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WIDE RANGE AMPLIFIER CIRCUITS

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Fig. 1

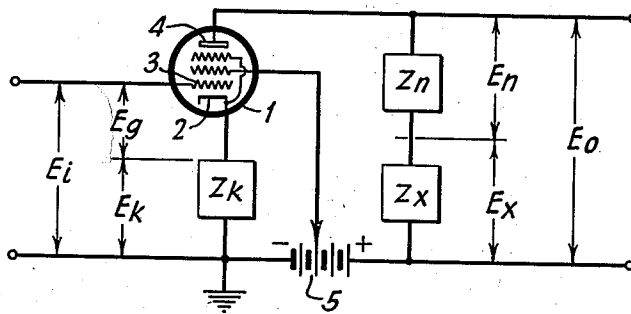


Fig. 2

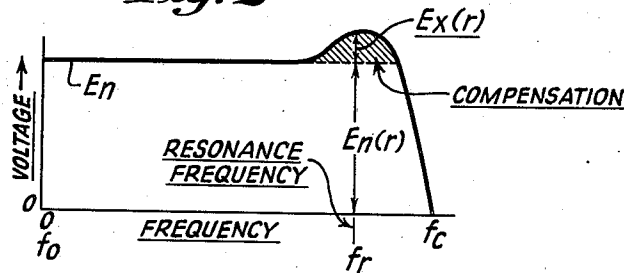
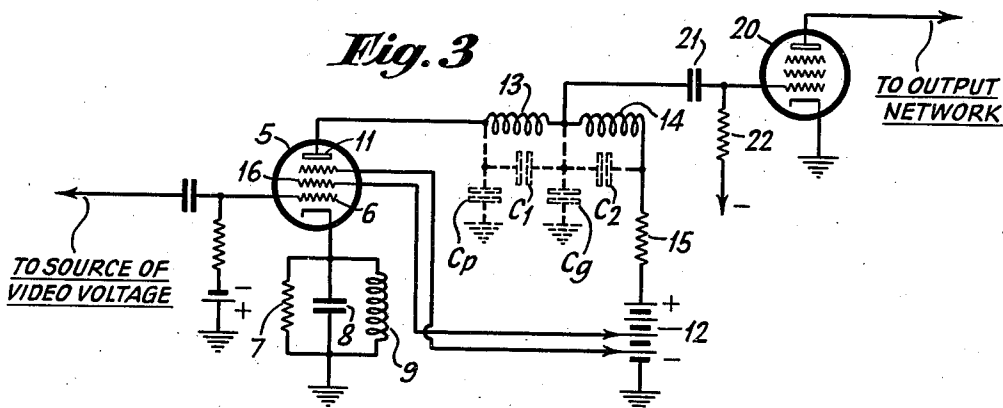


Fig. 3



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WIDE RANGE AMPLIFIER CIRCUITS

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Application October 26, 1939, Serial No. 301,319

2 Claims. (Cl. 179-171)

My present invention relates to wide range amplifiers, and more particularly to video amplifiers having a substantially flat response over the operating frequency range.

One of the main objects of my present invention is to provide selective inverse feedback in a video amplifier thereby to secure complete compensation of deviations in gain or phase within a certain frequency range and without loss of normal gain.

Another important object of this invention is completely to compensate for response-varying effects caused by circuit elements in the plate circuit of a wide band amplifier; particularly designed circuit elements being inserted in the cathode circuit to effect the compensation.

Another object of my invention is to provide a video amplifier having a plate circuit constructed to impart a peak in the frequency-response characteristic thereof, and the cathode circuit including a degenerative network whose constants are chosen to compensate for said peak.

Still other objects of my invention are to improve the response characteristic of video amplifiers, and more especially to provide compensation networks of the type disclosed hereinafter which are readily and economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawing—

Fig. 1 schematically illustrates the general circuit embodying the invention,

Fig. 2 shows a response characteristic of an amplifier employing the invention,

Fig. 3 shows a video amplifier network utilizing the invention.

Referring now to the accompanying drawing, the amplifier tube 1 of Fig. 1 has an input circuit connected to its cathode 2 and signal grid 3. The output circuit is connected between the plate 4 and the cathode, and includes the direct current source 5. The input voltage E_i is assumed applied between the input electrodes. The plate load impedance is considered as including a portion Z_n , or desirable fraction thereof, and the portion Z_x causing undesirable effects. The output voltage E_o may be considered as comprising the voltage E_n developed across Z_n , and E_x developed across Z_x . It can be shown that an impedance Z_k , connected between cathode and ground, can be designed to compensate for the

undesirable effects caused by Z_x in the plate circuit. The input voltage E_i is shown composed of grid to cathode voltage E_g and the voltage E_k developed across Z_k .

In general, the ratio and phase relation of E_i to E_o remain unchanged when E_k and E_x furnish similar vector diagrams; in other words, the phase angle between E_g and E_k is equal to the phase angle between E_n and E_x at any one frequency. Further, if the following relation holds true:

$$\frac{E_g}{E_k} = \frac{E_n}{E_x} \quad (1)$$

the effects of an impedance Z_k can be eliminated by inserting Z_k in the plate circuit (as disclosed in my application Serial No. 301,320, filed October 26, 1939) and, conversely, the effects of an undesirable fraction Z_x of the total plate impedance can be eliminated by inserting Z_k in the cathode circuit. Compensation over a frequency range requires that Equation 1 holds true over that range. If, therefore, the undesired effect in the plate circuit is a resonance effect, Z_x is found to be the impedance of a certain resonant circuit. Z_k is then designed as a similar resonant circuit having an equal resonance rise and an impedance at resonance which eventually resolves itself to:

$$Z_{k(r)} = \frac{1}{g_{m(k)}} \left(\frac{E_{x(r)}}{E_{n(r)}} \right) \quad (2)$$

Consider, now, a frequency-response characteristic as shown in Fig. 2. Frequencies are plotted against voltage, or gain, as ordinates. The solid curve is the voltage output without compensation, and rises to a peak near the cut-off frequency f_c . It is desired to obtain the dotted curve; the shaded area must be eliminated. Assume that its shape is closely matched by the resonance curve of a single parallel tuned circuit. Its resonant voltage is then $E_{x(r)}$ as shown; the normal voltage desired being $E_{n(r)}$. The impedance $Z_{k(r)}$ of the correction circuit has a positive value given by Equation 2 and can be realized. It is not desirable to design the coupling network of a video amplifier so that a "dip" occurs in the response characteristic, since in such case a negative value of $Z_{k(r)}$ would result and this would cause a loss of gain before compensation would be had.

In Fig. 3 there is shown a video amplifier network employing a correction circuit in the cathode lead of the video amplifier tube 5. This tube may be a pentode of the 1851 type and has its signal grid 6 connected to a source of video voltage. The cathode is connected to ground through resistor 7 which is shunted by condenser 8, and the latter condenser is in turn shunted by a coil 9. The plate 11 of tube 5 is connected to the positive terminal of the direct current source 12 through a path which includes coil 13, coil 14

and resistor 15 arranged in series. The negative terminal of current source 12 may be established at ground potential, and screen grid 16 will be connected to a desired positive potential point on current source 12. The suppressor grid is connected to a point on the current source which is at a substantially lower potential than the screen grid connection point. The junction of coils 13 and 14 is connected to the signal grid of a following video amplifier tube 20, the usual coupling condenser 21 and grid leak resistor 22 being included in the coupling network to tube 20.

The coupling network between tubes 5 and 20 carries of one pi section and one-half section. Coil 14 has a value which is one-half the value of coil 13; the symbol C_p denotes the shunt plate capacity shown in dotted lines, and the symbol C_g denotes the shunt capacity due to the grid circuit of the following tube and is also shown in dotted lines. The shunt capacities C_1 and C_2 , both shown dotted, are the respective distributed capacities of coils 13 and 14.

The cut-off frequency of a low pass filter may be expressed as follows:

$$f_c = \frac{1}{RC\pi} \quad (3)$$

In the much used single half-section filter (peaking coil) the value C in Equation 3 is: $C = 2(C_p + C_g)$, while for the circuit shown in Fig. 3, C is equal to C_g . The type 1851 tube has a capacity relation C_g equals two times C_p , which makes possible the use of the low pass filter shown in Fig. 3 for which this relation is required. The cut-off frequency f_c for Fig. 3 is, hence, theoretically three times higher for the same gain (same value of resistance of resistor 15) than for the normal circuit with a single peaking coil. Actually, the coil capacities C_1 and C_2

$$\left(C_1 = \frac{C_2}{2}\right)$$

cause about 15% reduction of this ratio. This follows from the fact that the following relation exists:

$$C = \sqrt{4C_p C_1 + C_g^2} \quad (4)$$

Normally, the useful frequency range of this circuit for video purposes is approximately $0.7 f_c$, because it has a characteristic similar to that shown by the solid curve in Fig. 2. The peak near cut-off is undesirable, and is eliminated by a correction impedance network 7-8-9 in the cathode circuit of tube 5 according to the discussion in connection with Fig. 1. Actual testing of an amplifier having seven circuits in cascade, and each circuit being of the type shown in Fig. 3, showed that one compensation network for the cut-off peak inserted in the cathode circuit of one of the tubes was sufficient for equalization of the entire video amplifier. The computed cut-off frequency of the amplifier was found to be $f_c = 9$ megacycles on 4 stages. Tests showed the end of the useful range to occur at 8 megacycles without causing transients. The equalizing circuit thus extended the useful range to $0.89 f_c$.

The present invention is not limited to the specific circuit shown in Fig. 3, but may be used to correct other response characteristics or transients originating in any part of an amplifier circuit by inserting a selective degenerative net-

work in the cathode circuit, or by inserting gain increasing circuit elements in the plate circuit according to the discussion in connection with Fig. 1. Because of the dependence of the correction impedance on g_m , a voltage adjustment for the grid bias or screen-voltage of tube 5 should be provided for the correcting stage which permits one to vary g_m . Re-adjustment of this control is necessary only to correct changes of g_m during the life of the tubes, the correct setting being apparent by the absence of transients in the amplified picture signal.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. A wide range video amplifier capable of amplifying frequencies up to approximately 9 megacycles comprising an electron discharge tube of the type including input and output electrodes, a video input circuit connected to the input electrodes, a load circuit including resistive and reactive components connected between the output electrodes, said reactive component tending to produce an undesirable deviation in the frequency response characteristic at the high frequency end of the range, and a reactive network in the space current path of said tube, common to the input and output circuits of the tube, for compensating for said undesirable deviation, said reactive network comprising the shunt connection of a resistance, a capacitance and an inductance between the tube cathode and ground and being resonant to the high frequency end of the video range and having its impedance matched to that of the reactive component of the output load circuit at said end of the range, and said load circuit comprising a low-pass filter and a resistance in series.

2. A wide range video amplifier capable of amplifying frequencies up to approximately 9 megacycles comprising an electron discharge tube of the type including input and output electrodes, a video input circuit connected to the input electrodes, a load circuit including resistive and reactive components connected between the output electrodes, said reactive component tending to produce an undesirable deviation in the frequency response characteristic at the high frequency end of the range, a reactive network in the space current path of said tube, common to the input and output circuits of the tube, for compensating for said undesirable deviation, said reactive network comprising the shunt connection of a resistance, a capacitance and an inductance between the tube cathode and ground and being resonant to the high frequency end of the video range and having its impedance matched to that of the reactive component of the output load circuit at said end of the range, said load circuit comprising a pair of coils and a resistance in series, and a second amplifier tube having its input electrode connected to the common terminal between the pair of coils.

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