

Sept. 19, 1939.

S. DOBA, JR
TRANSMISSION SYSTEM

Filed June 22, 1937

2,173,472

3 Sheets-Sheet 1

FIG. 1

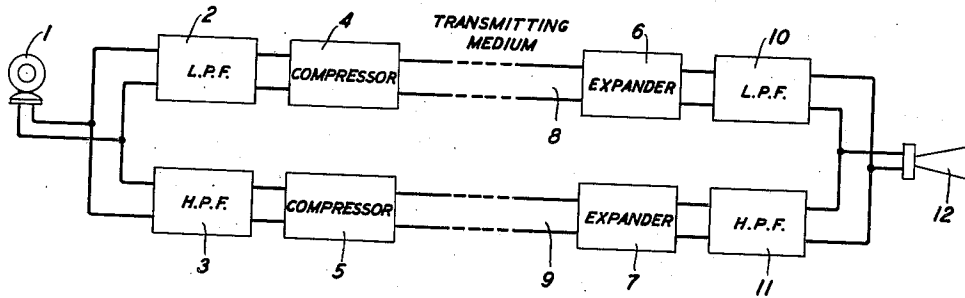


FIG. 2

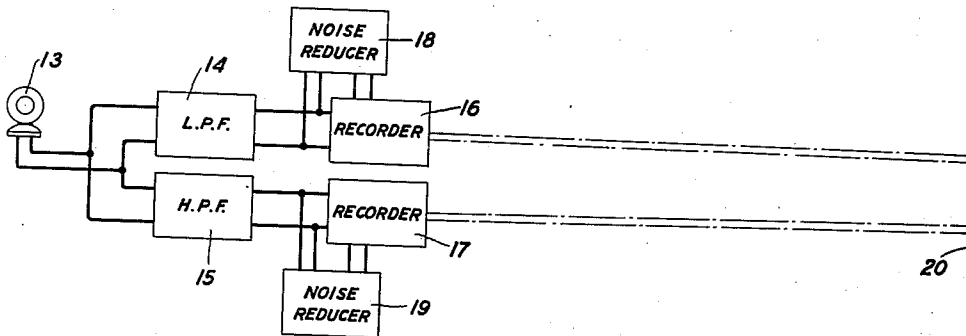
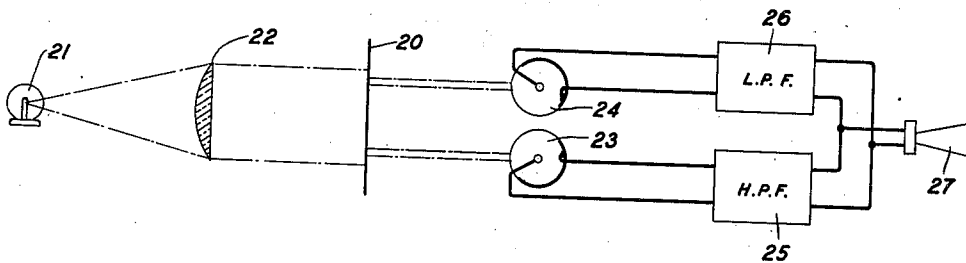


FIG. 3



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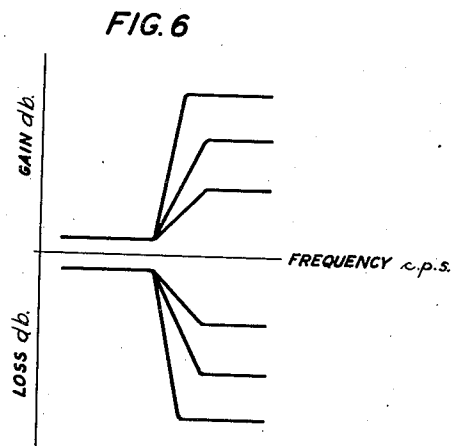
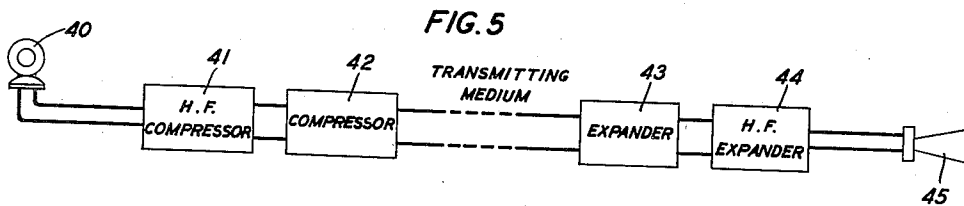
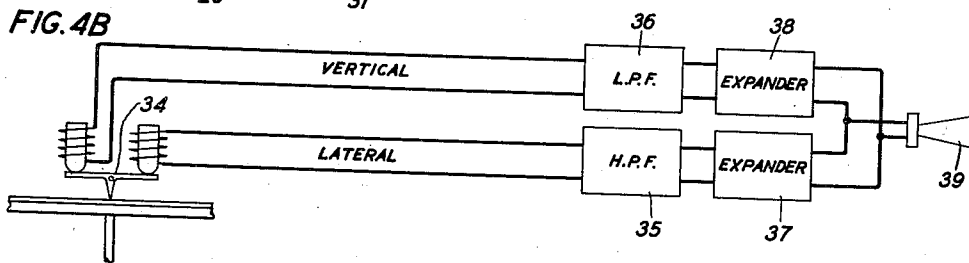
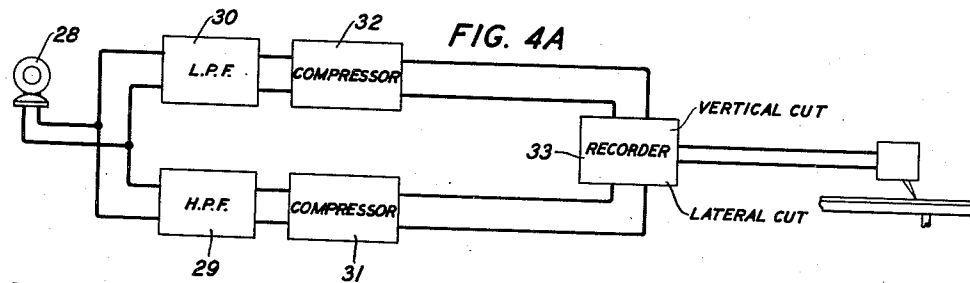
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

FIG. 7

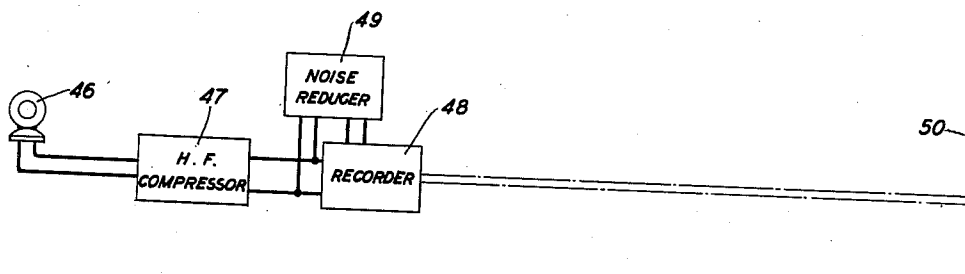
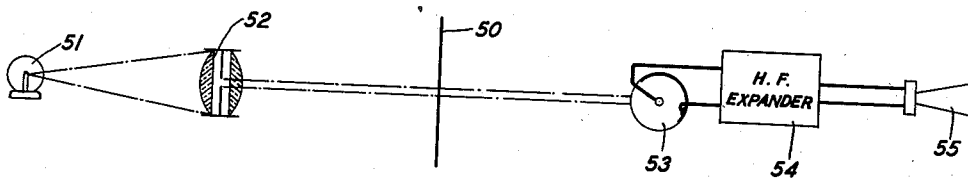


FIG. 8



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2,173,472

TRANSMISSION SYSTEM

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Application June 22, 1937, Serial No. 149,617
In Great Britain August 6, 1936

11 Claims. (Cl. 179—100.3)

This invention relates to the reduction of undesired currents arising during the transmission of modulated signal currents, and particularly to the reduction of the effect of the undesired currents produced during the reproduction of a sound record.

The object of the invention is a system for the transmission of modulated signal currents in which the effect of undesired currents is reduced in such manner that the undesired currents may be most effectively masked by the desired signal and the disadvantageous effects produced incidental to the reduction in the undesired currents also are reduced.

A feature of the invention is the division of the modulated currents into a plurality of bands of frequencies, and the reduction of the undesired currents individually in one or more of the bands.

Two methods are known for the reduction of the effect of undesired currents of small magnitude in a communication system. The undesired currents originate largely in the transmission medium, which may be a transmission line or some recording medium. In the first method, the smaller amplitudes of the signal currents are over-amplified until they are large with respect to the undesired currents. In order that the maximum amplitude of the signal currents does not overload the transmission medium, the larger amplitudes of the signal currents are under-amplified. Thus the range of volumes of the signal currents as transmitted is less than the original range, and the volume range may be said to be compressed. At the point of reproduction, a reverse process restores the volume range which may then be said to be expanded. Another method of reducing the effect of undesired currents produced during the reproduction of a sound record is to bias the recording device so that the recording medium is substantially completely modulated for all amplitudes of the signal currents.

In both of these systems, for small amplitudes of the signal currents, the undesired currents are reduced to a small magnitude, and the magnitude of the undesired currents increases as some function of the increase in amplitude of the signal currents. This frequent change in the magnitude of the undesired currents may be audible as a swishing sound, and has been termed the "hush-hush" effect. When transmitting signal currents which are deficient in high frequencies, the hush-hush effect is quite pronounced, whereas, when transmitting signal currents which are rich in high frequencies, the hush-hush effect is not

noticeable. The undesired currents produced by the transmission medium are usually of fairly high frequency, and the theory has been advanced that the low frequency signal currents do not effectively mask the high frequency noise currents thus producing the hush-hush effect, while the high frequency signal currents can mask the noise currents so that the hush-hush effect is not perceptible. Thus, if the signal currents are divided into a plurality of frequency bands, and the undesired currents are reduced only in the high frequency bands, the swishing sound will be masked by the high frequencies and the hush-hush effect will be reduced. As the low frequency currents due to speech or music are normally of fairly large amplitude with respect to the undesired currents, they may, if desired, be transmitted without reducing the amplitude of the undesired currents.

In the known systems, in order that the high frequency currents may efficiently mask the variation in the undesired currents, the system should operate with sufficient rapidity to follow the envelope of the high frequencies. But, if the system operates with such rapidity, it may be fast enough to follow the individual waves of the low frequency and thus produce an undesired modulation superimposed on the modulation due to the low frequencies. By dividing the frequency range into a plurality of bands in accordance with the invention this double modulation is avoided.

In known systems, the operation of the apparatus for reducing the effect of the undesired currents is made slow enough that perceptible double modulation does not occur. As the low frequency currents are generally of large amplitude compared to the high frequency currents, the operation of the apparatus is largely controlled by the low frequency currents. In some cases, the operation of the apparatus slightly changes the transmission conditions for the high frequency currents, resulting in an effect similar to a partial rectification of the high frequency currents, and producing a spurious low frequency current. In a system in accordance with the present invention, the low frequency currents are separated from the high frequency currents, thus this effect also is eliminated.

In the drawings:

Fig. 1 diagrammatically shows a transmission system embodying the invention;

Figs. 2 and 3 diagrammatically show a film sound recording and reproducing system embodying the invention;

Figs. 4A and 4B diagrammatically show a disc

sound recording and reproducing system embodying the invention;

Fig. 5 diagrammatically shows a transmission system embodying the invention, in which the control is serially exercised;

Fig. 6 shows curves explanatory of the action of Fig. 5;

Figs. 7 and 8 diagrammatically show a film sound recording and reproducing system embodying the invention, in which the control is serially exercised.

In Fig. 1, modulated signal currents from the source 1, which may be a microphone excited by acoustic waves, are supplied to the filters 2, 3. The low frequency currents are passed by the low pass filter 2, and the high frequency currents by the high pass filter 3. The cut-off frequencies of the filters are so adjusted that all the frequencies of the signal currents pass through one or the other, or both, of the filters. It is not necessary that the filters should have a sharp cut-off frequency, if all frequencies are passed equally into one or the other or both channels. Assuming, for example, that the system is transmitting frequencies from say 50 to 8,000 cycles per second, the total range of frequencies may be split into two equal ranges, say from 50 to 3,975 cycles per second and from 3,975 to 8,000 cycles per second, or may be split into two unequal ranges, say from 50 to 630 cycles per second (the geometric mean of the total range) and from 630 to 8,000 cycles per second. In the latter case, the total power carried by each channel may be made nearly equal.

The compressors 4, 5 and expanders 6, 7 may be of any suitable type, such as the devices described in an article "The Componder" by R. C. Mathes and S. B. Wright, published by the American Institute of Electrical Engineers in Electrical Engineering, vol. 53 No. 6, June 1934, pages 860 to 866.

The transmitting medium indicated by the dotted lines at 8, 9 may be any medium which can transmit the signal currents, such as a telephone line, a radio link, or a recording and reproducing system.

After expansion in the expanders 6, 7 the signal currents pass through the filters 10, 11 and are combined and supplied to some utilization device 12, such as a loud-speaker.

In Fig. 2, modulated signal currents from the source 13 are supplied to the filters 14, 15 which divide the currents into a plurality of frequency ranges or bands, in the same manner as the filters 2, 3 in Fig. 1. Each band of frequencies is supplied to an individual recorder 16, 17. One or more of the recorders 16, 17 preferably the high frequency recorder 17, is controlled by a noise reducer 18, 19 which may be of the type disclosed in U. S. Patent 1,855,197, April 26, 1932, H. McDowell, Jr., or U. S. Patent 1,923,757 Aug. 22, 1933, H. C. Silent or any other suitable type. The recording devices may be of any desired kind for producing variable density, variable area, or other type of record. In some cases, the high frequencies may be recorded as one type of record, for example a variable area record, and the low frequencies as another type of record, for example a variable density record, or vice versa. The two sound tracks will normally be recorded side by side on the film 20, and together occupy the same width on the film 20 as the present single track, but any other location or size may be used. The two tracks may be separated by a narrow zone to facilitate the separate reproduction of the rec-

ords. If the cut-off frequencies of the filters are chosen so that the channels carry equal powers, the records may be of equal width, though the two tracks need not be of equal width, and a wider track may be used for the channel having the higher frequencies, or greater power.

In Fig. 3, light from the constant source 21, is directed by a conventional lens tube, indicated by the lens 22, on the record tracks impressed on the film 20, which may be the film shown in Fig. 2, or a print thereof. The two records are individually scanned and excite the photoelectric cells 23, 24. The output of the photoelectric cells suitably amplified if desired, is supplied through the filters 25, 26 to the utilization device 27, which may be a loud-speaker.

In many cases, the high pass filter 25 in the reproducing channel may be omitted, and in some cases, both filters 25 and 26 may be omitted. Similarly, the filters 10, 11 in Fig. 1 may not be necessary.

In order to reduce the effect of undesired currents, the ratio of the amplitude of a desired current to the amplitude of an undesired current should be large, or, as it is commonly stated, the signal to noise ratio should be large. In the system shown in Fig. 1, the signals of smaller amplitude are relatively over-amplified, while the undesired currents arising in the medium are unchanged. In other words, the signal to noise ratio is made large by increasing the signal. In the system shown in Figs. 2 and 3, the noise reducers 18, 19 so modify the action of the recorders 16, 17 that the undesired currents produced by the recording medium are reduced in amplitude, that is, the signal to noise ratio is made large by reducing the absolute magnitude of the noise.

In Fig. 4A, modulated currents from the source 28 are divided by the filters 29, 30 and supplied to the compressors 31, 32. The outputs of the compressors 31, 32 are individually supplied to a dual recorder 33, or to two separate records. The dual recorder may be, for example, of the type shown in U. S. Patent 1,855,151, April 19, 1932, W. B. Jones. While wax recording is shown in Fig. 4A, it is apparent that two film recorders may be used in place of the two wax recorders, or the dual recorder.

In Fig. 4B the dual record may be reproduced by the dual reproducer 34, or the separate records may be reproduced by separate reproducers, and the outputs supplied through the high pass filter 35 and the low pass filter 36 to the expanders 37, 38. The outputs of the expanders 37, 38 are combined and supplied to a utilization device 39, which may be, for example, a loud-speaker.

In the systems shown in Figs. 1, 2, 3 and 4 the high frequency currents are separated from the low frequency currents and each band is separately treated in separate, parallel channels. In Figs. 5 and 7 the high frequency currents are treated first, then the whole range is later treated and the whole output is transmitted through one channel.

In Fig. 5, modulated currents from the source 40 are transmitted to the high frequency compressor 41. By means of the usual high pass filter in the control circuit of the high frequency compressor 41, the compressor 41 is given a gain-frequency characteristic of the type shown in the upper part of Fig. 6. The degree of compression of the high frequencies may be related to the amplitude of the undesired currents, and the compression of the compressor 42. The high frequency currents in the output of the compressor 41 will be large rela-

tively to the uncompressed low frequency currents. The whole range of frequencies is further compressed in the compressor 42 and transmitted over the transmitting medium indicated by the dotted lines, which may be a telephone line, a radio link, a recording and reproducing system or similar medium. The whole range of frequencies is expanded in the expander 43, then the high frequencies only are expanded in the expander 44, which as shown in the lower part of Fig. 6 has a loss-frequency characteristic which is the complement of the gain-frequency characteristic of the high frequency compressor 41. The expanded currents are then supplied to a utilization device 45.

In Fig. 7, modulated currents from the source 46 are supplied to the high frequency compressor 47, which has a characteristic similar to that of the compressor 41 in Fig. 5. The output of the compressor 47, is supplied to the recorder 48, controlled by the noise reducer 49, which may be similar to the recorder 16 and noise reducer 18 of Fig. 2. The recorder 48 produces a single record on the film 50.

In Fig. 8, light from the source 51, is focussed by a conventional lens tube represented by the lens 52 on the single record on the film 50, and the modulated light transmitted through the film 50 excites the photoelectric cell 53. The output of the photoelectric cell 53 is supplied to a high frequency expander 54 which has a loss-frequency characteristic which is the complement of the gain frequency characteristic of the compressor 47 in Fig. 7. The output of the expander 54 is supplied to a utilization device 55, which may be a loud-speaker. In Figs. 5, 7 and 8 the effect of the operation of the system may be approximately expressed as a reduction of the amplitude of the undesired currents by the compressor 42, or noise reducer 49, and a suppression of the hush-hush effect by the high-frequency-compressor-expander 41, 44 or 47, 54.

In film sound recording systems, in order that the two sound tracks may be recorded side by side on the same film, it may be necessary to employ mirrors, prisms or other light deflecting devices to bring the two beams from the recorders sufficiently closely together. The two recording devices may be differently tuned and adjusted so as to respond most efficiently to the high and low frequencies. The recording devices may advantageously be combined to form a single device, which may be in the form of a four ribbon light valve. The four ribbons may be arranged in two pairs, one pair being supplied with currents of one band of frequencies and the other pair being supplied with currents from another band of frequencies. As the recording slits formed by the two pairs of ribbons will normally be out of lateral alignment, an optical arrangement may be used to deflect one or both of the beams to bring them into alignment.

In reproducing sound records of this type separate photoelectric cells may be used or a single cell with multiple electrodes. The scanning light beams may be the same or a wider slit may be used for the low frequency record, and the outputs compensated by reducing the intensity of the impressed beam by an optical filter.

What is claimed is:

1. The method of recording signal modulated currents upon a photographic film which comprises separating the range of frequencies of said currents into two bands, separately modulating two beams of light with the currents in

said bands, reducing the exposure produced by one of said bands until the exposure is substantially completely modulated for all amplitudes of the currents in said band and recording said beams of light separately on said film.

2. The method of recording signal modulated currents upon a recording medium which comprises separating the range of frequencies of said currents into two bands, over-amplifying the small amplitudes of the currents in one band and under-amplifying the large amplitudes of the currents in said band to compress the range of amplitudes in said band and recording both said bands separately upon said medium.

3. In a transmission system, a source of signal modulated currents extending over a wide range of frequencies, filter means for separating said currents into two bands of frequencies having substantially the same power in each band, a controlled thermionic device for compressing the amplitude range of the currents in one band, separate channels for transmitting said bands, a controlled thermionic device having a characteristic which is the inverse of said compressing device for expanding the amplitude range of the currents in said band to its original value, filter means for combining said bands, and means for utilizing the combined output of said filter means.

4. In a sound recording system, a source of currents modulated in accordance with sound, filter means for separating said currents into two bands of frequencies, means for separately modulating two beams of light with the currents in said bands, a control circuit actuated by the currents in one of said bands for reducing the exposure of the beam modulated by said band until the exposure of said beam is substantially completely modulated for all amplitudes of the currents in said band, a photographic film moved at constant speed and means for recording said beams of light on separate portions of said film.

5. In a transmission system, a source of signal modulated currents, a controlled device for compressing the volume range of the high frequencies of said currents, a second controlled device for further compressing the volume range of the currents in the output of said first compressor, a channel for transmitting the output of said second compressor, an expander in said channel having a characteristic which is the inverse of the characteristic of said second compressor for expanding the volume range of the currents in said channel, a second expander having a characteristic which is the inverse of the characteristic of said first compressor for expanding the volume range of only the higher frequencies and means for utilizing the output of said second expander.

6. In a sound recording system, a source of sound modulated currents, a controlled device for compressing the volume range of only the higher frequencies of said currents, means for modulating a beam of light with said currents, a control circuit actuated by said currents for reducing the exposure of said beam until the exposure is substantially completely modulated for all amplitudes of said currents, a photographic film moved at constant speed, and means for recording said modulated beam of light on said film.

7. The method of recording signal modulated currents upon a medium which comprises separating the range of frequencies of said currents into a plurality of bands, compressing the range of amplitudes of the currents in at least one of said

bands by over-amplifying the small amplitudes and under-amplifying the large amplitudes of said currents, and recording all said bands upon said medium.

- 5 8. In a transmission system, a source of signal modulated currents extending over a wide range of frequencies, means comprising a controlled thermionic device for compressing the amplitude range of the currents in a limited band of said
- 10 frequencies, a medium for transmitting the compressed band, and the other frequencies, a controlled thermionic device having a characteristic which is the inverse of the characteristic of said compressing device for expanding the amplitude
- 15 range of the currents in said limited band of frequencies to its original value, and means for utilizing the expanded currents and the other transmitted currents.

9. In a recording system, a course of signal modulated currents, filter means for separating
- 20 said currents into a plurality of bands of frequencies, means for compressing the range of amplitudes of the currents in at least one of said bands by over-amplifying the small amplitudes
- 25 and under-amplifying the large amplitudes of the currents in said band, means for recording said compressed band in one sense upon a medium, and said other bands in another sense upon said medium, separately reproducing said records,

means for restoring the range of amplitudes of the currents in said compressed band, and means for utilizing said reproduced currents.

10. In a recording system, a course of signal modulated currents, filter means for separating said currents into two bands of frequencies, controlled thermionic means for separately compressing the amplitude ranges of the currents in the two bands, means for recording the currents of one band as a vertically cut record and for recording the currents of the other band as a laterally cut record, means for separately reproducing both said records, controlled thermionic means for separately expanding the amplitude ranges of the reproduced currents to their original value, and means for utilizing the combined output of both bands.

11. The method of recording and reproducing signal modulated currents on and from a recording medium which comprises dividing the range of frequencies of said currents into a plurality of bands, separately increasing the ratio of the amplitude of the signal modulated currents in each band to the amplitude of the undesired currents arising from said medium, separately recording each of said bands on said medium, reproducing all said records and supplying the output of all said records to a reproducing device.

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