Sept. 4, 1945. K. SCHLESINGER 2,384,263

VIDEO AMPLIFIER

Filed May 7, 1943 4 Sheets-Sheet 1

Fig. 1a.

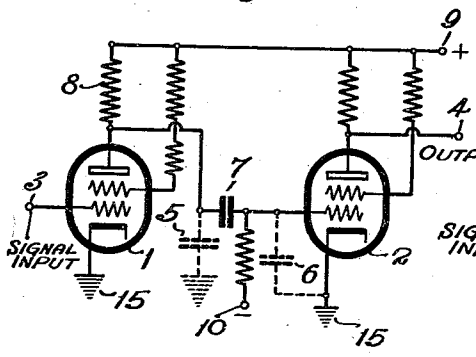


Fig. 1b.

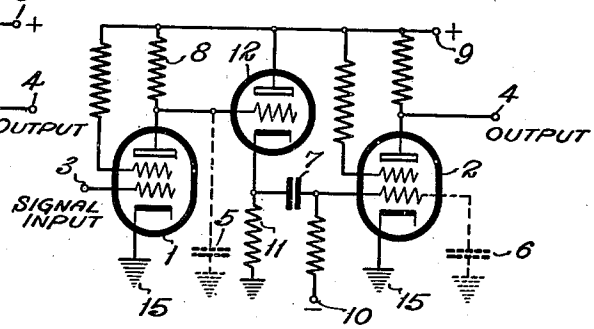


Fig. 2.

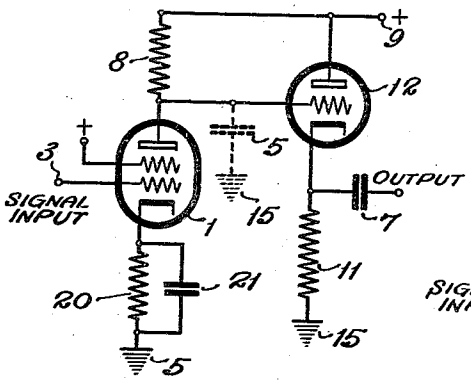


Fig. 4.

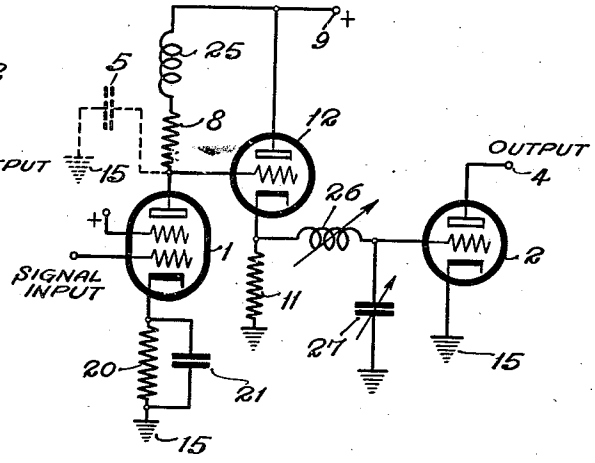
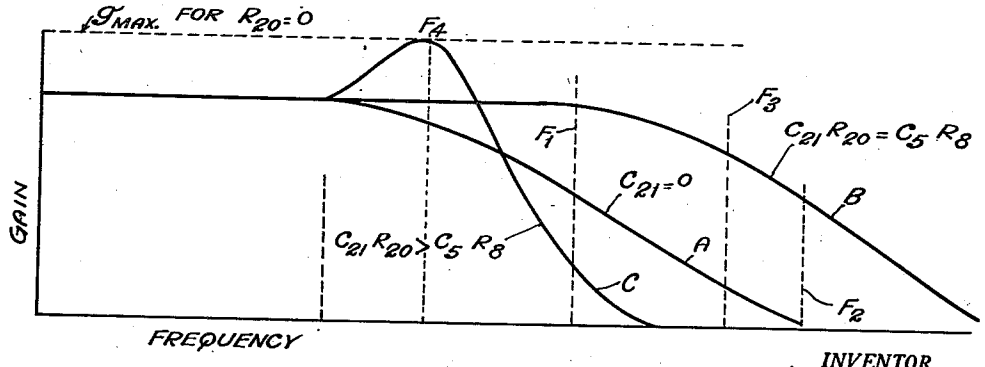


Fig. 3.



INVENTOR.

Kurt Schlesinger

BY H. G. Brower

ATTORNEY.

Sept. 4, 1945. K. SCHLESINGER 2,384,263

VIDEO AMPLIFIER

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Fig. 5.

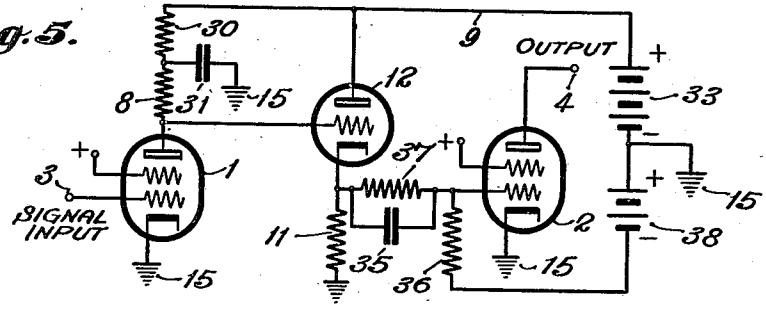


Fig. 6.

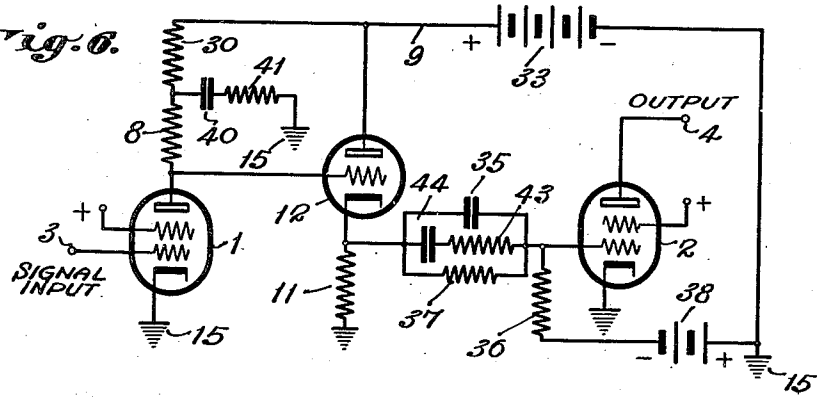
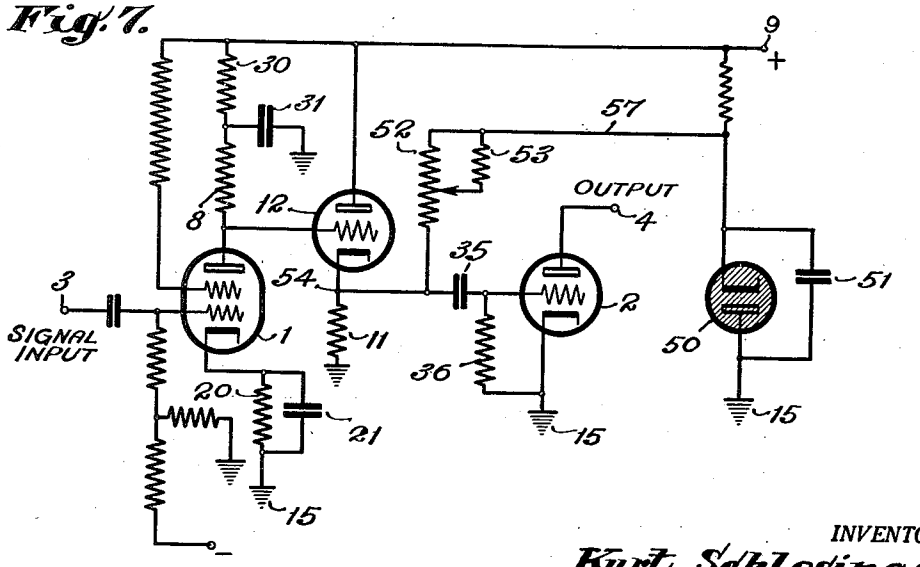


Fig. 7.



INVENTOR.

Kurt Schlesinger

BY

H. G. Brown

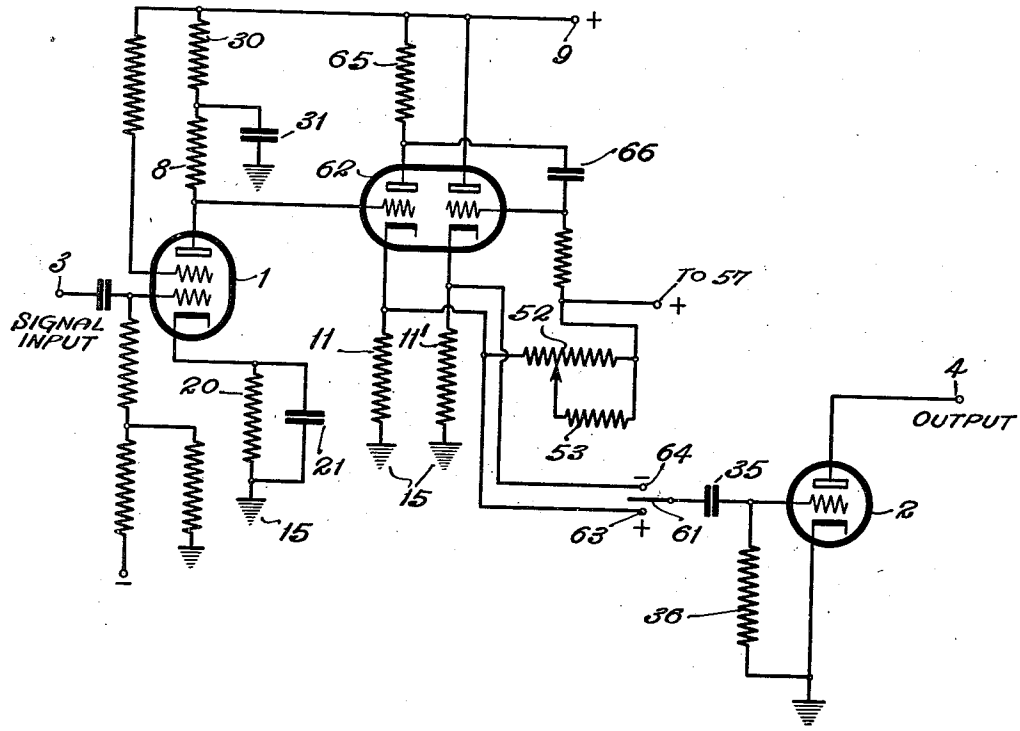
ATTORNEY

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Fig. 8.



INVENTOR.
Kurt Schlesinger
BY H. S. Brown.
ATTORNEY.

Sept. 4, 1945. K. SCHLESINGER 2,384,263

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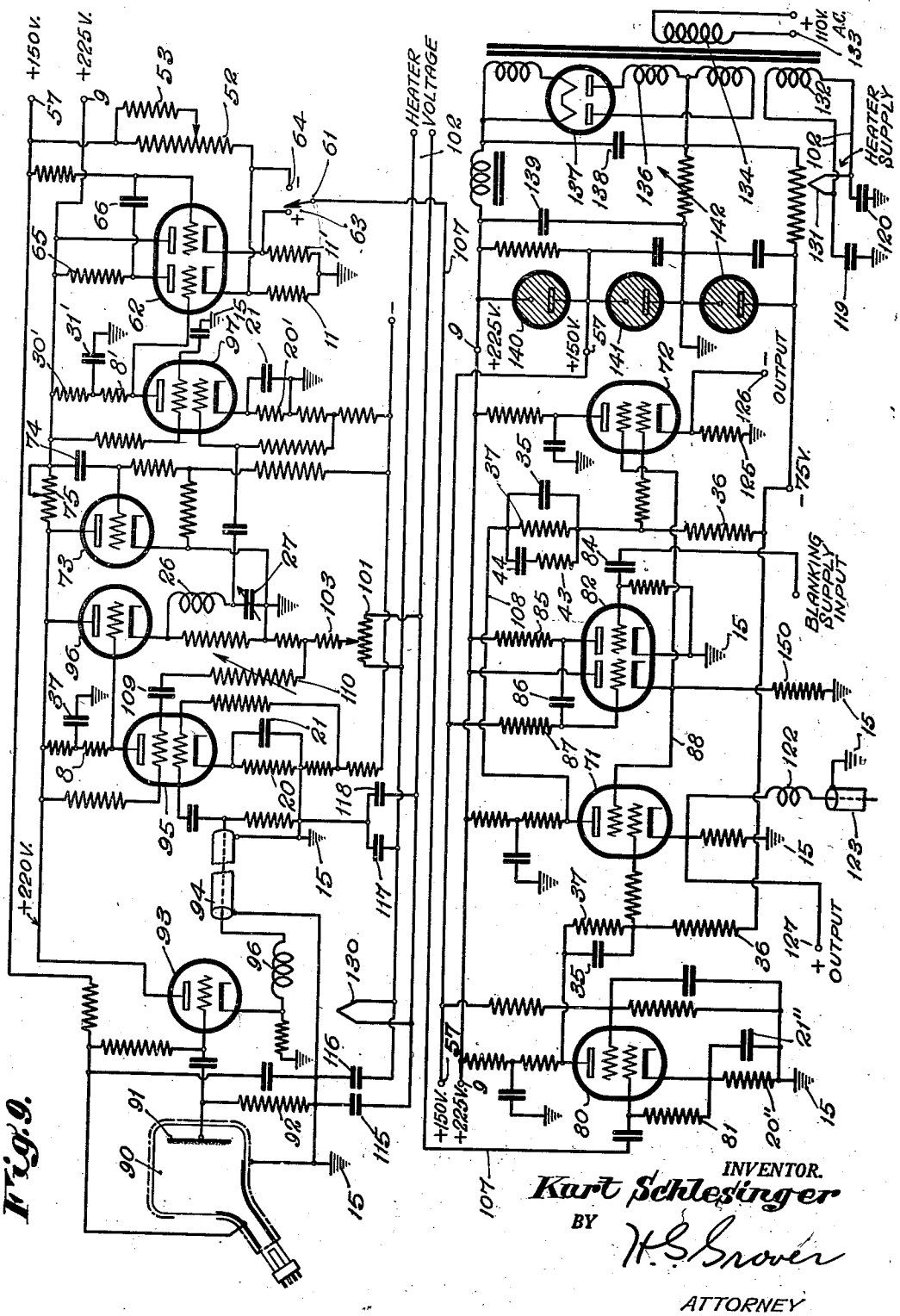


Fig. 9.

INVENTOR.
Kurt Schlesinger
BY
H. S. Grover
ATTORNEY

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UNITED STATES PATENT OFFICE

2,384,263

VIDEO AMPLIFIER

Kurt Schlesinger, West Lafayette, Ind., assignor to Radio Corporation of America, a corporation of Delaware

Application May 7, 1943, Serial No. 485,981

14 Claims. (Cl. 179—171)

This invention is directed to electronic amplifiers and particularly to an amplifier for handling a wide band of frequencies, such as finds extensive use in television video circuits. In its particular form, the amplifier includes a plurality of voltage amplifier stages with electronic tubes serving as the coupling elements between successive stages. These coupling tubes are connected between successive stages as cathode followers and they result in splitting the load capacitances across the voltage amplifier into two parts in such a way as to leave only the plate-to-ground capacitance of the driver tube as ballast, and, at the same time, to eliminate the grid-to-ground capacitance of the next amplifier by causing it to reappear across the cathode follower output where it forms a negligible load.

The amplifier herein to be described is one which permits a substantial increase in gain over circuits heretofore known and used. In addition, the amplifier is so constituted as to make possible a reasonably substantial increase in the band width or response frequency range accommodated. In its preferred form, suitable provision is made for high frequency peaking with readily obtainable values of variable condensers which are preferably connected at one side to ground. In such an arrangement these condensers are used in combination with appropriately designed inductance elements. As the amplifier is preferably constituted, series peaking at the output of the coupling tubes is relied upon, for the most part, but, under some circumstances, shunt peaking at the coupling tube inputs is also found feasible and utilized.

Still further, the amplifier makes provision for low frequency correction as well as for providing, where necessary, D. C. coupling between stages. In its preferred form, the amplifier is so arranged that adequate gain control may be provided without causing any appreciable change in the over-all frequency response and without introducing any noise.

In its broadest form, the amplifier comprises a plurality of thermionic amplifiers of which the output from one is coupled to the input of another, for instance, by way of a triode element having its grid directly connected to the output of the driver stage and with a direct connection to the grid or control electrode of the succeeding stage by way of a cathode follower connection. In order to provide for a more efficient utilization of a desired frequency band, where a number of amplifier stages are utilized, it is frequently desirable to provide some degeneration in the circuit and, at the same time, to introduce certain cathode-to-ground capacity which is preferably made equal to the plate-to-ground capacity insofar as the time constant of the resistance and capacity elements are concerned. With such an arrangement, a band stretching effect is conveniently realized.

In further refinement of the circuit, a suitable volume control arrangement is provided in connection with the cathode follower stage in such a manner that the picture quality which results from the transmission of the video signals through the amplifier is not impaired by the control, since the source is so connected as to act and appear as a low impedance.

In a still further refinement of the circuit, there is a switching unit from which a resultant output is derived which may be either positive or negative in sign. In a still further refinement, suitable provision has been made for operating a voltage regulator in the form of a stabilizing triode in combination with circuits of the foregoing types.

It accordingly becomes an object of this invention to provide an amplifier unit which will respond substantially uniformly over a wide range of frequencies and, at the same time, it becomes an object of the invention to provide an amplifier unit wherein provision for peaking at high frequencies is readily made available, while making it also possible to compensate for low frequency distortion.

Still other objects of the invention are those of providing an efficiently operating cathode follower amplifier with conveniently arranged gain control instrumentalities which are capable of operation without impairing picture quality.

At the same time, it becomes an object of the invention to provide a stabilized form of voltage regulation which lends itself readily to combination with the video amplifier.

Other objects of the invention are those of providing a circuit arrangement which overcomes one or more known defects of the prior art and, at the same time, simplifies the amplifier over those heretofore known while still retaining the advantages of wide band amplifiers to the extent that the band width of signals which can be uniformly amplified is materially increased.

Other objects and advantages of the system will become apparent to those skilled in the art to which the invention is directed when the following specifications and claims are considered

together with the accompanying drawings, wherein:

Fig. 1*a* discloses a resistance-capacity coupled amplifier;

Fig. 1*b* discloses a modification of Fig. 1*a* showing a cathode follower coupling between stages;

Fig. 2 is a circuit showing a modification of Fig. 1*b* and provides high frequency correction by cathode degeneration;

Fig. 3 is a series of curves to explain Fig. 2 and to show by curves A, B and C three possible conditions of operation;

Fig. 4 embodies a circuit illustrating high frequency peaking by series and parallel resonance in combination with the cathode follower;

Fig. 5 is a circuit showing one form of low frequency correction;

Fig. 6 discloses a modification of the circuit of Fig. 5;

Fig. 7 sets forth a circuit modification showing particularly a noiseless gain control system;

Fig. 8 is a modification of Fig. 7, showing combined use with picture inverter; and,

Fig. 9 sets forth a circuit showing a complete amplifier set-up incorporating features of above circuits.

Making reference to the accompanying drawings and first to Fig. 1*a*, an amplifier circuit is set forth wherein two successive stages of amplification are provided by the tubes 1 and 2. In this circuit arrangement, input signal energy is applied at input terminal 3, while output signal energy is derived from the output terminal 4. In a circuit of this type it is apparent that the plate-to-ground capacity 5 of the first tube 1, and the grid-to-ground capacity 6 of the second tube 2, which are coupled by the coupling condenser 7, act in parallel to shunt the load resistor 8 of the first tube 1. In this circuit, operating plate voltages for the tubes 1 and 2 are applied at the terminal 9, while suitable grid bias voltage is supplied at terminal 10, for instance. The cathode elements are suitably grounded, for example, at 15.

In such amplifiers it is customary to avoid the plate-to-grid capacity by the use of screen grid tubes and separately shielded leads, as is well known.

If, for illustrative purposes, the plate-to-ground capacity 5 is assumed to be equal to 6 mmf. and the grid-to-cathode capacity of the second tube is assumed to be equal to 11 mmf. then it is evident that the resultant capacity placed in shunt to the output resistor 8 of the first tube 1 is 17 mmf., for the tubes alone. This means that with strays considered, the total shunt capacity will be on the order of 20 mmf. or more, and also indicates that for a wide band amplifier the plate resistor will be relatively low in value. Consequently, for any customarily used television type amplifier tubes (such, for example, as the 6AC7), the gain per stage will be relatively low, and, for instance, usually of the order of not over 15, where the band width required in a television amplifier circuit approaches 4.5 megacycles.

If now, however, reference is made to Fig. 1*b*, it will be seen that a cathode coupler circuit has been set forth to transfer and transmit the plate voltage swing from the first tube 1 to the succeeding tube 2. This cathode follower coupler is diagrammatically represented by the tube 12, and, as is known, such a cathode follower offers practically no additional grid-to-ground capacity because there is no A. C. voltage between its grid and cathode. Consequently, with a circuit of this nature, the only shunt capacity remaining to shunt the output resistor 8 of the tube 1 is the plate-to-ground capacity 5, plus perhaps some stray capacity for wiring.

The grid capacity 6 of the tube 2 is effectively disconnected from the plate of the driver tube 1, as represented by Fig. 1*b*, and, as indicated, it acts as a load for the cathode-follower tube 12.

No matter what value the cathode resistor 11 of the tube 12 may happen to be, the cathode-follower stage 12 must be considered as a generator with the E. M. F. of its input dependent upon tube 1 and an equivalent internal resistance of $1/g$, where g represents the mutual transconductance of the tube 12.

Considering the tube 12, for example, to be a tube of the type known in the art as the 6J5, it can readily be calculated that the gain per stage, with a transmitted frequency band of the order of 6 mc., may be considerably in excess of 30, which is highly desirable in a television circuit, and indicates clearly that the available gain for a given band width is more than doubled by the cathode-follower coupling.

In the design of such multi-stage amplifiers, it is always apparent how much gain is required because the input signal strength is usually known, and, for the purpose of operating television image reproducing apparatus, the actuating signal strength necessary is likewise known. Accordingly, it is easily possible to calculate the necessary gain.

Under such circumstances, it frequently happens that two amplifier stages, cathode-follower coupled, may be insufficient to produce the required gain, and yet three amplifier stages will produce more gain than is required. Therefore, to take care of such situations, the gain per stage may be reduced by reduction of the plate impedance, but to obtain a more uniform response from the amplifier for wide frequency bands, it is preferable to introduce cathode degeneration. Such a method makes possible trading a loss in voltage gain for a gain in the band width uniformly handled, and is conveniently provided through the aid of a capacitive shunt used in grounded connection with the driving amplifier.

If now, reference is made to the modification of the circuit, as is shown by Fig. 2, it will be seen that a capacitive high frequency shunt 21 is provided in the connection between the cathode of tube 1 and ground 15. This capacitive shunt 21 is preferably shunted by a cathode resistor 20. Under such circumstances, it may be assumed that tube 1 is of the type known in the art as the 6AC7.

Several conditions of operation may be considered by making reference to the curves of Fig. 3, wherein the amplifier gain is plotted against the frequency response. The curve A represents the amplifier response condition with degeneration provided by the resistor 20, but where the capacity C_{21} of Fig. 2 is equal to zero. From this curve, it can be seen that from some intermediate frequency value F_4 the gain begins to fall off gradually. However, from the same curves of Fig. 3 it can be seen, by reference to curve B, that if the capacitor 21 is added and where the time constant of the circuit comprising the capacity 21 and the resistor 20 is made equal to the time constant of the plate-to-ground capacity 5 and the plate resistor 8 of the amplifier, the response remains at a substantially uniform value for a somewhat wider frequency

range (until frequency F_3, for instance) and then falls off more slowly than in the case where the shut capacity 21 is omitted in conjunction with the degenerating cathode resistor 20.

A third possible operating condition is shown by the curve C where a greatly peaked output is provided below the frequency value F_1, where the amplifier response under condition A first tends to fall off. However, further reference to curve C shows that while the amplifier response is substantially peaked at frequency F_4 (a lower frequency than F_3), it is nevertheless reduced to a substantially zero value at a much lower frequency value than when the operation took place under either condition A or condition B.

The operation under the condition of curve C is such that the time constant provided by the capacity 21 and the resistor 20 is greater than that provided by the capacity 5 and the resistor 8.

It thus is seen that curve C provides substantial peaking but no increased band width. Thus, operation of any cathode follower system for a wide band video amplifier is preferable under the conditions of curve B, provided some peaking effects are introduced in conjunction with this type of operation. Accordingly, reference may now be made to the further circuit modification shown by Fig. 4 wherein such peaking is introduced.

With the general type of circuit shown by Fig. 2, modification may readily follow (as in Fig. 4) to provide the necessary high frequency peaking. In many cases this high frequency peaking may be provided by virtue of the inductance element 25 connected in series with the load resistor 8. This provides a shunt peaking which is desirable for inter-stage coupling. Under some conditions, or for conditions where especially heavy loads are to be handled, it frequently becomes desirable to utilize a series peaking inductance, such as that shown at 26, intermediate the cathode output of the cathode-follower 12 and the driven tube 2. Where an inductance of this character is used, it sometimes becomes desirable to exclude the shunt peaking inductance 25, or to short circuit it, although both methods of peaking may efficiently be used simultaneously without in any way affecting the operation of each other. When the series peaking coil or inductance 26 is utilized, a condition of resonance is usually brought about by virtue of a capacity element 27. Such a circuit as is embodied by the inductance 26 and the capacity 27 to form the series resonance circuit should fulfill certain conditions, in that the circuit should be tuned to the peaking frequency and that it should be semi-aperiodic.

Following this type of analysis, it is evident that the capacity 27 may be made much larger and within much more reasonable and convenient size with series peaking than is provided by the usual grid-to-ground capacity of the more conventional circuit.

Under some conditions, where it is desired to derive an output directly from one cathode-follower stage, such as the tube 12, a piece of shielded cable may be connected in place of the condenser 27 and act as a load for the inductance element or peaking coil 26 as long as the capacity value is kept within the range where series resonance occurs at the desired peaking frequency. In this way, no appreciable losses of picture definitions occur by reason of transmission of the signal over short cable lengths, provided suitable peaking appears also at the output of the cable. This is particularly desirable where different stages of the amplifier are carried in separately shielded units.

Now, referring to Fig. 5, particular emphasis has been placed upon a circuit wherein special provisions have been made for low frequency correction, whereby the lowest frequency values may be faithfully transmitted, with the possible inclusion of the D. C. component. In the arrangement of Fig. 5, the circuit elements disclosed are essentially like those of Fig. 1b and also Fig. 4, but they provide, in addition, a low-pass filter in the form of the resistor 30, which is in series with the plate resistor 8, and the capacity 31 connected between the junction point of resistors 30 and 8, on the one hand, and ground 15 on the other hand. This circuit then acts as a high frequency trap and, at the same, provides low frequency emphasis. A further advantage is provided in that the voltage drop, which takes place through the resistor 30, is also made useful as a plate voltage supply for the cathode follower tube 12, which is connected directly in parallel to the plate supply 9 and the plate of the amplifier tube 1.

With the above arrangement, some of the low frequency waves are predistorted and contain even too much low frequency components. Accordingly, by virtue of the combination provided by the capacity 35 and the resistor 36, serving as a high-pass filter, this predistortion can be compensated. In this connection, the coupling condenser 35 is usually shunted by a critical resistor 37, provided that suitable negative bias voltage is supplied to the control electrode of the driven tube 2 from a suitable bias source, such as that conventionally indicated at 38. Where only the conventional A. C. video amplification is desired, the leakage resistor 37 may be omitted.

The arrangement thus described transmits not only the lowest frequencies of the desired response band, but it also makes provision for transmitting a steady-state condition, or the direct current component through the amplifier in a manner which can be readily ascertained from computations.

In a slightly further modification of the arrangement, which is particularly adapted for use where the condenser 31 is in the nature of an electrolytic condenser, with perhaps imperfect insulation, the combination may be represented by the condenser 40 and a series resistor 41, as shown by Fig. 6, where the resistor 41 represents the equivalent losses through the electrolytic condenser. Accordingly, to provide adequate compensation, a further series combination of condenser 44 and resistor 43 is connected, as indicated by Fig. 6, in parallel with the condenser 35 and the resistor 37.

With the cathode coupler circuits hereinabove described, considerable opportunity is afforded for the inclusion of the gain control circuit which has a wide range of operation with complete absence of noise introduction and, at the same time, offers no change in either frequency response or in the transmission of direct currents. In this connection, the circuit of Fig. 7 is particularly useful, it being understood however, that in the arrangement disclosed, the tube 2 will now act as the driver tube and, possibly, but not necessarily, the D. C. inserter.

The circuit of Fig. 7 is substantially like that of Fig. 5 with the band stretcher 20, 21, disclosed

by Figs. 2 and 4, also included. In the arrangement of Fig. 7, the cathode follower tube 12 derives its power supply through the resistor 11, but the apparent impedance of the tube 12 is much smaller than the actual value of the resistor 11. Between the cathode element of the tube 12, which cathode is connected to the tube 2 from the point 54, and a suitable constant voltage source, conventionally represented as the glow-discharge tube 50, shunted by condenser 51 for supplying voltage by a conductor 57, a variable resistor element 52 is connected. The operating conditions of the tube 12 are adjusted so that its cathode voltage is just equal to the voltage of the source represented at 50. The result is that no direct current leaks away through the gain control resistor 52, and it becomes apparent that this potentiometer can be operated without introducing any noise or "motor-boating" in the system because there is no D. C. drop across it. Stated in another way, when the voltage across the cathode resistor 11 is made equal to the voltage of the source 50, no current flows through the element 52. Any stray capacity to ground, which might be inherent in the installation, cannot affect the picture definition because the source impedance is too small to permit an attenuation of high frequency components. The range of operation is limited by the residual short circuit resistance of the element 52, which can readily be made adjustable by means of an additional resistor element 53. Any non-linearity in the described system may readily be taken care of and straightened out through the use of a logarithmic volume control element 52.

Now, making reference to the circuit of Fig. 8, there is provided a modification which combines the gain control of Fig. 7 with a picture inverter stage, whereby either positive or negative output energy may be derived. In this connection, signal input energy is supplied, as before, to the input terminal 3, and thence to the control tube 1, from which the energy is now fed to an inverter tube 62 which serves to connect the control tube 1, in cathode follower fashion, to the driver output tube 2. However, in accordance with the position of the switch element 61 relative to contacts 63 and 64 will be determined whether the resultant output energy supplied to the driver tube 2 is positive or negative, as will later be explained.

In connection with the arrangement of Fig. 8, the tube 62 is usually, for convenience, a double triode, such, for example, as the tube known in the art as the 6F8 or the 7F7, although other tubes may readily be substituted and even separate triodes used for the first and second sections thereof. With the system disclosed, the first half or left-hand half of the tube 62 preferably acts as 1:1 voltage amplifier provided with a suitable plate resistor 65 of reasonably low impedance. With a switch 61 positioned adjacent the contact point 63, a connection is made to the left half of tube 62 to provide for transmitting a positive picture, while with the switch 61 resting against the contact point 64, the connection is made to the output of the right-hand half of tube 62 to provide for transmitting a negative picture. Thus, the right-hand half of the tube 62, which is energized from the output of the left-hand half of this tube through the coupling condenser 66, then acts simply as a cathode follower with inverted polarity.

Bearing in mind the circuit hereinabove explained in Fig. 7, wherein the gain control was particularly described, it will be seen that the same circuit elements are set forth by Fig. 8, and consequently, with the arrangement disclosed, the same variable resistor or potentiometer unit 52 may serve as a volume or gain control for either polarity of picture, it being noted that the control range preferably should be of the order of about 1 to 10.

By the arrangement of Fig. 9, a substantially complete form of amplifier circuit to include the amplifier and the introduction of blanking signals, along with the picture or video signals, has been set forth. In connection with such high gain wide band amplifiers, it is particularly important that there be a substantially symmetric output; that the voltage supplied be suitably stabilized; and that further stabilization be introduced, particularly for the first stage of amplification, and what is known as the "pre-amplifier" or, in other words, the amplifier stage connected closest to the picture tube output. With a circuit of this character, stabilization has been indicated as being provided by means of suitable glow-discharge lamps or neon lamps, herein conventionally indicated and represented by the lamps 140, 141 and 142, from which, for purposes of illustration, assumed output voltage of 225 volts and 150 volts positive relative to ground 15, and 75 volts negative relative to ground are developed, will be assumed. By making the amplifier output symmetrical, as indicated by Fig. 9, adequate stability of output is maintained with a limited amount of capacity in parallel to the several neon lamps or glow-discharge tubes.

To this end, the two output stages 71 and 72 will be assumed, of which the former supplies the output signal energy of positive sign to the output terminal 127 or to the shielded cable 123, as will later be explained, and of which the latter supplies negative output energy to the output terminal 126. In connection with the disclosed arrangement, both of the output stages 71 and 72 operate as cathode followers, but the emission from the tube 71 is from some assumed minimum stationary current value up to some assumed maximum current value, whereas the emission from the tube 72 is from the assumed maximum current value down to the assumed minimum stationary value. The result is that the sum of both picture modulations just cancels, as can be determined from the common power supply.

Under these circumstances, and by this method of balancing the high power video output, the problem of how to avoid low frequency feedback and "motor-boating" is substantially simplified, and, at the same time, an additional video channel is available to carry the negative modulation, as is frequently useful in connection with the modulation of control equipment.

In connection with an amplifier of this character, it was pointed out above that electronic regulation of the plate voltage, for the pre-amplifier stage 93 and the first amplifier stage 95, is extremely important, and this voltage regulation is carried out by means of a stabilizing triode tube 73, connected in such a manner as to provide voltage stabilization. To this end, the condenser 74 is of such size as to transmit even very low fluctuations of the assumed 225 volt energy supply connected at the terminal 9 to the grid or control electrode of the tube 73. The plate resistor 75 of the tube 73 is made adjustable, as indicated, until the total gain within the triode

73 becomes unity. In this case, the output line, which is indicated by that portion of the high voltage line in Fig. 9 to the left of the triode 73, carries regulated voltage which may now be assumed as being at about +220 volts stabilized, with the adjustment of any voltage drop relative to the input being kept to a minimum by an adjustment of the plate resistor 75 of the tube 73 alone.

As is well known, in connection with the operation of wide band amplifiers, it is not usually practical to carry out the amplification of the initial signal energy by direct current amplifiers in all stages. The recourse to A. C. amplifiers results in the loss of the direct current component, due to the use of capacity connections, but by the use of a separate diode, or by the use of grid current action in one of the tubes of the latter stages of the amplifier and at one of the high amplification levels, the lost direct current component may be reinserted, as will herein be explained.

In this connection, initial output signal energy, representative of the picture or scene to be televised, results from a scanning action within a scanning camera or picture tube 90 where an optical image of the picture or other scene is suitably focused upon a mosaic element 91 to produce an output signal across the load resistor 92 whenever the mosaic 91 is scanned by a cathode ray beam in a manner well known in the art and therefore not herein specifically disclosed. The tube 90, and the manner in which scanning takes place, may be assumed to be in accordance with the description of such operations by Messrs. Rose and Iams in an article entitled "The orthicon, a television pickup tube," which was published in the "RCA Review" in October, 1939, or it may be in accordance with the principles and method set forth in an article by the same authors entitled "Television pickup tubes using low-velocity electron-beam scanning," which appeared in the "Proceedings of I. R. E." for September, 1939.

When scanning takes place within the picture or camera tube 90, output signals are developed which are then supplied to the amplifier tube 93, commonly known in the art as the "preamplifier," in that it is usually closely associated with the camera tube. The signals resulting from scanning are then amplified and supplied in cathode follower fashion, by way of the peaking inductance 95, to the transmitter cable 94. The peaking, by virtue of inductance 95, occurs in the manner described in connection with Fig. 4, with the there described capacity element 27 being represented by the capacity of the cable 94. The output from the cable 94 is now supplied to the first amplifier 96 whose output is supplied through a direct connection to the cathode follower tube 96. The output of the cathode follower tube 96 is then fed to the next amplifier stage 97 through a peaking inductance 26, as was explained by Fig. 4. In this connection, it may also be seen that the low frequency compensation is provided by the resistor 30 and the capacity 31 connected in the output of tube 95.

The output energy for the second amplifier tube 97 is supplied to the inverter or signal reversing tube 62 (as described in connection with Fig. 8) to provide, at the switch 61, either positive or negative picture outputs. From the switch element 61, signal energy output from the inverter tube 62 is fed by way of conductor 107 to the input of the driver stage 80, which precedes the output stages or the end stages 71 and 72, as was hereinabove set forth.

D. C. insertion of the lost components, due to the A. C. connections (as of amplifier 95, for example), may be carried forward by grid current action in one of the higher amplification stages. To this end, the tube 80 is so arranged that it derives zero grid bias through the grid leak resistor 81. Accordingly, tube 80 operates as an "audion" and consequently draws grid current, but the positive peak values of the grid swing are kept at zero relative to the cathode and never exceed such value. However, in order to avoid excessively heavy current through the tube, the screen voltage is considerably reduced, as indicated.

Thus, beginning with the tube 80, by which the D. C. level is set, all of the following tubes are direct current coupled and the low frequency compensation takes place by virtue of the arrangement hereinabove described, particularly in accordance with the circuits of Figs. 5 and 6, as indicated. To this end, output signals of either positive or negative sign are, with a D. C. component included, derived at terminals 127 and 126, respectively, in that the output from tube 71 is connected by way of the conductor 108 through a compensating network, of the type described in Fig. 6, to the tube 72.

In any amplifier of this character it is desirable that provision be made for injecting or modulating blanking signals into this video signal output without affecting the D. C. insertion. In the arrangement of Fig. 9, these blanking signals are injected into the stage 71, with a cathode feeder resistor 150, which follows the driver stage. Since the output stages in the circuit arrangement disclosed operate as cathode followers, the blanking signals are injected upon the screen electrodes. To this end, the blanking signals, which have been developed in any suitable sync signal generator (not shown), are applied at the terminal input 83 and fed through the coupling condenser 84 to the control electrode or grid of the right-hand half of the twin triode 82. In this connection, grid current, as indicated, provides adequate negative bias. The blanking signals, as they are amplified across the load resistor 85 connected to the right-hand section of the tube 82, are then coupled through the coupling condenser 86 to the control electrode of the left-hand half of the tube 82, which electrode is preferably connected to the voltage source at the terminal 57 by way of the resistor 87. By virtue of the conductor 88, the cathode element of the left-hand half of the tube 82 connects directly to the screen grid of the output stage 71 and, similarly, a connection is made also to the screen electrode of the second output tube 72. In this connection, the arrangement disclosed develops adequate power to take care of the screen current flowing through tube 71, and to keep the screen slightly above the indicated 150 volt potential at terminal 57 during the line sweep while it modulates the screen grid to a point below the cut-off value during the blanking period. The connection shown provides extreme freedom from hum which may exist across the high voltage line at terminal 9 and also offers low impedance for the screen circuit and ability for high-speed keying.

With this circuit arrangement disclosed by

Fig. 9, further provision is made for compensating for any hum condition and a complete A. C. operation is set forth through the use of the bleeder resistor 101, which is connected across the heater voltage line 102 which supplies the heater voltage to the various tubes, of which the heater 130 has been conventionally represented. The bleeder resistor 101 supplies compensating voltage of variable amplitude, which is further divided by the bleeder resistor combination 103 and 104, with the result that a compensating 60 cycle voltage (a 60 cycle source assumed) is impressed upon the screen electrode of the first amplifier stage 95 where it is made to eliminate the effects caused by the magnetic field due to the heater current. To eliminate further hum from the picture itself, a phase shifting circuit is also preferably included between the screen electrode 95 and the bleeder combination 103 and 104. Such a phase shifting network comprises condenser 109 and resistor 110, of which either or both elements may be made variable. The result is that it becomes unnecessary to provide for D. C. operation even for the heater of the first stages. However, in order to avoid any effects of high frequency feedback, the heater conductors 102 are blocked to ground by relatively large condensers connected at three points in the system, which may be illustrated, by way of example, by the condensers 115 and 116 connected in the pre-amplifier stage, the condensers 117 and 118 connected in the main amplifier stage, and by the condensers 119 and 120 which are indicated as in the power stage where the heater element 131 conventionally represents the heater cathodes of this stage.

Suitable power for the operation is derived from the alternating current source connected at 133 and feeding energy into the transformer primary 134 from which the heater current is derived by way of secondary winding 132. The high voltage is derived by way of the secondary winding 136 connected to the rectifier 137, in known manner, with the filter condensers 138 and 139 functioning as smoothing instrumentalities.

In the light of what has been hereinabove described, it will, of course, be apparent that various modifications may be made in the circuit without departing from the spirit or scope of what is set forth.

Having described the invention, what is claimed is:

1. An amplifier circuit including a signal input amplifier tube and a signal output amplifier tube, an electronic cathode follower coupling tube having at least a cathode, a control electrode and an anode, means to supply the output energy from the signal input amplifier to the control electrode of the said coupling tube, a cathode load resistor connected with said coupling tube, means to supply energy to the input of said signal output amplifier in accordance with the energy output of the said coupling tube as it appears across the said cathode resistor, a shunt connected inductive peaking element connected in the output circuit of the signal input amplifier tube and a series connected inductive peaking element connected intermediate the cathode output of said coupling tube and the input of the signal output tube.

2. An amplifier circuit including a signal input amplifier tube and a signal output amplifier tube, an electronic coupling tube having at least a cathode, a control electrode and an anode, means to supply the output energy from the signal input amplifier to the control electrode to the said coupling tube, a cathode load resistor connected with said coupling tube, means to supply energy to the input circuit of said signal output amplifier in accordance with the energy output of the said coupling tube as it appears across the said cathode resistor, a voltage source adapted to develop output energy of substantially the same magnitude as the voltage drop produced through the cathode load resistor of the coupling tube, a variable resistor connecting the said voltage source to said cathode resistor at a point adjacent its connection with the cathode of the coupling tube so that signal output may be noiselessly controlled by adjustment of said resistor, and means for applying the output energy of said coupling tube to the input of the signal output tube.

3. The circuit claimed in claim 2 comprising, in addition, resistor means connected with the input circuit of the said signal output tube for biasing the said tube, whereby predetermined signal output voltages may be maintained.

4. An amplifier circuit comprising at least a first amplifier tube and a second amplifier tube connected in cascade, means for supplying video signal energy to the input circuit of the first of said tubes, a cathode-follower coupled thermionic tube connected to receive in its input circuit the signal output from the first of said amplifier tubes and to deliver its cathode signal output to the input circuit of the second of the said amplifiers, resistor and condenser combinations connected in the output circuit of the first of said amplifier tubes and in the input circuit of the second of said amplifier tubes and the output circuit of the coupling tube to compensate for low frequency distortion in signal transfer from the first to the second of the amplifier tubes.

5. The circuit claimed in claim 4 comprising, in addition, a parallel resistor and condenser combination connected in the cathode circuit of the first of the amplifier tubes to provide controlled degeneration and to increase the signal band width amplified.

6. The amplifier claimed in claim 4 comprising, in addition, a resistor element connected in series with each of the cathode and anode elements of the first amplifier tubes, and a condenser connected to one terminal of each of said resistors and to a point of fixed potential, the condenser and resistor combination connected in the cathode circuit of said tube being adapted to be adjusted so that the time constant thereof is substantially equal to the time constant of the resistor and condenser combination connected in the anode circuit, whereby partial degeneration and increase in signal band amplification result.

7. In combination, a first amplifier tube and a second amplifier tube, means to supply signal energy to the input circuit of the first amplifier tube, a plurality of thermionic coupling tubes connected intermediate the first and the second amplifier tubes, a cathode output circuit for each of the said thermionic coupling tubes, means to supply the output energy from the first of said coupling tubes to the input of the second coupling tube, switching means to connect the input of the second of said amplifier tubes to the cathode output of one or the other of said thermionic coupling tubes, whereby signals of like and different polarity to the signal output energy of the first amplifier tube are transferred to the input of the second amplifier tube in selected negative and positive polarity.

8. A video amplifier circuit for television comprising at least a first amplifier tube and a second amplifier tube, means for supplying video signal energy to the input circuit of the first of said tubes, a cathode-follower connected thermionic coupling tube having its input circuit connected to receive the signal output from the first of said amplifier tubes and to deliver its cathode signal output to the input circuit of the second of the said amplifiers, resistor and condenser combinations connected in the output circuit of the first of said amplifier tubes and in the input circuit of the second of said amplifier tubes and the output circuit of the coupling tube to compensate for low frequency distortion in signal transfer from the first to the second of the amplifier tubes, and inductive means for peaking the higher frequency energy supplied to the second of the amplifier tubes.

9. The circuit claimed in claim 8 comprising, in addition, a parallel resistor and condenser combination connected in the cathode circuit of the first of the amplifier tubes to provide controlled degeneration and to increase the signal band width amplified.

10. The amplifier claimed in claim 8 comprising, in addition, a resistor element connected in series with each of the cathode and anode elements of the first amplifier tubes, and a condenser connected to one terminal of each of said resistors and to a point of fixed potential, the condenser and resistor combination connected in the cathode circuit of said tube being adapted to be adjusted so that the time constant thereof is substantially equal to the time constant of the resistor and condenser combination connected in the anode circuit, whereby partial degeneration and increase in signal band amplification result.

11. A television signal amplifier for amplifying uniformly a relatively wide band of frequencies comprising a first and a second amplifier tube, means to supply signal energy to the input circuit of the first of said amplifier tubes, a triode coupling tube in cathode-follower connection for supplying the signal output of the first amplifier tube to the signal input circuit of the second amplifier tube as a cathode load on the coupling tube, whereby the capacity load of the second amplifier tube on the first amplifier tube is substantially eliminated, a resistance and condenser combination connected in the output circuit of the first amplifier tube for enhancing low frequency gain, an inductive peaking element serially connected in the input circuit of the second amplifier tube, and a capacity connected to load said inductive element so that said elements provide for peaking in the higher frequency range of signals supplied to the second amplifier tube, a degenerating cathode resistor connected in the cathode circuit of the first amplifier tube and a condenser connected in parallel therewith whereby degeneration and band width stretching are introduced.

12. A television signal amplifier for amplifying uniformly a relatively wide band of frequencies comprising a first and a second amplifier tube, means to supply signal energy to the input circuit of the first of said amplifier tubes, a triode coupling tube in cathode-follower connection for supplying the signal output of the first amplifier tube to the signal input circuit of the second amplifier tube as a cathode load on the coupling tube, whereby the capacity load of the second amplifier tube on the first amplifier tube is substantially eliminated, a resistance and condenser combination connected in the output circuit of the first amplifier tube for enhancing low frequency gain, an inductive peaking element serially connected in the input circuit of the second amplifier tube, a capacity connected to load said inductive element so that said elements provide for peaking in the higher frequency range of signals supplied to the second amplifier tube, a degenerating cathode resistor connected in the cathode circuit of the first amplifier tube and a condenser connected in parallel therewith whereby degeneration and band width stretching are introduced, a third amplifier tube, a signal inverter tube connected in cathode-follower manner to supply the output energy of the second amplifier tube to the third amplifier tube, a switching means to connect the said cathode-follower signal inverter to the third amplifier tube to supply said third amplifier tube with signal input energy of positive or negative polarity, a terminal for connecting a source of alternating current to supply heating current to all of said tubes, and potentiometric means and capacity means to compensate for hum conditions introduced by said alternating heater current.

13. A television amplifier circuit including a first and a second amplifier tube each having included therein at least a cathode, an anode, and two grid electrodes of which one is a signal controlled element and the other of which is a screening element, an anode impedance for the first of said tubes which comprises a series combination of a resistance element, an inductive element and a capacitive-resistance combination which constitutes a low-pass filter through which a direct current voltage drop occurs and in which low frequency emphasis is added to signal input energy applied to the signal controlled grid, a coupling triode tube in cathode-follower connection between the first and the second of said amplifier tubes, said coupling triode having a cathode, an anode and a control electrode and having the control electrode and anode circuit directly connected in parallel with the said plate impedance of the first of said amplifier tubes, a resistor connected to the cathode of the coupling triode to control the current flow in the said tube, a capacity and resistance combination forming a high-pass filter combination connected between the cathode of the coupling tube and the signal control grid of the second amplifier tube, said capacity and resistance combination having a time constant equal to that of the said low-pass filter circuit so as to provide substantially uniform gain for the low frequencies in said amplifiers, and an output circuit for the second of said amplifiers.

14. A television amplifier circuit comprising a plurality of groups of amplifier units each including an amplifier tube having included therein at least a cathode, an anode and two grid electrodes of which one is a signal controlled element and the other of which is a screening element, an anode impedance for the said tube which comprises a series combination of a resistance element, an inductive element and a capacitive-resistance combination constituting a low-pass filter through which a direct current voltage drop occurs and in which low frequency emphasis is added to signal input energy applied to the signal controlled grid, a coupling triode tube in cathode-follower connection, said coupling triode having a cathode, an anode and a control electrode and having the control electrode and anode circuit directly connected in parallel with the said plate impedance of the first of said amplifier tubes, a

resistor connected to the cathode of the coupling triode to control the current flow in the said triode, a capacity and resistance combination forming a high-pass filter combination connected to the cathode of the coupling triode, said capacity and resistance high-pass filter combination having a time constant equal to that of the low-pass filter circuit so as to provide substantially uniform gain for the low frequencies in said amplifier, and an output connection from the said high-pass filter to the signal controlled grid element of the amplifier tube of the following group of tubes.

KURT SCHLESINGER.