which is impressed upon the screen grid 5, primary electrons derived from the cathode are accelerated toward and through the screen grid and strike the plate 6 with sufficient velocity to effect the emission of secondary electrons. By reason of the connection of the plate 6 to the sliding contact 16, which preferably is engaged with a relatively low voltage point on the resistor 15, the screen grid 5 is maintained at a considerably greater positive voltage than the plate 6. Consequently, the secondary electrons emitted by this electrode are collected by the screen grid 5. The electronic current flow through the lower portion of the resistor 15, the peaking coil 17 and the damping resistor 18 to the plate 6 of the amplifier tube 1 effects a voltage drop between the plate of this tube and ground. This voltage drop varies in accordance with the video signal voltage impressed upon the cathode resistor 12. However, it will be noted that inasmuch as the plate 6 serves as an electron emitter rather than an electron collector as in a conventionally connected vacuum tube, there is a phase reversal between the signals impressed upon the input circuit of the tube and the signals derived from the output circuit. Nevertheless, by reason of the described connection of the plate 6 of the first stage amplifier tube to a source of positive voltage of relatively low magnitude the signal voltage derived from the plate 6 with respect to ground is of relatively low magnitude. Consequently, it may be impressed upon the succeeding amplifier tube 2 by means of a conductive coupling to effect cathode excitation thereof in a manner similar to that described in connection with the first stage amplifier tube 1.

The second stage of the amplifier operates in substantially the same manner as the first stage. In this case, however, the negative biasing of the control grid 8 with respect to the cathode 7 which is produced by the battery 24 remains constant and there is no degenerative action in this stage of the amplifier. Obviously, if desired, degeneration may be effected also in this

stage by the provision of a facility similar to that employed in the first stage. It should be apparent that as many similar stages may be incorporated in an amplifier as may be desired to effect the required signal gain. So long as the equivalent circuit arrangement is employed for successive stages the output voltage of any stage with respect to ground is of a relatively small order of magnitude. Consequently, any output circuit may be conductively coupled to the cathode circuit of a succeeding stage for effecting excitation thereof. Inasmuch as this coupling is of a conductive nature, it is seen that such an amplifier will not discriminate between signal frequencies so as to exclude the relatively low frequency component of a video signal, where such a component is present. Likewise, it is apparent that the efficiency of such an amplifier is considerably greater than a conventionally arranged amplifier by reason of the elimination of the short circuiting effect of the interelectrode capacity between the control grid and the associated cathode of one of the amplifier tubes. Moreover, the amplified signal voltage derived from the output circuit of one of the amplifier stages is of a relatively low order of magnitude. Consequently, such a signal may be impressed upon the cathode circuit of one of the amplifier tubes without exceeding the break-down voltage of the insulation provided between the cathode and its associated heater element.

In the case where the unidirectional voltage impressed upon the cathode 3 of the tube 1 is zero with respect to ground, the unidirectional voltage impressed upon the cathode 7 of the tube 2 will be increased with respect to ground in an amount equal to the magnitude of the voltage impressed upon the plate 6 from the resistor 15. It is apparent, therefore, that the unidirectional voltage with respect to ground of the cathodes will increase as additional successive amplifier stages are used. Consequently, the number of cascaded stages which may be employed in an amplifier embodying this invention will depend upon the insulation between the cathodes and heater elements of the tubes and/or the voltage of the power pack or other source of a unidirectional voltage such as the batteries 14 and 25 illustrated herein. Nevertheless, it should be obvious that more stages in accordance with this invention may be used before reaching the limiting conditions than when using the conventional arrangements of the prior art.

It should be noted that it is not always necessary in practicing this invention that cathode excitation of all of the amplifier tubes be employed. For example, cathode excitation of the tube 1 may be effected as described, and the amplified signals may be derived from the output circuit of this tube also as described. However, in this case, the output circuit signal voltage may be employed to effect grid excitation of a succeeding stage of the amplifier, if desired. Such an arrangement, while not providing all of the advantages of a cascaded amplifier embodying the invention substantially as described, will produce a materially improved amplifier capable of operating more efficiently than those known prior to this invention. It is apparent that by utilizing cathode excitation of the amplifier tube 1 there is retained the beneficial effect of eliminating the control grid-to-cathode capacity, thereby enabling the use of such an amplifier for intelligence signals of relatively high frequency without the loss of any of the

signal energy by reason of the shunting action of the interelectrode capacity. Also, the utilization of the secondary electron emissive facility of the plate 6 will enable the derivation of amplified signals from an output circuit connected to this plate having a relatively small unidirectional voltage relative to ground. Similarly, it is apparent that the beneficial results of this latter feature may be realized also in the case where the amplifier tube is grid excited.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a television video signal amplifier, a plurality of vacuum tubes each having a cathode, a control grid, a screen grid and an electrode capable of emitting secondary electrons upon the bombardment thereof with primary electrons emitted by said cathode, an impedance device coupled to each of said cathodes, means for negatively biasing each of said control grids with respect to its associated cathode, a source of direct current connected in positive polarity to the screen grids of said vacuum tubes, a load circuit coupled between each of the secondary electron emissive electrodes of two of said vacuum tubes and a relatively low positive voltage point of said direct current source, an input circuit for said amplifier including the cathode-coupled impedance device of a first one of said two vacuum tubes, a coupling between the load circuit of said first vacuum tube and the cathode-coupled impedance device of the second one of said two vacuum tubes, a utilization circuit, and a coupling between the load circuit of said second vacuum tube and said utilization circuit.

2. In a television video signal amplifier, a pair of vacuum tubes each having a cathode, a control grid, a screen grid and a plate capable of emitting secondary electrons upon the bombardment thereof with primary electrons emitted by said cathode, an impedance device coupled to each of said cathodes, means for effecting a self-biasing coupling between each of said control grids and its associated cathode, a source of direct current connected in positive polarity to each of said screen grids, a load circuit coupled between each of said respective plates and a relatively low positive voltage point of said direct current source, an input circuit for said amplifier including the cathode-coupled impedance device of a first one of said vacuum tubes, a coupling between the load circuit of said first vacuum tube and the cathode-coupled impedance device of the second one of said vacuum tubes, a utilization circuit, and a coupling between the load circuit of said second vacuum tube and said utilization circuit.

3. In a television video signal amplifier, a pair of vacuum tubes each having a cathode, a control grid, a screen grid and a plate capable of emitting secondary electrons upon the bombardment thereof with primary electrons emitted by said cathode, an impedance device coupled to each of said cathodes, a coupling from each of said control grids to a point on the impedance device coupled to the associated cathode, a source of direct current connected in positive polarity to each of said screen grids, a load circuit connected between each of said respective plates and a relatively low positive voltage point of said direct current source, an input circuit for said amplifier including the cathode-coupled impedance device of a first one of said vacuum tubes, a conductive coupling between the plate of said first vacuum tube and the cathode-coupled impedance device of the second one of said vacuum tubes, a utilization circuit, and a conductive coupling between the load circuit of said second vacuum tube and said utilization circuit.

4. In a television video signal amplifier, a pair of vacuum tubes each having a cathode, a control grid, a screen grid and a plate capable of emitting secondary electrons upon the bombardment thereof with primary electrons emitted by said cathode, a resistor coupled to each of said cathodes, a connection from each of said control grids to a point on the associated cathode-coupled resistor, a source of direct current connected in positive polarity to each of said screen grids, means including an impedance device connected between each of said respective plates and a relatively low positive voltage point of said direct current source, an input circuit for said amplifier including the cathode-coupled resistor of a first one of said vacuum tubes, a conductive coupling between the plate of said first vacuum tube and the cathode-coupled resistor of the second one of said vacuum tubes, a utilization circuit, and a conductive coupling between the plate of said second vacuum tube and said utilization circuit.

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