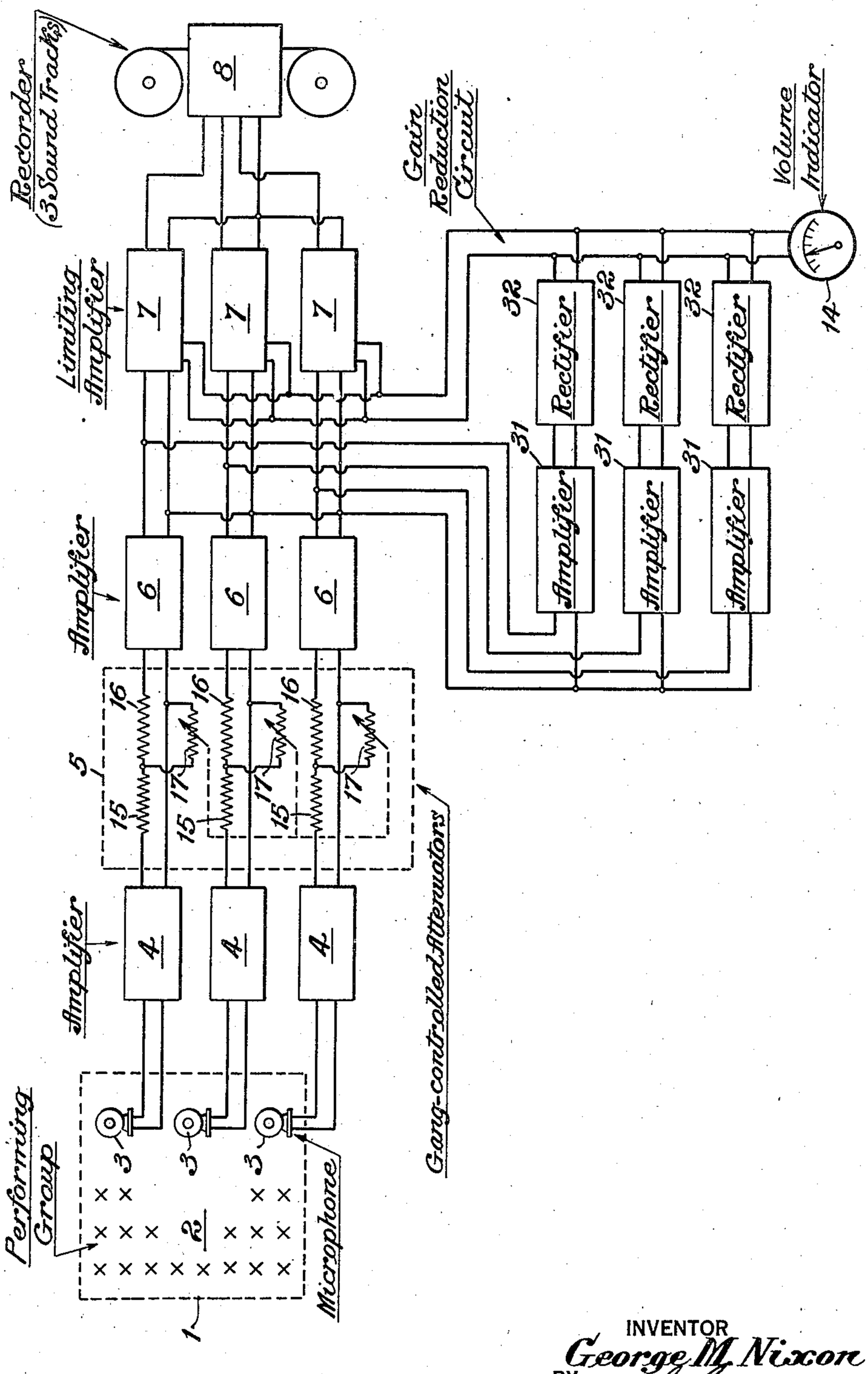
March 7, 1944. G. M. NIXON 2,343,471

BINAURAL TRANSLATING SYSTEM

Filed March 29, 1941 2 Sheets-Sheet 1

Fig. 1.



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Filed March 29, 1941 2 Sheets-Sheet 2

Fig. 2.

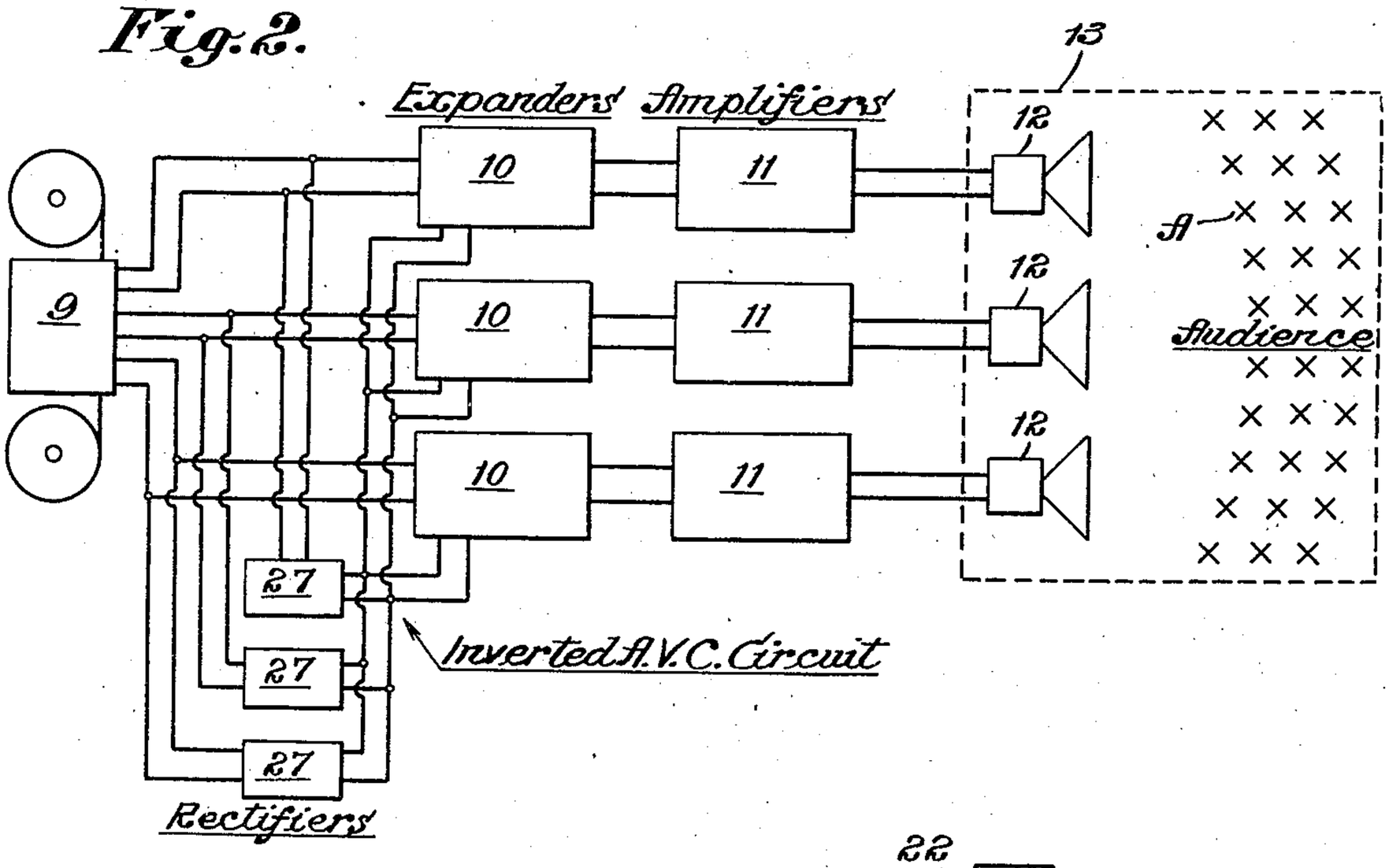
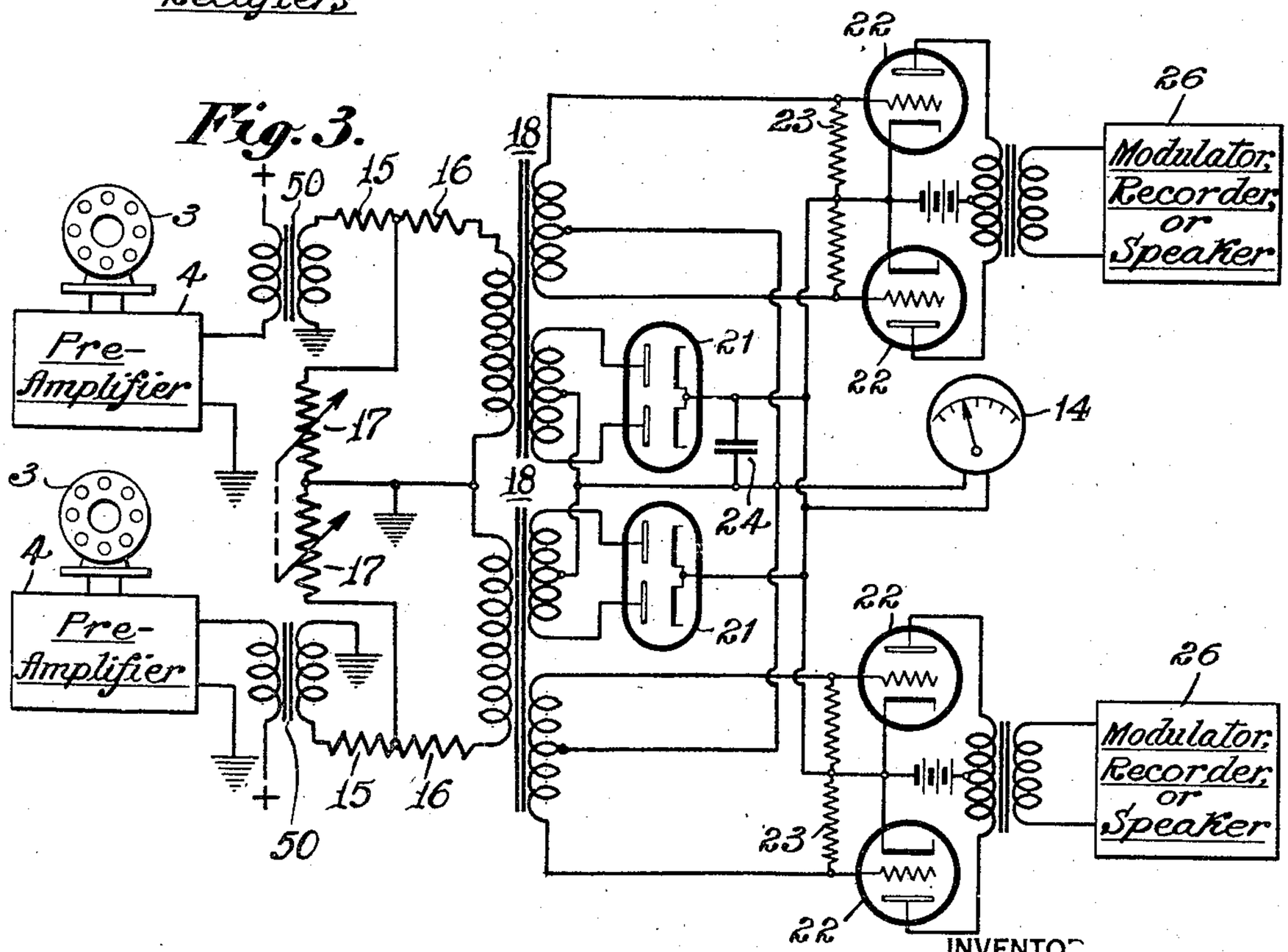


Fig. 3.



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BINAURAL TRANSLATING SYSTEM

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9 Claims. (Cl. 179—1)

This invention relates to binaural sound translating systems and more particularly to a system in which one or more microphones are connected to respectively different chains of amplifiers the output from which is ultimately carried to a suitable utilization device comprising different circuits, recorders, or loudspeakers; there being one or more such units for each microphone chain.

In monaural systems, sound from a performing group is picked up by one or more microphones, converted to electrical energy, amplified and then converted to sound energy by the loudspeaker. The listener in this case hears an orchestra or performing group without being able to orient the different sounds coming from the different members of the group. He, therefore, gets no impression of the space relation between the sources from which different sounds are derived.

In a binaural or stereophonic system the location of various members of a performing group can readily be sensed when the pick-up is obtained by means of two or more microphones located so as to receive the sounds in different intensities or phases. Each of these microphones or groups of microphones is associated with a different circuit so that when loudspeakers are placed in positions approximately corresponding to those of the microphones, but in another room, the listener obtains the same realistic impression of sounds coming from different sources.

In practice, both the monaural and the binaural system require adjustment of the gain of each channel in order to insure the transmission at a level as high as it is permissible without exceeding the load capabilities of the equipment. That is to say, the volume should be adjusted so as to avoid distortion and without noticeable impairment of the dynamic range. In a monaural system the monitoring of volume is readily accomplished according to well known practice. It is, however, an object of my invention to provide means for adjusting the gain in a plurality of channels simultaneously and proportionately so as to avoid overloading of the channels.

It is another object of my invention to provide a binaural system for the translation of sound energy into electrical energy and subsequently into reproduced sound energy wherein the natural range of amplitude of the sounds picked up by the microphones is first compressed and subsequently expanded so as to accommodate the transmission to the limitations of the channels.

My invention will now be described in more detail, reference being made to the accompanying drawings, in which

Figs. 1 and 2 show collectively and diagrammatically an arrangement of microphones, amplifiers, attenuators, and associated apparatus leading to utilization devices of any desired class whereby the performance may be reproduced and enjoyed at a remote point and whereby the impression of orientation of the different units of the performing group may readily be obtained at the remote point; and,

Fig. 3 shows more in detail certain of the circuit arrangements which I prefer to employ in carrying out the invention.

Referring first to Fig. 1, I show therein the outline of a studio 1, in which is indicated a performing group 2, which, for example, may represent the different members of an orchestra. A plurality of microphones 3 is shown, each with a separate circuit leading to an amplifier 4. The output from each amplifier is carried to an adjustable attenuator device 5 (enclosed in a broken line rectangle) which may, if desired, be manually adjusted, although at times it may be preferable to employ an automatic gain regulator. The several attenuator units enclosed in the rectangle 5 are ganged together for common control. This arrangement is quite essential since the binaural effect would be greatly impaired if the volume were to be differently adjusted in different channels.

In Fig. 1 it is presumed that the outputs from the separate volume control devices 17 will be individually amplified in the units 6 and then carried to a limiting amplifier 7 which is well known in the art and which has the function of reducing the volume range from that which was originally picked up. Limiting amplifiers may serve also as volume compressors and are frequently used in cases where the transmitting medium is of limited range. In such cases it is necessary to modify the very loud or very soft passages or both to bring them within the limits imposed by the transmitting medium with a consequent loss in contrast between the piano and fortissimo parts. Volume compression is quite advantageous in certain recording systems because it avoids the necessity for providing unduly wide sound tracks on the recording medium merely to accommodate the highest amplitude peaks. When volume compression is used to a considerable degree it is equally desirable that the output from the playback of a sound record shall be expanded so as to restore

the original volume range of the performance. Accordingly, I have shown the output of each limiting amplifier 7 as being utilized in a multiple track sound recording device 8.

In Fig. 2 I show a playback device 9 in which may be placed the recording medium that was produced on the device 8. The pickup from each track of the recording medium is preferably expanded in separate units 10 and further amplified, if desired, in the amplifiers 11, the outputs from which may be used in separate reproducing units such as the loudspeakers 12.

By placing the loudspeakers 12 in the room 13 in front of an audience A and in the same relative positions as the microphones 3 in room 1, the binaural effect will be preserved. That is to say, the corresponding placement of the microphones 3 and of the loudspeakers 12 results in the production of sound from different loudspeakers simultaneously in such a manner as to create the impression of just how the different members of the orchestra are situated in the studio 1.

In monaural systems a studio engineer is required to monitor the program and to manipulate an attenuator in accordance with his observation of a volume indicator and otherwise by listening to a monitoring circuit. To follow the same technique in the monitoring of a binaural program without the aid of my invention would impose an undue burden on the monitoring engineer. If he had to watch a plurality of volume indicators each associated with a different amplifier channel he would find it very difficult to avoid the confusion that would inevitably arise from the differences in readings simultaneously given by different indicators. Accordingly I have provided a volume indicator 14 which is jointly controlled by all of the amplifier channels. The operation of this indicator will presently be explained. Its use in combination with the attenuator 5 permits the regulation of the gain proportionately in each of the channels. When the gain is thus regulated transmission at a reasonably high level is insured without noticeable reduction in the dynamic range and without exceeding the modulation capabilities of the radio transmitter or other equipment in the channels.

However, over-modulation with consequent aural distortion sometimes occurs when the monitoring engineer fails to anticipate sudden high signal levels. This is because he cannot act quickly enough to reduce the gain, and because, too, the volume indicator does not necessarily indicate the exact magnitude of all signals which may cause distortion. Hence it is desirable to employ a limiting amplifier 7 in each of the channels. In each of these limiting amplifiers, or compressors, the gain is automatically reduced. The gain reduction is proportional to the magnitude of the strongest signal occurring in any of the channels and maintains all of the amplitude peaks of such signals below a predetermined critical level.

The gain in the limiting amplifiers 7 is, according to my invention, made dependent upon the joint action of a plurality of parallel-connected rectifiers 32, and the latter are each supplied with signal energy from appropriate amplifiers 31 the input circuits for which are connected or coupled to different ones of the amplifiers 6. The volume level indicator 14 may, if desired, be connected in circuit with the grid biasing conductors which supply gain control potentials to the limiting amplifiers 7 from the rectifiers 32. The purpose of the amplifiers 31 is to isolate the rectifiers 32 from the transmission lines between the amplifiers 6 and the input circuits of the respective limiting amplifiers 7. This arrangement is not absolutely essential, but is desirable in order to avoid any possibility of an adverse effect upon the quality of the signal which might be caused by diversion of too much of its energy for rectification purposes.

There are no essential differences between the embodiments of my invention as shown, on the one hand in Fig. 1, and on the other hand in Fig. 3. The details of a preferred circuit arrangement may, however, be more clearly explained by reference to Fig. 3, it being understood that like reference numerals apply to similar parts in the two figures. The details of the block diagram shown in Fig. 2 will be understood by those skilled in the art, and hence have not been included in Fig. 3. The utilization devices 26, as shown in Fig. 3, are so labeled as to refer generically to modulators in a radio transmitter, or to recorders such as the unit 8 in Fig. 1 (or to disk recorders if desired), or to loud speakers such as the units 12 in Fig. 2.

Referring to Fig. 3, I show two microphones 3 which may be the same as two of those indicated in Fig. 1. Each of these microphones has associated therewith a preamplifier 4. The attenuators in the unit 5 are indicated as comprising series resistances 15 and 16 and shunt resistances 17 which are adjustable in value. The adjustment of these values is made proportional by ganging together the different controls.

Each of the series resistances 16 is shown connected to ground through the primary winding of a transformer 18. Each transformer 18 has two center-tapped secondary windings. One such secondary winding supplies input potentials to the grids of a pair of push-pull tubes 22. Energy from the other secondary winding of transformer 18 is rectified in a double diode tube 21 for purposes to be presently explained. Fig. 3 shows only two sets of tubes 22 and 21, each set being associated with a separate preamplifier 4, but still another set may be used if there are as many as three preamplifiers 4, fed from separate microphones 3.

For the sake of simplicity the isolating amplifiers 31 of Fig. 1 have been omitted in the circuit arrangement of Fig. 3, but the consequent circuit changes are immaterial to the fundamental features of the invention.

The amount of energy rectified in the tube 21 determines the bias which is supplied to the grids of the triode tubes 22, this bias being rendered negative by inter-connection of all the center-taps on the secondaries of the transformers 18. Grid-leak resistors 23 are provided between the grids and cathodes of these tubes 22. The cathodes are also connected to the cathodes of the tubes 21 and a time constant device is thus provided by the association of the resistors 23 (common to all of the cathode-grid circuits of the tubes 22) with the capacitor 24.

The limiting action of the energy rectified in the tubes 21 may be well understood by those skilled in the art. It simply causes the grids in the tubes 22 to be biased more negatively in response to signals of high amplitude. The variation in bias may also be used to actuate the volume indicator 25.

It will be noted that by connecting the outputs of the rectifiers 21 in parallel the volume indi-

cations and the corresponding bias controls are determined by the combined energies in the two rectifiers. Also there is no cancellation of effects due to any possible phase relation between the program waves. The indications made on the instrument 25 are preferably of R. M. S. values or quasi-peak values of the program waves. By combining the effects of the rectified energies in the outputs from the tubes 21 so as to obtain a unitary gain reduction on all of the tubes 22, it is possible to limit the amplitude in each circuit in an identical manner so as to realize the benefits of multiple channel transmission.

It is well now to compare the advantages of my system when using limiting amplifiers with any heretofore known system for individually controlling the volume in a plurality of channels. If an attempt were made to reduce the volume in an overloaded channel without correspondingly reducing the volume in other channels, this would result in a program rendition which would be devoid of all sense of orientation of the different sounds. In other words, the binaural effect would be entirely lost. By reducing the gain in the different channels correspondingly, regardless of any inequalities in the amplitude of the different channels, the true proportions necessary for obtaining the binaural effect would be preserved.

The desirability of utilizing the technique of volume compression and subsequent volume expansion was discussed in the description of Figs. 1 and 2. The mode of operation of such a system when applied to a binaural arrangement is one which requires a common control for the different channels in order not to destroy the true proportions between the volume levels in these different channels. Accordingly it is necessary to utilize in the volume compression units 7 a gain control device which is common to them all. Such a gain control device is well illustrated in Fig. 3.

In the expanders 10 (Fig. 2) a common gain control device is necessary which will reduce the negative bias on the grids of the tubes proportionately to an increase in the volume. For such inverted volume control the cathodes of certain rectifier tubes in the units 27 would be connected to the grids of the amplifier tubes in the expanders 10. Hence when the original signals before compression were of high amplitude but afterwards compressed or reduced in amplitude, a commensurate increase in gain in these signals will be obtained in the expander and the amount of gain reduction effected by the volume compressors 7 will be correspondingly offset by a greater gain in the expanders 10. The dynamic range of the original production can, therefore, be substantially restored.

While I have illustrated my invention by one specific embodiment, it is to be understood that the scope of the invention itself is of considerable breadth and that modifications may be made by those skilled in the art without departing from the spirit of the invention.

I claim:

1. A stereophonic system having a plurality of at least three electrical wave transmission channels, a microphone coupled to the input end of each channel, said microphones being spaced apart, thereby to pick up sound waves at different intensities dependent upon the distances over which said waves travel in air, an amplifier in each channel, rectification means individual to each said amplifier, and means common to said amplifiers for controlling the gain therein, said means being operable in response to electrical energy derived from that one of the rectification means in which the energy amplitude is greatest.

2. A system for producing binaural effects having a plurality of at least three independent channels for transmission of electrical waves corresponding to sound waves picked up by microphones at different places, an attenuator and an amplifier in each channel, unit control means for manually adjusting said attenuators, a single volume indicator fed with energy derived from each of said channels, and an automatic gain control device for each said amplifier, said gain control devices being interconnected and arranged to maintain the volume level in each of said amplifiers within a predetermined range in response to the joint control of the electrical waves in each of said channels.

3. In a multiple channel system for the electrical transmission of waves representing an audible rendition, an attenuator and a main amplifier in each channel, unit control means for diverting a portion of the wave energy from each channel and for separately amplifying and rectifying said diverted energy portions, means for combining the rectified components of said diverted energies, and gain control devices jointly operative to produce a like limitation of the gain in each of said main amplifiers under control of said combined rectified energy components.

4. In a system of the class described, a plurality of translation channels each channel comprising a microphone, a pre-amplifier, an attenuator, a main amplifier, a limiting amplifier and a utilization device, all arranged in the order named, means common to said attenuators for adjusting the same simutaneously in like degree, means common to said limiting amplifiers for reducing the gain therein in like degree and in response to energy peaks of high amplitude occurring at any instant in any of said channels, and means effective on the energy transmitted through said channels to said utilization devices for substantially restoring the original range of amplitude variation of said energy so as to compensate for its amplitude limitation in said amplitude limiters.

5. In a system of the class described, a plurality of translation channels, a microphone at one end, and a recording device at the other end of each said channel, an attenuator for each channel, gang-control means providing corresponding adjustment of said attenuators by manipulation thereof, means for compressing in like degree the amplitude range of the energy applied to each recording device, and a play-back system effective to reproduce the sound waves corresponding to those stored in each said recording device, said play-back system including separate loudspeakers for each channel and means for expanding the volume range so as to compensate for the effects of said amplitude compressing means.

6. In a binaural translation system having microphones for differential pick-up of sound energy, a separate amplifier channel for each microphone, and a sound reproducing device responsive to energy translated by each amplifier channel, the method of controlling the volume of output from each sound reproducing device while preserving the binaural effect, which method comprises jointly regulating the attenuation of energy in like degree in each channel, providing a degree of gain control in each ampli-

fication channel in response to the rectification of the highest peaks of energy in concurrent derivatives from the energy content of the several channels, and causing the binaural effect to be preserved by the relative positioning of the several sound reproducing devices corresponding to the relative positions of said microphones.

7. In a binaural transmission system suitable for radio transmitter modulation, sound recording, public address devices and the like, a plurality of microphones, a pre-amplifier and an attenuator in circuit with each microphone, a separate transmission channel connected to the output side of each attenuator, a limiting amplifier in each channel, a pilot channel jointly fed by rectified derivatives from the attenuated energy components in each said transmission channel, means for utilizing the energy in said pilot channel to compress the dynamic range in like degree in each said limiting amplifier, and means to indicate the amplitude of the energy in said pilot channel.

8. The combination of elements according to claim 7 and including means for separately amplifying and rectifying said energy components prior to the combination thereof in said pilot channel.

9. The combination of elements according to claim 7 and including means for expanding the dynamic range of energy in said transmission channels subsequent to the compression of said range by the action of said limiting amplifiers.

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