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ROTARY TREMOLO DEVICE HAVING MEANS FOR MIXING SIGNALS
EMANATING FROM ROTARY AND NON-ROTARY SOURCES

Filed Dec. 21, 1959

3 Sheets-Sheet 1

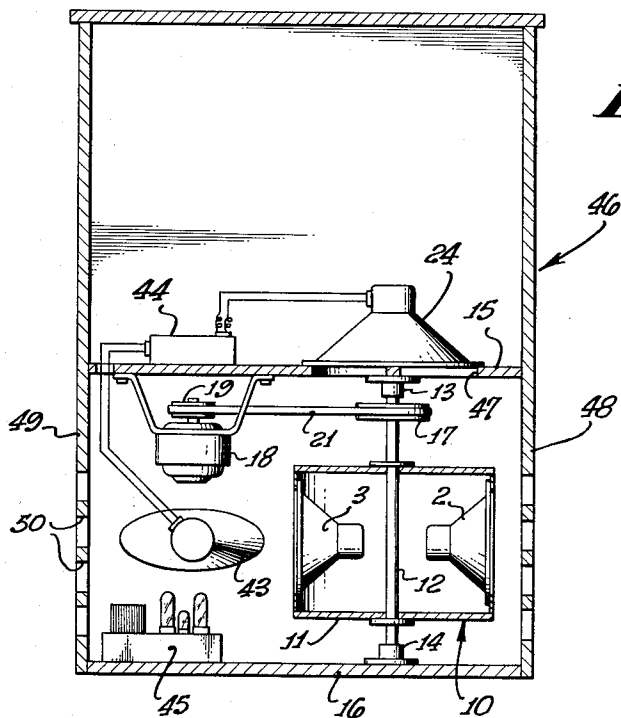


FIG. 1.

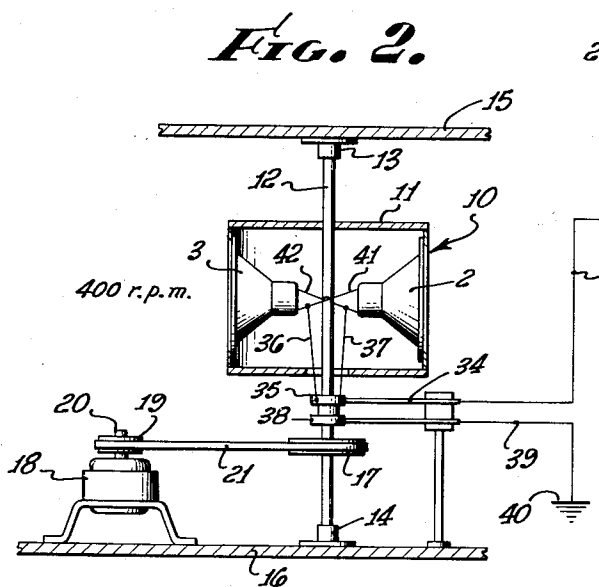
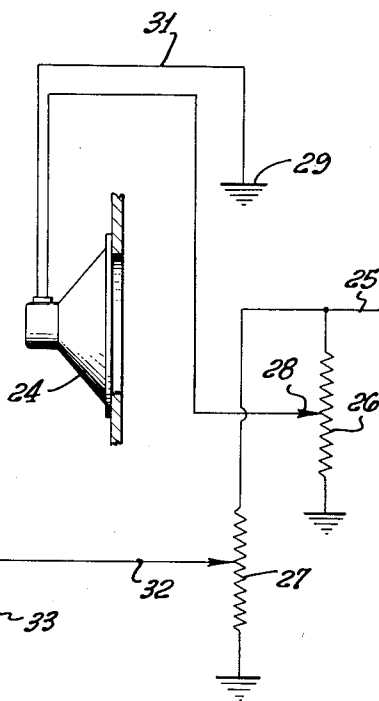


FIG. 2.



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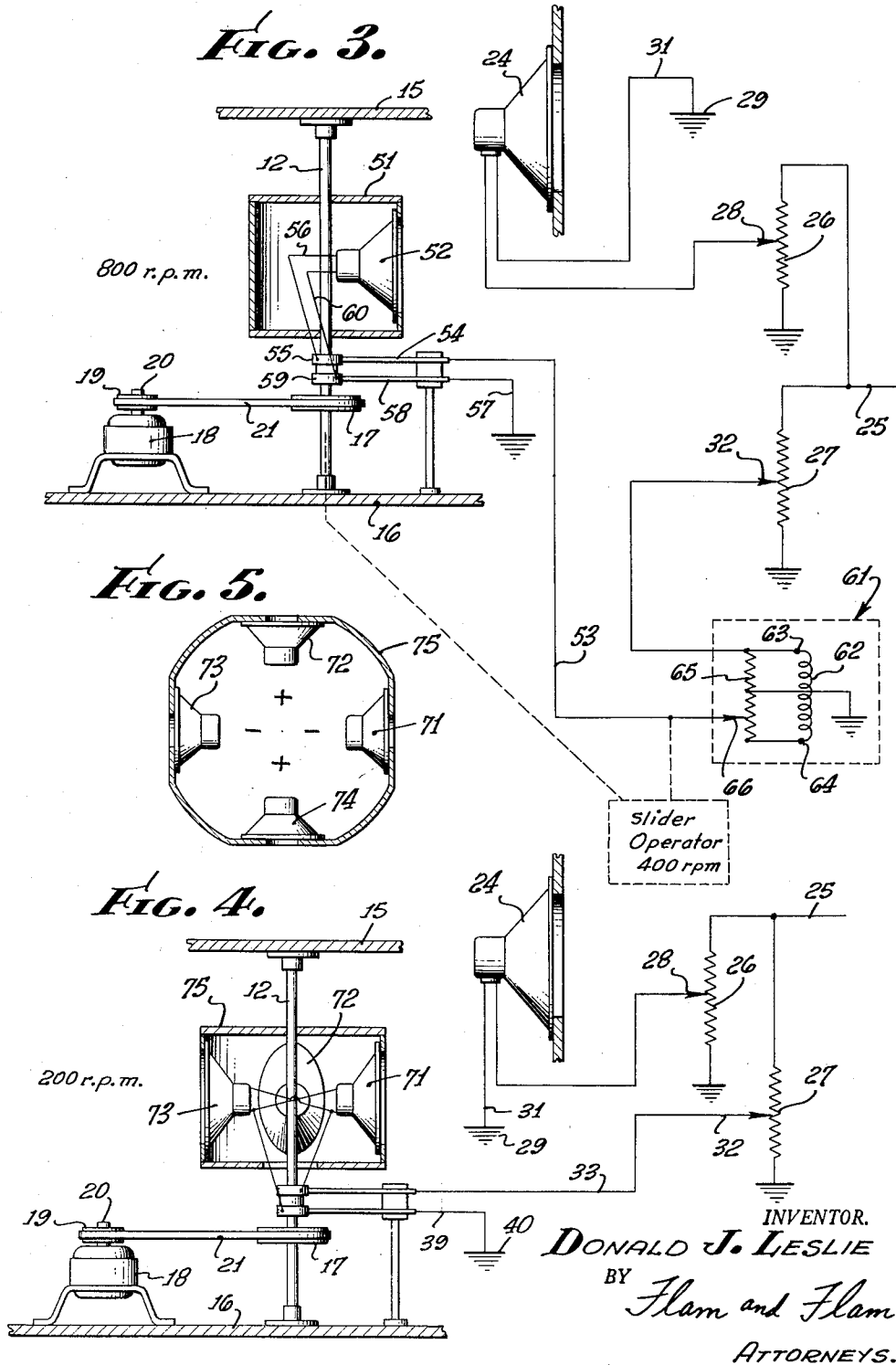
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3 Sheets-Sheet 2



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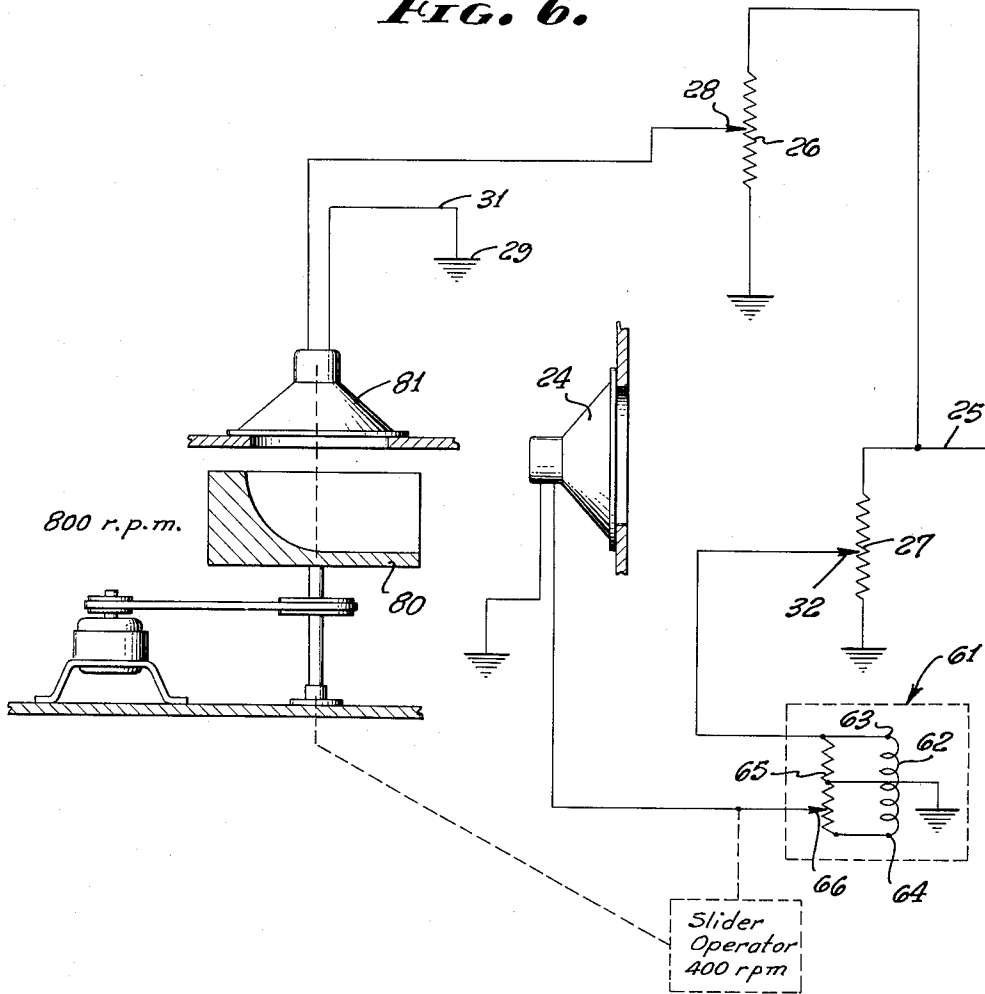
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FIG. 6.



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ROTARY TREMOLO DEVICE HAVING MEANS FOR MIXING SIGNALS EMANATING FROM ROTARY AND NON-ROTARY SOURCES

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5 Claims. (Cl. 84-1.25)

This invention relates to tremolo or vibrato apparatus characterized by the actual rotation of a sound radiation pattern. This may be accomplished by a rotary sound channel, such as a rotating speaker or a rotary horn co-operable with the stationary speaker. Optionally, a rotary reflecting plate may be provided for purposes of rotating the sound radiation pattern.

I have found that tremolo devices of this general character effectively provide a vibrant live quality and characteristic to the sound that is not obtainable by non-rotary or non-acoustic means. Such devices have found substantial acceptance with organs as well as with other forms of instruments using loud speakers.

In order to provide full, rich tremolo by acoustic means, such as typified above, a certain peripheral velocity is required to achieve an appropriate shift in frequency. It is frequency deviation or swing that produces a substantial portion of the effect. The greater the peripheral velocity, the greater the swing. To provide appropriate peripheral speed, obviously the diameter of the rotating structure can be increased. The objection in this connection, of course, is that the resultant structure may be bulky. Another apparent solution would be to increase the speed of rotation. Heretofore, this could not generally be done because vibrato or tremolo requires a characteristic acoustic recurrence rate of about five to seven or eight per second. Beyond this range, the result is undesirable noise.

Apparatus designed to produce tremolo not infrequently is fairly bulky and often it is accommodated in a cabinet separate from the organ itself. Organ manufacturers and consumers have voiced increasing demand for acoustic tremolo devices to be physically embodied in the organ console, or at least in compact auxiliary equipment. One object of this invention is to make it possible for the peripheral velocities necessary to produce appropriate phase shift or frequency deviation to be provided by increasing the rotational speed of the apparatus.

It has sometimes been proposed that two or more rotary sound channels be provided spaced angularly about a common axis in order to increase the spatial range of the apparatus. Heretofore, this has required a reduction in angular speed in order to keep the characteristic acoustic recurrence rate about six or seven per second, with a consequent loss in peripheral speed. Another object of this invention is to make possible the provision of a plurality of sound channels about a common axis without requiring any reduction in speed.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of one embodiment of the invention. For this purpose, there is shown a form in the drawings accompanying and forming part of the present specification. This form will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of this invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a rear view of a speaker cabinet illustrating apparatus incorporating the present invention, walls of the cabinet being in section;

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FIG. 2 is a diagrammatic representation of the speaker system of FIG. 1;

FIG. 3 is a diagrammatic representation of an alternate form of the present invention;

FIG. 4 is a diagrammatic representation of still another form of the present invention;

FIG. 5 is a diagrammatic view of the speaker structure of the FIG. 4 form; and

FIG. 6 is a diagrammatic representation of yet another form of the present invention.

In FIGS. 1 and 2, two speaker structures 2 and 3 are provided for producing by rotation suitable cyclic amplitude and phase changes.

The speakers 2 and 3 are mounted diametrically upon a common drum 10 and are so positioned that their cones or sound channels face radially outwardly in opposite directions. The drum 10 includes upper and lower walls 11 as well as a peripheral wall at which apertures are formed which register with the mouths of the cones of the respective speakers. The drum 10 is mounted for rotation upon a vertical shaft 12. The shaft 12 in turn is supported by the aid of bearings 13 and 14 fixed to horizontal walls 15 and 16 of the speaker cabinet. A pulley 17 mounted upon the shaft 12 is driven by the aid of a motor 18. For this purpose a pulley 19 is mounted upon the motor shaft 20. A belt 21 engages both pulleys 17 and 19. The motor 18 and pulleys 19 and 17 are so designed as to rotate the drum 10 and speakers 2 and 3 at a speed of about six or seven revolutions per second. This imparts orbital motion to the speakers. The two speakers seemingly provide a sound recurrence rate of about twelve or fourteen cycles per second since there are two speakers and the effect of the tremolo would be seemingly lost. However, in order to restore the characteristic tremolo rate of six or seven acoustic recurrences per second and without reducing the speed of the drum 10, a stationary or non-rotary speaker or channel 24 is provided.

The stationary or non-rotary speaker 24 and the rotary speakers 2 and 3 are all supplied by a common source or by separate sources that provide similar signals. Thus lead 25 indicates the output, for example, from a power amplifier driven by the output of an electronic organ. Energy from the source output 25 is applied in an adjustable amount to each of the speakers such as 24 and 2-3. For this purpose terminating resistors 26 and 27 are provided respectively for the non-rotary and rotary speakers or channels. A slider 28 cooperates with terminating resistor 26 and connects to one terminal of the stationary or non-rotary speaker 24. The other terminal of the speaker 24 can be connected to a return or ground 29 by the aid of a lead 31.

A slider 32 similarly cooperates with the other terminating resistor 27. The slider 32 connects to parallel connected terminals of the rotary speakers 2 and 3 by the aid of a lead 33, a brush arm 34, a slip ring 35 mounted on the shaft 12, and finally a lead 36 connected to the slip ring 35 and to the terminals of the speakers 2 and 3. The other connected terminals of the speakers 2 and 3 connect by the aid of a lead 37, a second slip ring 38, and a lead 39 to return or ground 40. The connections to the speakers are such that the vibratory movement of the speaker cones is opposite. Thus one cone is urged to move inwardly as the other is urged to move outwardly. In other words, the connections are of opposite phase.

The operation may now be understood by considering a listener at a fixed point relative to both speakers 24 and 2-3. At any specific point the sound emanating from the rotary speaker and the non-rotary speaker 24 will be in phase and additive at least at some time during rotation of the drum 10. A strong maximum signal will be perceived. At a half a revolution later, the positions

of the speakers 2 and 3 will be interchanged and the physical picture will be repeated. But the phase relationship will be opposite; hence, a minimum signal will be perceived because the stationary speaker 24 is in bucking relationship. Finally at the next half revolution, the acoustic recurrence cycle will be completed. It will now be appreciated that the acoustic recurrence rate is the same as the rotary rate of six or seven per second despite the fact that there are two channels or speakers. The acoustic recurrence rate is not twelve or fourteen per second as would result by equal energization of the speakers. The sliders 28 and 32 are adjusted to provide the degree of addition of signals desired or required. It is important to note that without the non-rotary speaker, the apparent recurrence rate would be this high value because the ear cannot distinguish phase per se. It is necessary to utilize this phase relationship additively to produce a psychological result.

In actual practice, and as illustrated in FIG. 1, the speaker 24 may be located at the axis of the drum 10 whereby a uniformity about the entire room is achieved. Mixing is therefore uniform at all listening points. Since the speaker 24 is downwardly oriented for uniform distribution, a loss of high frequency response is not unexpected because high frequency sound waves are highly directional. The restoration of high frequency response may be brought about by the use of a supplemental speaker 43, as indicated in FIG. 1. This speaker may be driven only by high frequency signals by the aid of a dividing or cross over network 44, in turn driven by an amplifier 45.

In practice, the walls 15 and 16 mounting the bearings for the drum shaft 12 comprise respectively a partition wall and a lower wall of a cabinet structure 46. The speaker 24 is located in that portion of the cabinet 46 above the partition wall 15 and in registry with an opening 47. That portion of the cabinet above the partition 15 may form a bass loading or bass reflex space to provide appropriate characteristic response of the speaker 24.

Located in the cabinet exterior walls 48 and 49 are openings 50 by the aid of which the sound from the rotary speaker structure 2 and 3 may be released to the room space.

In the form illustrated in FIG. 3, an arrangement similar to that of FIG. 2 is provided. However, in this instance, the drum 51 mounts but a single speaker 52. In this instance, the drum is rotated by the motor 18 at a rate of about twelve or fourteen revolutions per second. By virtue of this rotational speed it may be possible to diminish the size of the drum 51 and yet achieve substantial peripheral velocity so that the drum may be accommodated, for example, in an organ console. In this arrangement, a lead 53 connects with one terminal of the speaker 52 by the aid of a brush 54, a slip ring 55, and a lead 56. A ground lead 57 connects by a brush 58 and a slip ring 59 and a lead 60 to the other terminal of speaker 52. The stationary speaker structure 24 is provided as before. With the high rotational rate of the drum 51, the speaker 52 physically recurs about twelve or fourteen times per second. However, the recurrence of the sound pattern or acoustic recurrence is six or seven times per second. For this purpose the phase of the speaker 52 is reversed at every revolution. To accomplish this purpose, a phase shifting network 61 is provided and interposed in the lead 53. The phase shifting network may be of any suitable form but in the present instance there is diagrammatically illustrated a center-tapped coil or winding 62 that has one end connected to the source of the signal 25 via the tap 32. The center tap of the coil 62 is grounded.

A resistor 65 forming a part of a potentiometer or the like is connected across the terminals 63 and 64 of the winding 62.

By virtue of the very characteristics of the winding 62, the signals at the terminals 63 and 64 are precisely opposite in phase. Accordingly, by alternately utilizing the

signal at the terminals 63 and 64, the phase of the signal to the rotary speaker 52 can be reversed. For this purpose a slider 66 is provided. The slider cooperates with the resistor 65 and is reciprocated at the rate of six or seven times per second. Thus at a starting position, for example, the slider 65 determines the phase to be that of the terminal 63. Upon one revolution of the drum 51, the phase of the signal at the speaker 62 is reversed because the slider 65 has now moved to conductive relationship with the opposite terminal 64. It may thus be appreciated that the acoustic recurrence as distinguished from the physical recurrence of the sound channel is six or seven per second.

In the form of the invention illustrated in FIGS. 4 and 5, four speakers 71, 72, 73 and 74 are mounted in quadrants upon a common drum 75. In this instance the speed of rotation of the drum may be approximately three or four cycles per second.

Successive speakers are connected oppositely as to phase, and as indicated by the legends + and - adjacent the speakers in FIG. 5. It will be appreciated that, with the aid of the stationary channel or speaker 24, the acoustic recurrence rate of six or seven per second is established.

The form illustrated in FIG. 6 is similar to the arrangement illustrated in FIG. 3. The non-rotary or stationary speaker 24 is provided as before. A horn 80 cooperable with a non-rotary speaker 81 forms a rotary sound channel in place of the rotary drum 51 previously provided. The resulting operation however is equivalent. Resistors 26 and 27 are provided as before to serve as terminating resistors and the sliders 28 and 32 are provided respectively cooperating with the resistors 26 and 27. In the present example the speaker 24, that forms the non-rotary branch of the system is connected to the slider 32 via the phase shifting network 61, whereas in the form illustrated in FIG. 3, the rotary sound channel is connected via the phase shifting network 61. Correspondingly, the speaker 81 which drives the rotary sound channel or horn 80 is connected to the slider 28 directly and without interposition of the phase shifting network. The results, nevertheless, are similar upon rotation of the channel 80 at a speed of 800 r.p.m. or twelve or fourteen cycles per second, and rotation or reciprocation of the phase shifting network 61 at the rate of 400 r.p.m. or six or seven cycles per second.

The operation of the system of FIG. 6 may be appreciated by again considering the listener at a fixed point relative to both speakers 24 and 81. At any location there must be sometime during the rotation of the channel 80 that the sound emanating from the channel 80 and the non-rotary channel or speaker 24 are additive and in phase. A strong maximum signal will then be perceived. At one revolution later, the relative phase of the sound channel 80 is unchanged, whereas at the non-rotary channel or speaker 24, the phase is changed by 180°. Accordingly, at this time a minimum signal will be perceived. At the next revolution the original conditions will be duplicated. It will thus be apparent that the acoustic recurrence rate established by the speaker system is 400 r.p.m. or six or seven cycles per second, and suitable tremolo accordingly is produced.

It thus makes no difference whether the phase of the rotary channel is changed or the phase of the non-rotary channel is changed. The only important consideration is that the phase be changed relatively as between the rotary and non-rotary channels.

The inventor claims:

1. In apparatus for producing tremolo by acoustic means: a rotatable support; means forming a number of angularly spaced sound channel means on said support and operable in a musical range; means forming a separate sound channel operable in the same musical range; said sound channel means and said separate sound channel having electrical inputs; electrical signal source means

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for simultaneously driving the sound channel means and the separate channels by cooperation with said inputs; means for rotating said support such that the angular speed multiplied by half said number is of the order of six or seven cycles per second; and means operable between the signal source and at least one of the inputs for causing the phase of signals at successive repetitive physical recurrences of the sound channel means to be opposite with respect to said separate sound channel.

2. The combination as set forth in claim 1 in which said number is an interger multiple of two, and in which the speed of rotation is of the order of six or seven revolutions per second times said integer, and in which said means operable between the source and one of the inputs comprise alternate connections to the inputs for successive sound channel means.

3. The combination as set forth in claim 1 in which said number is one, and in which the speed of rotation is of the order of twelve or fourteen revolutions per second and in which said means operable between the source and one of the inputs comprises a phase shifting device oper-

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able at a frequency of approximately half that of the speed of rotation.

4. The combination as set forth in claim 1 in which said number is one, and in which the speed of rotation is of the order of twelve or fourteen revolutions per second and in which said means operable between the source and one of the inputs to the sound channel means comprises a phase shifting device operable at a frequency of half that of the speed of rotation and operable by rotation of said support.

5. The combination as set forth in claim 1 together with means for adjusting the level of energization of the sound channel means with respect to said separate sound channel.

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