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CONTROLLABLE STEREOPHONIC ELECTROACOUSTIC NETWORK

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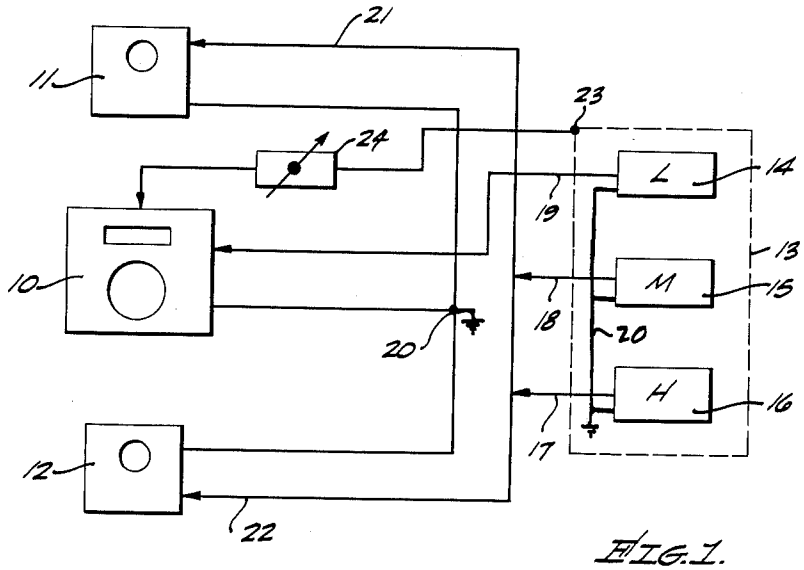

FIG. 1.

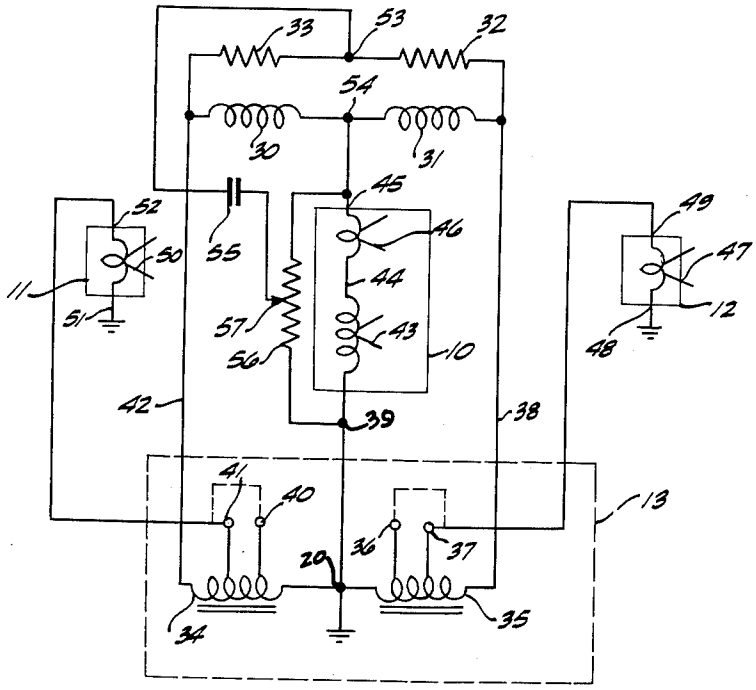

FIG. 2.

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CONTROLLABLE STEREOPHONIC ELECTRO-ACOUSTIC NETWORK

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1 Claim. (Cl. 179—1)

This invention relates to dual-channel stereophonic sound reproducing systems and more particularly to a controllable electroacoustic distribution network for such systems to selectively apply various proportions of predetermined ranges of frequencies in the audio spectrum to such systems.

The audio spectrum is conveniently divided into octaves. Nine octaves are said to encompass the range of human hearing and the range in which modern high quality audio amplifying and reproducing systems operate.

Thus, if one selects ranges encompassing 3 successive octaves one can call them a low, a mid and a high range, respectively, as the groups of three octaves increase in frequency.

Since the low range may arbitrarily be selected as including the three octaves from 40 through 320 cycles per second, the mid range may then be considered from 320 to 2560 c.p.s. and the high range would be included from 2560 through 20,480 c.p.s.

It has been determined by psychophysiological studies that in a stereophonic reproduction system the perception of the location and direction of the source of sound is impaired for frequencies in the low range, while for frequencies in the mid- and high-ranges the directional source may more readily be perceived. This is believed due to the average distance between one's ears which is less than a foot. The distance is such a small fraction of the wave length of tones in the low frequency range that the time-difference factors do not produce an appreciable response.

In the present use of plural amplifiers in audio systems for stereophonic sound reproduction of plural sources of recorded sound materials, it has been the practice to provide a complete full range speaker system for each channel connected to its associated amplifier. Such a full range speaker system is equal in cost and more frequently greater in cost than each of the amplifiers to which it is connected.

Because of the above mentioned psychophysiological phenomenon it would be warranted as an economic measure to provide limited range speaker systems for the mid and high ranges to provide acoustic sources placed in positions at the sides of a listening area, while retaining the full range speaker as a central speaker. Since the low frequencies are not as readily perceived as to direction of source, these should be prevalent in the low range speaker. The central speaker may be used in this way, while the side speakers can be made responsive to the mid- and high-ranges of frequencies.

It is a well established principle that to proportionately mix signals from the two channels of a stereophonic signal source, there results a reconstituted third channel substantially equivalent to that which would have been recorded in a third channel had a third microphone been positioned midway between the two normally used to record a stereophonic program.

This invention contemplates a more economical loudspeaker system incorporating a centrally located full-range speaker and a pair of mid- and high-range speakers located peripherally of the central speaker interconnected with a novel controllable network by which the selected ranges of frequencies may be applied to the loudspeakers

in appropriately controlled amounts to enhance the stereophonic impression.

Accordingly, it is an object of this invention to provide an electroacoustic network and system for stereophonic sound reproducing speakers whereby selectively controllable proportions of mid- and high-range signals from both channels of such a system may be applied to a center speaker normally a full-range speaker, and side speakers are provided responsive only to mid- and high-range signals.

It is a further object of this invention to provide a more economical stereophonic loudspeaker system that may be connected with existing full range speakers for dual-channel stereophonic reproduction system.

It is another object of this invention to provide in a stereophonic loudspeaker system selectively adjustable means for distributing controlled amounts of signals of predetermined ranges in the audible spectrum among predetermined ones of the loudspeakers in the stereophonic system.

It is still another object of this invention to provide in a loudspeaker system an audio signal distribution network by which a stereophonic sound reproducing system may be more effectively and economically utilized.

It is a still further object of this invention to incorporate in a stereophonic loudspeaker system an economical and compact means for enhancing the stereophonic perception by taking advantage of the psychophysiological response characteristics of the human ear to particular ranges of sound frequencies.

It is yet another object of this invention to provide a 3 channel stereo system utilizing a two channel source in conjunction with a controllable frequency separation and distributed network.

These and other objects of the invention will be more fully understood from the specification and the claim which follows when taken together with the drawing in which:

FIGURE 1 is a block diagram of an embodiment of the invention showing the elements thereof; and

FIGURE 2 is a circuit diagram of the interconnections of the elements of an embodiment of the invention.

As has been set forth above directional perception of the source of sounds is not as pronounced for frequencies in the low audible range, as it is for the mid- and high-audible ranges. These three ranges have been previously defined as encompassing nine octaves in groups of three from about 40 c.p.s. to about 20,000 c.p.s.

A good full-range loudspeaker system for monophonic listening encompasses these three ranges as does a good audio amplifier. For stereophonic listening two complete systems including in each an amplifier and full-range speaker have been required.

By the use of the system of this invention as illustrated in the block diagram of FIGURE 1, to which reference is now made, a second full-range speaker is not required and three channel operation will result.

Whereas two channels in a stereophonic reproduction system normally provide realistic lateral displacement perception, without a proportionate central position the transition of dynamic acoustic movement as perceived subjectively by the listener is not smooth and has in fact been experienced as a jump in the sound from say, left to right. This has been described in the literature as the "ping-pong effect." By creating a third channel proportionately composed of appropriate amounts of signals in preselected frequency ranges from each channel of the stereo sound source this "ping-pong" transitional effect is eliminated and the subjective perception of depth is added. The lateral transitions therefore are smooth and natural.

In FIGURE 1 a first loudspeaker 10 is the usual full-range speaker, a second speaker 11 is responsive to mid and high range signals only, and a third speaker 12 is similar to speaker 11. Speakers 10, 11 and 12 are each connected to a source of audio program signals 13, shown by the dashed box. The source 13 may be a stereophonic dual-channel amplifier. Each channel is provided with a output transformer means, each of which drives a separate loudspeaker. Source 13 has present therein low-, mid- and high-range audible signals in each channel thereof, identified by blocks 14, 15 and 16, respectively, and further indicated by the letters L, M, and H.

The signals from each channel of the stereo system including mid range on lead 18 and high-range on lead 17 are coupled respectively by leads 21 and 22, to speakers 11 and 12, respectively. Low-range signals represented by lead 19 are coupled to full-range speaker 10; all speakers, 10, 11 and 12 are brought to a common ground point or return circuit 20.

As is more fully described with reference to FIGURE 2, the signals represented by 17, 18 and 19, respectively, are each from plural source devices. From a point 23 on block 13 corresponding to 53 in FIGURE 2, an adjustable selective network 24 is connected between the source 13 and full-range speaker 10. From this network mid- and high-range signals are applied adjustably to speaker 10 and low-range signals are applied generally. The network 24 may be called a proportioning means.

Summarizing the operation of the invention as depicted in FIGURE 1, it may be seen that an audio-signal source 13, encompassing a two-channel stereophonic audio amplifier, for example, provides low-mid and high-range audio signals. The signals which appear in each channel are applied to the central speaker 10 only. Mid and high range signals are applied to each speaker 11 or 12 from the channel to which it is connected. The range limitation may be a function of the speaker itself or may be accomplished through networks not shown but known to the art. Additionally, mid- and high-range signals are applied through network 24 to speaker 10 in amounts controlled by the adjustment thereof.

Referring now to FIGURE 2, a detailed circuit diagram of an embodiment of this invention is shown. Dashed block 13 corresponds to the similarly identified block of FIGURE 1 and may be seen to include secondaries 35 and 34 of output transformers which are not shown in full but each is connected to the output of one channel, respectively, of a dual-channel stereophonic amplifier. The secondaries 34 and 35 have a common connection to ground as at 20. Secondary 35 has a tap 36 and a tap 37 and an end terminal lead 38. Secondary 34 has a tap 40 and a tap 41, and an end terminal lead 42. The windings and taps of secondaries 34 and 35 may be usually identical. Each provides a separate signal from a common program source including the full range of audibility.

End terminal 42 is connected to one end of an inductor 30 and one end of a resistor 33. Inductor 30 provides attenuation of mid- and high-range signals permitting only low-range signals to pass. Inductor 30 is commonly known as a low-pass filter. The device illustrated is in its simplest form. Other low-pass filters may be used equally well. The other end of inductor 30 is connected in common connection 54 with an identical inductor 31 described further below. The common connection 54 is connected to one terminal 45 of speaker 10, corresponding to the central speaker of FIGURE 1.

Full-range speaker 10 may, as an example, incorporate a "tweeter" 46 and a "woofer" 43, connected in series at 44, or any other well-known connection for high- and low-frequency speaker combinations such as the full-range speaker 10. The return circuit connection of speaker 10 is identified as 39 and is connected to common ground circuit 20.

The channel provided by secondary 35 is connected by its lead 38 to one terminal of a resistor 32, identical

with resistor 33 and to one terminal of inductor 31 previously mentioned which performs the identical filter function performed by its counterpart, inductor 30. The other end of inductor 31 connects to common terminal 54. Resistors 32 and 33 are connected together at a common terminal 53.

Across speaker 10 a potentiometer 56 is connected between terminals 45 and 39. Potentiometer 56 has a variable arm connection 57. Between variable arm connection 57 and common resistor terminal 53 a capacitor 55 is connected. The capacitor comprises a "high-pass" filter. Other types of high pass filters may be used, as is common in this art.

From either tap 36 or 37 of secondary 35 a connection is made to one terminal of mid and high-range speaker 12 previously identified in FIGURE 1. Speaker 12 would normally be a single unit as at 47, but may equally well be a combination speaker for mid and high ranges. The return terminal is connected to ground as indicated at 48. From either tap 40 or 41 on secondary 34 a connection is made to one terminal of a second mid and high-range speaker 11 previously identified in FIGURE 1. Speakers 11 and 12 are identical. The return terminal of speaker 11 is connected to ground as shown at 51.

The operation of the system of this invention may be described as follows: Audio program signals from a dual-channel amplifier providing stereophonic program material amplifier in the source 13. The signals of one channel appear in secondary 34. The signals of the other channel appear in secondary 35. The signals of secondary 34 are applied along lead 42 to the junction of resistor 33 and inductor 30. Similarly the signals in secondary 35 are applied along lead 38 to the junction of resistor 32 and inductor 31. Low-frequency signals are not attenuated by inductors 30 and 31 so that they are passed readily from both channels in common to speaker 10. Signals in the mid and high ranges are attenuated by this filter in being applied to the central speaker 10.

The high-range signals and mid-range signals from each channel appear somewhat attenuated by resistances 32 and 33 at the junction 53 along with equally attenuated low frequencies. Capacitor 55, however, acts as a high impedance for the low frequencies whereas at the mid and high frequencies it appears as a low impedance. Therefore at arm 57 of potentiometer 56 there will be present substantially higher signal level of the mid and high-range signals than of the low-range signals. Varying amounts of the high and mid-range signals may be injected across potentiometer 56 by the positioning of arm 57. Thus with the adjustment of potentiometer 56 a selected amplitude of mid and high-range signals may be applied across speaker 10 along with the normal low-frequency signal at terminal 45. As arm 57 is moved closer to terminal 39 there will be less signal of the mid and high-range applied than when the arm is closer to terminal 45. It may be seen that whereas inductors 31 and 30 are low-pass filters, the combination of capacitor 55 with potentiometer 56 forms an adjustable high-pass filter. Both filters are commonly connected to the two channels of source 13 so that the identical proportions of each channel's signal program information in the selected ranges are applied to the common or central channel provided by speaker 10.

Speakers 11 and 12 are responsive only to mid- and high-range signals, as has been noted above. Speaker 11 receives the program signal information from the channel supplying secondary 34. Speaker 12 receives the program signal information supplying secondary 35.

In the positioning of speakers for a stereophonic listening installation, speaker 10 may be the central speaker in the listening area and speakers 11 and 12 may be at left and right respectively.

The left program channel of the stereophonic source then appears in the left speaker with a substantial predominance of the mid- and high-range signals thereof.

This would be speaker **11**. Similarly the right program channel of the stereophonic source appears in right speaker **12**. Low-range signals from both of the channels are applied to center speaker **10** along with only preselected proportions of the mid- and high-range signals as derived from the adjustment of potentiometer **56** by its arm **57**. The adjustment of potentiometer **56** is accomplished by the listener to provide sufficient of the mid- and high-range signals mixed from both channels in the center speaker to give him the subjective experience of a central presence, such as might occur when there is a soloist at stage center in the original performance, and the left and right speakers, respectively, give the impression that specific portions of the program source are being performed at the left and others are at the right.

Thus by employing a circuit configuration of the novel form shown in FIGURE 2 and illustrated broadly in FIGURE 1, the psychophysiological impression of a live performance is recreated for the listener who experiences the sensation of the instruments and soloists or other program subject material in their apparently natural locations in the original occurrence of the performance or program. The result is accomplished with inexpensive components to provide the equivalent of a three channel system, whereas by prior methods a complete second full-range speaker system would have been required. Futhermore, the speakers such as **11** and **12** at the sides may be small and compact.

When the listener desires to experience the stereophonic result with the system of this invention he keeps the original wide-range speaker he may have had and with a second amplifier and a pair of economical speakers such as **11** and **12** he adds the element **24** of FIGURE 1, using his original speaker as speaker **10**. The resultant system is then connected as illustrated in FIGURE 2. Element **24** of FIGURE 1 encompasses the low-pass filters **30** and **31**, and the high-pass filter network including resistors **32** and **33**, capacitor **55**, and potentiometer **56**. Since the human psychophysiological reaction to the low frequencies does not provide a directional sense as does the response to mid and high-frequency signals, or sounds, speakers **11** and **12** need not be responsive below about 300 cycles per second. The low frequencies being present will in no way add to the directional perception expected in stereophonic listening. Speakers of the character of **11** and **12** are more economical and compact. A corollary result is achieved in the reduction of intermodulation distortion by relieving the side speakers of the requirement of bass reproduction.

The network **24** provides for the mixing of high- and mid-range signals from both channels in the original wide-range, also termed above full-range, speaker **10**. These

high- and mid-range signals may be completely eliminated from the speaker **10**, or applied at a predetermined level. Low-range signals from both channels appear in speaker **10** at one level and are normally not further adjusted. Speaker **11** responds to mid- and high-range signals from a left-channel source and speaker **12** responds to mid- and high-range signals from a right-channel source, while speaker **10** responds to signals of the low range from both channels, and to selected adjusted levels of the mid- and high-range signals from both channels. The mixing of the signals from both channels in speaker **10** does not effect the operation of either the left or right channel. More than one speaker for each of **11** or **12** may be used either near the side speakers or near the central speaker.

What is claimed as new is:

A loudspeaker system comprising: a two-channel source of audio signals; a first loudspeaker connected to one of said channels of said source, and being responsive to predetermined ranges of signals in said channel; a second loudspeaker connected to the other channel of said source, and being responsive to similar predetermined ranges of signals in said other channel; a third loudspeaker a pair of low-pass filters connected together at one end of each in a common junction, the other end of each, respectively, being connected to one, respectively, of said channels in said source, said common junction being connected to said third loudspeaker; a pair of resistors connected together at one end of each, forming a second common junction, the other end of each, respectively, being connected to one, respectively, of said chcannels in said source; a capacitor; and a potentiometer, said capacitor being connected between said second common junction and said potentiometer, said potentiometer being connected to said third loudspeaker, whereby said third loudspeaker normally responds to a range of frequencies passed by said low-pass filters from said two channels of said source of signals to said third speaker, and upon adjustment of said potentiometer responds also to said predetermined range of frequencies to which said first and second speakers are responsive.

References Cited in the file of this patent

UNITED STATES PATENTS

2,137,032	Snow	Nov. 15, 1938
2,179,840	Bucky	Nov. 14, 1939
2,273,866	Hoist et al.	Feb. 24, 1942
2,481,576	De Boer	Sept. 13, 1949
2,520,798	De Boer	Aug. 29, 1950

FOREIGN PATENTS

930,006	France	July 28, 1947