June 24, 1941. J. J. ISRAEL 2,246,593

ELECTROACOUSTIC SYSTEM AND METHOD

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Fig. 1

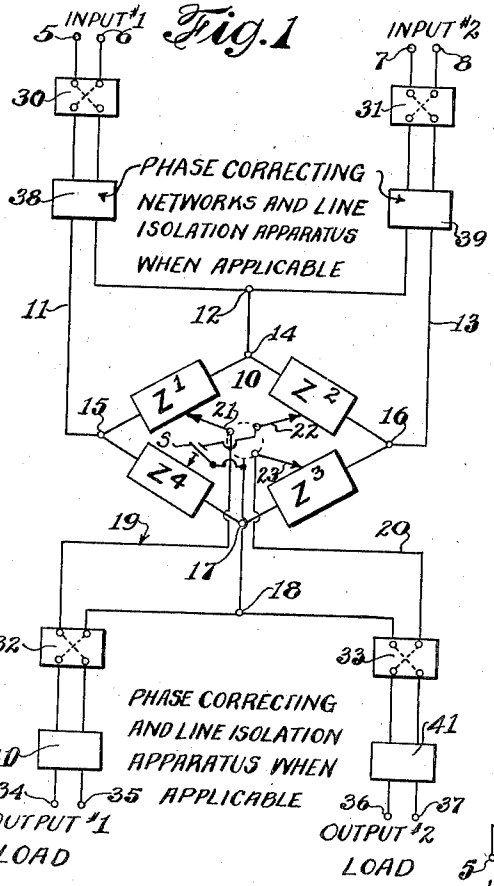


Fig. 2

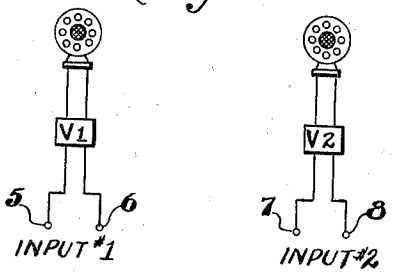


Fig. 2A

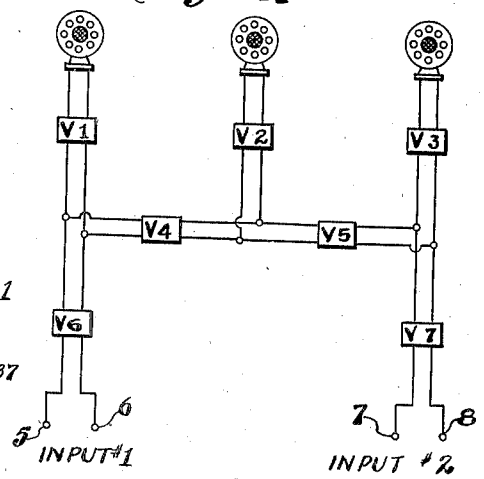


Fig. 3

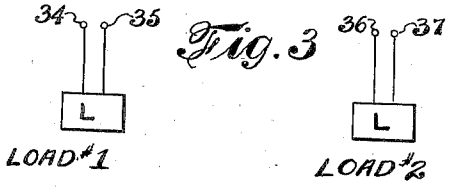


Fig. 3A

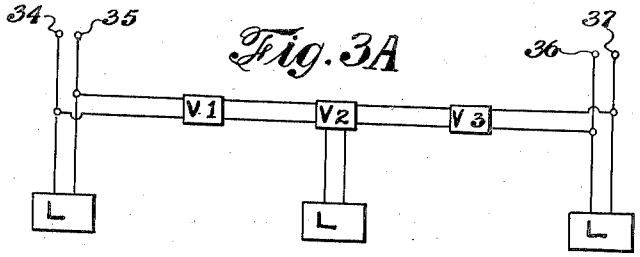
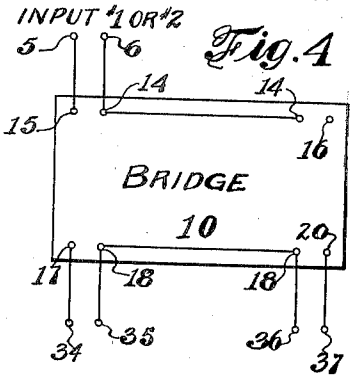


Fig. 4



INVENTOR

BY John J. Israel

Carelton Cohen

ATTORNEY

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Fig 5

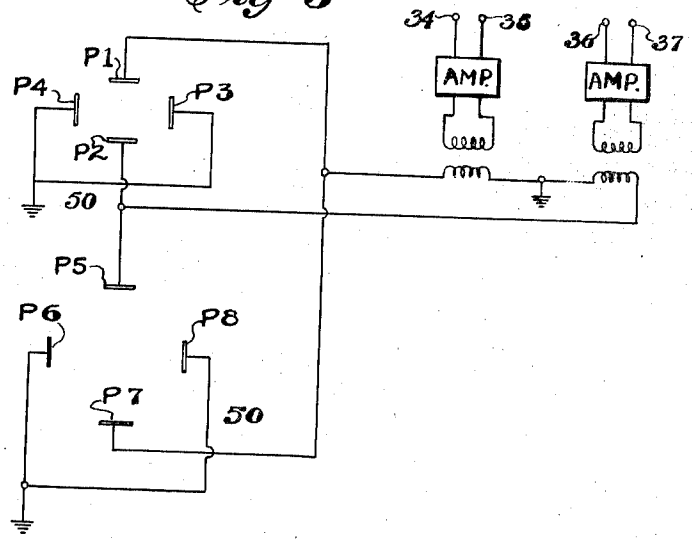
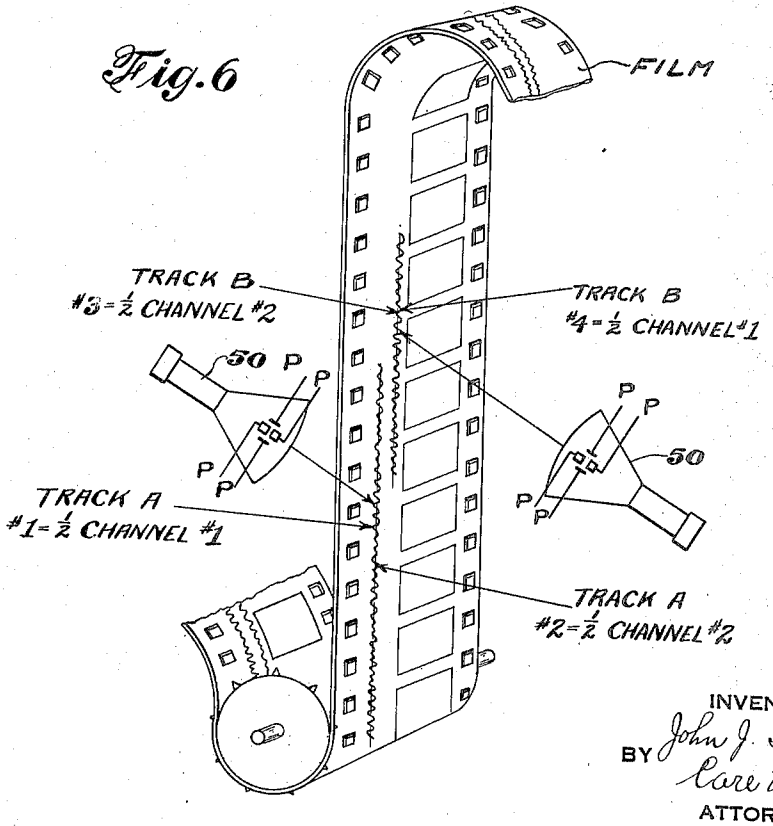


Fig. 6



INVENTOR

BY John J. Israel

Carl M. Cohen

ATTORNEY

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ELECTROACOUSTIC SYSTEM AND METHOD

John J. Israel, Brooklyn, N. Y.

Application December 13, 1937, Serial No. 179,432

32 Claims. (Cl. 179—100.3)

This invention relates to electro-acoustic systems and deals more specifically with the arrangement and operation of an electrical system which produces certain novel, unique and highly useful acoustic effects.

Under the prior art practice, sound is ordinarily transmitted via a single electrical channel. However, in order to give to electrically reproduced sound, a sense of location in space, multi-channel or binaural systems have been developed. Each channel in a binaural system may feed a loud speaker (or other sound transducing device), and by varying the gain in each channel at will, certain improved results have been obtained in sound reproduction. These results, nevertheless, leave much to be desired in sound engineering. For example, in the above mentioned binaural systems the best result to be hoped for is the manipulation of volume controls to reproduce on a virtual stage, conditions existing on an actual stage. Certain investigators have obtained a certain measure of success in attaining this goal. Under the present invention, it is not only possible to reproduce faithfully sound on a virtual stage as it originates on an actual stage; but I have been able to reproduce at will on a virtual stage conditions, that did not and possibly could not exist on an actual stage. By way of illustration, I have been able, with my system, to manipulate my controls so that, with an actor standing absolutely stationary on the actual stage, on the virtual stage the actor may be made to move diagonally out of the room, or, for that matter he may be made to move in any desired direction, subject only to the will of the operator and the way he manipulates the controls.

The prior art practice involves the variation in sound volume to get the various effects. My system differs, in that the effects are primarily obtained by phase relationship variation of the electrical impulses in each of the channels with respect to each other. Insofar as I am aware, I am the first to make use of this principle, and I have applied the same to many systems with surprising results, as will be more fully described below. This feature is a radical departure from prior art practices and I desire to secure protection on the same in its broadest aspects. The means whereby my novel results are realized will be fully described in connection with the many systems to which the same is applicable, reference being had to the accompanying drawings in which:

Figure 1 is a diagrammatic view of my invention showing the spatial control circuit, including two related inputs and two related outputs.

Figures 2 and 2A are diagrammatic views of two possible combinations of related inputs, which when connected to my system will produce the effects hereinafter described.

Figures 3 and 3A are similar to 2 and 2A except that they relate to outputs instead of inputs.

Figure 4 is a diagrammatic view of my bridge connected to a pseudo-binaural system.

Figures 5 and 6 are diagrammatic views of a system for recording sound tracks on film under control of my invention, certain standard parts being omitted for simplicity.

In Figures 1, 2, 2A, 3 and 3A I have shown my invention applied to sound systems, it being understood, of course, that two channels are necessary, each of which feeds a separate load, as for instance, a loud speaker or other sound transducing device. Referring in detail to these diagrams, two or more separately and suitably placed microphones or other suitable sources M feed into the bridge 10 thru amplifiers, when required by the leads 11, 12 and 13. The terminals 5, 6, 7 and 8 denote the points of connection of the pick up apparatus to the system. The bridge 10 comprises four matched impedances, Z^1, Z^2, Z^3, and Z^4 arranged as shown with the four terminals 14, 15, 16 and 17. The lead 11 connects to terminal 15; 12 to 14; 13 to 16. The moveable arm 21 arranged for variable contact with one member Z^1 is connected thru 19 to the output load terminal 34. The member Z^2 is provided with a variable contact 22 which connects thru lead 18 with one terminal of each of the output load terminals 35, 36. The third member Z^3 is similarly provided with a moveable contact 23 which is connected thru 20 to the output load terminal 37. It is understood of course that the three moveable contacts 21, 22 and 23 may be mechanically or otherwise interlocked together so that by manipulation of a single control (not shown) the point of contact on the respective impedances may be varied, and further may be continuously varied in any desired manner. Connected to each of the first output load terminals 34 and 35 and the second output load terminals 36 and 37 is a loud speaker, or other suitable load. Reversing switches 30, 31, 32 and 33 are connected across the amplifiers as shown, it being understood that by reversing related switches, phase changes of the order of 180° may be effected between the two channels. Thus if I throw 30 I get this effect; or if I throw 31 and return 30 to its normal position a similar

effect will be realized. Phase shifts of amounts less than 180° may be effected by means of phase shifting networks 38, 39, 40 and 41 inserted at suitable points in the circuits, as shown in the drawings, for example.

In the operation of this system, the movement of the contacts 21, 22 and 23 of the bridge 10 enables the operator to cause the source of sound reaching the microphones M apparently to move in a definite manner with respect to the movements of the contacts, and this may be realized even though the source of sound reaching the said microphones or their equivalents remains stationary. Continuing movements of the controls, of course, causes continuing apparent movement of the source of sound. Thus, for example, the source of sound can be made to appear to be moving in a circle merely by continuously turning the controls. Similarly, movement may be simulated in any desired direction. In actual operation, by manipulating the reversing switches as well as the moveable contacts of the bridge and certain other controls, I have caused sound originating from a fixed source to appear to travel in all directions in both horizontal as well as vertical planes. In other words, I am able to get a spherical effect at will.

Referring to Figure 4 I have shown a form of a pseudo-binaural system. The network or bridge 10 may be connected at the terminals 5, 6 to any single source of electrical oscillations (not shown), for example a microphone or other sound transducing and/or recording device, electrical pickup, motion picture projector, film phonograph, radio receiver or demodulators etc., and this connection will give effects in a certain sense similar to that realized in the system of Figure 1.

The underlying basic principle of operation of my system which distinguishes it from the prior art resides in the fact that, while in the prior art the spatial effects are primarily produced by variation of gain or volume, in my system even more startling and more realistic spatial effects, not possible with the gain variation system, are produced primarily by variation of the phase relationship of the channels used. A result of the operation of my system is a change in the apparent reverberation time of the auditorium thru the said variations in phase relationship of the sound. In addition to the foregoing effects, I have found that if two or more sounds of different spatial location are picked up on the two or more microphones or other equivalent sources, by rotating the control members of the bridge the apparent distances between the said sounds may be changed in a related manner at will. This phenomenon makes available to me a unique power of control over the electrical reproduction of a symphony concert, for example. I may not only vary at will the apparent distance between the players but also I may spread out or contract the orchestra at will and thus selectively bring out the renditions of a particular artist or group of artists. A soloist may be brought forward with maximum effectiveness while the musical background may be controlled to suit the operator. By apparently varying the distance between the players, effect may be given to desired variation (apparent) of the size of the auditorium. The more desirable effects of this phase of the invention will be further described below.

In the field of radio broadcasting I have found many effective and highly desirable advantages in the use of my invention. I shall now describe in detail the application of my invention to the broadcast field.

Firstly, it is desirable in radio broadcast programs to produce certain dramatic and realistic effects in the sound reproduced from the broadcast material. For example, in the rendition of a play or dramatic work, realism is added by the ability of the sending station to so control the transmission that the sound is made to move to fit the action being portrayed. As is well known, in the technique of the broadcasting art it is desirable that there be but small movement of the actors' voices or other sounds with respect to the microphone. This restriction of movement is necessary in order that certain deleterious effects (such as noise etc.) on program quality due to such movement may be avoided. The application of my invention permits of substantially this desired restriction of actual movement at the same time, providing that apparent freedom of movement required for dramatically effective rendition.

Also, in the broadcast of a symphony orchestra program, as already explained above, it is highly desirable to be able to control the acoustic properties of the program. Again, in the broadcast of certain types of programs, lack of realism obtains due to the fact that the studio may vary widely in its acoustic properties from the actual place from which the program is supposedly coming. It is highly desirable to alter the sound effects to give the impression that they actually are coming from the supposed source. By means of my invention, I am able to accomplish the foregoing desiderata.

In Figures 1, 2 and 2A, I have shown diagrammatic circuits which may also be used for picking up sound to be used in the modulation of a carrier wave or carrier waves for broadcasting. Two or more separate microphones M suitably positioned, or equivalent sources, are connected to the volume controls V^1, V^2, etc., as shown. Thus, I have two separate and independent channels which are coupled to the input circuits of the bridge 10 thru terminals 5, 6, 7, 8, at the transmitting end. The outputs of bridge 10, terminals 34, 35 and 36, 37 in Figure 1 are coupled to two separate, yet related, modulators, modulating related carriers. These modulated carriers when jointly demodulated by a conventional rectifier or detector may provide a complete single channel audio signal.

These carriers when separately demodulated will provide inputs to two separate yet related channels providing desirable binaural effects. These demodulated inputs may also be further fed into another bridge 10 at the receiving end and the outputs of this bridge fed to suitable loads as for instance, loud speakers. It is to be noted that an audio phase shift which may be provided in the transmission circuits may be realtered to correct for said phase shift in the demodulated circuits, such as to provide modulated signals as hereinbefore specified which may be utilized simultaneously by the conventional demodulator already mentioned as well as by the dual channel special demodulator herein disclosed.

More particularly, for example, the application of one audio signal to a single side band transmitter and the application of the other related audio signal to a complementary single side band transmitter with phase correction devices

to properly phase the audio components, and synchronizing or other devices to properly phase relate one carrier to the other, will achieve the desired purpose.

In binaural receivers with dual channel demodulators, phase restoring devices may be incorporated to correct for the possible phase shift which may be intentionally introduced in the transmission. As in Figure 1 phase shifting networks 38, 39, 40 and 41 may be introduced and connected to a bridge 10 to alter the tone characteristics to suit the taste of the operator. Obviously, since radio broadcasting is carried out on a given radio frequency, it may be desirable to form a composite radiated wave. This composite wave may be considered to be formed in the single side band transmitters. However, my bridge 10 which is connected between the amplifiers and the modulators, enables me to control the spatial phase relationships between the two channels, corresponding to the two or more microphones, or equivalent, sources, and thus enables me, by the manipulation of the switches and controls in the bridge, to get the various acoustic effects described above. For details of the bridge circuit see Figure 1.

On the broadcast reception end of a program which is transmitted thru the above described equipment, of course, ordinary receiving sets provided only with one amplifier channel and one loud speaker will respond to the program in the usual way, as if it has not been affected by the operation of my bridge. All the properties of this kind of reception will remain essentially as good as is now realized, and I therefore do not make obselete, equipment now in use. However, with a receiver modified in accordance with the principles of my invention all of the refinements and improvements added to the broadcast program may be rendered effective.

However, in a receiver designed to utilize fully the effects produced, it is merely necessary that I have the two separate demodulators and their audio channels with their respective loud speakers, and the current flowing in each will correspond to that in the separate channels at the broadcast station. If, as hereinbefore specified certain phase shifting circuits have been introduced into the audio circuits in the transmission, in order to permit of single channel reception, or for other reasons, it is, of course, understood that related or other phase shifting circuits may be introduced into the audio circuits of the dual channel receiver to correct for such transmission phase shift or for other purposes. The operation of this system is actually the same as that described above in connection with the other sound systems, the only differences being the changes made necessary to enable transmission thru the ether instead of over wires. It will be understood that the receiver can function to reproduce my improved effects with or without the use of a bridge 10 in the receiver circuit.

Now, the purpose of the bridge 10 is threefold. Firstly, it enables the use of the receiving set to get further control over a received program and to make adjustments of the set to compensate for acoustic properties of the room. The bridge 10 controls the apparent reverberation time of the room, as explained above, and it will be evident that many entertaining and desirable effects may be had by its operation.

Secondly, I shall describe below a new type of record for phonograph embodying the principles of my invention. Since the audio stages of many radio sets are used in conjunction with phonographs, when playing such records on such radio sets, the bridge 10 may be put to good use in controlling the properties of the playing of a record. Also, the bridge 10 may similarly be set up in a phonograph, not part of a radio receiver, for the same purposes.

Thirdly, where the bridge is not used at the broadcast (transmitting) end, but two channel pick up is used and combined into a composite modulated wave, the dramatic effects may still be made evident at the receiving end, by manipulating the controls of the receiver bridge in the manner already described. Separate control impulses may be transmitted simultaneously (or by means of a record) and the program be controlled so as to provide the desired effect at the receiver without altering the characteristics of the sound modulated wave in this regard.

Another exceedingly valuable and important application of the present invention resides in its use in the recording of sound, such as in the making of talking movies. Under present practice of making so-called talking movies, there are generally speaking two classes of shooting; simultaneous synchronized, and non-simultaneous synchronized. In the former, the sound for a scene is recorded at the time the picture is taken; in the latter the artist records the sound at some different time and later the action is filmed without the actual singing, the actor merely moving his lips to simulate the singing so that the films may be properly synchronized. Realism can only be but poorly approximated due to the limitations of present day equipment. It is current practice to use a set, usually a three-wall set, in a sound stage. The sound on the set can hardly be satisfying. In the first place the sound heard must correspond with the picture seen; the picture is dependent upon camera location and lens size. In the second place, even if they could be made to correspond somewhat in actual shooting at one instant, it is practically impossible to produce the proper effect of the variation of the sound quality as the actors move about the set.

In shooting a simultaneous synchronized scene of an actor going through a doorway, for example, the rapid movement of the microphone necessary to produce the desired acoustic spatial effects as the actor goes through the doorway practically eliminates this means of correction; only the dubbing room is left to complete the work as best it can with some unsatisfactory compromise expedient such as, for example, an alteration of frequency characteristic with possibly a change in volume.

By the use of my invention an entirely new field is opened to the operator in the dubbing room for, by manipulating the controls of the bridge, he is able to give to the sound during the process of rerecording, the actual dramatic effects and the realism that it needs. He thus renders the recording of the action and the sound quite independent of each other. Again, by so rendering the action and sound independent, the overhead cost of making movies may be substantially reduced. The cost of building suitable sets as well as the cost of artists' time are also very greatly reduced. In short, it should be possible to shoot sound on the shooting stage of all uniform quality and to put the quality control element of the sound almost entirely in the hands of the dubbing room operator. By this means, the completeness of the illusion of sound and picture can be immeasurably enhanced and yet

the cost of production can be appreciably reduced.

I have found that in applying my system to the movie field it is advisable to alter the method of recording the sound, for with my improved technique, to obtain full advantage, I can effectively utilize a frequency range wider than that at present used. The recording transducers now in use cannot readily be made to record faithfully over the desirable broad range and I have therefore devised a system of recording which knows no such frequency limitations within the audio band. In this system I use the bridge **10** which I may connect as shown in Figure 1. Two or more related imputs (or microphones connected thru suitable amplifiers) are connected as shown in Figures 2 or 2A and are connected to input terminals **5**, **6** and **7**, **8** of Figure 1. Output load terminals **34**, **35** and **36**, **37** may be connected (thru suitable amplifiers if necessary) to the plates P_1, P_2, P_3, and P_4 of one electronic discharge tube **50** or two related electronic discharge tubes. Phase shifting devices and/or isolation networks may be introduced at suitable points as shown in Figure 1. Here also, as described herein, the bridge **10** is inserted between the amplifiers and the electronic beam tube or tubes. The manipulation of this bridge causes to be recorded any desired apparent movement of the actor with respect to the microphone or other suitable input or inputs, and therefore, lends itself to the obtaining of unlimited valuable dramatic effects in the hands of an experienced operator. The electronic discharge tubes are used to expose a film to an electronic beam which is deflected by voltages applied to the plates of the tube in accordance with the signal or signals impressed thereon.

In preparing film, it is made sensitive to the electronic beam in a secondary manner by some such means as coating it with Willemite to render it fluorescent when the beams strike, and thereby causing exposure, or by coating with an emulsion which is affected directly by the electron beam. Such materials are well known in the art.

It will be understood that different methods and systems may be employed for forming sound tracks on the film under the control of my bridge. Referring in detail to Figures 5 and 6 I have shown two electronic beam tubes **50** having plates P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, connected to the output terminals **34**, **35**, **36** and **37** of the bridge **10** (not shown). While this figure illustrates two electronic tubes, it will be understood that one tube may be used and the connections of that one tube to the terminals **35**, **36** is the same as that shown for either one of the tubes as illustrated in Figure 5. Now, with a single electronic beam tube connected to the output terminals of the bridge **10** a single composite wave form may be impressed upon the sensitive film, one half of the track representing one channel, while the other half represents the other channel. In exposing the film the electronic beam is focussed upon the film, which as it moves by, has produced on it by the action of the electrons, the desired wave form.

When both of the tubes, having plates P_1, P_2, P_3, P_4, P_5, P_6, P_7 and P_8 are used I may impress a double track on the sensitive film and this dual track may consist of two composite tracks. If I call these tracks A and B, track A will consist of a composite wave form, one half of it representing one channel, and the other half representing the other channel. Similarly, track B may be similar to track A, except that the wave form on this track may be 180° out of phase with respect to track A. One half of this wave form will represent the last mentioned channel while the other half represents the first channel. I may also connect the two electronic tubes to my bridge in such a manner that two separate tracks may be formed, one track representing one channel, while the other track represents the other channel. In the composite wave form recording, each half of the single composite wave form recording, each half of the single composite form is recorded in the form of a rectified wave.

In the showing of sound movies provided with the composite sound track prepared as described above, theatres having monaural equipment will be able to reproduce the sound in the usual way, and thus avoid the scrapping of equipment now in use.

Pickup in the transducing device may be accomplished by means of 2 photo-electric cells connected in push pull arrangement to a single channel or monaural system for normal reproduction. For this purpose I may use the single composite, dual composite or dual wave form tracks.

However, for those theatres which want the best equipment, it is merely necessary to provide two separate sound reproducing channels. The film having the dual or dual composite track is passed between two independent light sources, each of which is arranged to illuminate only its own sound track and two photo-electric cells. One cell is connected to the amplifier of one channel, and the other cell is connected to the amplifier of the other channel. Light from one source passes thru one sound track, and the light variations thus produced are translated into electrical energy by the photo-electric cell which is connected to an amplifier, which is in turn connected to a loud speaker. Similarly, light from the other source passes thru the sound track, impinges on the other photo-electric cell, and the electrical impulses thus generated are amplified and passed on to operate the other speaker. Thus, I reproduce the sound in two channels in the same way that it is recorded, and whatever effects are imparted to the sound by manipulation of the bridge during recording, are reproduced in the projection of the picture.

A very important feature of my invention is my ability to control the apparent acoustic properties of the theatre by mounting one of my bridges between the amplifiers of the two channels of the sound reproducing equipment. I have already stated that the acoustic qualities of an auditorium depends upon the reverberation time of the room. In a room such as a movie theatre, a serious problem is presented by virtue of the fact that with a change in the number of people in the audience, the reverberation time changes. Best quality of sound reproduction cannot be obtained with this changing condition. With my bridge connected across the amplifiers, I am able to change the apparent reverberation time of the room. Thus an operator may, by merely turning a dial, compensate for changes in the auditorium due to differences in actual reverberation time. This bridge, it will be understood, is not for the purpose of altering the direction or location of sound, but merely is an additional refinement in perfecting the reproduction of sound.

In a recording system for making disc records having hill and dale or lateral grooves, it has been found that distortion occurs when playing these records, due to the presence of harmonies not present in the original rendition. I therefore propose to make a two channel or double sound track each being approximately 180° out of phase with respect to the other. This is accomplished by having a two styli cutter mounted so that adjacent parallel grooves are made during recording. In order to assure proper tracking, the space between the separate grooves of a given pair of parallel tracks is different than the space between the pairs of grooves themselves. For playing the record, I provide a reproducer also having two styli, one of which is operated by one groove, while the other is operated by the other groove. This arrangement practically eliminated certain harmonies. Phase correction devices may be used if necessary to effectively produce the desired cancellation. My bridge 10 may be introduced in the recording and/or the reproduction as hereinbefore specified.

It will be understood that many changes in the specific embodiments herein disclosed will readily suggest themselves to those skilled in the art. I, therefore, do not intend to be limited in the scope of this invention, except as required by the appended claims and the state of the prior art.

Having thus described my invention, I desire to claim and secure by Letters Patent of the United States:

1. An electro-acoustic system having an input circuit and an output circuit, each of said circuits having more than one channel, a single audio network having multiple impedances connected between said circuits, whereby one channel of the input circuit is connected to one channel of the output circuit thru two of said impedances, and the other channel of the input circuit is connected to the other channel of the output circuit thru two of said impedances.

2. An electro-acoustic system having an input circuit provided with two channels and an output circuit provided with two channels, a first impedance connected across one channel of said input circuit, a second impedance connected across the other channel of the input circuit, two additional impedances connected in parallel to said first mentioned impedances whereby to form a four arm bridge, a variable contact connecting a point on one impedance to one terminal of one channel of said output circuit, a variable contact connecting one point on a second impedance to the other terminal of said last mentioned channel, and also connecting to a terminal of one channel of said output circuit, and a variable contact connecting one point on a third impedance to the other terminal of said last mentioned channel.

3. An electro-acoustic system having an input circuit provided with two channels and an output circuit provided with two channels, a first impedance connected across one channel of said input circuit, a second impedance connected across the other channel of the input circuit, two additional impedances connected in parallel to said first mentioned impedances whereby to form a four arm bridge, a variable contact connecting a point on one impedance to one terminal of one channel of said output circuit, a variable contact connecting one point on a second impedance to the other terminal of said last mentioned channel, and also connecting to a terminal of one channel of said output circuit, and a variable contact connecting one point on a third impedance to the other terminal of said last mentioned channel, and means connecting said contacts together for concerted movement.

4. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, a sound transducing device connected to each of said channels, and means connected to both of said channels to control the phase relationships of the electrical oscillations flowing therein independently of the frequency of said oscillations.

5. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, a sound transducing device connected to each of said channels, and continuously variable means connected to both of said channels to control the phase relationships of the electrical oscillations flowing therein independently of the frequency of said oscillations.

6. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, a sound transducing device connected to each of said channels, a multiple arm bridge connected across said channels, and three variable contacts each of which is connected separately with one arm of said bridge and one of said channels, and means to operate said contacts simultaneously.

7. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, each of which has an input-section and an output-section, a four arm bridge connected to said channels with one arm thereof across the input of its channel and another arm across the input section of the other channel, three contacts each of which is variably connected to an arm of said bridge, connections between each of said output sections and two of said contacts, a sound transducing device connected to each of said output-sections, and means to vary the point of connection between said contacts and said arms.

8. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, each of which has an input-section and an output-section, a four arm bridge connected to said channels with one arm thereof across the input-section of its channel and another arm across the input-section of the other channel, three contacts each of which is variably connected to an arm of said bridge, connections between each of said output sections and two of said contacts, a sound transducing device connected to each of said output-sections, a reversing switch connected in each section of each of said channels, and means to vary the point of connection between said contacts and said arms.

9. In a system in which sound vibrations are converted into electrical oscillations, and electrical oscillations are converted into sound vibrations, two electrical channels, each of which has an input-section and an output-section, a four arm bridge connected to said channels with one arm thereof across the input of its channel and another arm across the input-section of the other channel, each of said arms comprising an imped-

ance, three contacts each of which is variably connected to an arm of said bridge connections between each of said output-sections and two of said contacts, a sound transducing device connected to each of said output-section channels, and means to vary the point of connection between the said contacts and said arms.

10. The step in the method of reproducing sound electrically in a binaural system, which comprises varying the phase relationship of the audio frequency current flowing in the channels of the system independently of the frequency of said current and independently of the position at which the sound is picked up.

11. The step in the method of reproducing sound in an auditorium in the audio frequency band by means of a binaural system, which comprises varying the apparent reverberation time of the auditorium by means of a phase varying device which functions independently of the frequency of the current and independently of the position at which the sound is picked up.

12. The method of reproducing sound which comprises converting sound vibrations into electrical oscillations at audio frequencies in two separate channels, controlling the phase relationship of said oscillations and independently of the position at which the sound is picked up in said channels independently of the frequency of said oscillations, and reproducing independently the electrical oscillations in each of said channels into sound vibrations.

13. In the method of reproducing sound in a binaural system, the step of rendering said sound apparently directional, which comprises electrically controlling the phase relationship of the electrical oscillations at audio frequencies which produce the sound independently of frequency in accordance with the desired directional effect by means of variable impedances.

14. In a sound recording system in which sound impulses are picked up at two spaced points and converted independently into electrical oscillations, means to vary the phase relationship of said oscillations, means to combine said oscillations into composite wave, an electronic beam device having plates and arranged for exposing film, and means for impressing said wave on said plates, whereby the said film is exposed to the electronic beam under control of said wave.

15. In a sound recording system in which sound impulses are picked up at two spaced points and converted independently into electrical oscillations, a variable bridge to vary the phase relationship of said oscillations, means to combine said oscillations into a composite wave, an electronic beam device having plates and arranged for exposing film, and means for impressing said wave on said plates, whereby the said film is exposed to the electronic beam under control of said wave.

16. In a sound recording system the combination of a two channel pickup, a phase controlling device connected between said two channels, means responsive to one half of one electrical wave in one channel, means responsive to one half of the other electrical wave in the other channel, means to combine both said electrical responses, an electronic beam device for exposing the sound track of film, and means to impress said combined electrical responses upon said cathode ray device, whereby to expose said film under control of said pick up devices and said phase controlling device.

17. In a sound recording system the combination of a two channel pick up, a bridge having four variable impedances connected between said two channels, means responsive to one half of one electrical wave in one channel, means responsive to one half of the other electrical wave in the other channel, means to combine both said electrical responses, an electronic beam device for exposing the sound track of film, and means to impress said combined electrical responses upon said cathode ray device, whereby to expose said film under control of said pick up devices and said phase controlling device.

18. A system for electrically reproducing sound comprising in combination a first channel input and output circuits, means connected to each of said input circuits to produce electrical undulations corresponding to sound vibrations, phase and amplitude varying means connecting each of said input circuits with each of said output circuits, whereby energy is transmitted in unaltered form from one channel to the other, and means to vary said means whereby to control said energy transfer, and a sound transducing device connected to each of said output circuits.

19. A system for electrically reproducing sound comprising in combination a first channel having an input circuit and an output circuit, a second channel having an input circuit and an output circuit, means connected to each of said input circuits to convert sound vibrations into electrical undulations phase and amplitude varying means connecting one input circuit with one output circuit to transfer in unaltered form a predetermined amount of energy therebetween, said means also connecting another input circuit to said one output circuit to transfer in unaltered form a different predetermined amount of energy, therebetween, and means to vary said connecting means.

20. A system for electrically reproducing sound comprising in combination a first channel having input and output circuits, a second channel having input and output circuits, phase and amplitude varying means connected to each of said input circuits to convert sound energy into electrical energy, means to distribute the electrical energy to each input circuit between the two output circuits in a predetermined manner and in unaltered form, means to vary said last mentioned means, and a sound transducing device connected to each of said output circuits.

21. The method of electrically reproducing sound which comprises converting the sound vibrations into electrical undulations in two channels dividing in unaltered form said undulations produced in each channel between two separate sound transducing devices, and varying the division and phase relationships of said undulations.

22. A system of the class described comprising an input circuit and an output circuit, each of said circuits having two channels, a single audio network having multiple impedances variably interconnected between said circuits, whereby one channel of the input circuit is connected to one channel of the output circuit thru two of said impedances, and the other channel of the input circuit is connected to the channel of the output circuit thru two of said impedances.

23. A system of the class described comprising a two channel input circuit, a two channel output circuit, in combination with variable electrical means inter-connected between said channels to vary the phase relationships of the cur-

rent flowing in the output circuit as compared to that flowing in the input circuit, whereby to produce desired electrical effects at the will of the operator.

24. A system of the class described comprising a two channel input circuit, a two channel output circuit, and a bridge having multiple impedances inter-connecting said channels of the input circuit with said channels of the output circuit.

25. A system of the class described comprising an input circuit and an output circuit, said output circuit having two channels, a bridge variably connected between said circuits, whereby to vary the phase relationship of the current flowing in each channel of the output circuit with respect to that flowing in the other channel, of said output circuit and to vary the phase relationship between the current flowing in either of said channels with respect to that flowing in said input circuit, at the will of operator.

26. A system of the class described comprising an input circuit, a bridge circuit having a plurality of impedances, said circuit being connected across one of said impedances, and an output circuit having two channels, one of said channels being variably connected to two of said impedances and the other of said channels being connected to two of said impedances, whereby to reproduce pseudo binaurally electrical oscillations generated monaurally.

27. A system of the class described comprising an input circuit, a bridge circuit having a plurality of impedances, said circuit being connected across one of said impedances, and an output circuit having two channels, one of said channels being variably connected to two of said impedances and the other of said channels being connected to two of said impedances, whereby to reproduce pseudo binaurally electrical oscillations generated monaurally and a sound transducing device connected to each of said channels.

28. The method of reproducing sound electrically which comprises the steps of picking up sound intelligence by means of microphones which convert the sound vibrations into electrical oscillations, varying the amplitude and phase of said oscillations, dividing said resultant oscillations between two channels, and converting said last mentioned oscillations back into sound vibrations by means of two transducing devices, whereby the last mentioned vibrations embody modifications of the spatial character of the original sound intelligence picked up conveying effects which differ therefrom.

29. The method of reproducing sound electrically which comprises the steps of picking up sound intelligence by means of a microphone which converts the sound vibrations into electrical oscillations, varying the amplitude and phase of said oscillations, passing said oscillations over an electrical bridge device where certain electrical characteristics thereof are altered, dividing said resultant oscillations between two channels, and converting said last mentioned oscillations back into sound vibrations by means of two transducing devices, whereby the last mentioned vibrations embody modifications of the spatial character of the original sound intelligence picked up conveying effects which differ therefrom.

30. The method of reproducing sound electrically which comprises the steps of picking up sound intelligence by means of a microphone which converts the sound vibrations into electrical oscillations, varying the amplitude and phase of said oscillations, dividing said resultant oscillations between two channels, and converting said last mentioned oscillations back into sound vibrations by means of two transducing devices, whereby the sound issuing from said transducing devices may be made apparently to come from any point spatially removed from said pick up microphones at the will of the operator.

31. A sound reproducing system comprising in combination pick up microphones, means connected to said microphones to alter the output thereof, two electrical channels connected to said last mentioned means, and a sound transducing device connected to each of said channels, said means being constructed and arranged to so alter the phase and amplitude of the impulses issuing from said microphones that in reproduction the sound may be made apparently to originate at any point spherically spaced from the original source.

32. A sound reproducing system comprising in combination a pick up microphone, an electrical bridge connected to said microphone to alter the output thereof, two electrical channels connected to said last mentioned bridge, and a sound transducing device connected to each of said channels, said bridge being constructed and arranged to so alter the impulses issuing from said microphone that in reproduction the sound may be made apparently to originate at any point spherically spaced from the original source.

JOHN J. ISRAEL.