

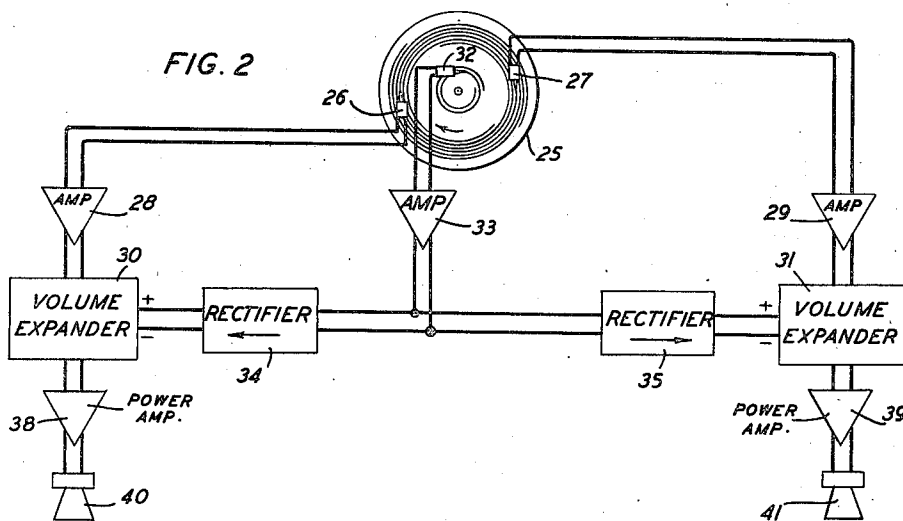
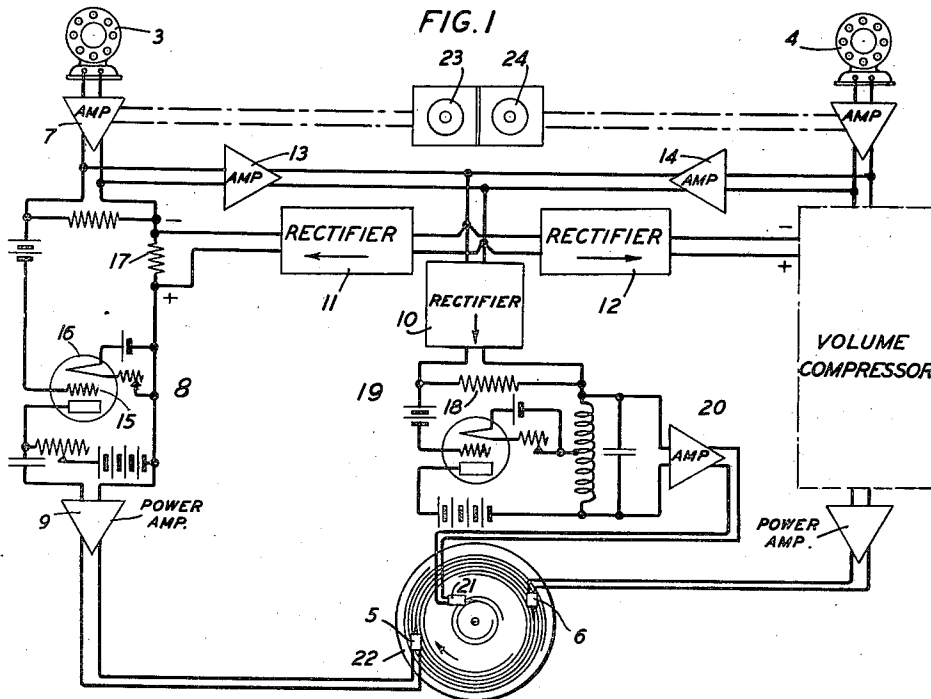
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H. D. ARNOLD

2,069,810

SOUND RECORDING AND REPRODUCING SYSTEM

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SOUND RECORDING AND REPRODUCING
SYSTEM

Harold D. Arnold, deceased, late of Maplewood,
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8 Claims. (Cl. 179—100.4)

This invention relates to systems for the reproduction of sounds and with respect to certain features, it relates more particularly to systems which reproduce the sounds with the spatial distribution of the original sounds. In general the invention applies to systems in which the sounds are picked up and transmitted for immediate reproduction and also to those in which records are made for subsequent reproduction.

Systems of both these types have been proposed heretofore in which the volume range capacity of the transmitting system or the recording medium have been effectively increased by compressing the volume range before transmission or recording and expanding it in a complementary manner before reproduction. Typical systems of these types are disclosed respectively in Patent 1,565,548 to Clark, December 15, 1925 and Patent 1,623,756 to Sacia, April 5, 1927. In these systems the gain or effective amplification is varied in such a way that the loudest sounds do not overload the system and the faintest sounds are sufficiently amplified to be well above the level of extraneous noise originating in the system. This method, however, is entirely unsuited for reducing the level of noise which is picked up by the microphones along with the sound since no system yet devised can discriminate between desired and undesired sounds of the same frequency.

It has also been proposed heretofore, as shown by such patents as 1,589,139 to Foley, June 15, 1926 and British Patent 23,620 of 1911, to reproduce sounds in their original spatial relation by using two or more separate transmission channels with the receivers disposed with respect to the desired virtual source of the reproduced sounds, in a manner corresponding to the relation of the microphones to the actual source of the sounds. To produce a satisfactory illusion of this kind, the recording and reproducing system or the transmission system must be capable of reproducing very wide ranges of both volume and frequency particularly for sounds of certain types such as orchestral music. The volume range capacity of the best recording systems available is insufficient for the full range of a large orchestra and long telephone lines for transmitting such a range of volumes are very expensive.

The object of this invention is to overcome these and other limitations of present sound reproducing systems.

The extraneous noise picked up by the micro-

phones along with the sound is ordinarily not particularly noticeable except when the sounds to be translated are produced at low volume levels. According to one feature of this invention, which is applicable to any sound reproducing system, the light passages of music, for example, are played much louder than they would be played for an audience listening directly to the music so that the margin of the signals over the noise is increased and the leader or a control operator is provided with manually operable means for each microphone used, to reduce the energy level of these passages to their proper relative levels for transmission.

According to another feature of the invention volume compression and expansion is applied to multi-channel systems to increase their effective volume range capacity without excessively complicating the system. By compressing all channels in accordance with the sum of the pick-up currents in all the microphones, only one control record or pilot channel is required to control the expansion during reproduction. The compression may be carried out manually or automatically and may be used either alone or in conjunction with the noise reducing scheme already described. The control record may function in the reproducing system either to restore the volume range of the original sound or to increase it by attenuating the lighter passages or emphasizing the loud passages to simulate a much larger orchestra or both.

In one embodiment of this feature as applied to multi-channel systems for spatial distribution of the reproduced sounds, the several independent compressed records of the sounds are recorded in multiple spiral grooves of a disc record and the control record representing the compression in the records is placed on the central, normally blank portion of the disc. This record may be in the form of a spiral groove of low frequency and varying amplitude or one of constant amplitude and varying frequency. A reproducer cooperating with this groove is connected to suitable instrumentalities for effecting the desired expansion of the volume range in the reproducing system. Since it is necessary for the preservation of the spatial distribution of the reproduced sounds, that complete isolation of each channel from all the others be maintained throughout, the compressing and expanding means must be such that no conductive path is created between the channels.

In the drawing, Fig. 1 is a two-channel recording system according to the invention and Fig. 2

is a reproducing system for records made with the system of Fig. 1.

In Fig. 1, the microphones 3 and 4 are suitably spaced before the source of sounds to be recorded and connected with separate transmitting channels terminating in recorders 5 and 6. Each channel includes a preliminary amplifier 7, a volume compressor 8 and a power amplifier 9. The input to the rectifiers 10, 11 and 12 is derived from both channels by means of amplifiers 13 and 14 or other devices unilaterally conducting only in the direction indicated so as to maintain the electrical isolation of the channels. The output of the rectifiers 10, 11 and 12 is, therefore, proportional to the sum of the microphone currents at all times.

The volume compressor 8, which is merely illustrative of the several known devices for reducing volume range, is fully described in the Sacia patent referred to above and, as is well known, effects a compression in the range of volumes transmitted in accordance with the variations in the biasing voltage on the grid 15 of the vacuum tube 16. The output of the rectifier 11 is applied across the resistance 17 in the grid return circuit to vary the biasing voltage and hence the gain of the tube 16 according to the sum of the microphone current. A similar compression is effected in the other channel by the rectifier 12. It will be understood, of course, that the signal current may be compressed to any desired extent by properly coordinating the gain of amplifiers 13 and 14 and the value of the resistance 17. The primary advantage in controlling the compression in accordance with the sum of the microphone currents is that in this way only a single control record is required to effect the expansion during reproduction irrespective of the number of channels in the system. While such a system is inherently somewhat less flexible than one in which the compression in each channel is controlled independently, the volume range of the system can be greatly extended in this way without unduly complicating the reproducing system since no separate control record disc is required nor does the single control record groove reduce the space available for the sound track.

While the gain of the compressors is being varied to reduce the volume range of the signals transmitted, the rectifier 10 is producing a correspondingly varying potential across the resistor 18 in the grid circuit of the oscillator 19 which is preferably tuned to a low frequency such as 200 cycles per second, which can be satisfactorily recorded on the central portion of the disc. The output of the oscillator varying in amplitude according to the variations in the output voltage of the rectifier 10 is fed through a suitable amplifier 20 to a recorder 21 which engages only the central normally unused portion of the record blank 22 and makes a control record for effecting the necessary expansion when the records are reproduced.

The softer passage of music or other sounds which are normally near the noise level may if desired be produced at any convenient level which provides a satisfactory margin over the extraneous noise and when this is done the orchestra leader or a control operator then restores such passages to their proper relative levels by means of the manually operated volume controls 23, 24 associated with the preliminary amplifiers. This attenuation reduces the noise level along with the signal currents and maintains the original margin which can be much greater than when the

fainter sounds are produced originally at their proper intensities. This procedure not only substantially eliminates random extraneous noises and the bowing noises produced in playing stringed instruments but it also avoids the deterioration in quality incident to the playing of certain instruments very softly. These manual controls may also be used by the orchestra leader to increase the volume level during climaxes in the rendition so that, with a small orchestra, effects may be obtained which ordinarily can be produced only with a much larger orchestra.

A still other advantage in this procedure is that, since the noise level is reduced with respect to the signals, smaller minimum groove undulations are practical in the record so that a given range of volumes can be represented by smaller maximum groove undulations. This reduces the necessary spacing of the grooves and increases the playing time of the record which is important in a system such as this where the recorders 5 and 6 preferably cut two concentric spirals in the same record blank. It will be seen that the outputs of the amplifiers 7 will be the same (except for the ratio of signal to noise) whether the procedure just outlined is used or not and that the operativeness of the volume compression system is in no way dependent upon the use of the manual volume control.

The record 22 or a pressing 25 made therefrom may be reproduced by the system of Fig. 2 to give a "stereophonic" or spatial distribution effect with a range of volumes equal to or greater than that of the original sound. The reproducers 26, 27 engage their respective concentric spiral grooves on the record and deliver their outputs to the preliminary amplifiers 28, 29 and the volume expanders 30, 31 which may be substantially identical with the volume compressor 8. The reproducer 32 delivers a 200 cycle control frequency of varying amplitude to the amplifier 33 and the rectifiers 34, 35 which in turn impress correspondingly varying voltages on the resistors in the grid circuit of the volume expanders 30, 31. It should be noted, however, that since volume range expansion instead of compression is required in this case, the output leads of the rectifier should be connected to the resistors in reversed polarity as indicated in the drawing.

The variations in the potentials applied to the grids of the tubes in the volume expanders may be adjusted to restore the volume range of the original sounds or to produce a range of volume greater or less than that of the original sound according to the capacity of the reproducing system. The output of the expanders is then suitably amplified by amplifiers 38, 39 and delivered to the loud-speakers 40, 41 which are suitably spaced with respect to the reproducing stage. Since there is apt to be a slight time lag in the operation of the volume range compressors and expanders a more accurate reproduction of the original volume range may be obtained by slightly displacing the reproducers 26, 27 or the reproducer 32, or both, from the exact positions in the grooves corresponding to the recorder positions until the best artistic effect is obtained.

While the invention has been described with reference to a multi-channel recording and reproducing system for purposes of illustration, it will be understood that the principles of the invention are equally applicable to a system in which the signal currents are transmitted over

telephone lines for immediate reproduction, in which case only one channel is required. Such a system would be identical with the systems illustrated in the drawing except that the recorders and reproducers would be eliminated and the recorder inputs would be connected by telephone lines to the reproducer output circuits.

What is claimed is:

1. In a system for reproducing sounds with a spatial distribution corresponding to the original sounds, a plurality of spaced pick-up microphones, a plurality of loud-speaking receivers, a separate transmission channel connecting each microphone with a corresponding receiver, means actuated by current from all the microphones for reducing the range of amplitude variations in all the channels, a control channel carrying a current varying in accordance with the operation of the range reducing means and means responsive to the variation in the current for increasing the range of amplitude variations impressed on all of the receivers.

2. A sound recording system comprising a plurality of spaced pick-up microphones, a recorder for each microphone, means responsive to the sum of the microphone outputs for varying the input to the recorders and means for recording the variations in the recorder inputs.

3. The combination with a plurality of records of sounds from the same source corresponding to different pick-up positions and a control record varying in accordance with the sum of the sound variations at said positions and representing the relation of the volume variations in each record to the volume variations of the original sound at the corresponding pick-up position, of separate reproducing systems cooperating with the sound records, a reproducer for the control record and means responsive to the output of the reproducer for operating the systems with the volume range of the original sounds.

4. In a multi-channel transmission system for reproducing sounds of a wide range of volume levels with their original spatial distribution, the method of reducing the extraneous noise in the reproduction which comprises producing the softer sound passages at disproportionately high volume levels, translating the sounds into corresponding currents in each channel, attenuating the currents representing the softer passages to their proper relative level in each channel to discriminate against extraneous sounds actuat-

ing the pick-up means, compressing the volume range of the currents in each channel for transmission in accordance with the sum of the currents in all the channels so that the currents representing the softer passages are well above the noise level of the channel and the currents representing the loudest passages are within the capacity of the channels, and selectively amplifying the currents transmitted to obtain the desired volume range in the reproduction of each channel.

5. A sound record for stereophonic reproducing systems comprising a plurality of separate compressed records of sounds from the same source corresponding to different pick-up positions and a single control record comprising variations proportional to the sum of the sound intensities at the pick-up positions and representing the compression in the sound records.

6. A disc phonograph record having a plurality of separate spiral grooves each containing a modified representation of currents corresponding to sounds from the same source and a spiral groove in the central normally blank portion of the disc in accordance with the modifications of the currents.

7. In a sound recording system the combination with a plurality of spaced pick-up microphones, a recorder for each microphone, and a separate circuit including an amplifier connecting each microphone with a corresponding recorder, of means for deriving a potential proportional to the sum of the outputs of all the microphones, means for varying the gain of all the amplifiers in accordance with said potential, and means for recording the variations in said potential.

8. In a system for reproducing sound with spacial distribution, the combination with a plurality of sound recordings representing the sound at different pick-up positions, a control recording representing volume range compression in the sound recordings, and a reproducing channel associated with each of said sound recordings, of a variable gain device in each channel, a reproducer cooperating with the control recording and a unilaterally conducting element connecting the reproducer with each device.

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