

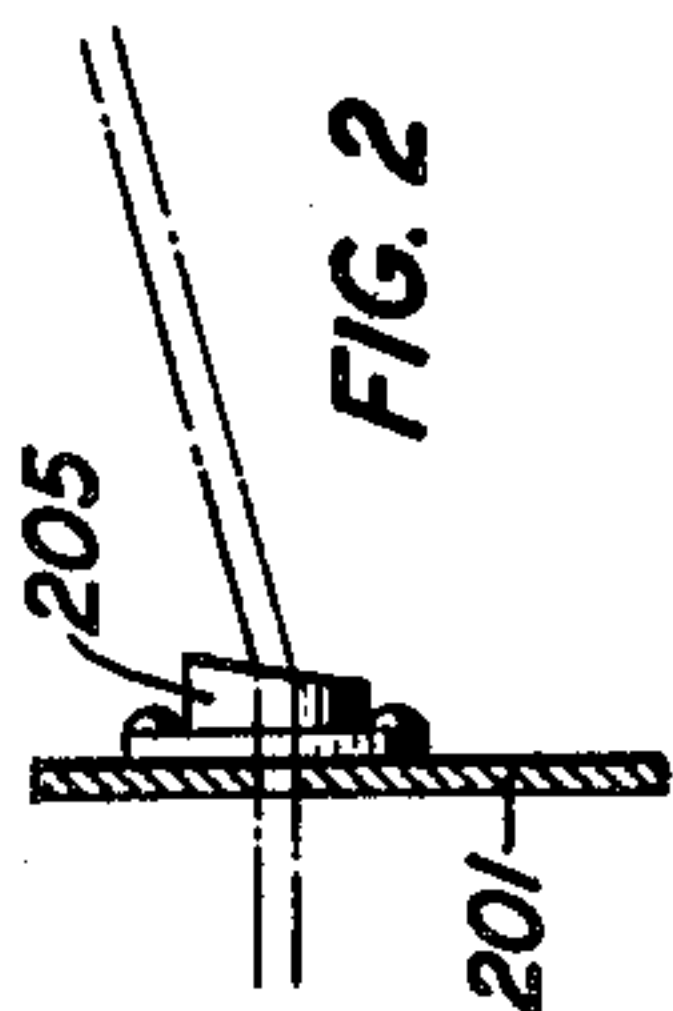
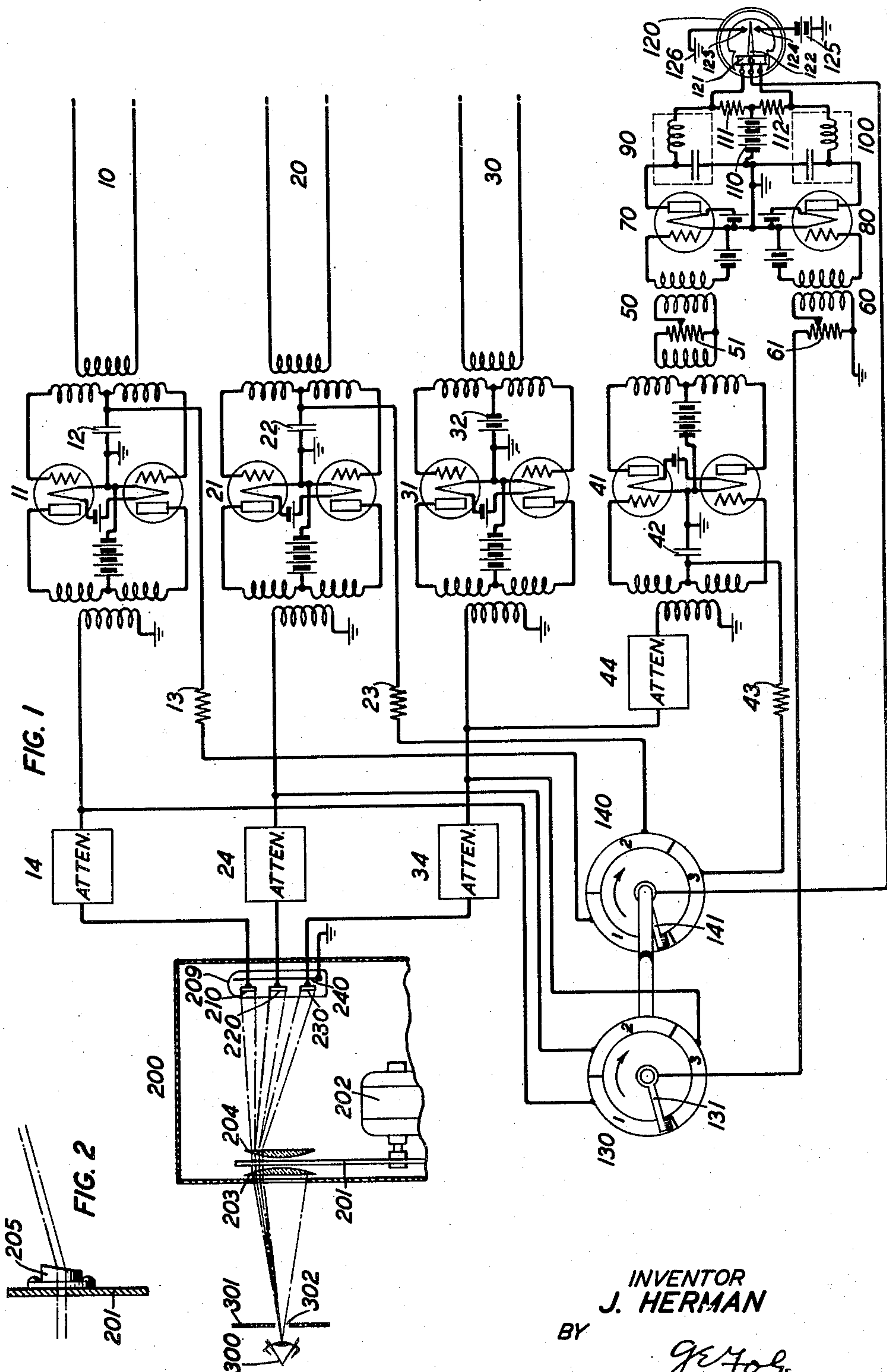
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AUTOMATIC LINE LEVEL REGULATION OF MULTIPLE CHANNEL TELEVISION SYSTEMS

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AUTOMATIC LINE LEVEL REGULATION OF  
MULTIPLE CHANNEL TELEVISION SYSTEMSJoseph Herman, Westfield, N. J., assignor to  
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This invention relates to multiple channel signal transmission and more particularly to a method and means for equalizing the intensity of the signals in the various channels at the receiving station of a multiple channel electro-optical system.

An object of this invention is to provide apparatus for and methods of automatically causing the signal currents transmitted over the different channels of a multiple channel transmission system to have substantially equal intensities when impressed upon the translating device at the receiver, irrespective of different transmission variations in the several transmission channels.

Heretofore, manual means have been provided for adjustment of each of the transmission channels so as to cause the component parts of a received signal from each channel to uniformly affect the receiving device and thus eliminate variations as between the different channels and also to hold the transmission level of each channel to a given level.

In this system one of the channels is used as a reference channel and the variations in level of the other channels are automatically equalized therewith so that the effective level of all channels is substantially the same although not necessarily of constant value.

In multiple channel television systems in which successive line series of elemental areas of a field of view are being scanned simultaneously and transmitted over different channels, it is necessary to keep the relative transmission levels of the different channels substantially constant. If this is not done the channel having a higher or lower transmission level gives to the received image a strongly lined appearance, which to a large extent offsets the higher resolving power obtained from multiple channel operation. The arrangement disclosed herein overcomes this disadvantage by automatically adjusting the transmission level of the different channels at the receiving station and also at an intermediate repeating station if desired, so that the effective level will be substantially the same on all channels. For this purpose the transmission level of one of the channels averaged over a small period such as a complete scanning cycle is taken as the reference level and the other channels are adjusted to substantially the same level. This is automatically done continuously and rapidly from channel to channel while the signals are being received. The operation of the system is conditioned upon each channel transmitting signal current generated at the transmitting station by

the scanning of at least a part of the elemental areas distributed throughout the field of view or the entire object being scanned at the transmitter so that the signal energy of each scanning as impressed upon the respective transmission channels is obtained from substantially the same field. In other words, the signal current transmitted by each channel is in effect characterized by the light tone values from all parts of the entire object whose image is transmitted. This condition is practically fulfilled for example in multiple channel television systems in which successive juxtaposed line series of elemental areas are scanned by different channels and in systems where wider strips comprising a plurality of elemental strips are scanned by the different channels if a rotation of the scanning occurs as between the different wide strips and the different channels so that each channel repeatedly scans substantially the entire field.

In the arrangement shown for illustrating a method and means for carrying out this invention, the automatic level regulator is applied at the receiving station to a three channel electro-optical system. The three incoming transmission channels are connected to the input sides of three push-pull amplifiers, respectively, the output sides of which are connected to the three channels of a multiple electrode receiving neon tube or three separate light sources. The receiving light translating device is associated with suitable multiple channel scanning means for producing the image, the scanning means shown consisting of a scanning disc in which the apertures are provided with suitable optical prisms so that the light from the three electrodes of the light source is properly deflected and distributed in constructing the image. A suitable multiple channel scanning arrangement of this kind is disclosed in the patent of Herbert E. Ives, 1,989,618, dated January 29, 1935. Another suitable arrangement is disclosed in the copending application of O. B. Blackwell and J. Herman, Serial No. 393,568 filed September 18, 1929.

A more detailed description of the invention follows and is illustrated in the accompanying drawing:

Figure 1 is a schematic representation of the receiving apparatus of a multiple channel television system arranged for automatically equalizing the intensity of the signals in the several channels; and

Fig. 2 is a sectional view of a portion of the scanning disc through an aperture thereof.

Fig. 1 shows the transmission level regulator



as applied to the receiving end of a three channel television system. The level regulating apparatus is applicable to other systems than television systems and may also be applied at an intermediate repeating station. When applied at an intermediate point it, of course, only equalizes for variations up to that point and if appreciable level variations occur beyond the regulator, it may also be applied at the receiving station.

The three incoming transmission channels 10, 20 and 30 are connected to the input sides of three push-pull amplifiers 11, 21 and 31, respectively, equipped with vacuum tubes having variable  $\mu$  characteristic or arrangements for controlling the gain of the amplifiers in small steps by electrical or electromagnetic means. The output sides of these amplifiers are connected to the three channels of the television receiving lamp 200 of the television receiver 200. Separate light sources, one for each channel might be used in place of the multiple electrode light source 200. The receiving lamp as shown consists of three electrodes 210, 220 and 230 connecting respectively with one terminal of the output side of the amplifiers associated with channels 10, 20 and 30 and a common electrode 240 connecting in common with the other terminals of the circuit which is grounded. Each of the three electrodes 210, 220 and 230 forms separate light sources whose light varies in accordance with the current variations received over the transmission channel with which each is connected. The lens system 203—204 images the light sources 210, 220 and 230 in the eye of the observer 300 through the opening 302 in the observer positioning plate 301. A scanning disc 201 associated with lens system 203—204 and driven by motor 202 contains a set of spirally arranged apertures, each aperture of which is equipped with a prism or the equivalent for directing light through its associated aperture from one of the light sources. As many prism equipped apertures as there are multiple channels operating simultaneously pass the viewing field and simultaneously direct light from each of the different channels into the eye of the observer. In a three-channel system as shown in the drawing the angle of each prism in such that one-third of the prisms direct the light into the eye from each of the three channels, respectively, during a scanning cycle. For example, apertures 1, 2 and 3 of the spiral may direct light from channels 10, 20 and 30, respectively; apertures 4, 5 and 6 of the spiral also may direct light from channels 10, 20 and 30, respectively, and so on. The scanning operation at a receiving station is, of course, performed in synchronism with a similar scanning operation at a transmitting station. Such a scanning arrangement for both transmission and reception is disclosed in the patent of Herbert E. Ives, No. 1,989,618, dated January 29, 1935, supra.

Fig. 2 shows a section of a portion of scanning disc 201 and a light deflecting prism 205 associated with a scanning aperture. The lens 204 collects light from the light sources of all channels and directs it to the field of view while each of the prisms transmits through its associated aperture the light which comes only from the light source of one channel. This is brought about by designing each prism to give the proper degree of deflection to associate its aperture with the light source of a given channel.

Referring again to Fig. 1, channel 30 is used as a reference channel. It is provided with an amplifier having the usual negative grid battery 32. Channels 10 and 20 have condensers 12 and 22

connected in the grid circuits of their amplifiers instead of grid batteries in order to permit of gain adjustments by the impressing of different values of negative voltage on these condensers. An auxiliary amplifier 41, which is connected permanently across the output of amplifier 31 is also provided with a condenser 42 for gain adjustment. The charging and discharging circuits of these condensers are provided with resistance 13, 23 and 43 to limit the rate of charging and discharging.

The level regulating device consists of two circuit networks comprising two detectors or rectifiers 70 and 80, two low-pass filters 90 and 100, and a differential voltmeter relay 120. A rectified current depending upon the signal current strength in channel 30 is continuously obtained from rectifier 70 whose input is connected to the output of amplifier 41 through the transformer 50 and the adjustable potentiometer 51. A second rectified current depending upon the current strength in each of the several channels, respectively, is obtained from rectifier 80 whose input is connected to the brush arm 131 of the distributor 130 which, through transformer 60 and the regulating potentiometer 61, connects it in turn with channels 10, 20 and 30, respectively, for a time interval which may conveniently be a multiple of the picture scanning period of  $\frac{1}{30}$  to  $\frac{1}{60}$  of a second. If the time interval is made too short, the samples of received current taken from channels 10 and 20 for comparison with the current of channel 30 may not be of sufficient duration to show the average intensity of the signals on these channels. This is because the relative intensity of the currents on the various channels may differ greatly during a short period of time since they are produced by the scanning of slightly different portions of the field of view which may have a large degree of contrast. Only by taking samples corresponding to a fairly large part of the field of view or to one or more complete scanings of the field of view and averaging or smoothing out the variations in rectified current derived from each channel, can the relative intensity of the signals received over the different channels be accurately determined. The low-pass filters 90 and 100 are used for the purpose of smoothing out the rapid variations in the rectified television currents. The band width of these filters is dependent upon the length of the time interval allowed for each sample of current. The shorter the time interval the greater the band width which must be used. For time intervals corresponding to several complete scanings, the filter need pass only the frequencies up to about 15 cycles or less. The current at the output of filter 100 is a smooth but continuous envelope of the average rectified current of the successive samples taken from the various channels by means of the distributor 130, while the current at the output of filter 90 is an equally smooth and continuous envelope of the average rectified current derived from the reference channel. These envelopes of current are applied differentially to the voltmeter relay 120 and move its armature to one or the other of its contacts whenever one or the other of the two currents predominates.

A source of space current 110 is connected to rectifier 70 through resistance 111 and low-pass filter 90, and to rectifier 80 through resistance 112 and low-pass filter 100. When the output currents of rectifiers 70 and 80 are equal, balancing opposing currents flow through similar resistances 111 and 112, respectively, and there is no



unbalanced voltage drop between the exterior terminals of these resistances to which the winding 121 of the voltmeter relay 120 is connected. Consequently the armature 122 of the relay 120, under these conditions, remains in its neutral position with its contact arm midway between adjustable contacts 123 and 124, but if the output currents of rectifiers 70 and 80 are unequal a voltage drop occurs between the exterior terminals of the resistances 111 and 112 and a current flows in winding 121 of relay 120 causing its armature 122 to move its contact arm to engage one or the other of contacts 123 or 124 depending upon whether the output current from rectifier 70 or 80 is the larger. The rectified current in the output of rectifier 80 depends upon the current strength of the particular channel to which it happens to be connected by the distributor 130, while the rectified current in the output of rectifier 70 depends upon the current strength in the reference channel 30. The contact arm of armature 122 of the regulating relay, which may connect with either the negative battery 125 or ground 126 or take a neutral position, is connected to brush arm 141 of distributor 140 which rotates in synchronism with brush arm 131 of distributor 130. The segments of distributor 140 connect the contact arm of relay armature 122 to the various condensers 12, 22 and 42 for gain adjustment purposes. Attenuators 14, 24 and 34 are connected in series with each of the output circuits from the different channel amplifiers and attenuator 44 is connected in the input circuit of amplifier 41, the purpose of which will be described later.

A feature of the level regulating device is its automatic and continuous action both to control the relative levels of the signals and also to remove any differences in sensitivity between the two sides or networks of the regulating apparatus.

The operation of the arrangement is as follows: Both branches or networks of the regulating device should be free of any unbalance and this condition may be obtained by connecting both branches to the same source of current. This occurs when the brush arms 131 and 141 are in contact with segments 3 of distributors 130 and 140, respectively. In this position both branches of the regulating device are connected in parallel to the same source of signal current, namely, that on channel 30. A local source of current might be used for this purpose by using suitable obvious connecting means to properly connect and disconnect this source. If the regulating apparatus is unbalanced the contact arm of the relay armature 122 will be moved against one or the other of contacts 123 or 124. This will either increase or decrease the charge on the biasing condenser 42 and thus vary the gain of amplifier 41 until the current passing through the two branches of the regulating apparatus is balanced. If the larger current is flowing through the branch containing rectifier 70 the contact arm of the relay armature 122 will be drawn against contact 124, thus connecting the condenser 42 with the biasing battery 125 which results in reducing the gain of this branch until the current passing through it is equal to that of the other branch and the relay armature 122 assumes a neutral position with its contact arm between the contacts 123 and 124. If the current flowing through the branch of the regulating device containing rectifier 80 is larger than that flowing through the other branch the contact arm of

the relay armature 122 is drawn against contact 123 and the condenser 42 is then connected to ground and the gain of amplifier 41 increased until the currents flowing through the two branches are balanced. In this way the balancing action within the regulating apparatus takes place with each revolution of distributor brush arms 131 and 141. As these brush arms rotate and make contact with the other segments of their respective distributors, the average level of channels 10 and 20 is balanced against the average level of channel 30. When rectifier 80 is connected to the output of amplifier 11 of channel 10 through segment 1 of distributor 130 and the contact arm of the regulating relay 15 connected to condenser 12 through segment 1 of distributor 140 this condenser will be charged or discharged depending upon the position of the relay armature 122. If the strength of the signal currents, as smoothed out by the low-pass filters 20 90 and 100 in the regulating circuits is greater in channel 10 than in channel 30 the relay 120 will connect the negative battery 125 to condenser 12 thereby reducing the gain of the amplifier 11 of channel 10. If the current strength in channel 10 is smaller than in channel 30 the relay will connect ground to condenser 12 thereby reducing its charge and increasing the gain of amplifier 11. A similar operation takes place on amplifier 21 of channel 20 when distributor 130 30 through segment 2 connects rectifier 80 to channel 20, thus adjusting the gain of amplifier 21. As the brush arms continue to rotate they next connect both branches of the regulating device in parallel to the same source of signal current, namely, that of channel 30 and any necessary balancing of the two branches of the regulating apparatus again takes place.

The purpose of this parallel connection of the two branches of the regulating device is, of course, not to regulate the transmission level of channel 30 but to compensate for any unbalance in the regulating apparatus as already described. This system permits ordinary transmission level variations in the reference channel to occur and its regulating action is primarily to automatically adjust the other channels to cause the average current in each to be substantially equal to that in the reference channel.

Since the maintenance of substantially equal levels at the outputs of different channel amplifiers does not insure equal brilliancy in the light emitting elements of the light source 209 in the receiver 200, attenuators 14, 24 and 34 are connected in series with each of the output circuits from the amplifier to permit adjusting the input currents to the light translating device so as to produce equal brilliancy from equal signal currents. This adjustment, however, need be made only when setting up the apparatus or when replacing the light translating device or the like. An additional attenuator 44 is connected in the input of amplifier 41 for the purpose of partly off-setting and adjusting the gain introduced by this amplifier into the circuit of rectifier 70.

While the level regulating arrangement which has been described above has been shown as applied to a three channel television system, it is obvious that it can be readily applied to a system having a much larger number of channels. It is also obvious that such transmission level equalizing arrangements are not limited to television systems but are applicable to other communication systems in which the average energies or currents transmitted into various channels at



the sending station and/or to be received at the receiving station, are approximately equal. Examples of such systems are multi-channel two-tone carrier telegraph, multi-channel and carrier or radio telephone systems in which the carrier current is transmitted.

It will also be obvious that the regulating apparatus may be caused to function in such a manner that instead of maintaining equal relative transmission levels at the output of the amplifiers 11, 21 and 31, it will maintain predetermined differences in the relative levels. This can be accomplished by connecting attenuators in series with the leads from the output of amplifiers 11, 21 and 31, to the segments 1, 2 and 3 of distributor 130. If an attenuator having a certain loss is connected in series with the lead to segment 1, the output of amplifier 11 will be adjusted to a level which is higher than that of amplifier 31 by the loss in the attenuator. Similarly, an attenuator in series with the lead to segment 2 will increase the output level of amplifier 21 with respect to that of 31 by the amount of loss in the attenuator. An attenuator in series with the lead to segment 3 will however cause a lower level at the output of amplifiers 11 and 21 with respect to that of 31 by the loss introduced by the attenuator. A similar result is of course accomplished by considering the output of the amplifiers to include the attenuators 14, 24 and 34 and adjusting these attenuators to obtain the desired differences in level.

While the invention in its narrower aspects pertains to the automatic adjustment of the transmission levels of the channels of a multiple channel television system, certain features of the invention may obviously find other uses. The various features or aspects of the invention are defined in the following claims.

40 What is claimed is:

1. The method of operating a multi-channel signaling system which comprises simultaneously cooperatively utilizing signaling currents received in two of said channels at a receiving station of said system to automatically change the transmission level characteristic of at least one of said channels.

2. The method of operating a multi-channel signaling system which comprises simultaneously cooperatively utilizing current received in two of said channels at a receiving station of said system both to reproduce the signal and to automatically change the transmission level characteristic of at least one of said channels.

3. The method of operating a multi-channel signaling system which comprises cooperatively utilizing energy transmitted over the several channels to reproduce the signal, permitting the transmission level of one of said channels to vary with changes in the transmission characteristics thereof and automatically adjusting the transmission level of the other channel or channels to maintain substantially constant the relative transmission level or levels with respect to that of said first mentioned one channel.

4. The method of operating a multi-channel signaling system which comprises cooperatively utilizing energy transmitted over the several channels to reproduce the signal, permitting the transmission level of one of said channels to vary with changes in the transmission characteristics thereof and automatically and periodically adjusting the transmission level of the other channel or channels to substantially that of said first mentioned channel.

5. The method of operating a multi-channel image producing system which comprises cooperatively utilizing image currents transmitted over a plurality of channels of said system to produce an image, permitting the transmission level of one of said channels to vary with the transmission characteristics of said channel and automatically and periodically adjusting the transmission level of the remaining channel or channels to correspond to that of said first mentioned channel.

6. The method of operating a multi-channel television system which comprises simultaneously cooperatively utilizing current received in two of said channels at a receiving station of said system both to reproduce the image and to automatically and periodically adjust the transmission level in one of said channels to correspond to a changing transmission level of the other of said channels.

7. The method of operating a multi-channel signaling system which comprises cooperatively utilizing current received in two of said channels at a receiving station of said system to effect an adjustment to restore a desired relationship between said currents with respect to an amplitude characteristic thereof whenever changes in transmission characteristics of said system have caused a change in said relationship.

8. A multi-channel television system comprising means for receiving signal energy representative of the light tone values of individual elemental areas of a field, means for simultaneously utilizing said signal energy received over the different channels to control the production of an image and means for automatically and simultaneously cooperatively utilizing a portion of said signal energy received over a plurality of said channels respectively to adjust the transmission level of at least one of said channels.

9. In a multiple channel signaling system, means for periodically averaging energy transmitted by each of the different channels for definite equal periods of time, and means for automatically and periodically adjusting the average output energy of one of said channels to substantially that of the average output energy of another channel under control of said average energy in said other channel.

10. In a multiple channel signal receiving system, regulating means for successively adjusting the energy level of the different channels to that of one of said channels, the said regulating means including two electrical networks for comparing energy levels and means for periodically balancing the sensitivity of the two networks.

11. A television system comprising receiving means at a receiving station for receiving signaling energy representative of the light tone values of individual elemental areas of a field and for utilizing it to repeatedly set up complete images of an object field each within the period of the persistence of vision, means for averaging over an entire field scanning period signaling energy derived from the received signal and having the same wave form, and means for utilizing said averaged energy to control a transmission characteristic of said system.

12. A multi-channel television receiving system comprising an amplifier in each channel, a pair of comparison circuits, means for continuously associating the output of one of said amplifiers with one of said comparison circuits, distributing means for periodically associating in succession the output circuits of the other of



said amplifiers with the other of said comparison circuits, and means under control of said comparison circuits for maintaining fixed relationships between the output currents of said last mentioned amplifiers and that of the remaining amplifier.

13. In a multiple channel signaling system comprising a plurality of transmission channels each of which may vary independently of the others to vary its transmission characteristic, means for simultaneously utilizing the signal energy received over the different channels to produce an image, means for rectifying and averaging the signal current transmitted over each of the several channels, means constituting one of said channels a reference channel including means for controlling and automatically adjusting the transmission level of each of the other channels under control of the current of changing level in the said reference channel and in accordance with the level of said current so that the relationship between the levels in all channels remains substantially constant whatever their values may be.

14. In a multiple channel signaling system comprising a plurality of transmission channels each of which may vary independently of the others to vary its transmission characteristic, means for simultaneously utilizing the signal energy received over different channels to produce an image, means for amplifying the signal received over each of said channels, means for adjusting the gain of the said amplifying means in all but one of said channels to maintain the transmission level of each of the said channels substantially equal to that of the said one channel as the latter changes, and means controlled by incoming signal energy for controlling said adjusting means.

15. In a multiple channel signaling system comprising a plurality of transmission channels and means for simultaneously utilizing the signal energy received over the different channels to produce an image, means for successively averaging for a definite period of time a portion of the energy transmitted over each of said channels except one of said channels which is used as a reference channel, means for continuously averaging a portion of the energy transmitted over said reference channel, means for periodically equalizing said averaged energy received over each of said channels except the said reference channel to substantially that of the average energy received over the said reference channel.

16. An image transmission system comprising two transmission channels for transmitting image currents which during a scanning cycle or a substantial part thereof are respectively representative of different elemental areas of the object field but have substantially the same average amplitude whenever said channels have the same attenuation characteristic, image producing means at a receiving station for utilizing the currents from said channels to produce an image, means for producing a voltage proportional to the current in one of said channels averaged over a substantial portion of a scanning cycle, means for producing a voltage proportional to the current in the other of said channels averaged over the same period, and means for simultaneously utilizing said voltages to automatically adjust the attenuation characteristic of at least one of said channels to maintain a de-

sired relationship between the attenuation characteristics of said channels.

17. The method of operating an image producing system which comprises averaging at a receiving station an image current over a period at least of the order of that required to completely scan the field of view and periodically effecting an adjustment of said system under control of said averaged current.

18. The combination with a repeating device of means for applying an image current to said repeating device, current averaging means upon which the output current from said repeating device is impressed to average the image current variations, and means under control of said current averaging device to periodically adjust the transmission characteristic of said repeating device.

19. The combination with current averaging means, of means for continuously applying an image current to said averaging means, a repeating device, a condenser associated with said device for controlling its operation, and means under control of the image current averaged by said averaging device for periodically adjusting the charge on said condenser.

20. The combination with means for repeatedly averaging a television current, produced as the result of repeatedly scanning the same field of view, over separated periods each of at least the order of a complete scanning period, a condenser, and means for periodically charging said condenser under control of said averaging means.

21. A television system comprising two current averaging means, means for simultaneously impressing different portions of the television current upon said averaging means respectively, and means under the joint control of said averaging means for controlling a transmission characteristic of said system.

22. A television system comprising an amplifier at a receiving station, means for impressing a television current upon said amplifier representative of the tone values of elemental areas distributed throughout the field of view and produced during a period at least of the order of that of scanning the complete field of view, means associated with the output circuit of said amplifier for averaging said current, and means under control of said averaged current for periodically adjusting a transmission characteristic of said system.

23. In a multi-channel signaling system, means for cooperatively utilizing signaling energy received at a receiving station in two channels of a multi-channel signaling system to automatically change the transmission level of one of said channels, comprising means for comparing the transmission levels of said channels, and means controlled thereby for adjusting the level of one of said channels.

24. In a multi-channel signaling system, means for cooperatively utilizing signaling energy received at a receiving station in two channels of a multi-channel signaling system to automatically change the transmission level of one of said channels, comprising means for comparing the transmission levels of said channels, means controlled thereby for adjusting the level of one of said channels, and means for automatically adjusting a transmission characteristic of said comparing means.

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