March 3, 1970 D. J. LESLIE 3,499,114

SPEAKER SYSTEM FOR PULSATO AND CELESTE EFFECTS

Filed July 28, 1967

FIG. 1.

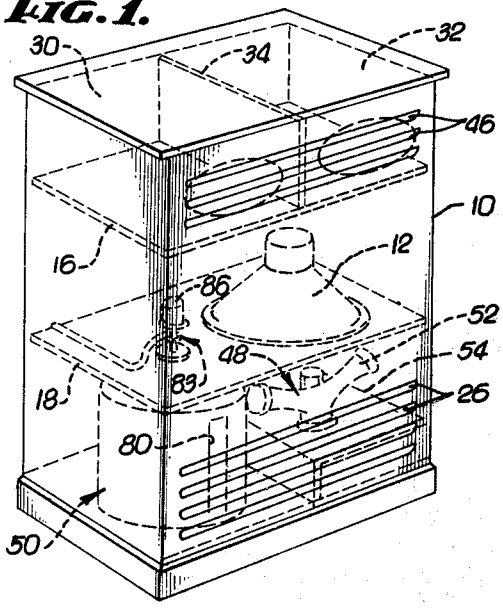


FIG. 3.

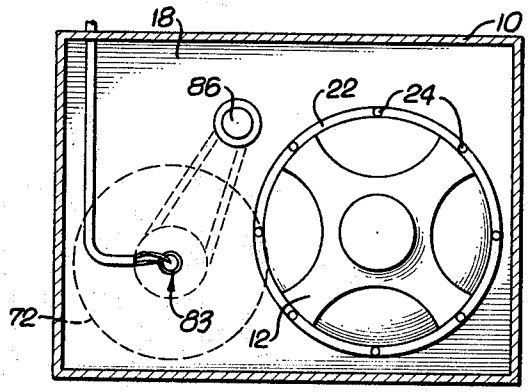


FIG. 2.

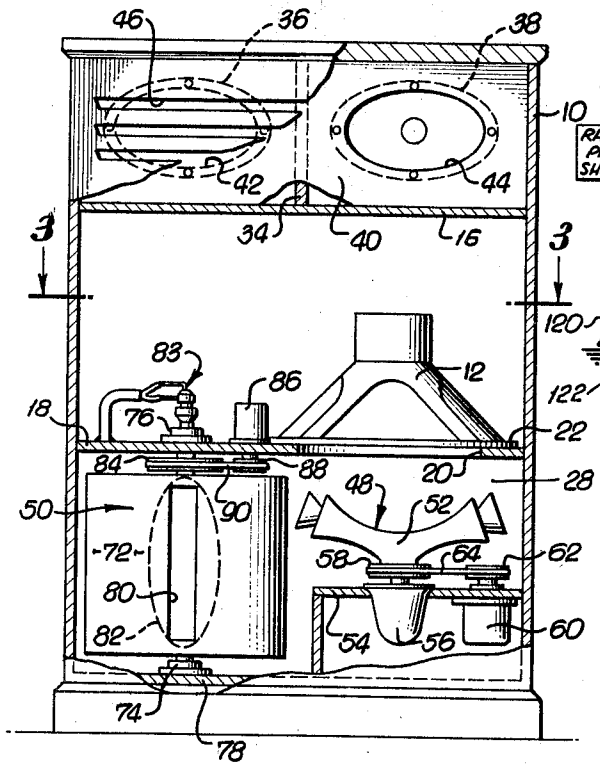
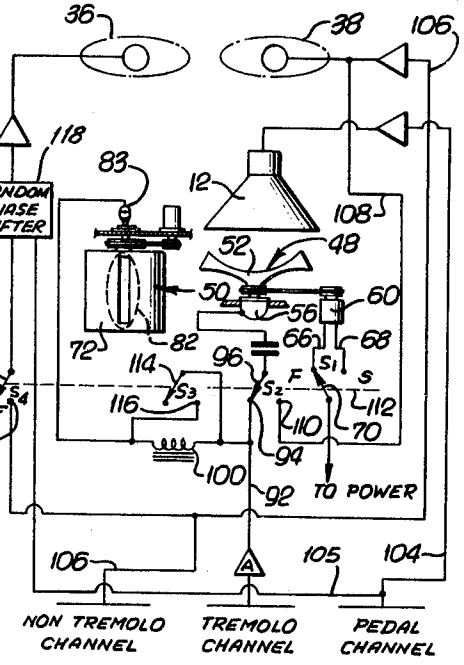


FIG. 4.



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United States Patent Office 3,499,114
Patented Mar. 3, 1970

3,499,114

SPEAKER SYSTEM FOR PULSATO AND CELESTE EFFECTS

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Filed July 28, 1967, Ser. No. 656,827
Int. Cl. G10k 11/10, 1/04
U.S. Cl. 179—1 14 Claims

ABSTRACT OF THE DISCLOSURE

The cabinet **10** houses a speaker **12** for pedal range tones. For the other frequency ranges, fixed speakers **36** and **38** and rotary speaker assemblies **48** and **50** are provided. The speaker assemblies **48** and **50** in one operational mode handle the impulses in the tremolo channel and the speaker **38** handles the impulses in the non-tremolo channel. In an alternate mode speakers **36**, **38** and the speaker assembly **48** comprise separate elements of a chorus group while speaker assembly **50** sustains the entire burden of the tremolo channel. A random phase shifter **118** produces an electrical phase shift between speakers **36** and **38** while speaker assembly **52** operated at a reduced speed provides acoustic phase shifts.

BRIEF SUMMARY OF THE INVENTION

This invention relates to speaker systems for producing pulsato and celeste effects.

In recent years, designers of electronic organs have been concerned with the fact that a single set of electronic generators normally produces only one voice at a time whatever means may be provided for changing the tone characteristics. A number of systems have been proposed whereby a plurality of distinct voices can be produced simultaneously from a single set of electronic generators by the aid of frequency shifting devices. One system of such character is shown and described in my prior Patent No. 3,251,924 issued May 17, 1966 and entitled Apparatus for Producing a Derivative Celeste or Chorus Rank for Electronic Organs. Another system of such character is shown and described in my prior application Ser. No. 350,717 filed Mar. 10, 1964, now Patent Number 3,372,225 and entitled Electronic Organ System.

When a celeste or chorus rank is added by such frequency shifting devices, it is ordinarily necessary to provide a separate electrical-acoustic channel therefor in order to maintain the separate identity of the voices and to avoid certain intermodulation distortions or beat effects. If acoustic vibrato and tremolo is to be provided by the use of rotary sound channels for both normal and celeste components, the speaker system equipment necessary becomes rather extensive. Thus I have heretofore provided for such systems two identical speaker systems, each of which includes a cabinet in which rotary sound channels are mounted for high and low frequency range components.

The primary object of this invention is to provide a speaker system capable of adequately accommodating celeste or chorus ranks and capable of producing acoustic pulsato (vibrato and/or tremolo) all with a minimum of speaker equipment housed in a single cabinet. In order to accomplish this object, the rotary components are required to operate in two modes, one for translation of the normal organ output only, and one for the translation of celeste or chorus output along the normal organ output. By slightly compromising the frequency response characteristics of the acoustic pulsato apparatus, and by using part of the pulsato apparatus for celeste or chorus functions, a compact yet versatile speaker system may be provided.

Another object of this invention is to provide compact packaging of speaker and acoustic pulsato apparatus.

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 a 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.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a pictorial view of a speaker cabinet, components thereof being shown in phantom lines.

FIG. 2 is a front elevational view of the cabinet with the front wall thereof broken away and shown in section.

FIG. 3 is a horizontal sectional view taken along the plane corresponding to line 3—3 of FIG. 2.

FIG. 4 is a wiring diagram.

DETAILED DESCRIPTION

The cabinet **10** shown in FIGS. 1 and 2 houses a low frequency speaker **12** designed efficiently to translate into sound, electrical impulses in the pedal range. By way of example, the speaker **12** may have a cone diameter of approximately 15". The speaker **12** is accommodated in an intermediate compartment **14** defined by upper and lower horizontal partition walls **16** and **18**.

The lower partition wall **18**, as shown in FIG. 2, is provided with a circular opening **20** about which the cone of the speaker **12** is placed. The speaker has a suitable peripheral flange **22** (FIG. 3) secured about the edges of the opening **20** by suitable fasteners **24**. Except for the opening **20**, the compartment **14** is entirely closed, whereby radiations from the back of the speaker **12** are appropriately isolated. Sound from the speaker **12** passes outwardly from the cabinet **10** via suitable louvred openings **26** (FIG. 1) in a lower compartment **28** beneath the partition **18**.

An upper compartment formed above the partition wall **16** is divided into two isolated sections **30** and **32** by the aid of a vertical wall **34**. Respectively accommodated in the compartment sections **30** and **32** are speakers **36** and **38** designed efficiently to translate into sound, electrical impulses in the medium and higher acoustic ranges. By way of example, the speakers **36** and **38** may be oval, measuring 6" by 9". The speakers are fastened to a common mounting panel **40** (FIG. 2) at oval openings **42** and **44**. The panel in turn is fastened to the inside of the front wall of the cabinet **10**. Suitable louvred openings **46** (FIGS. 1 and 2) provide for the outward passage of sound while the compartment sections **30** and **32** isolate back radiations. In the lower compartment **28** two rotary speaker assemblies **48** and **50** are provided for the purpose of providing acoustic pulsato. The speaker assembly **48** has an alternate mode for introducing suitable phase shifts. The speaker assembly **48** is similar to the high frequency rotary speaker assembly shown in my prior Patent No. 2,489,653, issued Nov. 29, 1949, and entitled "Rotatable Tremulant Sound Producer."

The speaker assembly **48** includes a rotary horn structure **52** supported by a bearing, in turn mounted in a bracket plate attached to a box-like frame **54**. The rotary horn **52** has a throat registering with a high frequency driver **56** suspended from the bracket plate. Formed on or attached to the rotary horn **52** is a pulley wheel **58** whereby the horn **62** may be rotated. A motor **60** suspended from the frame **54** carries a pulley **62** connected to the horn pulley **58** by a belt **64** whereby the horn is rotated.

The motor **60** has a fast and slow speed mode. By way of example, the motor **60** may be wound to provide smaller and larger numbers of poles for fast and slow speed operation. Windings of the motor **60** to achieve these alternate operations are accessible externally, as indicated diagrammatically by leads **66** and **68** (FIG. 4). A switch S1 has an arm **70** operable to connect power to the motor **60** either via the high speed lead **66** or the slow speed lead **68**. In the position of FIG. 4, the motor **60** is connected for fast speed.

When the motor **60** operates in its fast speed mode, pulsato is imparted to the sound issuing from the horn **52**. If the horn **52** has but a single opening for sound emission (the opposite horn then being a dummy for dynamic balance), the horn is rotated at a rate of about five to eight cycles per second whereby characteristic pulsato is added. If the horn **52** provides two sound openings on diametrically opposite sides, then the horn is rotated in the range of from two and a half to four cycles per second to achieve a recurrence in the sound radiation pattern at the rate of five to eight cycles per second.

The speaker assembly **50** includes a substantially cylindrical drum **72** mounted for rotation about its axis by the aid of bearing structures **74** and **76** located respectively on the bottom wall **78** of the cabinet and the partition **18**. The drum **72** has on one side a slit or opening **80** elongated in a direction parallel to the drum axis. The drum is otherwise closed. An oval speaker **82** is attached to the drum on the inside of the opening **80**. The drum serves as an acoustic enclosure for the speaker **82**. Connections for the speaker **82** are achieved through the drum shaft by a slip ring assembly **83** such as shown and described in my prior Patent No. 3,014,192, issued Dec. 19, 1961, and entitled "Mercury Slip Ring Assembly."

The drum shaft carries a pulley **84** located beneath the partition **18** by the aid of which the drum **72** is rotated. A motor **86**, supported on the partition **18** in the intermediate compartment **14**, has a shaft projecting through the partition **18**. A pulley **88** carried by the motor shaft is coupled to the pulley **84** by a belt **90**. Pulsato is added to the sound emitted from the opening **80** upon rotation of the drum **72** at the characteristic pulsato rate of from five to eight cycles per second. Multiple speakers may be mounted on the drum **72** if desired.

Experience has shown that the rotary horn structure **52** provides a very full, clear vibrant pulsato characteristic, especially for frequencies in the higher range. The speaker assembly **50** provides excellent pulsato characteristics especially in the medium and low medium frequency range. For optimum pulsato results, both speaker assemblies **48** and **50** are used.

When the motor **60** operates in its fast speed mode, speaker assemblies **48** and **50** both produce pulsato in substantially adjacent frequency bands for a "tremolo" channel derived from the organ; speaker **38** radiates acoustic energy for a "non-tremolo" channel; and speakers **12** and **36** radiate acoustic energy for the "pedal" channel. When the motor **60** operates in its slow speed mode, speaker assembly **50** alone sustains the entire burden of the tremolo channel; speakers **36**, **38** and the speaker assembly **48** form distinct elements of a chorus or ensemble group for the non-tremolo channel; and, as before, speakers **12** and **36** cooperate with the pedal channel.

In order to determine these alternate modes of operation, switches S2, S3 and S4 are provided that are operatively interlocked with the switch S1. In FIG. 4, the switches S1, S2, S3 and S4 are illustrated in one position to achieve the pulsato mode of operation; when the switches are moved to their opposite positions, the chorus mode is achieved.

In the position shown in FIG. 4, a tremolo channel indicated by lead **92** connects to the speaker assembly **48** via a contact **94** and switch arm **96** of switch S2, and a filter condenser **98** to the driver **56**. The tremolo channel lead **92** also connects to the speaker **82** through a high frequency choke **100** and the slip ring assembly **83**. The condenser **98** and the choke **100** form elements of a crossover network that has a nominal crossover point of about 800 cycles per second. However, frequencies below 800 c.p.s. are transmitted to the high frequency speaker assembly **48** with attenuation proportional to the frequency deviation, and similarly, frequencies above 800 c.p.s. are transmitted to the speaker assembly **50**. Excellent results are obtained for this mode of operation. In the position shown, switch arm **70** of switch S1 is positioned to operate the pulley motor **60** at high speed corresponding to pulsato. Switches S3 and S4 are open.

The pedal channel is connected to two speakers independently of the switches. A lead **104** connects the pedal channel to the low frequency speaker **12**. A lead **105** connects the pedal channel to the speaker **36** via a random phase shifting device **118**. The random phase shifter **118** introduces a frequency shift of the order of, say, one or two cycles per second. Thus a frequency component of 440 c.p.s. applied to the input of the phase shifter **118** appears at the output with a frequency of, say, 442 c.p.s. The actual frequency shift changes in a random manner in magnitude alone or in magnitude and direction to prevent a certain sameness to the tone quality. A random phase shifter of this type is shown and described in my co-pending application Ser. No. 350,717, filed Mar. 10, 1964, now Patent No. 3,372,225 and entitled "Electronic Organ System." The phase shifting device **118** together with the speaker **36** supplement the sounds issuing from the speaker **12** whereby a certain broadening and tone enhancement is achieved.

It may be desirable to use the tremolo channel **92** in conjunction with the output from one manual of the organ while a non-tremolo channel is available for use in conjunction with another manual. The non-tremolo channel indicated by a lead **106** connects to the fixed speaker **38**. It will be understood that the leads **92** and **106** may be switched for cooperation with any one or more of the manuals of the organ by conventional switch means under the control of the organist at the organ console.

In the alternate mode of operation, the speaker assembly **48** and speakers **36** and **38** form three distinct elements of a chorus group actuated by the non-tremolo channel, while the speaker assembly **50** sustains the entire burden of the tremolo channel. By the aid of the phase shifting device **118**, there is created a slight disparity in frequency between the signals applied to the respective speakers **36** and **38**, while the horn **58** is rotated slowly to add acoustic phase shifts to the higher frequency components. The combined chorus effect is highly pleasing. Instead of pulsato, a soft, slowly changing tone is achieved.

An auxiliary lead **108** is provided to connect the non-tremolo channel **106** to the speaker assembly **48**. This lead connects with a contact **110** engaged by the switch arm **96** when switch S2 is moved to a position opposite that illustrated in FIG. 4. At the same time, the switch S1 moves to the slow position. The horn **52** has only slight inertia, and hence quickly changes its speed upon operation of the switch S1. However, to ensure against unmusical sounds during the transition period, the organist may utilize the manual or manuals connected to the non-tremolo channel which at all times is connected to the speaker **38**. If desired, a rotary sound channel (not shown) could be provided for the speaker **38** to impart mild tremulant as desired.

The switches S1, S2, S3 and S4 are interconnected for movement in unison by a common actuator **112**. The actuator **112** is preferably operated by a suitable solenoid or relay coil (not shown) in turn controlled remotely by the organist at the console. In place of a common actuator **112**, the various switches may be provided with separate relays interlocked electrically rather than mechanically.

In order to cause the speaker assembly **50** in the alternate mode to provide pulsato for all frequencies of the

tremolo channel **92**, a shunt circuit is provided for the choke coil **100**. The shunt circuit is completed by parts of the switch S3, namely, a switch arm **114** connected to one side of the coil and a contact **116** connected to the other side. The switch S3 closes when the actuator **112** is moved from the position shown to select the chorus or ensemble mode. When the actuator **112** is so moved, the arm **96** of switch S2 moves away from the contact **94** whereby the tremolo channel is disconnected from the speaker assembly **48**.

In the chorus mode, the speaker **38** is connected to the non-tremolo channel **106** as before; the non-tremolo channel **106** now also connects to the companion speaker **36** through the random phase shift device **118** by the aid of contact **122** and switch arm **120** of switch S4. The switch S4 closes when the actuator is moved to select the chorus mode.

Various amplifiers A may be provided in the various electrical channels as required. These amplifiers may be mounted in the cabinet **10**.

By virtue of the arrangement shown and described, excellent pulsato and chorus effects are achieved in a compact speaker system.

I claim:

1. In a speaker system: a first speaker assembly having a rotary sound channel; a second speaker assembly having a rotary sound channel; means selectively operable to rotate the rotary sound channel of said first speaker assembly at a rate to produce pulsato and at a sub-pulsato rate to produce phase shifts; means operable to rotate said rotary channel of said second speaker assembly at a rate to produce pulsato; said speaker assemblies having different frequency characteristics; means forming a pair of electrical channels; filter means coupling one of said electrical channels to said speaker assemblies for dividing frequency components therebetween; means directly coupling said second speaker assembly to said one of said electrical channels independently of said filter means upon operation of said first speaker assembly at sub-pulsato rate; and means coupling the other of said channels to said first speaker assembly upon operation of said first speaker assembly at sub-pulsato rate.

2. In a speaker system: a first speaker assembly having a rotary sound channel; a second speaker assembly having a rotary sound channel; means selectively operable to rotate the rotary sound channel of said first speaker assembly at a rate to produce pulsato and at a sub-pulsato rate to produce phase shifts; means operable to rotate said rotary channel of said second speaker assembly at a rate to produce pulsato; said speaker assemblies having different frequency characteristics; electrical channel means forming an output of an electrical musical instrument; filter means coupling said electrical channel means to said speaker assemblies for allocation of frequency components therebetween; means directly coupling said second speaker assembly to said channel means independently of said filter means upon operation of said first speaker assembly at sub-pulsato rate; and means coupling the channel means to said first speaker assembly upon operation of said first speaker assembly at sub-pulsato rate.

3. In a speaker system: a first speaker assembly having a rotary horn, a driver coupled to said horn and two speed motor means for rotating said horn at a pulsato rate and at a sub-pulsato rate; a second speaker assembly having a rotary drum, a speaker mounted in the drum and registering with an opening in the periphery of said drum, said drum forming an enclosure for said speaker; means rotating said drum at a rate to produce pulsato; a fixed speaker; means forming a pair of electrical channels; switch means movable to two positions; first filter means coupling one of said electrical channels to said driver when said switch means is in one position to suppress lower frequency components; second filter means coupling said one of said electrical channels to said speaker when said switch means is in said one position; means coupling the other of said electrical channels to said fixed speaker; means coupling said one of said electrical channels to said drum speaker independently of said filter means when said switch means is in its other position; means coupling the said other of said electrical channels to said driver when said switch means is in its said other position; and control means for said two speed motor for causing said motor to operate said horn at pulsato rate when said switch means is in its said one position and for causing said motor to operate said horn at sub-pulsato rate when said switch means is in its said other position.

4. The combination as set forth in claim **3** together with a second fixed speaker; an electrical phase shifting device operable to shift the frequency of impulses between its input and its output; and means coupling said second fixed speaker to said other electrical channel in serial dependency with said phase shifting device when said switch means is in its said other position.

5. The combination as set forth in claim **4** together with a third fixed speaker; means forming a pedal channel connected to said third fixed speaker, and through said phase shifting device to said second fixed speaker.

6. In a speaker system: a cabinet having a partition forming two compartments, said partition having an opening; a pedal range speaker mounted in one of said compartments in registry with said opening, said one compartment being otherwise acoustically closed to form an enclosure for the back of said pedal speaker; rotary pulsato means in the other of said compartments; means forming openings from said other compartment to the exterior of said cabinet; said rotary pulsato means including a pair of mechanically independent speaker assemblies, one of said speaker assemblies having a rotary horn, a driver coupled to said horn and two speed motor means for rotating said horn at a pulsato rate and at a sub-pulsato rate; said second speaker assembly having a rotary drum, a speaker mounted in the drum and registering with an opening in the periphery of said drum, and means rotating said drum at a rate to produce pulsato, said drum forming an enclosure for said speaker; means forming a pair of electrical channels; switch means movable to two positions; first filter means coupling one of said electrical channels to said driver when said switch means is in one position to suppress lower frequency components; second filter means coupling said one of said electrical channels to said speaker when said switch means is in said one position; means coupling said one of said electrical channels to said drum speaker independently of said filter means when said switch means is in its other position; means coupling the said other of said electrical channels to said driver when said switch means is in its said other position; and control means for said two speed motor for causing said motor to operate said horn at pulsato rate when said switch means is in its said one position and for causing said motor to operate said horn at sub-pulsato rate when said switch means is in its said other position.

7. The combination as set forth in claim **6** in which said cabinet has a further partition defining a pair of separate auxiliary compartments; fixed speakers in said auxiliary compartments respectively; means coupling one of said fixed speakers to said other electrical channel; an electrical phase shifting device operable to shift the frequency of impulses between its input and its output; and means coupling said other of said fixed speakers to said other electrical channel in serial dependency with said phase shifting device when said switch means is in its said other position.

8. In a speaker system: a first speaker assembly having a rotary sound channel; a second speaker assembly having a rotary sound channel; two speed motor means for operating the rotary sound channel of one of said speaker assemblies optionally at a pulsato rate and at a sub-pulsato rate to produce phase shifts; first switch means

movable to select the mode of operation of said motor means; means for operating the rotary sound channel of the other of said speaker assemblies at a pulsato rate; a pair of electrical channels; a high frequency choke connecting one of said channels to said other of said speaker assemblies; condenser means serially associated with the said one of said speaker assemblies; a second switch means selectively connecting said one of said speaker assemblies to said channels; third switch means for shunting said choke; and a common actuator means for said switch means for determining alternate modes of operation in one of which said choke is not shunted, said motor means is operated at pulsato rate and said second switch means connects said one of said speaker assemblies, to said one of said channels and in the other mode of which said choke is shunted, said motor means is operated at sub-pulsato rate and said second switch means connects said one of said speaker assemblies to the other of said channels.

9. The speaker system as set forth in claim **8** together with a fixed speaker; and means connecting said fixed speaker to said other electrical channel.

10. The speaker system as set forth in claim **9** together with a second fixed speaker; an electrical frequency shifting device; and a fourth switch means operable in said other mode to connect said second fixed speaker to said other electrical channel in serial dependency upon said device.

11. The speaker system as set forth in claim **8** together with a common cabinet for said speaker assemblies.

12. The speaker system as set forth in claim **9** together with a common cabinet for said speaker assemblies and said fixed speaker.

13. The speaker system as set forth in claim **10** together with a common cabinet for said speaker assemblies and said fixed speakers.

14. In a speaker system: a plurality of speakers; an electrical frequency shifting device serially associated with one of said speakers; a rotary sound channel associated with another of said speakers; means producing electrical signals for applications to said speakers; motor means for operating said sound channel at a high speed to produce pulsato or at a low speed to produce phase shifts; auxiliary pulsato apparatus; means for dividing frequency components in a range between said pulsato apparatus and said other of said speakers when said rotary sound channel is operated at high speed; and means for applying all frequency components in said range to said auxiliary pulsato apparatus when said rotary sound channel is operated at low speed.

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U.S. Cl. X.R.

84—1.25; 181—27