

May 7, 1940.

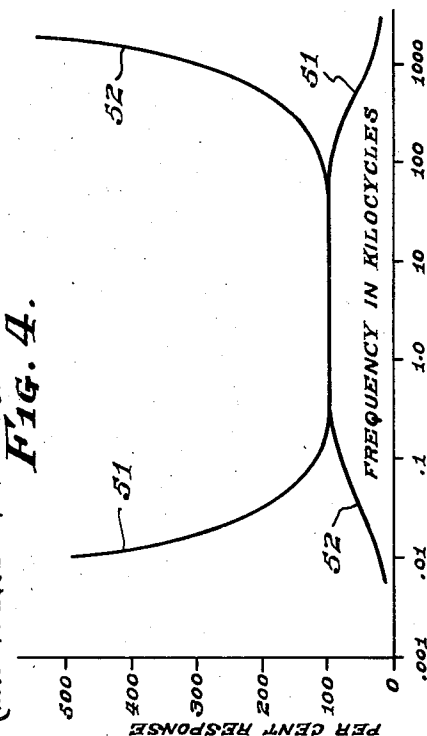
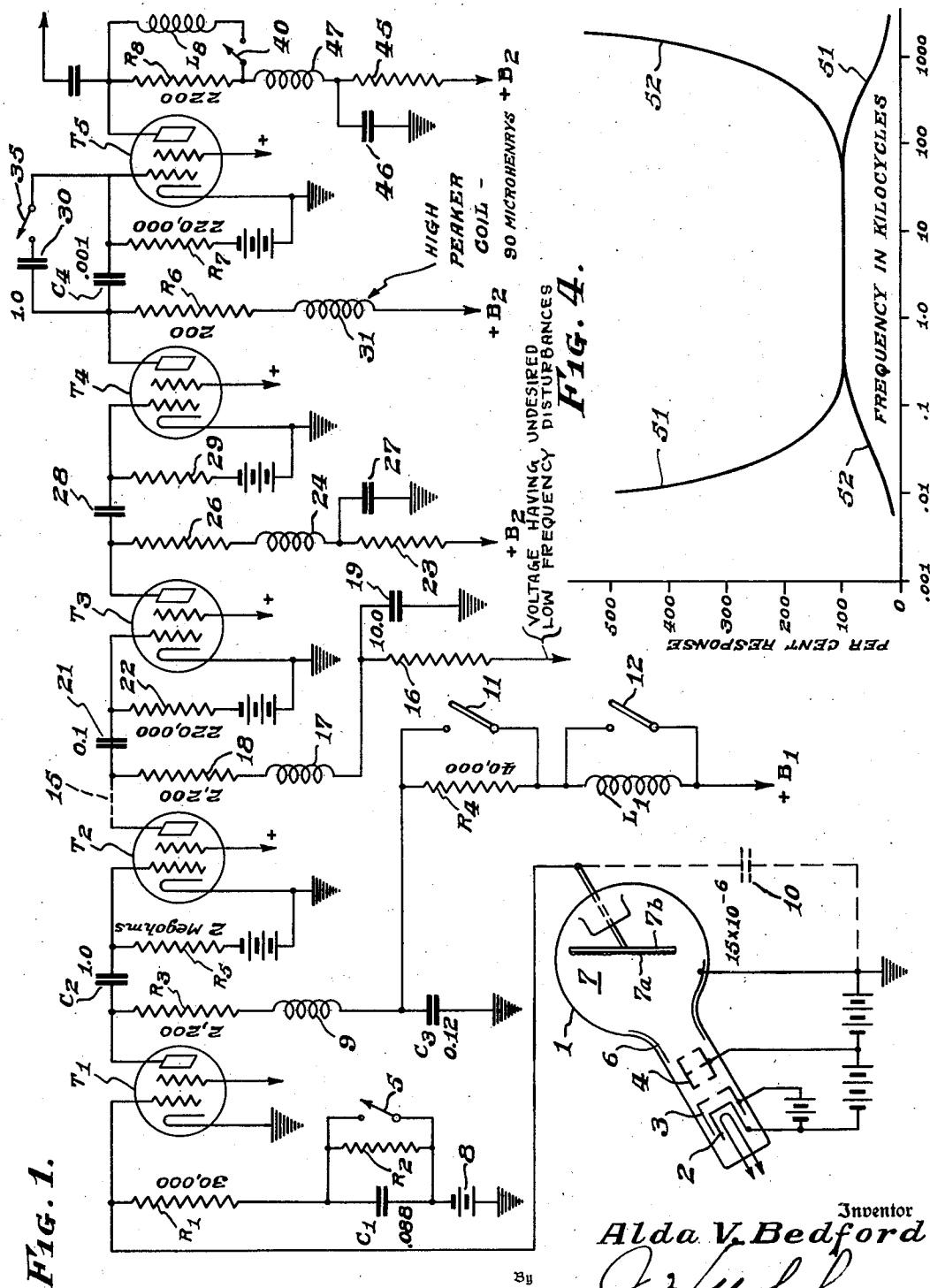
A. V. BEDFORD

2,200,073

ELECTRICAL TRANSMISSION SYSTEM

Filed Sept. 30, 1937

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Fig. 2.

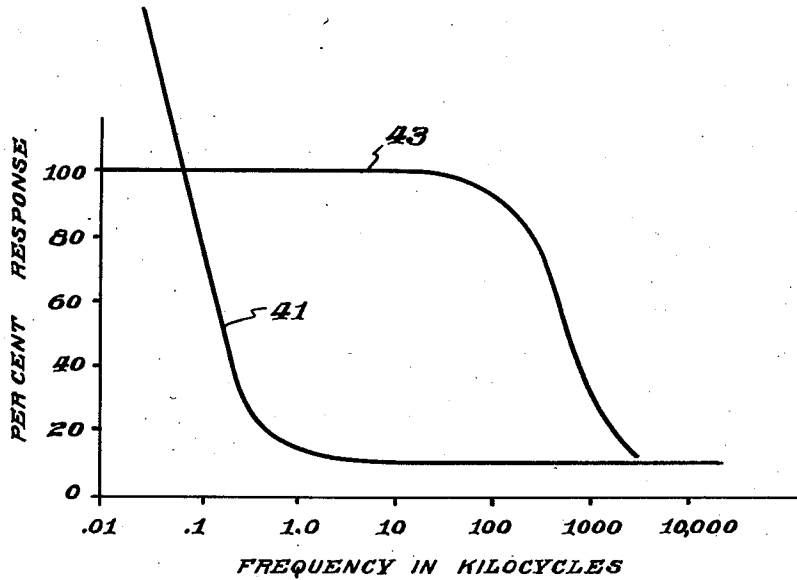
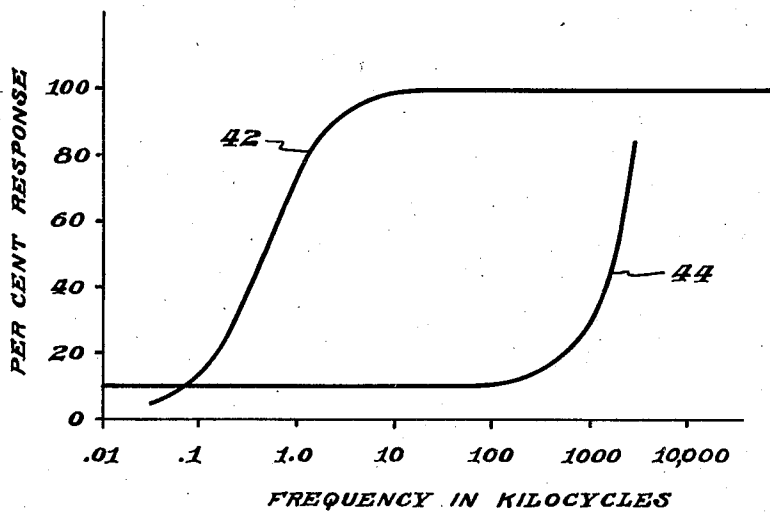


Fig. 3.



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UNITED STATES PATENT OFFICE

2,200,073

ELECTRICAL TRANSMISSION SYSTEM

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of Delaware

Application September 30, 1937, Serial No. 166,627

17 Claims. (Cl. 179—171)

My invention relates to apparatus for conveying or transmitting signals covering a wide frequency band, and particularly to transducers such as transmission lines or amplifiers for transmitting or amplifying picture signals in television systems.

In a picture signal or video amplifier, because of the extremely wide range of frequencies which must be amplified, resistance coupled amplifier stages are employed in which the plate resistance is low. As a result, the gain per stage is low and a rather large number of stages is required to obtain the required gain.

If the input signal is weak, as is the case when a cathode ray transmitter tube supplies the signal, the first few stages of the amplifier operate at such low level that trouble arises from pickup in the amplifier of low frequency disturbances occurring in the plate and screen grid voltage supplies. High frequency disturbances give less trouble since they are more easily removed by filters in the voltage supply.

Low frequency disturbances may originate from other sources. For example, an imperfect ground system will introduce such disturbances, especially if signals are being transmitted for a considerable distance over a cable. In this particular case, the ground connections at the two ends of the cable are widely separated and it has been found in practice that there is a slowly varying potential difference between the two ground connections.

Also, in the case of a long coupling conductor (such as the conductor of a cable) between amplifier stages, low frequency disturbances may be picked up by this wire.

It is, accordingly, an object of my invention to provide an improved means for and method of reducing low frequency disturbances in a wide frequency band transducer.

A further object of my invention is to provide an improved wide frequency band amplifier.

More specifically, one object of my invention is to provide a wide band picture signal amplifier so designed that trouble caused by low frequency disturbances is reduced.

A further object of my invention is to provide an improved picture signal amplifier for amplifying the signal output of a cathode ray transmitter tube in a television transmitter.

In one embodiment of my invention, I so design one of the earlier stages in an amplifier, preferably the first stage, that it has considerably more gain at the extreme low frequency end of the frequency range than at the higher fre-

quencies. Thus, the signals in the frequency region where voltage supply disturbances occur, are transmitted through the succeeding stages at a level high enough to give a good "signal to noise" ratio. In one of the later amplifier stages the low frequency signals are attenuated as compared with the higher frequency signals to bring the amplification of all frequency components to the same level. In other words, this last-mentioned amplifier stage is given a frequency characteristic which is complementary to the frequency characteristic of the first amplifier stage.

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 an amplifier embodying my invention, and

Figures 2, 3 and 4 are groups of curves which are referred to in explaining my invention.

Referring to Fig. 1, there is shown a portion of a television transmitter which includes a cathode ray transmitter tube 1 of a well known type. The tube 1 comprises a highly evacuated envelope having therein an electron gun which includes a cathode 2, a control grid 3, and a first anode 4. A second anode 6 accelerates the electrons and aids in electrostatically focusing them upon a photo-electric screen 7. The screen 7 consists of a mosaic of photo-electric globules 7a, microscopic in size, the globules being insulated from each other and from a metallic back-plate 7b.

The image of the scene to be transmitted is projected upon the screen 7 and is scanned by the cathode by means of suitable deflecting devices not shown.

The resulting picture signal is supplied to an output resistor R_1 which is connected between the back-plate 7b and ground when a switch 5 is closed, the connection to ground being through a biasing source, such as a battery 8. Resistor R_1 is also included in the input circuit of a suitable amplifier tube T_1 , the battery 8 supplying a suitable biasing potential to the control grid of tube T_1 . The output capacity of the tube 1 is indicated at 10.

The amplifier tube T_1 , as well as the amplifier tubes which will be referred to hereinafter, may be of any suitable type, such as the screen grid tube illustrated.

The resistor R_1 may be given a comparatively high value for the purpose of increasing the signal to noise ratio and a "high peaker" stage included at a later point in the amplifier to compensate for the resulting non-linearity, as de-

scribed and claimed in my application Serial No. 18,136, filed April 25, 1935, U. S. Patent No. 2,151,072, granted March 21, 1939 and assigned to the Radio Corporation of America. My invention will be described in connection with an amplifier embodying a resistor R_1 of high value and a "high peaker" stage but, as will be apparent from the description which follows, this feature of the amplifier design may be omitted in some cases.

As explained in my application Serial No. 18,136, when the "high peaker" stage is employed the resistor R_1 preferably should have a resistance at least three times the reactance of the capacity in shunt thereto at the highest frequency to be amplified. Also, the "high peaker" or compensating stage should have an amplification which is substantially proportional to

$$\frac{1}{R_1} + j2\pi fC$$

where R_1 is the resistance of resistor R_1 , C is the capacity of the distributed capacity 10,

$$j = \sqrt{-1}$$

and f equals frequency in cycles per second.

In accordance with one embodiment of my present invention, I so design the first amplifier stage that it amplifies the signals at the extreme low frequency end of the frequency range more than the signals at the higher frequencies, this being done by including in series in the plate circuit of tube T_1 a plate resistor R_3 and a filter condenser C_3 in series, the condenser C_3 having such small capacity that the impedance of the plate circuit is comparatively high at low frequencies. The commonly employed peaking coil 9 may be included in series with R_3 and C_3 to hold up the frequency response of the amplifier at the extreme high frequency end of the amplifier characteristic. However, the use of the conventional peaking coil 9 is no part of the present invention and it may be omitted, if desired. A suitable operating voltage is supplied to the plate of tube T_1 through a high impedance choke coil L_1 and a filter resistor R_4 of high resistance. Either the resistor R_4 or the coil L_1 may be omitted or short circuited, as indicated by the switches 11 and 12. The impedance of the circuit R_4-L_1 is so high that it has negligible admittance as compared with C_3 , this portion of the plate circuit serving only to supply the D. C. voltage to the plate of tube T_1 .

Since tube T_1 is a high impedance tube, its amplification is substantially proportional to its load impedance. Therefore, since the capacity of C_3 is so small that the load impedance increases greatly at the low frequencies, say frequencies of the order of 60 cycles, the amplification of such frequencies may be many times the amplification of the higher frequencies.

It is well known in the art that an excessive low frequency response due to a filter condenser such as C_3 being too small can be corrected, that is, the amplifier response made linear, by making the coupling condenser between amplifier stages small enough to attenuate the low frequencies. In this way, according to past practice, each amplifier stage has been made to have a linear frequency response in both phase shift and amplitude. Specifically, in the circuit shown where amplifier tubes T_1 and T_2 are coupled by a condenser C_2 and where tube T_2 has a grid leak resistor R_5 , the first amplifier stage would be made linear by making $R_5C_2 = R_3C_3$ if the usual practice were followed. In this equa-

tion, and in equations which follow, the reference characters for resistors and condensers represent the values of the corresponding elements in ohms and microfarads.

It may also be noted that in the conventional amplifier the gain for the low frequencies as compared with the gain for the higher frequencies is usually less than 2 to 1.

In accordance with my invention, the excessive gain at low frequencies caused by the small capacity of C_3 is not equalized in the first stage but, instead, is equalized several stages later in the amplifier. For example, the signal with the attenuated low frequencies may be amplified by three amplifier stages, including tubes T_2 , T_3 and T_4 and the excessive gain equalized by giving the coupling condenser C_4 located between tube T_4 and the succeeding tube T_5 and the grid resistor R_7 of tube T_5 the correct values. These values are such that $R_3 \times C_3 = R_7 \times C_4$. In this case switch 35 would be open.

Preferably, the three stages located between the elements C_3R_3 and C_4R_7 are made to have an over-all linear frequency response. Thus, in the plate circuit of tube T_2 , where voltage is supplied to the plate of T_2 through a filter resistor 16, a peaking coil 17 and a plate resistor 18, the filter condenser 19 accentuates the low frequencies a certain amount which is compensated for by giving the coupling condenser 21 and grid resistor 22 the proper values.

Likewise, in the next stage, including tube T_3 which is supplied with plate voltage through filter resistor 23, peaking coil 24 and plate resistor 26, the low frequency accentuation caused by filter condenser 27 is compensated for by giving coupling condenser 28 and grid resistor 29 the proper values.

It will be understood that the peaking coils 17 and 24, like peaking coil 9, may be omitted if desired.

As previously stated, the accentuated low frequency response due to C_3 is reduced by giving the coupling condenser C_4 and the grid resistor R_7 the proper values rather than by following the usual practice of utilizing elements C_2 and R_5 for this purpose. Therefore, the condenser C_2 is given such large capacity, 1 microfarad, for example, that the attenuation of low frequencies at this point in the circuit is substantially negligible.

An analysis of the effect of the small condenser C_3 shows that at low frequencies, in addition to accentuating the amplitude response, the phase is shifted such as to cause the output of amplifier T_1 to lag the input. Analysis also shows that the effect of the compensating circuit C_4R_7 is to restore both the phase and the amplitude.

In the specific amplifier illustrated, the amplifier stage which includes tube T_4 is the "high peaker" stage, the plate circuit of tube T_4 including an inductance coil 31 which accentuates the frequencies at the high frequency end of the amplifier to compensate for the falling off of high frequency response caused by the high resistance of resistor R_1 and the shunting distributed capacitance 10.

As explained in my above-mentioned pending application, the plate resistor of the high peaker stage should have very low resistance. For example, as indicated at R_6 , it may have a resistance of 200 ohms. In this stage the filter resistor and filter condenser preferably are omitted, it being assumed that the voltage supply bus to

which the coil 31 is connected has substantially zero impedance to ground at all frequencies.

The operation of my amplifier will be better understood by referring to the curves shown in Figs. 2 and 3.

In Fig. 2 the curve 41 shows how the frequency response at the extreme low frequency end of the amplifier range is accentuated. It is apparent that the very low frequency picture signals pass through the succeeding amplifier stages at a level high enough to override the low frequency power disturbances. At the input circuit of tube T₅, the elements C₄ and R₇ produce an attenuation of the low frequency signals and disturbances which, as shown by the curve 42 in Fig. 3, is complementary in multiplication, to the earlier low frequency attenuation. It will be apparent that by means of this amplifier design I have increased the signal to noise ratio in the frequency region where the power supply causes disturbances, and have obtained a net uniform response.

The action of the "high peaker" is represented by the curves 43 and 44 in Figs. 2 and 3, respectively. As shown by curve 43, the low frequency and middle or intermediate frequency picture signals are amplified to a fairly high level because of the high resistance of R₁, but the gain at the higher frequencies falls off. The gain of the "high peaker" stage, as determined by coil 31, is made complementary to the gain shown by curve 43, the gain of this stage being shown by curve 44.

On the drawings, the values of certain resistors and condensers have been indicated, by way of example, in ohms and microfarads. With the values indicated, the gain of a 60 cycle signal in the first amplifier stage is about twelve times the gain of the higher frequency signals, that is, of signals from 1000 cycles up. It will be understood that the falling off in gain of the high frequencies as indicated by curve 43 does not occur in the first stage proper but, rather, in the output circuit of the cathode ray tube 1. From the foregoing description, it will be apparent that in the example illustrated, any disturbances occurring at 60 cycles are attenuated to $\frac{1}{12}$ the value they would have as compared with the picture signals in a conventional amplifier. Lower frequency disturbances will be attenuated still more.

It may be noted that power line disturbances introduced into the amplifier through the tube T₁ are not reduced by utilizing the small condenser C₃. Because of this, it may be desirable in some cases to supply the screen grid and plate electrodes of tube T₁ with voltage from a separate voltage supply such as a battery while supplying the D. C. voltages to the succeeding tubes from the usual rectified and filtered 60 cycle supply.

The attenuation of the low frequencies accentuated by condenser C₃ may be accomplished by other means than by the use of a small coupling condenser such as C₄. For example, by closing a switch 35 the condenser C₄ is shunted by a condenser 30 which has large enough capacity to prevent any substantial attenuation of the low frequencies.

The desired attenuation of low frequencies is then obtained by properly designing the plate circuit of tube T₅. This plate circuit includes the usual filter resistor 45, filter condenser 46, peaking coil 47 and plate resistor R₈. As described thus far, the plate circuit of tube T₅ is the same as the plate circuits of tubes T₂ and T₃.

However, it is given the desired characteristic by providing an inductance coil L₈ which is shunted across the resistor R₈ by means of a switch 40. The correct value of L₈ in henrys is given by the following equation: $L_8 = R_8 \times R_3 \times C_3 \times 10^{-6}$ where C₃ is in microfarads.

Up to this point my invention has been described on the assumption that the desired accentuation of low frequencies is accomplished by the small condenser C₃. Instead of accentuating low frequencies by means of condenser C₃, they may be accentuated when the switch 5 is open by means of a condenser C₁ which is connected in series with R₁. A resistor R₂ is connected across condenser C₁ whereby a suitable bias is applied to tube T₁. The resistance of R₂ is much greater than the resistance of R₁. For example, R₂ may have a resistance of 1 megohm. It will be understood that the output circuit of tube 1 may be coupled to the input circuit of tube T₁ through a coupling condenser, bias being applied to the grid of tube T₁ through the usual grid leak resistor.

At first glance it might appear that where my "high peaker" invention is used the low frequencies can be accentuated as much as is desired by increasing the value of R₁. However, the amplifiers may be working at such level that an increase in the resistance of R₁ will overload them, whereas the use of condenser C₁ of the proper value will accentuate only the very low frequencies and will not overload the amplifiers.

The following description of a variation of the design where C₃ accentuates the low frequencies will make this clear. In certain television amplifiers in which the lowest useful frequency to be transmitted is 60 cycles per second (this being the framing frequency), there are troublesome power supply variations which may have an average frequency of about 6 cycles per second. Also, these amplifiers may be working at such level that any very large accentuation of the 60 cycle per second response would overload them. It has been found impracticable to remove the harmful 6 cycle signal from the amplifier channel by the introduction of filters which cut-off the extreme low frequency response because of the harmful phase shift which such a filter introduces at the useful 60 cycle frequency.

It should be noted that the amplifier design first described, the condenser C₃ had such small capacity that it caused a large accentuation of frequencies in the region of 60 cycles per second. In the case of the television amplifiers just mentioned, the harmful signals in the region of 6 cycles per second may be greatly reduced as follows:

The condenser C₃ is given a value such that the accentuation of a signal at 60 cycles per second is small, say 1.41 to 1, whereby the amplifiers are not overloaded. In this specific case the reactance of C₃ at 60 cycles per second equals the resistance of R₃, C₃ being 1.21 mfd. where R₃=2200 ohms. Then the accentuation of a signal at 6 cycles per second is about 10 to 1. With the switches 35 and 40 open, the complementary frequency response characteristic is obtained at amplifier T₅ by proportioning C₄ and R₇ in the manner previously described. Or switches 35 and 40 may be closed and R₃ and L₈ given the proper values determined by the equation previously given.

Referring now to the use of condenser C₁ to accentuate low frequencies, it will be assumed that C₃ is given the usual capacity of a filter

condenser whereby it causes very little accentuation of low frequencies. C_1 , however, is given such capacity as to accentuate signals of 6 cycles per second in the ratio of about 10 to 1. Signals at 60 cycles will not be accentuated enough in this case to overload the amplifier. In a late stage in the amplifier the accentuated 6 cycle signals are attenuated 10 times as much as the high and middle frequency signals, this late stage and the output circuit of cathode ray tube 1 being complementary. For example, with switches 35 and 40 open, condenser C_4 provides the desired attenuation. The several values of the complementary networks are determined by the equation

$$C_1 \times R_1 = C_4 \times R_7.$$

Or the desired attenuation may be provided by closing switches 35 and 40 and giving the several elements the values determined by the equation

$$L_8 = R_1 \times R_8 \times C_1 \times 10^{-6}.$$

The curves in Fig. 4 show the frequency characteristics of an amplifier designed as just described. Curve 51 shows the frequency response characteristic of the output circuit of the cathode ray tube 1. It will be apparent that the high frequency response falls off whereby the "high peaker" stage is required and that the very low frequencies are greatly accentuated whereby low frequency attenuation in a late stage is required. The curve 52 is the over-all characteristic of the "high peaker" stage T_4 and the late stage T_5 . The low frequency end of the characteristic curve 52 represents the characteristic of either network C_4-R_7 or network R_8-L_8 depending upon which one is being utilized for low frequency attenuation.

In some amplifiers it may be desirable to accentuate low frequency signals by both C_3 and C_1 . In that case the network C_4-R_7 may be used to correct for the boosting of lows by C_3 while the network R_8-L_8 is used to correct for the boosting of lows by C_1 .

In the foregoing description of Fig. 1, it has been assumed that all the amplifier stages are located near each other. In some instances the amplifier stages may be separated into two groups spaced apart several hundred feet or even several miles. For example, as indicated by the dotted conductor 15, amplifier stage T_2 may be a considerable distance from stage T_3 . The conductor 15 may be a transmission line such as a cable several miles long. In that case it will be understood that the resistor 18 will be reduced in value to make it match the characteristic impedance of the cable, reduced to the order of 500 ohms, for example.

Disturbances due to inductive pick-up by conductor 15, or due to difference in ground potential at the two ends of the conductor are therefore reduced by the invention.

I claim as my invention:

1. In a signal transducing system, a signal generating means for producing a useful signal covering a wide band of frequencies, said signal consisting of low frequency components, intermediate frequency components and high frequency components, transducing means having an input circuit and an output circuit, said input circuit being coupled to said generating means, a source of extraneous undesired signal which combines with said useful signal to produce a mixed signal in said transducing means, a first frequency selective means for accentuating said low frequency components impressed upon said input circuit, and a second frequency selective means in said output circuit for selectively at-

tenuating the low frequency components of said mixed signal in a manner substantially complementary to the accentuation by said first frequency selective means, said first frequency selective means having a frequency response curve which is concave upward where frequency response is plotted against the logarithm of frequency.

2. In combination, a source of signals covering a wide band of frequencies and having low frequency components, intermediate frequency components and high frequency components, a signal transducer which includes a transmission line, said transducer having an input circuit and an output circuit, said input circuit being coupled to said source, a first frequency selective means for accentuating the low frequency components of said signals impressed upon said input circuit, and a second frequency selective means at said output circuit for selectively attenuating said low frequency components in a manner substantially complementary to the accentuation by said first frequency selective means whereby low frequency disturbances introduced by the presence of said transmission line are reduced in amplitude, said first frequency selective means having a frequency response curve which is concave upward where frequency response is plotted against the logarithm of frequency.

3. An amplifier for amplifying signals covering a wide frequency band, said signals comprising low frequency components, intermediate frequency components and high frequency components, said amplifier comprising a plurality of amplifier stages connected in cascade by resistance coupling, one of the first of said stages comprising an amplifier tube having a plate circuit so designed that its impedance is several times as high for said low frequency components as for said intermediate frequency components whereby its frequency response curve at said low frequencies is concave upward where frequency response is plotted against the logarithm of frequency, one of the later stages of said amplifier being so designed that its frequency response characteristic is substantially complementary to the frequency response characteristic of said first-mentioned stage, and the over-all frequency response characteristic of the amplifier stages coupling said first-mentioned stage and said second-mentioned stage being substantially flat for said low frequency and intermediate frequency components.

4. In combination, a plurality of resistance coupled amplifier stages, one of the first of said stages comprising an amplifier tube having a plate circuit so designed that its impedance increases rapidly at low frequencies whereby signals at said low frequencies are amplified more than signals at higher frequencies, and whereby the frequency response curve of said one stage at said low frequencies is concave upward where frequency response is plotted against the logarithm of frequency, one of the later stages being so designed as to attenuate signals at said low frequencies, the frequency response characteristics of said first-mentioned stage and of said second-mentioned stage being substantially complementary and the amplifier stages coupling said first-mentioned stage and said second-mentioned stage having a frequency response such that they amplify said low frequency signals at least as much as said higher frequency signals whereby said low frequency signals are at a higher level

than the said higher frequency signals when they reach said second-mentioned stage.

5. The invention according to claim 4 characterized in that the plate circuit of said first mentioned stage includes a plate resistor and a filter resistor in series, a filter condenser connected in shunt relation to said filter resistor, the capacity of said filter condenser being so small that the impedance of said plate circuit at 60 cycles per second is at least five times its impedance at frequencies of 5000 cycles per second and higher.

6. The invention according to claim 4 characterized in that the plate circuit of said first mentioned stage includes a plate resistor and a filter resistor in series, a filter condenser connected in shunt relation to said filter resistor, the capacity of said filter condenser being so small that the impedance of said plate circuit at 10 cycles per second is at least five times its impedance at frequencies of 5000 cycles per second and higher.

7. An amplifier comprising a plurality of resistance coupled amplifier stages which, with the exception of two stages, have a substantially flat frequency response characteristic from below 60 cycles per second to approximately 10,000 cycles per second or above, one of said two stages being one of the first stages in said amplifier and having a frequency response characteristic represented by a curve which is concave upward where frequency response is plotted against the logarithm of frequency and which is such that signals having a frequency of 100 cycles per second or lower are amplified more than signals at the higher frequencies, and the other of said two stages being located near the output end of said amplifier and having a frequency response characteristic which is substantially complementary to said first-mentioned frequency response characteristic whereby low frequency signals originating between said two stages are attenuated.

8. An amplifier for amplifying signals covering a wide frequency band, said amplifier comprising a plurality of amplifier stages connected in cascade by resistance coupling, one of the first of said stages comprising an amplifier tube having a plate circuit which includes a plate resistor and a filter resistor in series, a filter condenser connected in shunt relation to said filter resistor, the capacity of said filter condenser being so small that the impedance of said plate circuit increases rapidly at frequencies of the order of 60 cycles per second and lower whereby the frequency response curve of said one stage is represented by a curve which is concave upward at said frequencies where frequency response is plotted against the logarithm of frequency, one of the later stages of said amplifier being so designed that its frequency response characteristic is substantially complementary to the frequency response characteristic of said first-mentioned stage, and the over-all frequency response characteristic of the amplifier stages coupling said first-mentioned stage and said second-mentioned stage being substantially flat.

9. A picture signal amplifier comprising a plurality of cascade coupled amplifier stages designed to pass signals having a frequency from below 60 cycles per second to above 100,000 cycles per second, the first of said stages being designed to accentuate signals having a frequency of 60 cycles per second and below, and the last of said stages being designed to have a frequency response characteristic substantially complementary to that of said first stage, there being at least one stage

intermediate said first and last stages which is supplied with voltage from a power line whereby undesired low frequency disturbances are introduced and later attenuated in said last stage.

10. A television amplifier for transmitting signals representing pictures occurring at a certain frame frequency, said amplifier comprising a plurality of amplifier stages connected in cascade, an early one of said stages being so designed that as compared with signals at 5000 cycles per second and higher it accentuates signals at said frame frequency not substantially more than 2 to 1 but accentuates signals at 6 cycles per second at least 4 to 1, a late one of said stages having a frequency response characteristic which is substantially complementary to said early stage, and the remaining stages of said amplifier having a substantially flat over-all frequency response characteristic for the frequency range between 6 cycles per second and 5000 cycles per second.

11. The method of amplifying picture signals originating in a photoelectric cell device which consists of low frequency components, intermediate frequency components and high frequency components, said signals being produced in groups each representative of a complete picture, said groups occurring at a certain frame frequency, said method comprising accentuating in the output circuit of said device certain of said low frequency components below said frame frequency with respect to said intermediate frequency components, amplifying said low frequency components and said intermediate frequency components after said low frequency components have been accentuated, and next attenuating said low frequency components with respect to said intermediate frequency components, said attenuation being substantially complementary to said accentuation.

12. The method of amplifying picture signals originating in a photoelectric cell device and which are produced in groups each representative of a complete picture, said groups occurring at a certain frame frequency, said method comprising accentuating the low frequency signal components below said frame frequency with respect to the intermediate frequency components in the output circuit of said device, holding up the intermediate frequency response in said output circuit with respect to the high frequency components of said signals and permitting the high frequency response to fall off, amplifying said picture signals and next attenuating said low frequency components with respect to said intermediate frequency components and accentuating said high frequency response, said attenuation being complementary to said low frequency accentuation and said high frequency accentuation being complementary to said falling high frequency response.

13. In combination, a signal generating device having high internal impedance and having output terminals, an electric discharge tube having an input circuit and an output circuit, an output resistor and a condenser connected in series and connected between said output terminals, said input circuit being connected across said series combination of output resistor and condenser whereby accentuated low frequency signals appear in said output circuit, means for amplifying the signals appearing in said output circuit, and means for next attenuating said low frequency signals in a manner complementary to their accentuation.

14. In combination, a signal generating device

having high internal impedance and having output terminals, an electric discharge tube having an input circuit and an output circuit, an output resistor, a condenser, a biasing source connected in series in the order named and connected between said output terminals, said input circuit being connected across said output resistor and said condenser whereby accentuated low frequency signals appear in said output circuit, and a resistor connected across said condenser whereby bias is supplied to said electric discharge tube, said resistor having high resistance compared with the resistance of said output resistor.

15 In combination, a signal generating device having high internal impedance and having output terminals, an electric discharge tube having an input circuit and an output circuit, an output resistor, a condenser, and a biasing source connected in series in the order named and connected between said output terminals, said input circuit being connected across said output resistor and said condenser whereby accentuated low frequency signals appear in said output circuit, a resistor connected across said condenser, said resistor having high resistance compared with the resistance of said output resistor, means for amplifying the signals appearing in said output circuit, and means for next attenuating said low frequency signals in a manner complementary to their accentuation.

16 In combination, a signal output device for supplying picture signals occurring in groups at a certain frame frequency, said device having high internal impedance and having output terminals, an amplifier tube having input electrodes, a loading network which couples said output terminals to said input electrodes, said network comprising a resistor and a condenser in series, said series combination of said resistor and said condenser being connected between said output terminals and having a certain capacity C in shunt thereto, said network having an effective resistance R which is at least three times the capacity reactance of said network at the highest frequency to be amplified, the capacity of said series condenser being such that frequency components of said signals below said frame frequency

but not signals at said frame frequency are greatly accentuated with respect to the intermediate frequency components of said signals, means for amplifying the signals supplied by said amplifier tube, a compensating amplifier stage following said amplifying means and having an amplification which is substantially proportional to

$$\frac{1}{R} + j2\pi fC$$

where

$$j \text{ equals } \sqrt{-1}$$

and f equals frequency in cycles per second, and a compensating network following said amplifying means which is so designed as to attenuate the said frequency components which have been accentuated by said condenser, said attenuation being substantially complementary to said accentuation.

17 A signal transducing system comprising a signal supply circuit for supplying signals covering a wide band of frequencies, said signal consisting of low frequency components, intermediate frequency components and high frequency components, said signal supply circuit including a first amplifier stage, said system further comprising at least one intermediate frequency amplifier stage and at least one late amplifier stage, said signal supply circuit having a frequency response characteristic such that its frequency response curve is concave upward at said low frequencies and concave downward at said high frequencies where frequency response is plotted against the logarithm of frequency, the frequency response curve of said late stage being concave downward at said low frequencies and being concave upward at said high frequencies and being substantially complementary to said first frequency response curve, each of said frequency response curves being substantially flat at said intermediate frequencies, and the over-all frequency response of said system being substantially flat over the complete range of said wide band of frequencies.

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