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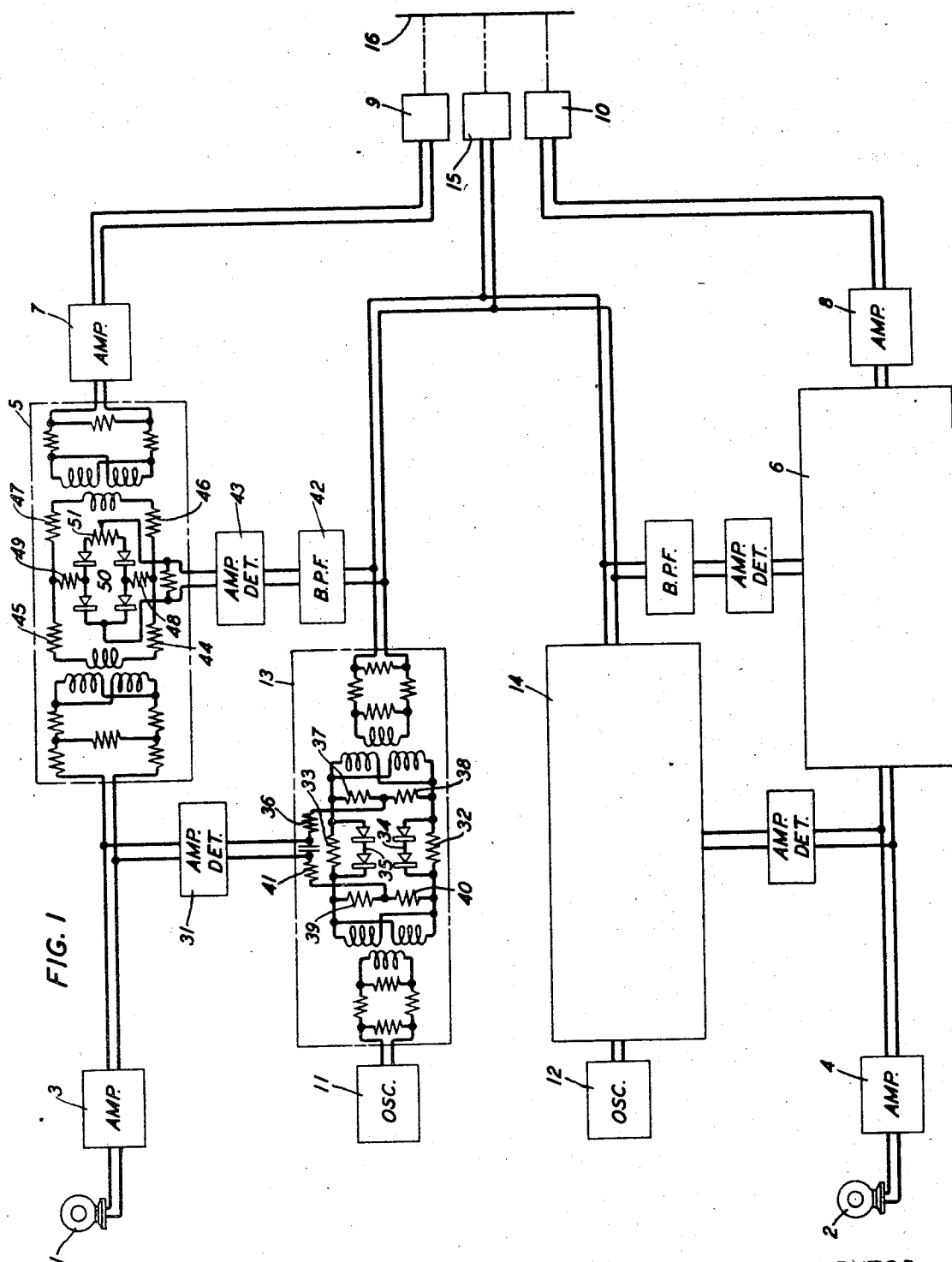
W. B. SNOW

2,258,662

SOUND TRANSMISSION SYSTEM

Filed April 5, 1940

2 Sheets-Sheet 1



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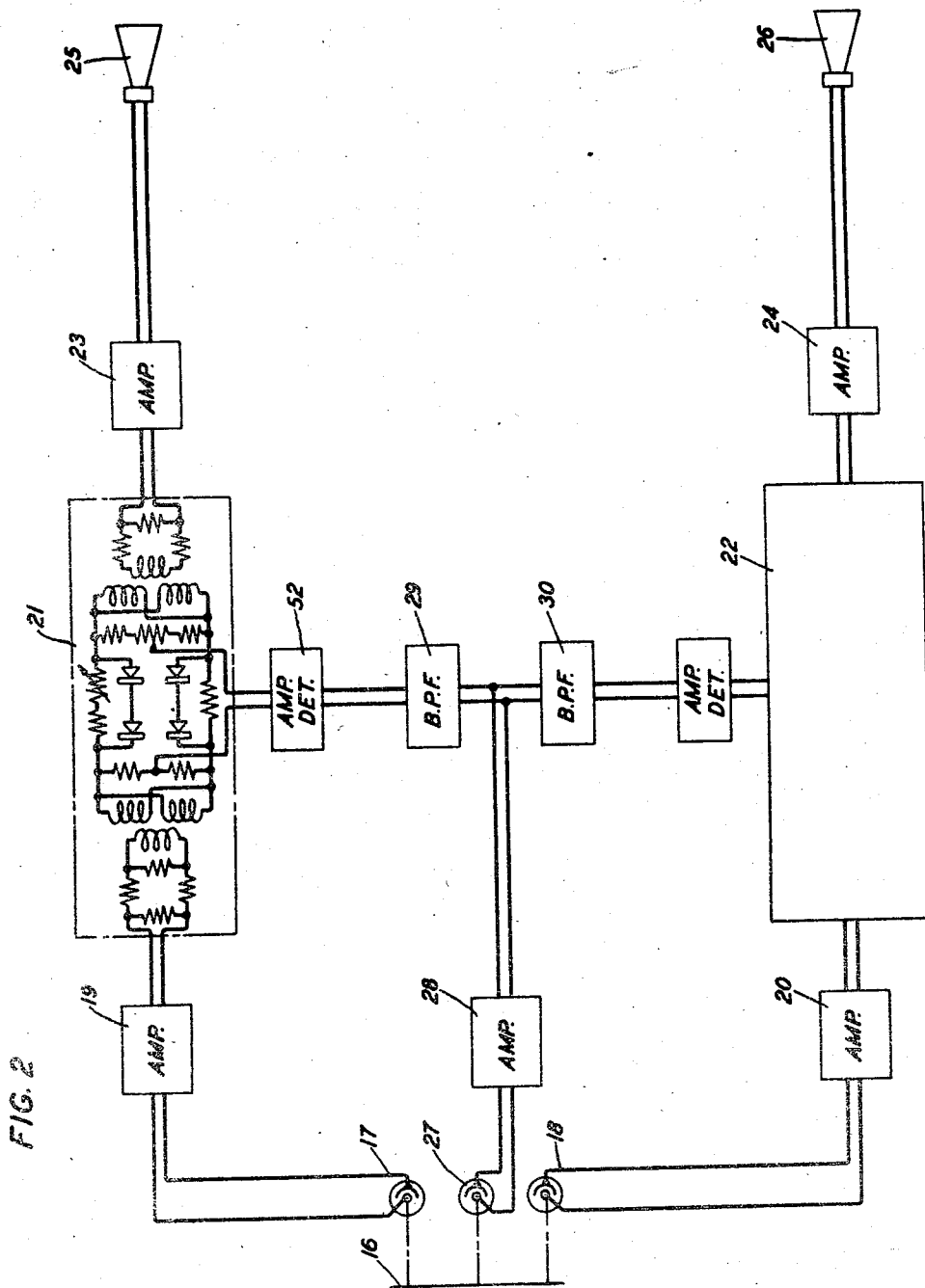
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SOUND TRANSMISSION SYSTEM

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8 Claims. (Cl. 179—1)

This invention relates to systems for the reproduction of sound and more particularly to systems which reproduce the sound with the spatial distribution of the original sound. The invention applies to systems in which the sound is detected and transmitted for immediate reproduction and also to systems in which the sound is detected and recorded for subsequent reproductions.

Sound transmitting systems and sound recording and reproducing systems have been proposed heretofore in which the volume range capacity of the transmitting medium or the recording medium is effectively increased by compressing the volume range before transmission or recording and expanding the volume range in a complementary manner before the reproduction of the sound. Typical systems of these types are disclosed respectively in Patents 1,565,548, December 15, 1925, A. B. Clark; and 1,623,756, April 5, 1927, C. F. Sacia. In systems of this character the effective amplification, that is, the gain or loss in the transmission channel, is varied in such a way that the louder sounds do not overload the system and the faintest sounds are amplified sufficiently to be well above the level of extraneous noise originating in the system.

It has also been proposed heretofore, to reproduce sounds in their original spatial relation by using a plurality of separate transmission channels with the reproducers disposed with respect to the desired virtual source of the reproduced sound in a manner corresponding to the relation of the microphones to the actual source of the sound. Systems of this character are shown, for example, in British Patent 23,620 of 1911, A. Rosenberg, and United States Patent 1,589,139, June 15, 1926, E. H. Foley. To produce a satisfactory illusion of the spatial distribution of the sound, the transmission system, which may include a sound recording and reproducing link, must be capable of reproducing a very wide range of both the volume and the frequencies of the sound.

The object of the present invention is a multi-channel stereophonic sound transmission system capable of transmitting a very wide range of both volume and frequency of sound.

A feature of the invention is the use of volume compression and expansion individually in each channel of the system to increase the effective volume range capacity of the system.

Another feature of the invention is the use of a constant frequency carrier current individual to each channel, varied in accordance with the

degree of compression applied to the transmitted sound.

A further feature of the invention is in the use of the same constant frequency varying amplitude carrier current to control both the compressor in the transmitting channel and the expander in the reproducing channel.

A further feature of the invention is the transmission of all of the control currents from the various channels over a single transmission channel, or the recording of all of the control currents from the various channels as a single record on the medium.

In the drawings:

Fig. 1 diagrammatically discloses the sending end of a transmission system embodying the invention; and

Fig. 2 diagrammatically discloses the receiving end of a transmission system embodying the invention.

The microphones 1, 2 are appropriately disposed in the vicinity of the source of sound to form a stereophonic pick-up system. The sound waves are detected by the microphones 1, 2 in the form of electrical waves which are amplified in the amplifiers 3, 4, compressed in the compressors 5, 6, further amplified if desired in the amplifiers 7, 8 and applied to separate transmission channels which may, if desired, be in the form of the recording devices 9 and 10. Carrier currents of constant frequency are generated by the oscillators 11, 12, modulated by the control circuits 13, 14, and, after modulation, are transmitted over a common circuit which may, if desired, have the form of the common recording device 15. The oscillator associated with any given channel generates a frequency which differs from the frequencies generated by the oscillators associated with the other channels. If desired, the carrier frequencies may be harmonically related, in which case the individual oscillators may be replaced by a common oscillator and a known form of harmonic generator with suitable filters for each channel or by an oscillation generator capable of producing a plurality of harmonically related frequencies. Preferably the carrier frequencies form a series of odd harmonics, because, when thus related, the beat frequencies due to any intermodulation between the carrier frequencies will form a series of even harmonics which may easily be eliminated by the band-pass filters. The pass bands of the respective filters will pass the desired odd harmonic but are too narrow to pass the even harmonics lying on each side of the desired odd harmonic. The upper

harmonics are also so phased with respect to the lower harmonics that they subtract from the peak value of the lower harmonics thus reducing the maximum load impressed on the recording device 15 and increasing the average load on the recording device.

The records produced by the recorders 9, 10 and 15, may conveniently be placed side by side upon the same medium 16 which may have the form of a photographic film. The records on the medium 16 may be detected by the reproducers 17, 18, amplified if desired in the amplifiers 19, 20, expanded in the expanders 21, 22, further amplified if desired in the amplifiers 23, 24 and reproduced as sound waves by the reproducing devices 25, 26. The reproducers 25, 26 are related to the apparent source of sound in the same way that the microphones 1, 2 are related to the real source of sound. All of the control currents are reproduced by the reproducer 27, amplified if desired by the amplifier 28 and supplied to suitable band-pass filters 29, 30 which select the appropriate carrier frequency and supply the current to control the expanders 21, 22. If desired the sound recorders and reproducers may be omitted, and the channels connected directly from the input of the recording devices 9, 10 and 15, respectively, to the output of the reproducing devices 17, 18 and 27, respectively.

A portion of the electrical waves in the output of the amplifier 3 are supplied to a conventional type of amplifier-detector 31 and are there converted into a unidirectional current varying as some function of the variations in amplitude of the electrical waves in the output of the amplifier 3. The varying unidirectional control currents are supplied to the modulating device 13 in the output of the oscillator 11. The modulating device 13 is a modified form of the device disclosed in French patent of addition 39,757 published March 12, 1932, and in United States Patent 2,034,703, March 24, 1936, F. W. Metzger. The modulator 13 comprises two series resistors 32, 33, respectively shunted by non-linear resistance elements 34, 35 having the property of changing their resistance with the current flowing through the element. The non-linear resistance elements 34, 35 may conveniently comprise a plurality of the known copper, copper-oxide couples. The slowly varying unidirectional current from the amplifier-detector 31 flows through the resistor 36 to the junction of the resistors 37 and 38 and there divides equally. One half of the current flows through the resistor 37 through the resistors 33 and 35 in parallel and through the resistor 39. The other half of the current flows through the resistor 38, the resistors 32 and 34 in parallel and the resistor 40, the combined current flowing through the resistor 41 back to the amplifier-detector 31. The unidirectional current flowing in the resistors 34 and 35 changes the resistance of these resistors and thus changes the loss suffered by the constant frequency current from the oscillator 11 in passing through the device 13. The current at the output of the device 13 will then have the form of a constant frequency carrier current varying in amplitude in accordance with the variations in the unidirectional current from the amplifier-detector 31. The transformer and resistance pads at the input and output of the device 13 prevent the variations in the impedance of the device 13 from being reflected into the other part of the circuit. Other forms of modulator, such as the one dis-

closed in United States Patent 1,936,176, November 21, 1933, R. R. Scoville, may be used in place of the modulator shown.

A portion of the output of the modulator 13 is selected by the band-pass filter 42 and supplied to the amplifier-detector 43 where it is converted into a slowly varying unidirectional current. The slowly varying unidirectional current in the output of the amplifier-detector 43 is supplied to the compressor 5. The compressor 5 is a modified form of the device disclosed in United States Patent 2,035,263, March 24, 1936, R. W. Cushman et al., and is essentially a balanced resistance pad formed by the series resistors 44, 45, 46, 47 and the shunt network formed by the resistors 48 and 49 in series with the non-linear resistance network 50. The slowly varying unidirectional current in the output of the amplifier-detector 43 is supplied to the potentiometer 51 and flows through the element of the network 50 back to the amplifier-detector 43. These currents flowing in the network 50 change the resistance of the network 50, thus varying the shunt resistance of the resistance network and effectively varying the loss introduced by the compressor 5 in the channel of the microphone 1. The potentiometer 51 may be adjusted to improve the balance of the network 50. The transformers and resistance network at the input and output of the device 5 prevent the changes in the impedance of this device from being reflected into the channel.

The compressor 5, which is essentially a variable loss device, may be replaced by a variable gain device such as disclosed in United States Patent 1,623,756, April 5, 1927, C. F. Sacia.

The compressor 5 in the channel leading from the microphone 2 may be of the same type as the compressor 5 and is controlled by the output of the modulator 14 which may be of the same character as the modulator 13. The varying carrier currents from the modulators 13 and 14 are combined into one channel for transmission and may, if desired, be recorded by a single recording device 15.

While a two-channel stereophonic system has for convenience been disclosed, it is, of course, evident that three or more channels may be used, the three or more control currents being combined and transmitted in a single channel, or recorded by a single recording device 15.

In Fig. 2 the proper control current in the output of the amplifier 28 is selected by the band-pass filter 29 and supplied to an amplifier-detector 52 where the control current is converted into a slowly varying unidirectional current, which flows from the amplifier-detector 52 through the network formed by the expander 21 back through the amplifier-detector 52. The expander 21 is of essentially the same construction as the modulator device 13 and operates in a similar manner; thus a detailed description of the operation of this network is believed to be unnecessary. The potentiometer and variable resistance shown in the circuit of the device 21 assists in balancing the circuit. The expander 21 affects the current transmitted through the device in a manner which is the inverse of the effects of the compressor 5 on the current transmitted through that network. In other words, the compressor 5 inserts a loss in the channel which increases with an increase in the amplitude of the current transmitted through the channel, while the expander 21 introduces a loss into the reproducing channel which decreases with an increase in the amplitude of the current from the microphone.

As the compressor 5 is controlled by a slowly varying unidirectional current which is a function of the electrical wave from the amplifier 3, it is evident that this compressor 5 could be controlled directly by the output of the amplifier-detector 31. In the present system, however, the output of the amplifier-detector 31 is first converted into the form of a slowly varying carrier which is selected by the band-pass filter 42 and then converted back into a unidirectional current by the amplifier-detector 43 and it is the output of the amplifier-detector 43 which controls the compressor 5. A very real advantage is gained by this method of control. If the compressor 5 were to be directly controlled by the output of the amplifier-detector 31, and the expander 21 is controlled by the carrier current from the modulator 13, this would require that the modulator 13 and oscillator 11 operate as strictly linear devices so that there would be exact proportionality between the output of the amplifier-detector 31 and the output of the amplifier-detector 52. However, in the present system, both the compressor 5 and the expander 21 are controlled by unidirectional current derived from the same carrier output of the modulator device 13, thus it is not necessary that the oscillator 11 and modulator device 13 be linear in their operation and one difficult circuit requirement has been eliminated. In either case, it is, of course, essential that the expander 21 should be a fairly exact inverse of the compressor 5.

What is claimed is:

1. In a transmission system, a source of sound, a plurality of detectors for converting sound waves from said source into electrical waves, a plurality of transmission channels respectively associated with said detectors, means individual to each of said channels for controlling the transmission of electrical waves through said channel, a plurality of sources of electrical currents of different constant frequencies, one source being associated with each transmission channel, means individual to each of said sources of constant frequency current for controlling the output of said source in accordance with a function of the electric wave transmitted through the channel, means for combining the output of all of said control means in a single transmission channel separate from the channels transmitting said electrical waves.

2. In a transmission system, a source of sound, a plurality of detectors for converting sound waves from said source into electrical waves, a plurality of transmission channels respectively associated with said detectors, means individual to each channel for compressing the range of amplitude of the electrical waves transmitted through the channel, a plurality of sources of electrical current of constant frequency respectively associated with said channels, means for deriving from the electrical waves in each channel, a current varying with a function of the amplitude variation of the waves in the channel, means individual to each source of current of constant frequency for controlling the output of said source in accordance with the current derived from the waves in the associated channel, means for controlling the compressor in the channel by means of the controlled output of said source of constant frequency current, an expander individual to each channel, and means controlled by the constant frequency current associated with said channel for controlling the operation of said expander.

3. In a transmission system, a source of sound, a microphone for converting sound waves from said source into electrical waves, a reproducer for converting said electrical waves into sound, and a transmission channel connecting said microphone and said reproducer and having a compressor associated with said microphone and an expander associated with said reproducer, a carrier current generator associated with said channel, means associated with the output of said microphone for deriving a current varying with a function of the amplitude variations of the electric waves from said microphone, means operated by said derived current for controlling the output of said carrier current generator and means for controlling said compressor and said expander by the controlled output of said carrier current generator.

4. In a sound recording system, a plurality of spaced microphones, a recorder for each microphone, a separate circuit including control means connecting each microphone with the corresponding recorder, a plurality of sources of current of different constant frequencies, means for deriving currents varying with the envelope of the currents in the separate circuits and respectively modulating the outputs of said sources, and means for recording all of said modulated outputs in a single record track and respectively controlling the control means in one of said circuits by the modulated output of the source corresponding to said circuit.

5. In a sound recording system, a microphone, a recorder, a circuit including amplitude control means connecting said microphone and said recorder, means for deriving a current varying with the envelope of the amplitude variations of the current from said microphone, a source of current of constant frequency, means for modulating the output of said source with said envelope current, means for making a record of said modulated output, and means for deriving a current varying with the envelope of the amplitude variations of said modulated current and controlling said amplitude control means with said current.

6. In a sound recording system, a plurality of microphones, a recorder for each microphone, a separate circuit including control means connecting each microphone with the corresponding recorder, a plurality of sources of currents of different constant frequencies, means for deriving currents varying with a function of the currents in the separate circuits and respectively modulating the outputs of said sources, and means for recording all of said modulated outputs in a single record track.

7. In a transmission system, a plurality of sources of electrical waves, a plurality of transmission channels respectively associated with said sources, means individual to each of said channels for controlling the transmission of electrical waves through said channel, a plurality of sources of electrical currents of different constant frequencies, one source being associated with each transmission channel, the frequencies of said sources of constant frequency currents forming a series of odd harmonics, the upper harmonics being so phased with respect to the lower harmonics that the peak value of the lower harmonics is reduced, means individual to each of said sources of constant frequency current for controlling the output of said source in accordance with a function of the electric waves transmitted through the channel, and means for combining the output of all of said control means in a

single transmission channel separate from the channels transmitting said electrical waves.

8. In a sound reproducing system, a recording medium comprising a plurality of records of sound and a separate record of a plurality of carrier current control records, a pick-up device individual to each of said sound records, a sound reproducer individual to each of said sound records, a transmission channel contain-

ing control means respectively connecting each pick-up to the corresponding reproducer, a common pick-up for all said control records, and means for selecting from the output of said common pick-up the carrier current corresponding to a given channel and for controlling the control means in said channel with said current.

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