

Oct. 27, 1942.

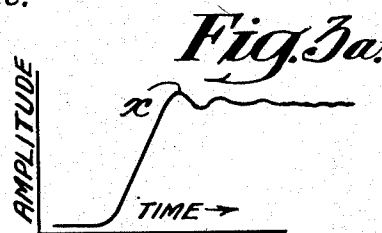
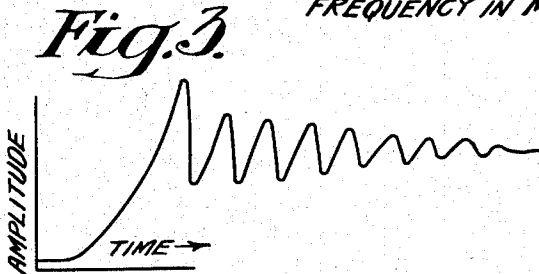
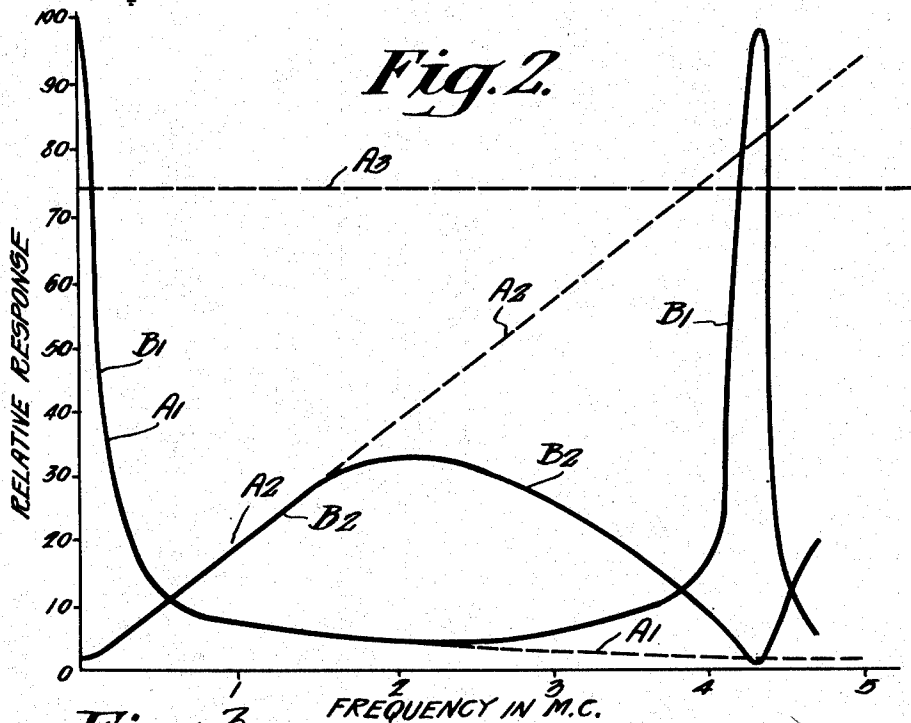
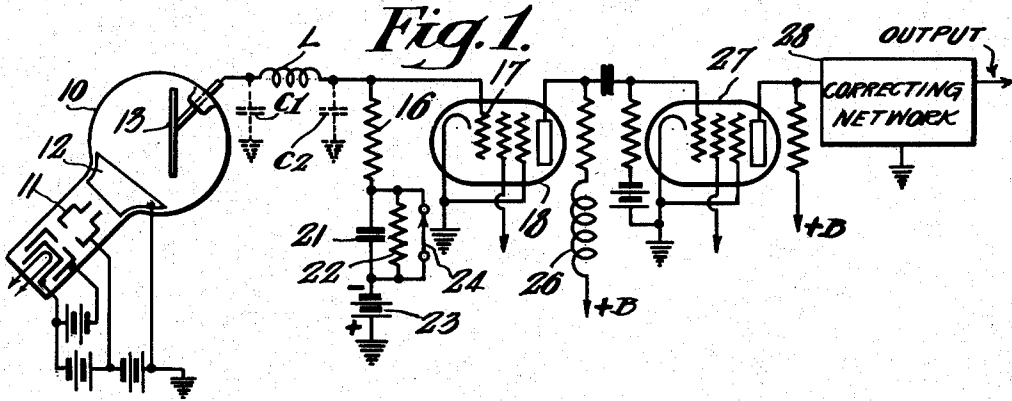
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2,299,875

TELEVISION TRANSMITTER

Filed Oct. 24, 1940

3 Sheets-Sheet 1



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2,299,875

TELEVISION TRANSMITTER

Filed Oct. 24, 1940

3 Sheets-Sheet 2

Fig. 4.

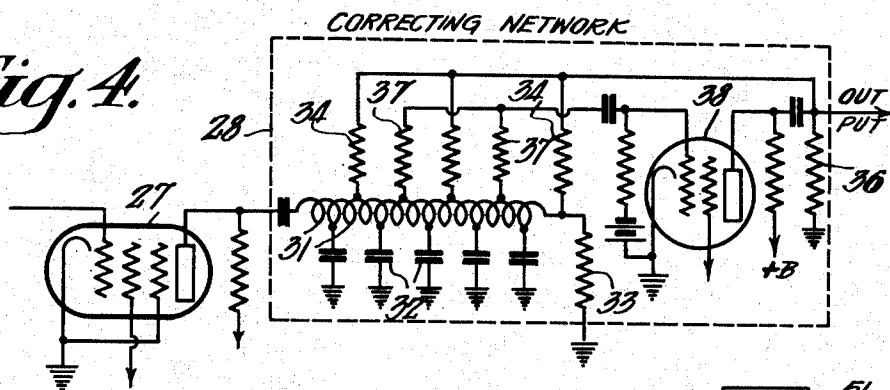


Fig. 5.

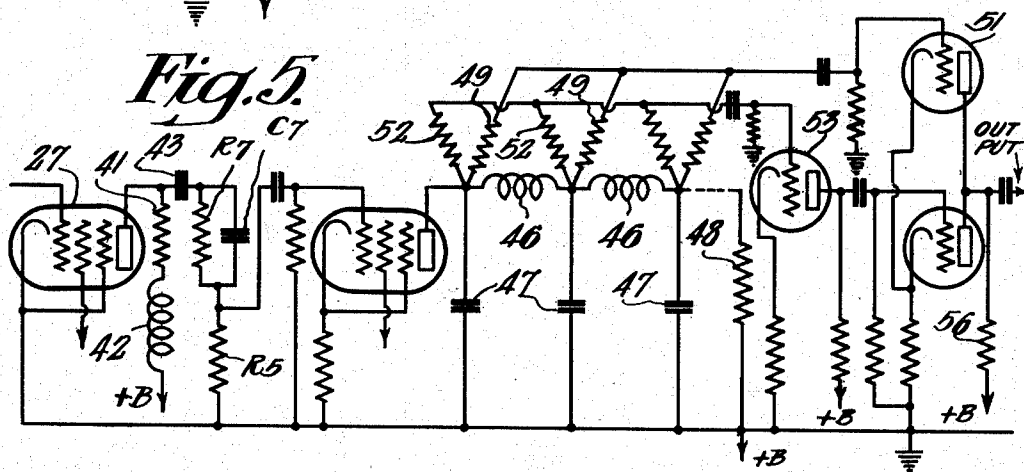
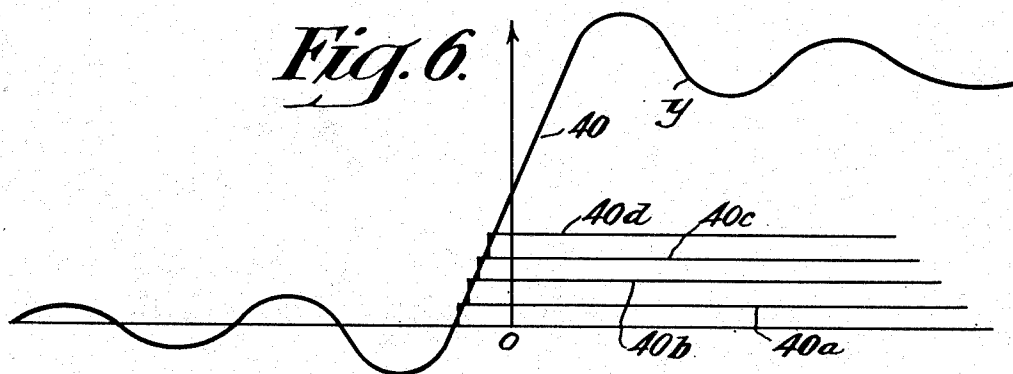


Fig. 6.



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TELEVISION TRANSMITTER

Filed Oct. 24, 1940

3 Sheets-Sheet 3

Fig. 7.

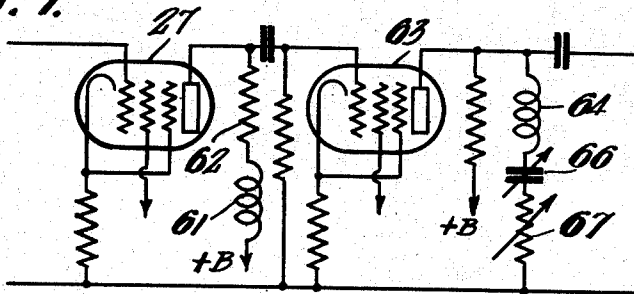


Fig. 8.

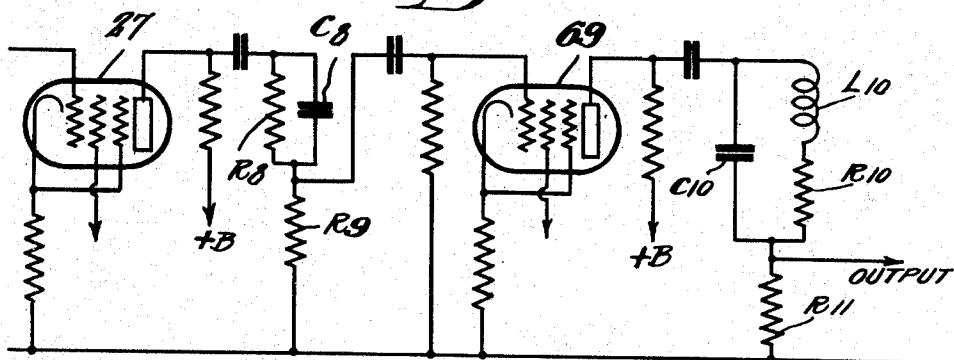
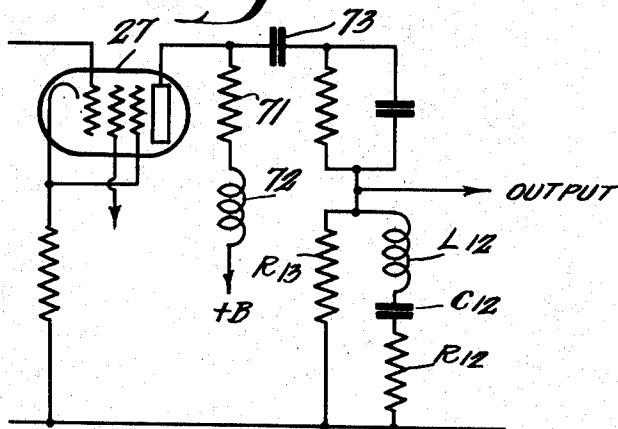


Fig. 9.



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UNITED STATES PATENT OFFICE

2,299,875

TELEVISION TRANSMITTER

Alda V. Bedford, Collingswood, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

Application October 24, 1940, Serial No. 362,547.

5 Claims. (Cl. 178-7.2)

My invention relates to signal amplifying systems and particularly to amplifiers for picture transmitters of the type employing cathode ray pick-up or transmitter tubes.

One of the major problems in television is that of obtaining a good picture signal to noise ratio without using too brilliant illumination on the subject being televised or without opening the lens aperture of the camera so wide that the depth of focus is too shallow. At times the problem is simply that of obtaining a useable picture signal under the lighting conditions available.

At one time it was the practice to make the resistance of the output resistor of a cathode ray pick-up tube low enough to give the output circuit of this tube a flat frequency-response characteristic over the entire picture frequency range.

More recently the output resistor has been given a much higher value than indicated above whereby the picture signal components are held up to a good signal strength for the lower frequency components (up to about 100 kilocycles, for example). Generally the output resistor has a resistance of from 50,000 ohms to 200,000 ohms and the stray capacitance thereacross is from 15 to 25 micro-microfarads. The response characteristic therefore is not flat and falls off for the higher frequencies, this falling off of the characteristic being compensated for in a later stage. The circuit just described is usually referred to as the "high peaker" circuit and is covered by my Patent 2,151,072 issued March 21, 1939, and assigned to the Radio Corporation of America.

An object of the present invention is to further improve the signal-to-noise ratio of a picture signal by holding up or accentuating the picture signal amplitude in the region of the higher frequency components and later compensating for this accentuation.

Stated more broadly, an object of the invention is to increase the useable signal output of a picture transmitter tube.

In practicing my invention an inductance coil is connected between the output electrode of the cathode ray transmitter tube and the control grid of the first amplifier whereby the output capacity of the transmitter tube and the input capacity of the amplifier are separated by the coil. This forms a low pass filter section. If conventional filter practice were followed, this filter section would be terminated in its surge impedance to prevent reflections. However, if this were done, the transmitter tube would work into an impedance too low for obtaining satis-

factory signal-to-noise ratio, the impedance under these conditions being of the order of 3000 ohms, for example, where the above-mentioned capacities are about 10 micro-microfarads each and where the inductance coil is adjusted for a cut-off frequency of about 4.5 megacycles. Because of this, prior to my invention the separation of tube capacities in the pick-up tube output circuit by means of an inductance coil was considered undesirable.

In the present invention I discard the conventional theory that major reflections at the end of a filter should not be allowed. Instead of terminating the filter section in its surge impedance of 3000 ohms, for example, it is terminated in a very high resistance such as 100,000 ohms. This results in a tremendous peak in the picture signal in a certain region of the higher frequency components, the location of this peak depending upon the inductance value of the coil.

After a suitable amount of amplification, the picture signal is passed through a compensating circuit which has the proper characteristic to make the over-all frequency response characteristic of the pick-up tube and associated amplifier and compensating circuit substantially flat. This means, of course, that the compensating circuit is so designed that the picture signal components in the region of the above-mentioned peak are amplified less than the picture signal components of less amplitude. The result is that the noise, also, in the region of picture signal peak is amplified less whereby the overall signal to noise ratio is improved. The compensating circuit, in addition to providing amplitude correction, corrects for undesirable phase shift which is introduced by the filter section.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which:

Figure 1 is a circuit diagram of one embodiment of my invention;

Figure 2 is a group of curves showing frequency response characteristics which are referred to in explaining the circuit of Fig. 1,

Figure 3 is a curve showing the square-wave response of the circuit of Fig. 1 with the correcting network omitted,

Figure 3a is a curve showing the square-wave response of the circuit of Fig. 1 where the correcting network is included,

Figure 4 illustrates one form of correcting network that may be utilized in the circuit of Fig. 1,

Figure 5 is a circuit diagram illustrating an embodiment of my invention in which the cor-

rection or compensation is obtained in successive amplifier stages by different networks.

Figure 6 is a group of curves which are referred to in explaining the operation of the network of Fig. 4, and

Figures 7, 8 and 9 are circuit diagrams illustrating other correcting circuits which may be employed in practicing my invention, Figure 9 being the preferred circuit.

Referring to Fig. 1 the transmitter circuit comprises a cathode ray transmitter or pick-up tube 10 consisting of an evacuated envelope having therein an electron gun 11 for producing a beam of electrons, a second anode 12 and a mosaic 13 of light sensitive elements. In this particular type of pick-up tube a light image of the picture to be transmitted is projected upon the mosaic 13 by means of a suitable lens system, not shown. This causes an electrical image of the picture to be formed on the mosaic whereby picture signals representative of the conditions of light and shade in the picture are reproduced as the mosaic is scanned by the electron beam. The beam is caused to scan the mosaic by means of deflecting coils or plates, not shown. It will be understood that the invention is not limited to the specific type of pick-up tube 10, this type of tube being selected merely for the purpose of giving a specific example. Also, the invention may be applied to signal output devices other than picture signal producing devices.

As stated in my above mentioned "high peaker" patent, and as well known in the art at the present time, the mosaic 13 may be constructed in various ways. In all cases, however, it will be found that there is a substantial amount of capacity between the output electrode of the pick-up tube and ground, and that this is one of the limiting factors in obtaining a picture signal output of substantial amplitude for the higher frequency components of the picture signal. As explained in my above-mentioned patent this difficulty can be overcome to a certain extent by making the output resistance of the cathode-ray tube much higher than the value required for a flat over-all response and compensating at a later point in the circuit for the resulting falling off of the signal amplitude at the higher frequency components.

In accordance with the present invention, in addition to giving the output resistor, shown at 16, a high resistance value as taught in my "high peaker" patent, I connect an inductance coil L between the output terminal of the cathode-ray tube 10 and the control grid 17 of the first amplifier tube 18 whereby the output capacity of the cathode-ray tube indicated at C1 and the input capacity of the first amplifier tube indicated at C2 are separated. It will be evident that now instead of the sum of the capacities C1 and C2 appearing between the output terminal of the cathode-ray tube and ground, the cathode-ray tube feeds into a section of a low pass filter C1—L—C2.

In terminating this filter section C1—L—C2, however, conventional filter theory is not followed since filter theory would require that the output resistor 16 (which terminates the filter section) have a resistance very much lower than the resistance actually employed. As previously indicated, filter theory would require that the filter section be terminated in a resistance of about 3000 ohms whereas in practicing my invention,

the filter section is terminated in a resistance of 100,000 or 200,000 ohms, for example.

It will be understood that the inductance value of the coil L will depend upon the other circuit constants and upon the desired location of the resonant peak in the curve B1 of Fig. 2. As an example, however, the inductance of coil L may be of the order of 300 microhenrys.

As a result of the high resistance filter termination, the frequency response curve, taken at the control grid 17 of the first amplifier tube, is as represented by the curve B1 (Fig. 2). It will be seen that this curve has a very high peak in the region of the high frequency components of the picture signal as a result of the high resistance termination of the filter section. It will be noted that curve B1 also has a large amplitude in the region of the lower frequency components of the picture signal as a result of the benefit derived from the high resistance of the output resistor 16 as described in my "high peaker" patent.

Perhaps it should be mentioned that the frequency response curves in the present application and those shown in my "high peaker" Patent 2,151,072 are drawn to scales which are so unlike that at first glance corresponding curves in the two cases do not look alike. In the "high peaker" patent, the curves are drawn up to one megacycle only and they are drawn to a logarithmic scale which "stretches out" the low frequency end of the scale. On the other hand the frequency scale for the curves of Fig. 2 in the present application is linear and goes out to 5 megacycles.

In actual practice it usually is desirable to accentuate the very low frequency components, components of the order of 60 or 100 cycles per second, for example, by means of a condenser 21 connected in series with the output resistor 16 and shunted by a resistor 22. The desired negative bias for the amplifier tube 18 may be provided by a biasing battery 23. In the illustration of Fig. 1, the condenser 21 and resistor 22 are shown short circuited by means of a switch 24 to make them ineffective. The curves in Fig. 2 are drawn for the condition of operation where the switch 24 is closed.

The use of the circuit 21—22 for accentuating the very low frequency components is described in my Patent 2,200,073 issued May 7, 1940. Here again, the frequency scale for the curves in the patent is logarithmic whereby the curve in the region of the lower frequencies is "stretched out." Since this accentuation of the signal occurs only in the general region of 100 cycles it is apparent that it could not very well be shown in Fig. 2 where the frequency scale is linear and covers 5 megacycles.

Still referring to Fig. 1, the amplifier tube 18 preferably is provided with the usual inductance coil 26 for holding up the high frequency response. The output of this amplifier is passed through one or more amplifier stages, such as the one including amplifier tube 27, and supplied to a suitable correcting or compensating network indicated at 28. As will be explained hereinafter, the correcting network 28 may be designed in accordance with the teachings of the copending application Serial No. 266,756, filed April 8, 1939, as a joint invention of Blumlein, Kallmann and Percival and assigned to Radio Corporation of America.

The operation of the circuit embodying my invention will now be more fully explained with

reference to the curves in Fig. 2. The curve A1, which at the lower frequencies coincides with the curve B1, represents the frequency response characteristic of the circuit of Fig. 1 with the coil L omitted. It will be evident that the use of the high resistance output resistor 16 has held up the picture signal output in the region below one megacycle. Following the teachings of my "high peaker" Patent 2,151,072 a flat over-all response, such as shown by the curve A3, would be obtained by means of a later compensating or "high peaker" stage having the frequency response characteristic shown by the curve A2.

With the coil L included in the circuit, as illustrated in Fig. 1, the frequency response curve measured at the control grid 17 of the first amplifier tube is that shown at B1, there being a high peak in this curve in the region of the higher frequency components of the picture signal, this peaking being located between 4 and 5 megacycles in the particular example illustrated.

The correcting or compensating network 28 is designed to have the frequency response characteristic shown at B2. The frequency response characteristic B2 is made such that the overall frequency response is flat. It will be noted that the flat over-all frequency response curve (not shown) is obtained by multiplying the ordinates of curves B1 and B2 together rather than by adding them together since the over-all gain of two stages in cascade is obtained by multiplying rather than by adding the gains of the individual stages.

The characteristic of the circuit of Fig. 1 with and without the correcting network 28 is further illustrated by Figs. 3 and 3a. Fig. 3 shows the square-wave response of the circuit with the coil L but without the correcting network, while Fig. 3a shows the square-wave response of the circuit after the undesirable transient response introduced by the coil L has been compensated for by means of the correcting network. As illustrated in Fig. 3a, the square-wave response of the corrected circuit preferably has a small amount of "overswing," indicated at X, because experience has shown that this is desirable for best picture quality.

In Fig. 4, where parts corresponding to those in Fig. 1 are indicated by like reference numerals, there is illustrated one form of correcting network that may be employed in practicing my invention, this being one of the networks described and claimed in the above-mentioned Blumlein et al. application. It comprises a delay network of conventional design consisting of a plurality of sections each having series inductance indicated at 31 and shunt capacitance indicated at 32, the network being suitably terminated by a resistor 33. Signal is taken off this delay network at suitable points through resistors 34 and combined in an output resistor 36 of comparatively low impedance. Signal is taken off the delay network at other points through resistors 37 and, after being reversed in phase by an amplifier tube 38, is combined with the rest of the signal in the output resistor 35. By properly selecting the delay, amplitude and phase reversal as taught in the above-mentioned Blumlein et al. application this correcting network 28 may be given any desired characteristic. In the present instance the network 28, of course, is designed to have the frequency response characteristic shown by the curve B2 in Fig. 2 in order to correct for the frequency response characteristic B1 of the preceding apparatus.

It will be understood, of course, that the specific network 28 illustrated in Fig. 4 is purely for the purpose of illustrating the general character of the Blumlein et al. type of network and that it might be desirable to have a different number of delay network sections and a different number of points at which the signal is tapped off and/or reversed in phase.

The principal of operation of the correcting network shown in Fig. 4 is illustrated by the curves in Fig. 6, this figure corresponding to one of the figures in the Blumlein et al. application. The procedure in designing the correcting network is as follows: First, the desired frequency response characteristic for the network is determined, this being represented by the curve B2 of Fig. 1 in the example under consideration. Next the square wave or transient response for a network having this frequency response characteristic is determined by calculation. For the purpose of illustration it will be assumed that this transient response is represented by the curve 40 in Fig. 6. It is then possible in a network such as shown in Fig. 4 to select the points at which the signal is delayed the proper amount and to select the proper signal amplitude to build up the desired curve as shown by the small stepped curves 40a, 40b, 40c and 40d in Fig. 6. It will be evident that where there is a dip in the curve 40 as at y, it is necessary to reverse the phase of some of the delayed signal.

The great improvement that may be obtained in the signal-to-noise ratio by practicing my invention will be seen more clearly from the following considerations. The curves A2 and B2, respectively, indicate the actual amplification following the grid 17 of the first amplifier tube that is necessary in order to obtain the same picture signal output for the case where the inductance coil L is omitted as for the case where it is included in the circuit. Since most of the noise in the system generally originates in the first amplifier tube 18 (assuming the case where the output resistor 16 has large resistance), the relative noise obtained with my invention as compared with that obtained without my invention is shown by a comparison of the ordinates of curve B2 and A2, respectively. Obviously, my invention causes a substantial reduction in noise in the picture signal since the curve B2 is much lower in amplitude than the curve A2 over a large portion of the upper frequency range.

If the coil L were employed and the resulting filter section terminated in its surge impedance, the relative response at the grid of amplifier tube 18 would be so low that the high subsequent amplification represented by curve A3, for example, would be required over the entire frequency band of signal components. The disadvantage with respect to signal-to-noise ratio is obvious.

The position of the peak of the curve B1 in the high frequency region may be shifted either toward the high end or toward the low end of the frequency band by changing the value of the inductance coil L. It has been found that, in some cases, at least, it may be preferable to have this peak located at a slightly lower frequency than shown in Fig. 2 if maximum noise reduction is to be obtained.

It is usually desirable to operate the circuits of Fig. 1 with the switch 24 open whereby the previously described accentuation of the very low frequency components is obtained. It will be understood that when so operated there is provided at some later point in the circuit a com-

plementary attenuating means such as a small coupling condenser, as described in my Patent No. 2,200,073.

Referring to Fig. 5 of the drawings, there is illustrated an embodiment of the invention in which the frequency response characteristic shown by the curve B2 of Fig. 2 is obtained by employing correcting circuits in two successive amplifier stages rather than by employing a single correcting network, as illustrated in Figs. 1 and 4. Like parts in Figs. 1 and 5 are indicated by the same reference characters.

In the circuit of Fig. 5 there is provided in the output circuit of the amplifier tube 27 a high peaker circuit R7—C7—R5 of the character described in my "high peaker" Patent No. 2,151,072. In this output circuit, an operating voltage preferably is supplied to the plate of the amplifier tube 27 through a plate resistor 41 and through the usual inductance coil 42 provided for holding up the high frequency response of the amplifier. The inductance coil 42 may be omitted if the plate resistor 41 is given a resistance low enough to make the amplifier characteristic substantially flat, but good amplifier practice usually indicates the use of the coil 42. The condenser 43 functions merely as a coupling condenser and for this purpose should have fairly large capacity. In the high peaker circuit itself, the resistor R5 has a resistance which is low compared with that of the resistor R7 whereby the percentage of the total signal voltage for a given frequency component appearing across the resistor R5 becomes greater for the higher frequencies.

The frequency response characteristic of the high peaker network R7—C7—R5 itself is shown essentially by the curve A2 of Fig. 2.

The desired over-all frequency response characteristic represented by the curve B2 is obtained by including in the next amplifier stage a network of the type previously described in connection with Figs. 1 and 4. This correcting network comprises a delay network consisting of a plurality of sections each including a series inductance 46 and a shunt capacitance 47, the delay network being suitably terminated in accordance with conventional practice by means of a resistor 48. As previously described, the picture signal is taken off the delay network at suitable points and supplied through resistors 49 to an amplifier tube 51 and through resistors 52 and a phase-reversing tube 53 to an amplifier tube 54 having a plate circuit common to the amplifier tube 51 whereby all the picture signals are added and appear across the output resistor 56.

By referring to Fig. 2, it will be seen that in the lower frequency region of the picture signals, the curve B2 coincides with the curve A2. It is evident that, in this region, the correction is provided solely by the "high peaker" circuit R7—C7—R5, while, for the higher frequency components, the correction represented by the curve B2 is provided by a combination of the characteristics of the circuit R7—C7—R5 and of the correcting network in the following stage.

In Figs. 7 and 8, there are shown other circuits for obtaining the desired frequency response characteristic B2, these circuits also comprising a "high peaker" amplifier stage and another stage in cascade therewith to compensate for the high resonant peak of the curve B1. In these figures the parts corresponding to like parts in Fig. 1 are indicated by the same reference numerals.

Referring to Fig. 7, the "high peaker" stage comprises the amplifier tube 27 which has an op-

erating voltage applied to its plate through an inductance coil 61 and a plate resistor 62, this resistor having much lower resistance than would be employed in an amplifier stage designed to have a flat over-all frequency response characteristic. Therefore, this stage itself has the rising characteristic A2 of Fig. 2. The design of such a "high peaker" stage is described in my above-mentioned Patent No. 2,151,072. In a following amplifier stage 63, there is connected across the plate circuit of the amplifier tube a series-resonant circuit consisting of an inductance coil 64, a condenser 66, and a resistor 67, this circuit being tuned to be series-resonant at the frequency at which the high resonant peak appears in the curve B1. By varying the resistance of the series resistor 67, the amount of damping in the circuit may be varied for the purpose of shaping the frequency response characteristic. The two stages in combination have the characteristic B2 of Fig. 2.

In Fig. 8, the "high peaker" circuit R8—C8—R9 is the same as that shown in Fig. 3. In a following stage, compensation for the high resonant peak of the curve B1 is obtained by employing in the plate circuit of an amplifier tube 69 a correcting network C10—L10—R10—R11 which is similar to the "high peaker" circuit of the preceding stage except that it includes the inductance coil L10. This inductance coil L10 and the condenser C10 are tuned to form a circuit which is parallel resonant at the frequency of the high resonant peak in the curve B1, whereby the amount of signal flowing through the resistor R11 at this frequency is very small, as indicated by the dip in the curve B2.

In Fig. 9, where parts corresponding to those in Fig. 1 are indicated by the same reference characters, there is illustrated a preferred circuit which may be substituted for the correcting network 28 indicated in Fig. 1, this circuit being preferred because of its simplicity and ease of adjustment. It is substantially the same as the "high peaker" circuit illustrated in Fig. 5, with the addition thereto of a series-resonant circuit consisting of an inductance coil L12, a condenser C12, and a resistor R12, connected in series with each other and connected across the output resistor R13 of the "high peaker" network. The said series-resonant circuit is tuned to series resonance at the frequency of the high resonant peak in the curve B1.

As described in connection with Fig. 3, the plate of the amplifier tube 27 has an operating voltage applied thereto through a plate resistor 71 and an inductance coil 72 provided for holding up the high frequency response of the amplifier tube 27. The condenser 73 functions simply as a coupling condenser.

The specific circuit shown in Fig. 9 is being claimed in copending application Serial No. 362,494, filed on the same day as the present application, in the name of Gordon F. Fredendall, and assigned to the Radio Corporation of America.

From the foregoing description, it will be apparent that various other modifications may be made in my invention without departing from the spirit and scope thereof.

I claim as my invention:

1. Electrical apparatus comprising a signal output device, said device having an output terminal which has unavoidable capacity to ground, an amplifier tube having a control electrode which has unavoidable capacity to ground, an inductance coil connecting said output terminal to said

control electrode whereby said coil and said capacities form a filter section, a termination for said filter section comprising a resistor having such high resistance that said section is terminated in an impedance many times its surge impedance whereby the signal output appearing at said control electrode has a resonant peak in the region of its higher frequency components, and means connected in cascade with said amplifier tube to correct for amplitude and phase distortion introduced by said filter section.

2. Picture transmitting apparatus comprising an electric discharge device for converting pictures into electrical signals, said device having an output terminal which has unavoidable capacity to ground, an amplifier tube having a control electrode which has unavoidable capacity to ground, an inductance coil connecting said output terminal to said control electrode whereby said coil and said capacities form a filter section, a termination for said filter section comprising a resistor having such high resistance that said section is terminated in an impedance many times its surge impedance whereby the picture signal output appearing at said control electrode has a resonant peak in the region of its higher frequency components, and means connected in cascade with said amplifier tube to correct for amplitude and phase distortion introduced by said filter section.

3. The invention according to claim 2 wherein said filter terminating resistor functions as a grid leak for said amplifier tube and wherein said resistor is the only direct current connection between the output terminal of said picture converting device and ground.

4. Picture transmitting apparatus comprising an electric discharge device for converting pictures into electrical signals, said device having an output terminal which has unavoidable capacity to ground, an amplifier tube having a control electrode which has unavoidable capacity to ground, an inductance coil connecting said output

terminal to said control electrode whereby said coil and said capacities form a low pass filter section, a termination for said filter section comprising a resistor having such high resistance that said section is terminated in an impedance many times its surge impedance whereby, at the control electrode of said amplifier tube, the frequency response is held up for the lower frequency components of the picture signal and whereby there is produced a resonant peak in the frequency response in the region of the high frequency components of the picture signal, and a compensating circuit connected in cascade with said amplifier tube and designed to have a frequency response characteristic substantially complementary to the frequency response characteristic of the apparatus as measured at said control electrode.

5. Picture transmitting apparatus comprising a cathode ray tube having therein a mosaic of capacity elements positioned to be scanned by the cathode ray whereby picture signals may be caused to appear at an output terminal of said cathode ray tube, said cathode ray being designed to produce picture signals having frequency components up to at least four megacycles, an amplifier tube having an input electrode, an inductance coil connecting said output terminal to said input electrode whereby a low pass filter section is formed as a result of tube capacity to ground, a high resistance termination for said filter section, said termination having an impedance many times the surge impedance of said filter section, and means connected in cascade with said amplifier tube to compensate for the resulting falling off of the frequency response characteristic at the high picture frequency component as measured at said input electrode and to compensate for the resulting resonant peak appearing in said characteristic in the region of the higher frequency signal components as measured at said input electrode.

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