United States Patent [19]

Anazawa et al.

[11] **3,916,104**

[45] **Oct. 28, 1975**

[54] **SOUND SIGNAL CHANGING CIRCUIT**

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[73] Assignee: **Nippon Columbia Kabushikikaisha,** Japan

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[21] Appl. No.: **362,006**

Related U.S. Application Data

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[52] **U.S. Cl.** ..... **179/1 G;** 179/1 B

[51] **Int. Cl.²** **H04R 5/00**

[58] **Field of Search** ..... 179/1 VC, 100.1 VC, 1 G, 179/1 D, 1 SW, 1 B; 325/476

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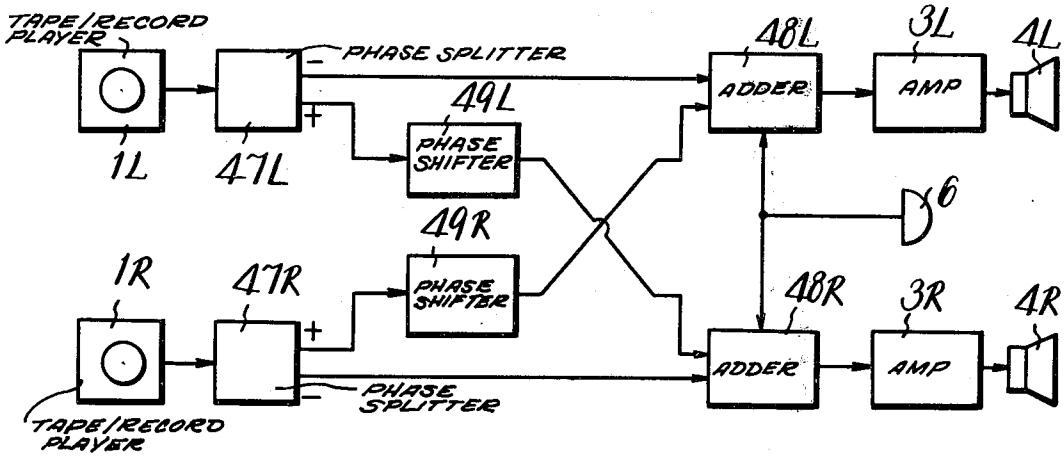
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Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara, & Simpson

[57] **ABSTRACT**

A sound signal changing circuit in which a sound signal component such as singing voice or the like contained in a signal reproduced from a pre-recorded tape, a record or the like is attenuated or removed and a sound signal from a microphone is inserted in the first-mentioned signal in place of the attenuated or removed signal component.

8 Claims, 16 Drawing Figures



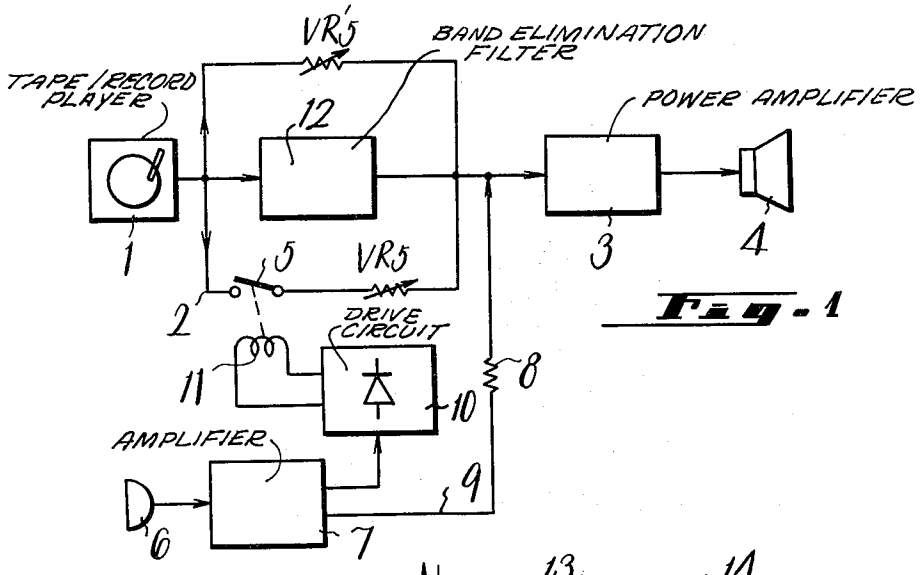


Fig - 1

Fig - 2

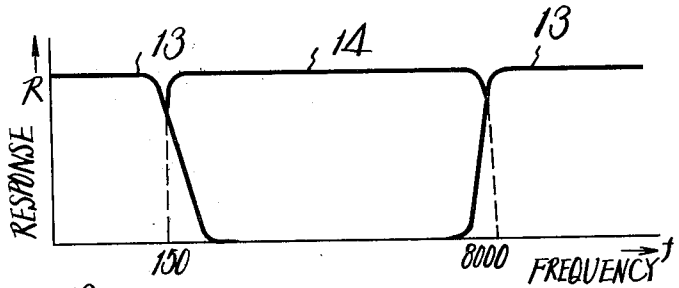


Fig - 3

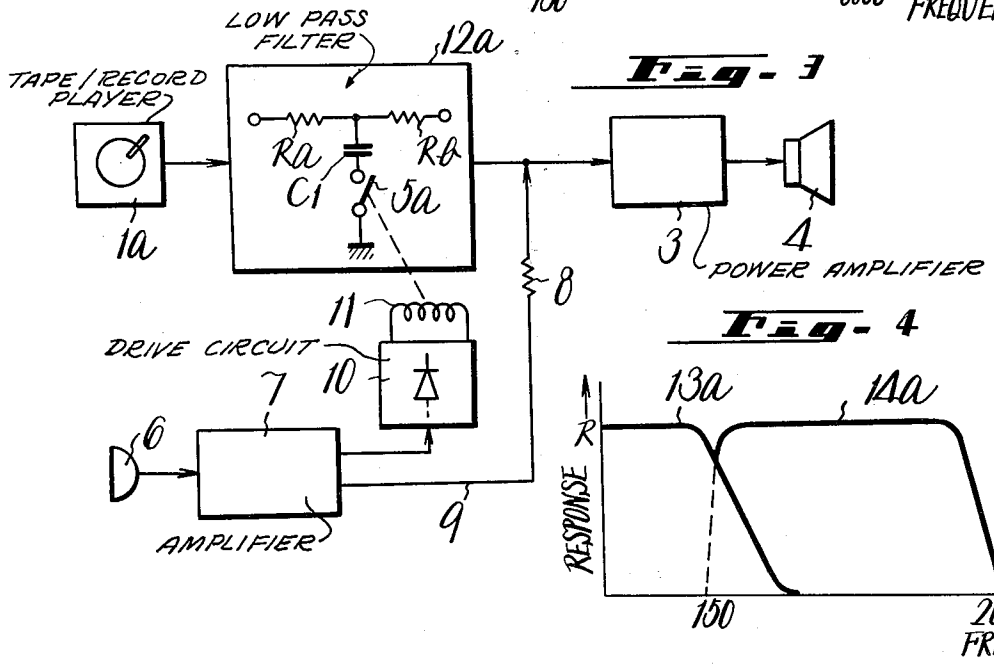


Fig - 4

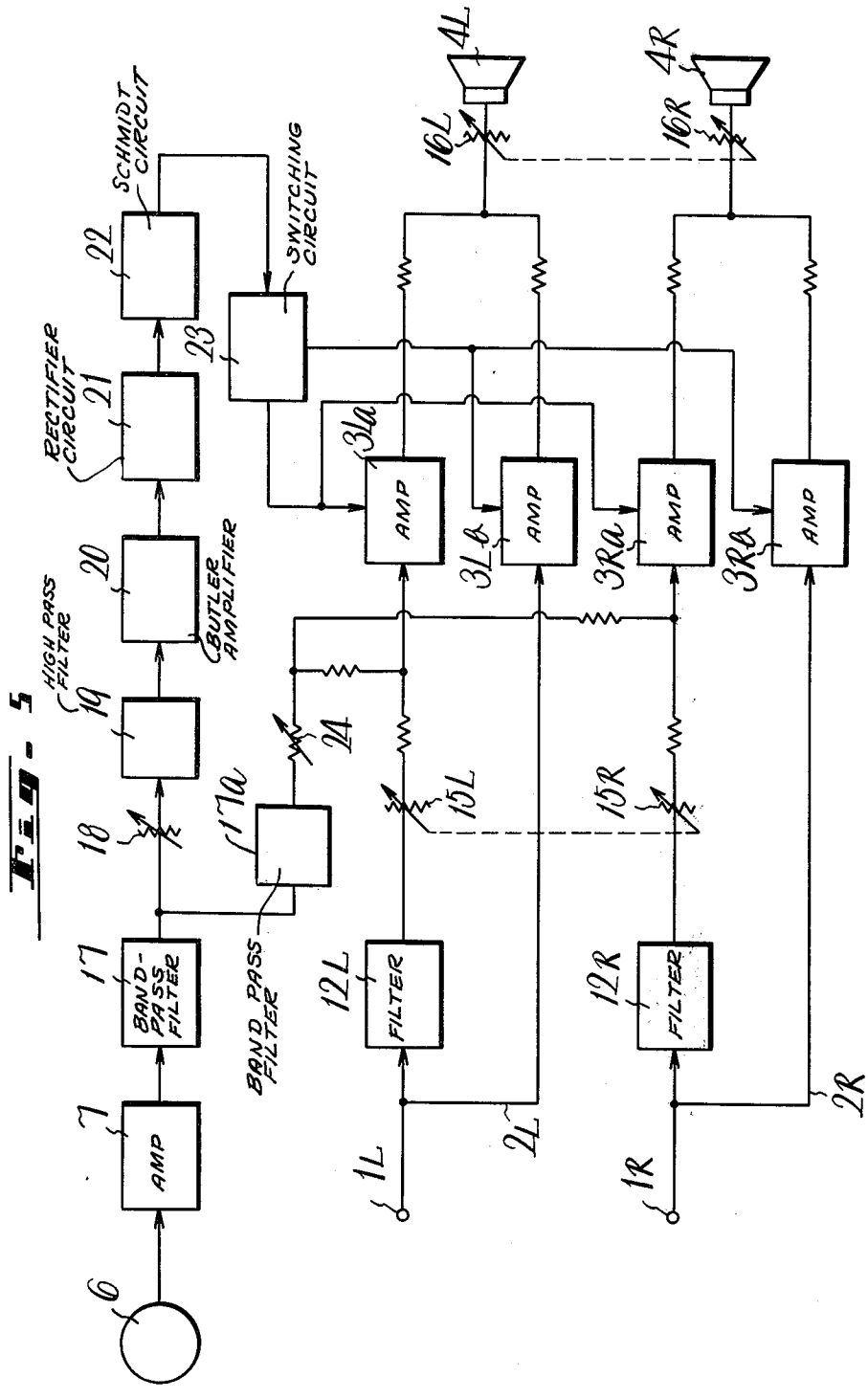

SCHMIDT CIRCUIT
SWITCHING CIRCUIT
RECTIFIER CIRCUIT
BUTLER AMPLIFIER
HIGH PASS FILTER
BAND PASS FILTER
BAND-PASS FILTER
AMP
FILTER
4L
4R
16L
16R
22
23
21
20
19
18
17a
17
7
6
3a
3L
3Ra
3R
24
15L
15R
12L
12R
1L
1R
2L
2R

Fig - 5

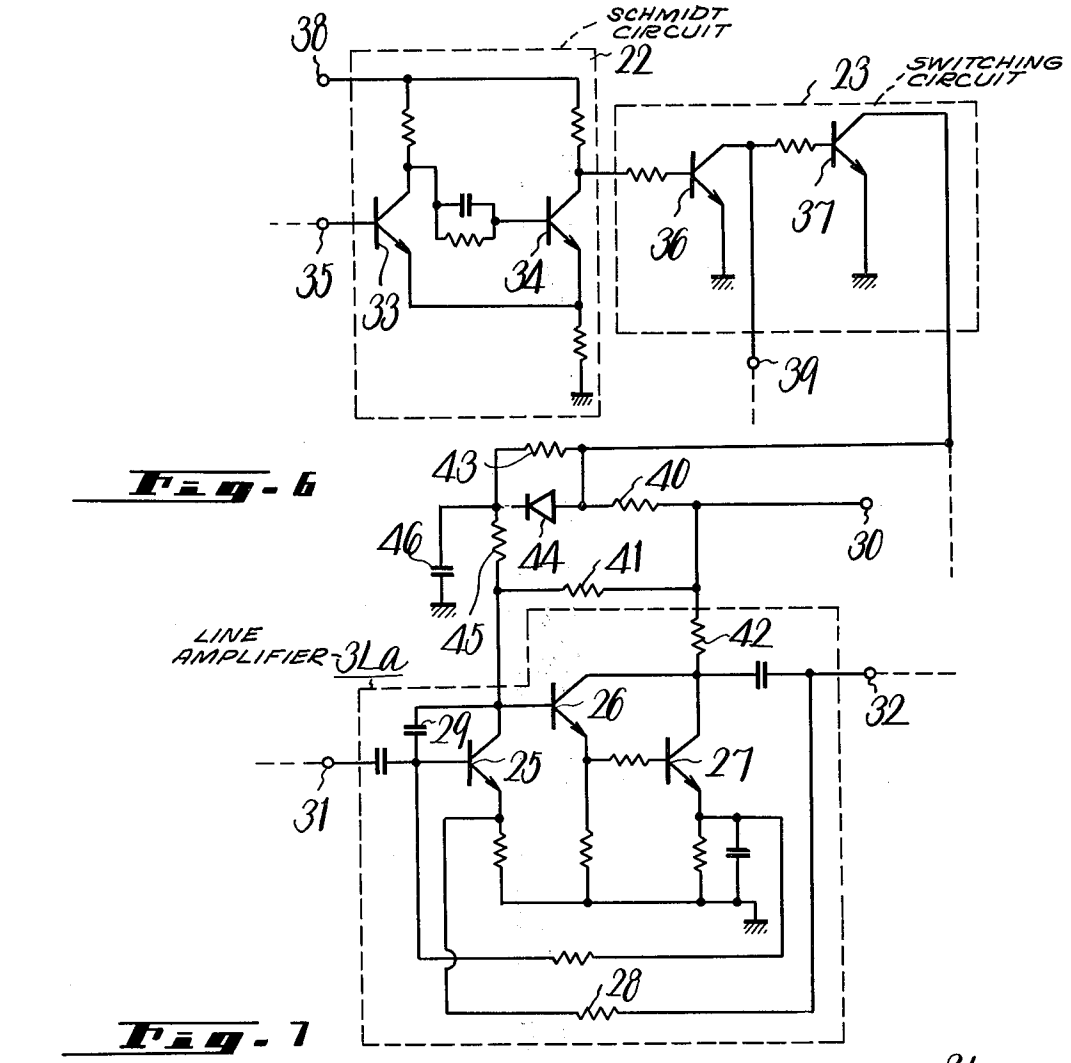

SCHMIDT CIRCUIT
22
23
SWITCHING CIRCUIT
38
35
33
34
36
37
39
43
40
46
44
41
30
45
42
LINE AMPLIFIER 31a
26
29
25
27
32
31
28

Fig. 6

Fig. 7

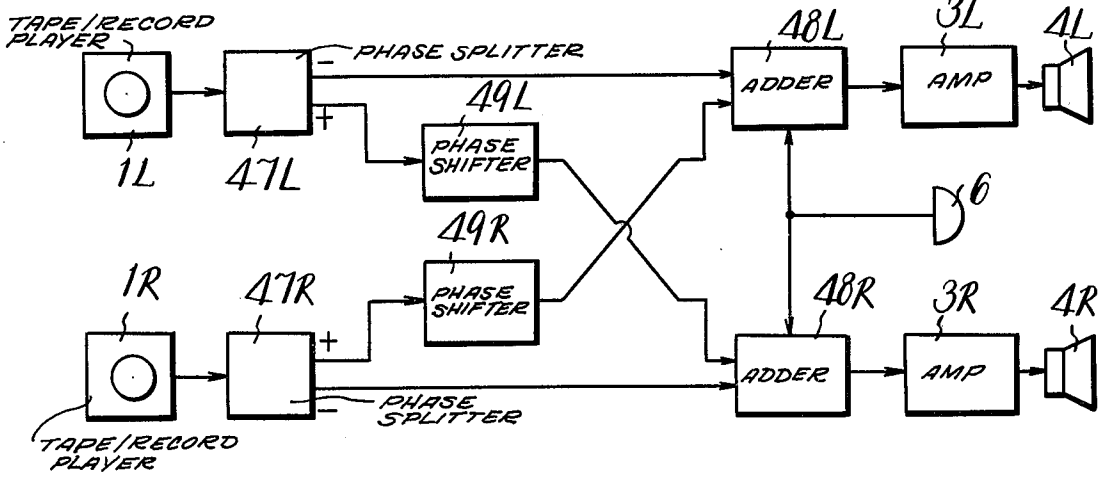

TAPE/RECORD PLAYER
PHASE SPLITTER
48L
3L
4L
ADDER
AMP
49L
PHASE SHIFTER
1L
47L
6
49R
1R
47R
PHASE SHIFTER
48R
3R
4R
ADDER
AMP
PHASE SPLITTER
TAPE/RECORD PLAYER

Fig. 8

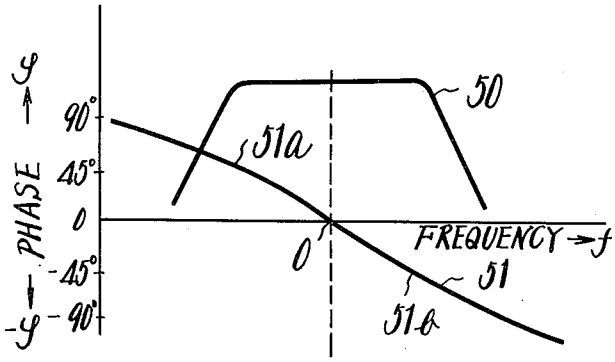


Fig. 13

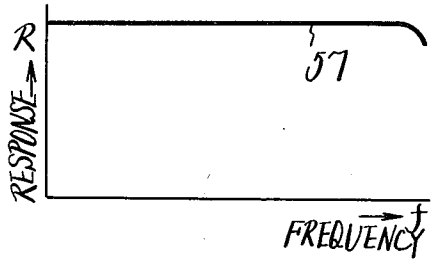


Fig. 14

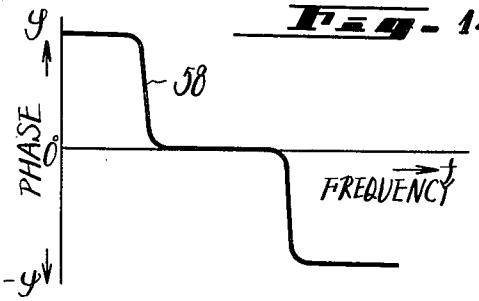


Fig. 9

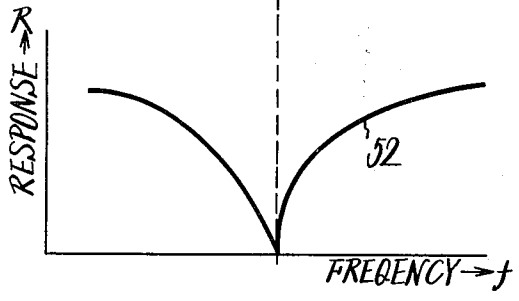


Fig. 15

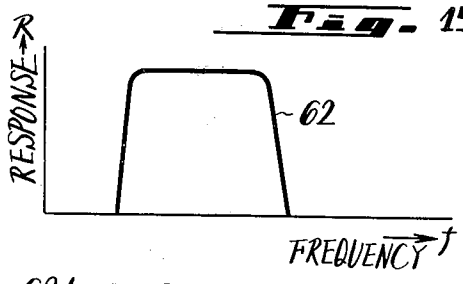
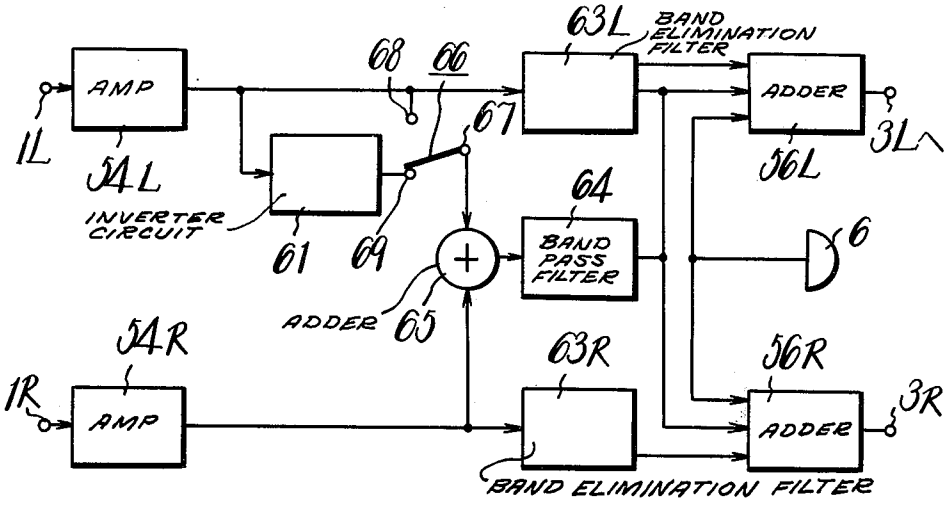
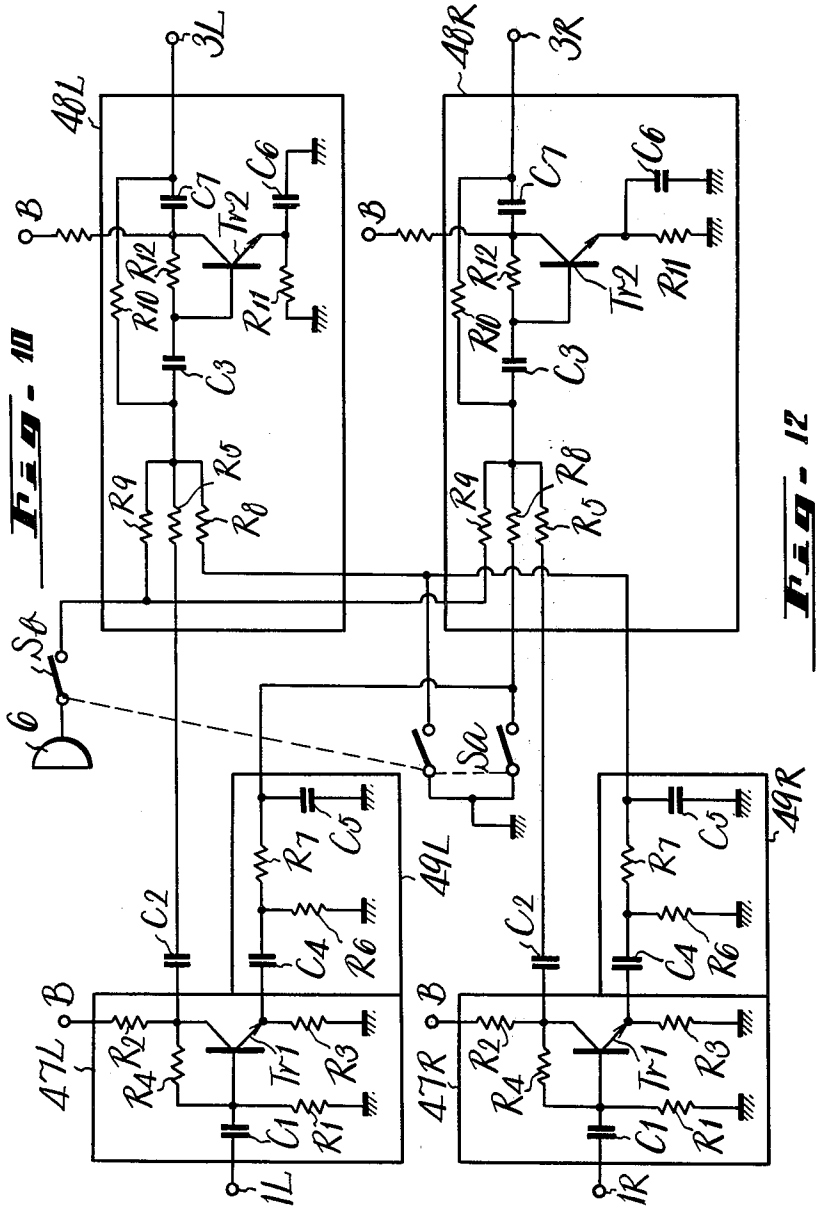
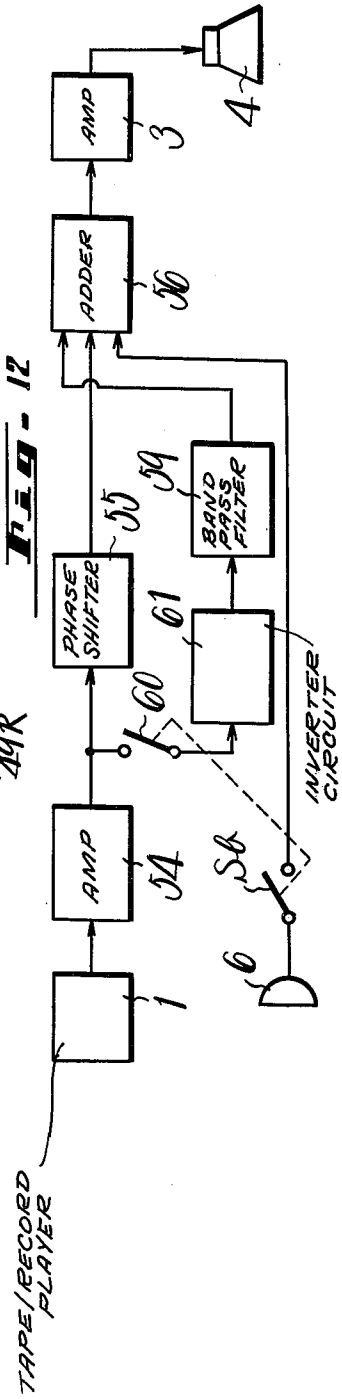


Fig. 16




Fig - 11
1L
1R
47L
47R
49L
49R
48L
48R
3L
3R
B
C1
C2
C3
C4
C5
C6
C7
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
Tr1
Tr2
Sa
Sb
6


Fig - 12
TAPE/RECORD PLAYER
1
AMP
54
60
61
PHASE SHIFTER
55
BAND PASS FILTER
59
ADDER
56
AMP
3
4
INVERTER CIRCUIT
Sb
6

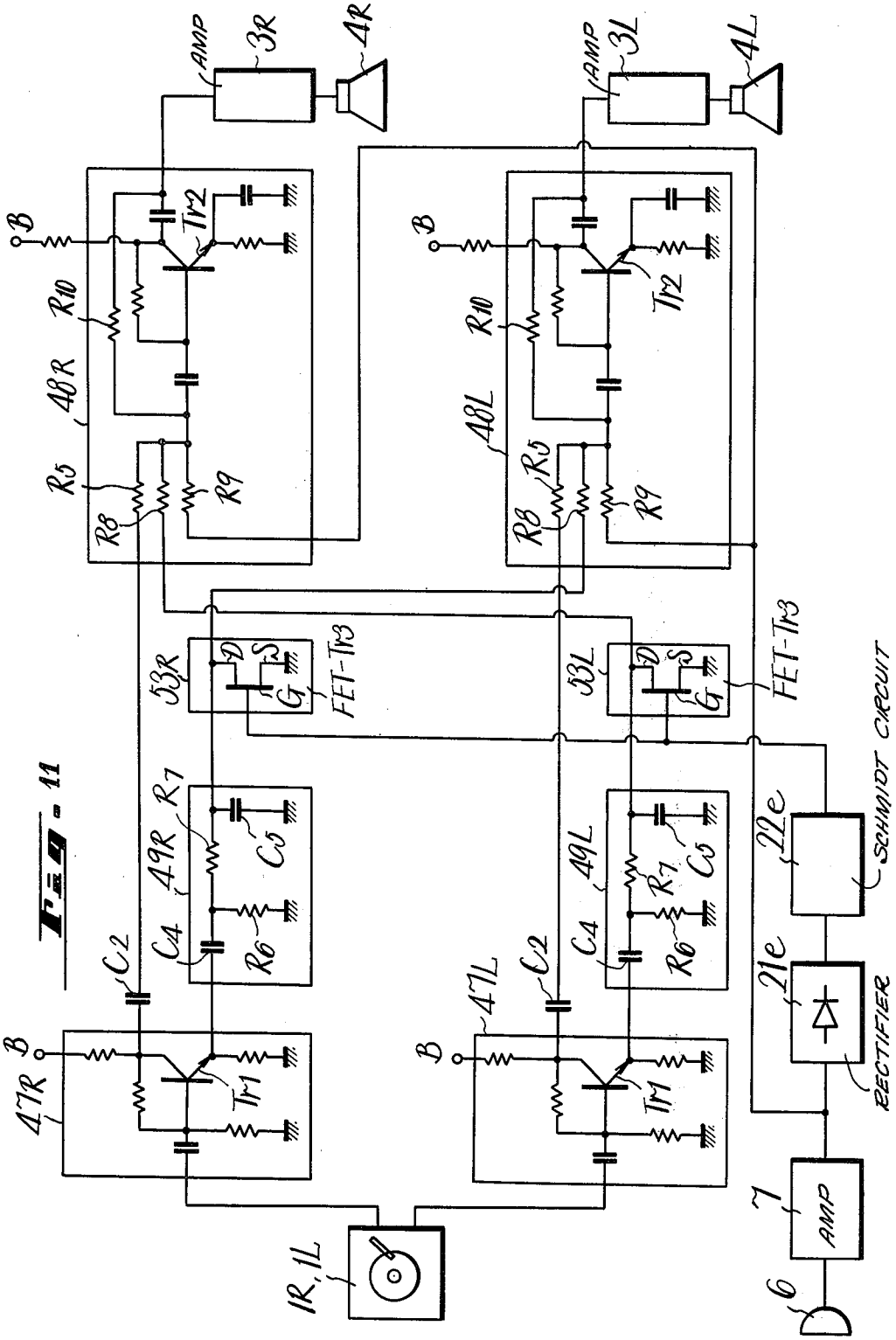

AMP
3R
4R
3L
4L
B
Tr2
R10
48R
48L
R5
R8
R9
53R
53L
FET-Tr3
D
S
G
R7
49R
49L
C5
C4
R6
C2
47R
47L
Tr1
1R, 1L
22e
SCHMIDT CIRCUIT
21e
RECTIFIER
7
6

Fig. 11

SOUND SIGNAL CHANGING CIRCUIT

This is a division of application Ser. No. 276,945 filed Aug. 1, 1972, now U.S. Pat. No. 3,845,244.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates a sound signal changing circuit in which a sound signal eliminating circuits consisting of a band pass filter, a low pass filter or the like and a mixing circuit for mixing a different sound signal with the output signal of the sound signal eliminating circuit are provided or in which a sound signal eliminating circuit for cancelling the stereosignals from a stereo-record in-phase and same in level and a mixing circuit for mixing a different sound signal with the output signal of the sound signal eliminating circuit are provided.

2. Description of the Prior Art

Means for removing noise signal components to make sound signals easy to hear has already been disclosed in the U.S. Pat. Nos. 3,057,960, 3,109,066 and so on. However, there has not been proposed such a sound signal changing circuit that only a singing voice recorded on a disc record or a pre-recorded tape together with an accompaniment is attenuated or removed and a singing voice of the user through a microphone can be inserted in place of the attenuated or removed singing voice originally recorded.

SUMMARY OF THE INVENTION

One object of this invention is to provide a sound signal changing circuit which is adapted so that only vocal sound signal component is removed or attenuated in the signal reproduced from a pre-recorded tape, a disc record or the like and a sound signal applied through a microphone or the like is mixed in place of the removed or attenuated vocal sound signal component.

Another object of this invention is to provide a sound signal changing circuit in which a sound signal removing circuit is automatically actuated upon application of a sound signal through a microphone or the like.

Another object of this invention is to provide a sound signal changing circuit which is adapted to prevent howling due to a microphone and a speaker.

Another object of this invention is to provide a sound signal changing circuit which is adapted to ensure actuation of a switching circuit.

Another object of this invention is to provide a sound signal changing circuit which is adapted so that a vocal sound signal is attenuated or removed in a signal component reproduced from a stereophonic record or the like and signals of the same phase and level to that of the vocal sound signal are cancelled by a sound signal removing circuit.

Still another object of this invention is to provide a sound signal changing circuit in which a switching circuit has a delay characteristic.

Other objects, features and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system diagram of one example of this invention;

FIG. 2 is a graph showing the frequency characteristics of a band elimination filter and a microphone signal in FIG. 1;

FIG. 3 is a system diagram of another example of this invention;

FIG. 4 is a graph, similar to FIG. 2, showing the frequency characteristics of a low-pass filter and a microphone signal in FIG. 3;

FIG. 5 is a system diagram of another example of this invention;

FIG. 6 is a circuit diagram, for explaining a delay circuit part in FIG. 5;

FIG. 7 is a system diagram of another example of this invention;

FIG. 8 is a graph showing the amplitude and phase characteristics of a phase shifter employed in the example of FIG. 7;

FIG. 9 is a graph showing the frequency-response characteristic of the phase shifter;

FIG. 10 is a circuit diagram showing one example of the concrete circuit construction used in the example of FIG. 7;

FIG. 11 is a circuit diagram illustrating another example of the circuit construction of the example of FIG. 10;

FIG. 12 is a system diagram of another example of this invention;

FIGS. 13 to 15, inclusive, are graphs showing the amplitude and phase characteristics of a phase shifter and a band-pass filter employed in the example of FIG. 12; and

FIG. 16 is a system diagram of still another example of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIGS. 1 to 16 embodiments of this invention will hereinafter be described in detail.

In FIG. 1, reference numeral 1 indicates a tape recorder or a disc record player. An output signal component from a tape or a disc record is suitably amplified and, under normal conditions, the amplified output signal component is applied through a line 2 and a power amplifier 3 to a speaker 4, producing a sound therefrom.

The line 2 has incorporated therein a normally closed contact 5. Upon application of a sound signal from a microphone 6, the sound signal component is amplified by an amplifier 7 and the amplified component is supplied to the power amplifier 3 through a mixing resistor 8 of a line 9. While, one part of the output signal from the amplifier 7 is applied to a drive circuit 10. The drive circuit 10 energizes a solenoid 11 with a DC component having detected the signal component of the amplifier 7, turning off the normally closed contact 5. Thus, the signal component from the tape recorder or disc record player 1 is applied to a band elimination filter 12 in which a sound signal component is eliminated over a frequency range determined by a frequency limiting the band of the band eliminating filter and, as a result of this, an output such as shown in FIG. 2 which is mixed with the sound signal component from the microphone 6 is derived from the speaker 4. In FIG. 2, the abscissa represents frequency f and ordinate response R and a curve 13 indicates the frequency characteristic of the band elimination filter 12 and a curve 14 that of the sound signal from the microphone 6. The limited frequency of the band elimination filter 12 is selected within the range of the sound signal. According to our various experiments, good results were obtained with a

lower limit frequency of about 150Hz and an upper limit frequency of about 8000Hz in the case of cutting off only man's voices but the upper limit frequency depends upon the conditions for eliminating recorded signals to be cut off. In the above case the signal from the tape or disc record is entirely eliminated but if the normally closed contact **5** of the line **2** is replaced with a variable resistor VR5 or if a variable resistor VR5' is connected in parallel with the band elimination filter **12**, the signal from the tape or disc record can be attenuated by controlling the variable resistors VR5 or VR5'. In this case, it is a matter of course that the drive circuit **10** and the solenoid **11** are unnecessary.

Referring now to FIG. **3**, another example of this invention will be described in detail. In the figure, parts corresponding to those in FIG. **1** are identified by the same reference numerals. Reference numeral **1***a* designates a signal source such as a TV signal component or a signal component including a sound signal of FM radio broadcast wave. In the present example, the band elimination filter **12** in FIG. **1** is replaced with a low-pass filter **12***a* and the low-pass filter **12***a* consists of two resistors R_1 and R_2 and a capacitor C_1, and the capacitor C_1 and the aforementioned relay contact **5** are interposed between the connection points of the series connection of the two resistors R_1 and R_2 and ground. The contact **5** is a normally open contact in this case.

With such an arrangement, the output signal from the signal source **1***a* such as a tape recorder or record player is somewhat attenuated by the resistors R*a* and R*b* and then applied to the power amplifier **3**. Upon application of a sound to the microphone, the normally open contact **5***a* connected in series with the capacitor C_1 is turned on to constitute the low-pass filter **12***a*, by which the sound signal frequency range of the signal component from an imput signal **1***a* is cut off to provide a low frequency component **13***a* such as depicted in FIG. **4**, which is applied to the power amplifier **3**. At this time, a signal component **14***a* from the microphone **6** is mixed with the low frequency component **13***a*. In this case, the frequency band corresponding a mixed chorus is completely cut off, so that a user's sing through the microphone **6** is mixed with the musical signal.

Although the foregoing examples have been described to employ the band elimination filter **12** and the low-pass filter **12***a* respectively, these filters may be any type of filters so long as they attenuate or cut off signals of man's voice frequency components and a high-pass filter may be used therefor. It has been found that the use of the low-pass filter is simple and makes the reproduced sound appear natural to a listener. Further, the position of the connection of the filter is not so important and it may be disposed forwardly or rearwardly of any one of several stages of voltage amplifiers (not shown) located at the stage prior to the power amplifier **3**. Connected to the stage prior to the voltage amplifier, the low-pass filter **12***a* is likely to pick up induced noise to produce hum but it does not matter if care is taken of in the shielding and in the arrangement of parts. Especially where an input signal from the tape recorder **1** or the like is great, substantially no induced noise is picked up. Further, the cut off frequency is selected lower than the lowest frequency of the man's voice and when the cutoff frequency is too low, the reproduced sound becomes unnatural and when it is too high, the sound signal from the input **1** is a little reproduced. Similarly, if the attenuation factor is too high, the reproduced sound becomes unnatural, so that the attenuation factor is usually selected to range about 6 to 12dB/oct. According to our experiments, it has been found that 12dB/oct is the best.

While the drive circuit **10** has been described to be automatically actuated by the output signal from the amplifier **7**, it may also be actuated by hand. It is possible, of course, that a silicon controlled rectifier, a transistor or the like is used as the drive circuit while being gated.

Turning now to FIG. **5**, a further sound signal changing circuit of the invention will be described in detail which is capable of faithful reproduction of the mixed sound signals without generating howling. In the figure parts corresponding to those in FIG. **1** are marked with the same reference numerals. Reference numerals **1R** and **1L** designate input terminals supplied with, for example, stereo right and left signals from a pickup respectively. The input terminal **1L** is connected to a speaker **4L** through a line amplifier **3L***b* inserted in a line system **2L** and, at the same time, it is connected to the speaker **4L** through a band elimination filter **12L** inhibiting the passage therethrough of the intermediate frequency (800 to 5000Hz) component and through a line amplifier **3L***a*. Likewise, the input terminal **1R** is connected to a speaker **4R** through a line amplifier **3R***b* inserted in a line system **2R** and, at the same time, it is connected to the speaker **4L** through a band elimination filter **12R** inhibiting the passage therethrough of the intermediate frequency component and through a line amplifier **3R***a*. Between the band elimination filter **12L** and the line amplifier **3L***a* and between the band elimination filter **12R** and the line amplifier **3R***a* variable resistors **15L** and **15R** connected respectively which are ganged with each other, and variable resistors **16L** and **16R** are provided in association with the speakers **4L** and **4R** respectively.

The output from the microphone **6** is supplied to a band-pass filter **17** through the amplifier **7**. The band-pass filter **17** passes only the intermediate frequency component unlike the aforesaid band elimination filters **12L** and **12R**. The output of the band-pass filter **17** is applied through a variable resistor **24** to the line amplifiers **3L***a* and **3R***a* and through a variable resistor **18** to a high-pass filter **19** which is provided, if necessary, and permits the passage therethrough only of a high frequency component (higher than 3000Hz). The output of the high-pass filter **19** is converted by a buffer amplifier **20** into a low impedance output, which is rectified by a rectifier circuit **21**. With the output of the rectifier circuit **21**, a Schmidt circuit **22** is actuated and a switching circuit **23** is actuated with the output of the Schmidt circuit **22**. The switching circuit **23** consists of, for example, two NPN-type transistors having emitters grounded and is constructed so that either one of the transistors may be turned on with the output of the Schmidt circuit **22**. The collector of the one transistor is connected to power source terminals of the aforesaid line amplifiers **3L***b* and **3R***b*, while the collector of the other transistor is connected to power source terminals of the aforementioned line amplifiers **3L***a* and **3R***a*. Namely, when no sound input is applied to the microphone **6** and consequently when no output is derived from the band-pass filter **17**, the output of the Schmidt circuit **22** is at ground potential and the switching circuit **23** is in its normal condition and the power source

terminals of the line amplifiers 3L*a* and 3R*a* are grounded. On the other hand, when an output is derived from the band-pass filter **17**, the power source terminals of the line amplifiers 3L*b* and 3R*b* are grounded. Such a switching operation is achieved several seconds after the output of the Schmidt circuit **22** rises up to a high level.

With the construction described above, accompaniment is reproduced by the disc record player and then the reproduced signal is supplied to the input terminals **1L** and **1R** from the pickup. Where no input is applied to the microphone **6**, the power source terminals of the line amplifiers 3L*a* and 3R*a* are grounded, so that the reproduced signals from the input terminals **1L** and **1R** are amplified by the line amplifiers 3L*b* and 3R*b* and supplied to the speakers **4L** and **4R**. When voices, by way of example, are applied to the microphone **6**, a sound signal is derived at the output of the band-pass filter **17** and the sound signal is supplied as an input to the line amplifier 3L*a* and, at the same time, rectified and supplied to the Schmidt circuit **22**. While, supplied with the rectified input, the Schmidt circuit **22** provides an output which lasts at high level and the switching circuit **23** is thereby actuated. As a result of this, the power source terminals of the line amplifiers 3L*b* and 3R*b* are rendered at the ground potential and, at the same time, the power source terminals of the line amplifiers 3L*a* and 3R*a* are put to a predetermined operative potential. Thus, the reproduced signals from the input terminals **1L** and **1R**, after having their intermediate frequency components removed, are mixed with the sound signal from the microphone **6** and amplified by the line amplifiers 3L*a* and 3R*a* and applied to the speakers **4L** and **4R** to produce sounds that the accompaniment and vocal sound are mixed together. Of course, it is also possible to mix narration with background music.

With the above construction, since the speakers **4L** and **4R** and the microphone **6** are provided, it may be considered probable that howling occurs. However, occurrence of howling can be effectively prevented with the construction of this invention that the band-pass filter **17** is connected to the output of the microphone **6**. Namely, when the signal derived from the pickup or the signal that this signal and the sound signal from the microphone **6** are mixed together is applied to the speakers **4L** and **4R** to produce sound, even if the produced sound is applied to the microphone **6**, only the intermediate frequency component (800 to 5000Hz) is supplied through the band-pass filter **17** to the speakers **4L** and **4R**, so that the low frequency component (mainly 500 to 800Hz) which is the cause of howling can be prevented from being applied to the speakers **4L** and **4R**. Especially, when the audio signal that the sound signal derived from the microphone **6** and that from the pickup are mixed together is applied to the speakers **4L** and **4R** to produce sound, the audio signal is complicated in frequency component and high in level, and consequently howling is likely to occur. Also in such a case, if howling occurs, it can be removed by making the microphone **6** inoperative momentarily or stopping supply of the sound momentarily. Thus, since the operation of the switching circuit **23** has a time constant of about several seconds, the signals from the input terminals **1L** and **1R** pass through the band elimination filters **12L** and **12R** for the period of several seconds to remove their intermediate frequency components and the signals are applied to the speakers **4L** and **4R**. Further, even if the sounds from the speakers **4L** and **4R** are applied to the microphone **6**, the low frequency component likely to cause howling is removed by the band-pass filter **17**, so that howling can be well prevented from occurrence.

Further, in the present invention, the high-pass filter **19** is provided, by which the switching circuit **23** is prevented from being actuated by frequency components lower than 3000Hz, which is likely to cause howling. Accordingly, in this case, the output of the microphone **6** is not supplied to the speakers **4L** and **4R**, ensuring to avoid howling.

With the present invention, occurrence of howling can be prevented positively by the various howling preventive operations described above and, as a result of this, the signal that the reproduced signal from the record or the tape and the sound signal from the microphone **6** are mixed together can be faithfully reproduced through the speakers **4L** and **4R**. In the above example, it is also possible, of course, that a band-pass filter **17***a* is inserted in the mixing line at a stage prior to the variable resistor **24** separately or together with the band-pass filter **17** as indicated by a broken line.

The apparatus described above is defective in that clicks are heard from the speakers **4L** and **4R** at the time of change-over of the switching circuit **23**. In addition, even if the sound input to the microphone **6** is momentarily interrupted, the switching circuit **23** often operates to produce clicks.

With reference to FIG. **6**, another example of this invention will hereinafter be described in detail which is adapted so that the signal path is changed over by the switching circuit **23** a predetermined time after an output is derived from the microphone **6** to ensure effective prevention of clicks. The line amplifier 3L*a* is formed with, for example, NPN-type transistors **25, 26** and **27** directly coupled with each other and includes a negative feedback loop having inserted therein a resistor **28** and an oscillation preventive capacitor **29**. Reference numeral **30** designates a power source terminal of the line amplifier 3L*a*, 31 an input terminal supplied with the output of the band elimination filter 12L and 32 an output terminal. The Schmidt circuit 22 is made up of NPN-type transistors 33 and 34 and its input terminal 35 is supplied with the output of the rectifier circuit 21. The output terminal of the Schmidt circuit 22 is connected through a resistor to the base of an NPN-type transistor 36 having its emitter grounded and the collector of the transistor 36 is connected through a resistor to the base of an NPN-type transistor 37. These transistors 36 and 37 constitute the switching circuit 23. Reference numeral 38 identifies a power source terminal of the Schmidt circuit 22.

A terminal **39** connected to the collector of the transistor **36** of the switching circuit **23** is connected to power source terminals of the line amplifiers 3L*b* and 3R*b*, though not shown, While, the collector of the transistor **37** is connected through a resistor **40** to the power source terminal **30** of the line amplifier 3L*a*. Similarly, the collector of the transistor **37** is connected to a power source terminal of the line amplifier 3R*a*. The power source terminal **30** is connected through a resistor **41** to the collector of the transistor **25** of the line amplifier 3L*a* and, at the same time, to the collectors of the transistors **26** and **27** through a resistor **42**. Further, the connection point of the collector of the

transistor 37 of the aforesaid switching circuit 23 with the resistor 40 is grounded through a parallel circuit consisting of a resistor 43 and a diode 44 and a capacitor 46. The electrode of the capacitor 46 which is not grounded is connected to the collector of the transistor 25 through a resistor 45 and, at the same time, to the collectors of the transistors 26 and 27 through resistors 41 and 42.

With the arrangement described above, when no sound input is applied to the microphone 6, no input signal is applied to the Schmidt circuit 22, so that the transistor 33 of the Schmidt circuit 22 is turned off while the transistor 34 thereof is turned on. Consequently, the transistor 36 of the switching circuit 23 is turned off while the transistor 37 is turned on. Thus, the line amplifiers 3L*b* and 3R*b* are operative, while the line amplifiers 3L*a* and 3R*a* have their power source terminals grounded, and hence are inoperative.

Upon application of a sound to the microphone 6, the on and off states of the transistors 33 and 34 of the Schmidt circuit 22 are inverted to turn on the transistor 36 and off the transistor 37. Then, the capacitor 46 is charged by the DC current from the power source terminal 30. The charging time constant at this time is substantially determined by the resistor 40 and the capacitor 46. Accordingly, the line amplifier 3L*a* is put in its operative condition after a predetermined period of time determined by the charging time constant after the application of the sound to the microphone 6. Thus, the line amplifier 3L*a* is altered from its inoperative condition to its operative condition with a predetermined time after changing over the Schmidt circuit 22 and the switching circuit 23, so that clicks are not reproduced through the speakers.

On the contrary, when the supply of sound to the microphone 6 is interrupted, the transistor 36 of the switching circuit 23 is turned off and the transistor 37 is turned on. Accordingly, the power source terminal 30 is grounded, but charge stored in the capacitor 46 is discharged through the resistor 43. The discharge time constant is substantially determined by the resistor 43 and the capacitor 46. Also in the case where the line amplifier 3L*a* is altered from its operative condition to its inoperative one, it becomes inoperative with a predetermined period of time after no output is derived from the microphone 6, so that no clicks are produced through the speakers.

Although the power source terminal 30 is connected through the resistors 41 and 42 to the collectors of the transistors 25, 26 and 27, this is a loop for the so-called preheating for flowing a preliminary current to the transistors by the fact that the resistance values of the resistors 41 and 42 are selected great enough to cut off the transistors. It may be also possible to construct the resistors 41 and 42 as variable resistors and select the charge and discharge time constants suitable. Of course, the line amplifiers 3R*a*, 3L*b* and 3R*b* except the line amplifier 3L*a*, which are controlled by the switching circuit 23 to be operative or inoperative, are also similarly constructed.

Thus, the present invention provides an apparatus that no uncomfortable clicks are produced through the speakers 4L and 4R when the line amplifiers 3L*b*, 3R*b* or 3L*a*, 3R*a* are changed over in accordance with the presence or absence of the output from the microphone 6. Especially, even if the output of the microphone 6 is momentarily interrupted, for example, during narration, the line amplifier is held in its controlled condition for a predetermined time period, for example, 1 to 2 seconds, so that it is possible to reproduce faithfully the audio signal that the voice and the reproduced signal from the input terminals 1L and 1R are mixed together.

With such voice suppressing means, the signal component of a musical sound of a musical instrument other than the voice is also removed according to the selection of the band frequency of the band elimination filter and faithful reproduction is impossible and, in addition, the overall circuit construction is complicated.

With reference to FIGS. 7 to 17, sound suppression circuits will hereinbelow be described which are free from the above defects and novel in construction. In stereophonic reproducing apparatus, when a stereosignal of musical instruments containing vocal signal is recorded on a record or tape, in order to locate the vocal signal and the signal of the musical instruments at a proper position, they are mixed with each other with a predetermined level and phase. This will be specifically described with reference to right and left channels of the stereophonic reproducing apparatus. In order to direct the vocal sound signal at the center between right and left speakers, the vocal sound signal must be applied to the right and left channels in the same phase and at the same level. Sounds of rhythm instruments and other melody instruments are suitably spread out to right and left from the center. (In the case of two channels, the phase does not matter, so that the sound signals are processed as in-phase between the two channels.)

Thus, the stereosignal containing a vocal signal from the musical instruments is reproduced with a stereophonic effect as if the sound of each musical instrument is disposed stereophonically. This invention is to remove only a specific sound positioned between the right and left signals recorded on a record or a pre-recorded tape with minimum influence on the other musical sounds in the playback system. In FIG. 7, elements corresponding to those in FIG. 5 are identified by the same reference numerals and no detailed description will be repeated. First signal components recorded on a record or a pre-recorded tape in a manner to be positioned centrally and supplied to the input terminals 1L and 1R are applied to phase spliters 47L and 47R to provide outputs of opposite phases respectively. The negative phase components (−) from the phase spliters 47L and 47R are applied to adders 48L and 48R and the in-phase components (+) are also fed to the adders 48R and 48L but through phase shifters 49L and 49R. A vocal sound signal component desired to be mixed with the first signal components is applied to the respective adders 48L and 48R from the microphone 6, so that while the microphone 6 is operative, sound having the vocal sound signal component is mixed in the band and a vocal sound signal reproduced from the record or the pre-recorded tape is suppressed and the microphone signal can be reproduced from the speakers 4L and 4R through the power amplifiers 3L and 3R.

The frequency-phase and amplitude characteristics of the above-mentioned phase shifters 49R and 49L are selected as shown in FIG. 8. As will be apparent from the phase characteristic curve 50 showing the amplitude characteristic between the inputs and outputs of the phase shifters 49R and 49L, the outputs of the phase shifters 49R and 49L are completely opposite in

phase to each other at the point of the phase shift being zero, so that if their levels are exactly equal to each other, the amount of amplitude is zero and their elimination characteristics are such as indicated by a curve **52** in FIG. **9**.

If the left and right output signals are taken as Lout and Rout respectively, the following equations hold:

$Lout = L - R(\phi)$

$Rout = R - L(\phi)$

where L and R are left and right input signals and $R(\phi)$ and $L(\phi)$ functions determined by the phase characteristics of the phase shifters.

FIG. **10** is a concrete circuit diagram of the example depicted in FIG. **7**. The input terminals **1L** and **1R** are connected to the bases of transistors Tr_1 of the phase spliters **47L** and **47R** through coupling capacitors C_1 respectively. Reference characters R_1 and R_4 designate base resistors, R_3 emitter resistors, R_2 load resistors and B voltage sources. The collectors of the transistors Tr_1 are connected to the bases of amplifying transistors Tr_2 through coupling capacitors C_2 and C_3 and mixing resistors R_5 respectively. Further, filters each consisting of a capacitor C_4 and a resistor R_6 and having such a phase characteristic **51***a* in FIG. **8** that an emitter output of each transistor Tr_1 opposite in phase to its collector output is converged from +90° to 0 and filters each consisting of a resistor R_7 and a capacitor C_5 and having such a phase characteristic **51***b* in FIG. **8** that the above-mentioned emitter output is converged from −90° to 0 are connected in series to each other, providing the phase shifters **49L** and **49R**. The outputs of the phase shifters **49L** and **49R** are applied to opposite side adders **48R** and **48L** through resistors R_8 respectively. The aforesaid resistors R_5 and R_8 and those R_9 for mixing the output signal from the microphone **6** are connected to the bases of the transistors Tr_2 in parallel to each other, by which added outputs determined by the ratios of the above resistors to those R_{10} connected between the bases and collectors of the transistors Tr_2 can be derived at output ends.

Reference character C_6 indicates by-pass capacitors, R_{11} emitter resistors, R_{12} base resistors and C_7 coupling capacitors. Reference character S*a* designates a switch for making this circuit inoperative, which is preferred to be ganged with a microphone switch S*b*.

In FIG. **11** there is illustrated an example in which the switch S*a* ganged with that S*b* of the microphone **6** in FIG. **10** is formed with a field effect transistor FET-Tr_3. The parts corresponding to those in FIG. **10** are marked with the same reference numerals and characters and no detailed description will be given. The signals derived from the left and right phase shifters **49L** and **49R** are applied to left and right gate circuits **53L** and **53R** respectively. Each of the gate circuits **53L** and **53R** may be formed with the field effect transistor FET-Tr_3 and the output signal of each phase shifter is applied to the drain D of the field effect transistor FET-Tr_3, the source S of which is grounded and the gate G of which is supplied with a drive pulse from the microphone **6**. The outputs of the left and right gate circuits **53L** and **53R** are applied to left and right mixing circuits **48L** and **48R** so that they may be mixed with opposite signals.

While, the signal component from the microphone **6** is applied to the mixing resistors R_8 after suitably amplified by the amplifier **7**. One part of the amplified signal component is, for example, envelope-detected by a detector circuit **21***e* and shaped by a waveform shaping circuit **22***e*, so that a gate waveform may be obtained when a vocal sound signal is applied to the microphone **6**. The gate waveform thus obtained is applied to the gates of the field effect transistors FET-Tr_3.

The operation of the circuit constructed as described above will be described. Under normal conditions that the microphone **6** is held inoperative, the signal components derive from the collectors of the transistors of the left and right phase spliters are fed through the left and right mixing circuits and the left and right power amplifiers **3L** and **3R** to the left and right speakers **4L** and **4R**, producing sound therefrom.

In this case, since no vocal sound signal is derived from the microphone **6**, the resistance between the sourse S and drain D of the field effect transistor FET-Tr_3 of each gate circuit is low. Accordingly, if the impedance on the side of each phase shifter is selected higher than the resistance between the source S and drain D, the signals from the phase shifters **49R** and **49L** are cut off.

When a vocal sound signal component is derived from the microphone **6**, it is amplified by the amplifier **7** and mixed in the mixing resistor R_8. The signals reproduced from the record or the tape and applied through the input terminals **1L** and **1R** are converted into signals of opposite phases by the phase spliters and their output signals are applied to the gate circuits **53L** and **53R**. However, since the gate of the field effect transistors FET-Tr_3 of each gate circuit is supplied with a gate pulse which is produced by detecting and shaping the vocal sound signal, the resistance between the drain D and source S of the field effect transistor is high and the output of each phase shifter is gated.

The same is true of the left signal component, so that only the vocal sound signal is removed or suppressed but the signal component of the sound of the musical instrument within the band of the vocal sound signal is not removed or suppressed, as in the case of employing the band elimination filter.

In FIG. **12** there is shown another example of this invention which is adapted to attain the same object as that in the example of FIG. **11**. In the figure, elements corresponding to those in FIG. **11** are identified by the same reference numerals and characters and no detailed description will be repeated.

The signal component from a record or a prerecorded tape **1** is amplified by an ordinary amplifier **54** and applied to the speaker **4** through a phase shifter **55**, an adder **56** and the power amplifier **3**, producing sound. The frequency-amplitude characteristic of the phase shifter **55** is selected substantially flat in an audible frequency range as indicated by a curve **57** in FIG. **13** and the frequency-phase characteristic is selected equal to the phase characteristic of a band-pass filter **59** described later, as indicated by a curve **58** in FIG. **14**. Further, the adder **56** is so constructed as to be determined by a constant ratio of a resistor connected between the collector and base of one amplifying transistor with a mixing resistor connected to the base of the amplifying transistor, as is the case with the circuits indicated by **48R** and **48L** in FIG. **11**.

By turning on the normally open switch S*b* associated with the microphone **6**, a normally open switch **60** which is ganged with the switch S*b* and connected to the output end shunted from the amplifier **54** is turned on.

To the normally open switch **60** are connected an inverter circuit **61** to which a band-pass filter **59** is connected to achieve an additive operation with the aforementioned adder **56.** The frequency-amplitude characteristic of the band-pass filter **59** is selected to permit the passage therethrough of a certain band, for example, only the vocal signal component, as indicated by a curve **62** in FIG. **15.** Further, its frequency-phase characteristic is selected to be flat in a certain band like the amplitude characteristic, indicated by a curve **58** in FIG. **14.** Consequently, only the vocal component contained in the signal component from the record and contained from the output of the amplifier **54** and inverted by the inverter circuit **61** is permitted to pass through the band-pass filter **59** but since this component is inverted by the inverter circuit when applied to the adder, it is subtracted relative to a similar vocal component applied through the phase shifter and they are cancelled with each other and the vocal sound signal component, for example, a singing voice, from the microphone **6** is superimposed in the band in which the above-mentioned components have been cancelled with each other. In this case, since the phase characteristic of the phase shifter **55** is selected flat only in the band of the vocal signal component, the other signal components of the musical instruments or the like in the band are not cancelled and can be reproduced through the speaker **4.** Accordingly, only the vocal component can be faithfully attenuated or removed.

Turning now to FIG. **16,** another example of this invention will be described, in which similar references designate similar components and stereophonic signals are only handled and the frequency-phase characteristic is not discussed unlike in the above example.

The output signal components are applied to the input terminals **1L** and **1R** and then fed to the power amplifiers **3L** and **3R** through ordinary amplifiers **54L** and **54R,** band elimination filters **63L** and **63R** and adders **56L** and **56R** respectively.

One part of the left signal is applied to an adder **65** through the inverter circuit **61,** a fixed contact **69** of a switch **66** and its movable contact **67** and one part of the right signal is also fed to the adder **65.** Further, a fixed contact **68** of the switch **66** is directly connected from the left signal path so that when the movable contact **67** is turned down to the side of the fixed contact **68,** the left signal component is directly applied to the adder **65.**

The output of the adder **65** is applied to a band-pass filter **64,** the output of which is fed to the left and right adders **56L** and **56R.**

As is the case with the example of FIG. **12,** the signal component from the microphone **6** is added to the aforesaid adders **56L** and **56R.**

The band elimination filters **63L** and **63R** have the same amplitude characteristic as indicated by the curve **13** in FIG. **2** and the band-pass filter **64** has also such an amplitude characteristic as indicated by a curve **62** in FIG. **15.**

If the pass and elimination bands of the band-pass filter **64** and the band elimination filters **63L** and **63R** are selected to correspond to, for example, the vocal signal band, since the movable contact **67** of the switch **66** is turned down to the side of the fixed contact **68** under normal conditions that no mixing is carried out, the vocal signal having passed through the band-pass filter **64** is superimposed by the adders **56L** and **56R** in the band removed by the band elimination filters **63L** and **63R** and, as a result of this, signals within the entire audible frequency band are reproduced through the speakers.

When a vocal signal to be mixed is applied through the microphone **6,** the movable contact **67** of the switch **66** is automatically or manually changed over to the side of the fixed contact **69** and the left signal component is inverted by the inverter circuit **61** and applied to the adder, so that it is cancelled with the right signal component and no vocal components in the left and right signal components are derived from the output of the band-pass filter. Consequently, the vocal component from the microphone **6** is mixed by the adders **56L** and **56R** in the band from which the vocal components in the left and right signal components are removed or attenuated by the band elimination filters **63L** and **63R.**

This invention is featured in that even if a specific band is removed and mixing is achieved as described above, relatively faithful reproduction is possible.

The foregoing examples have been described in connection with the case where man's vocal sound signal component is removed or attenuated from a sound signal frequency component and another man's vocal sound signal is mixed but since only man's voice can be picked up by using a band-pass filter in place of the band elimination filter, the sound signal components of musical instruments can be removed or attenuated. Accordingly, sound signals of other musical instruments can also be mixed very easily.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of this invention.

We claim as our invention:

1. A circuit for eliminating a band of audio frequencies from a stereophonic audio signal and inserting an intermittent audio signal comprising, a left audio signal input terminal, a right audio signal input terminal, a pair of left and right phase splitters respectively connected to said left and right audio signal input terminals and each phase splitter producing two signals separated in phase by 180°, a pair of left and right adders respectively connected to said pair of left and right phase splitters and each adder receiving one of said two signals therefrom, a pair of phase shifters respectively receiving the second of said two signals from said pair of left and right phase splitters and each having the characteristics of band pass filters, one phase shifters receiving an input from said left channel phase splitter and supplying an input to the right channel adder, second phase shifter receiving an input from said right channel phase splitter and supplying an input to the left channel adder, a microphone supplying said intermittent source of audio signals connected to said pair of adders, and a pair of sound reproducers respectively connected to said pair of adders.

2. A circuit for eliminating a band of audio frequencies according to claim **1** including switching means for disconnecting said pair of phase shifters from said pair of adders when said microphone does not supply said intermittent audio signal.

3. A circuit for eliminating a band of audio frequencies according to claim **2** wherein said phase splitters comprise a pair of transistors.

4. A circuit for eliminating a band of audio frequencies according to claim **3** wherein said phase shifters each comprise two section R-C filters with the first sec-

tion having a capacitor in the series leg and a resistor in the parallel leg and the second section having a capacitor in the parallel leg and a resistor in the series leg.

5. A circuit for eliminating a band of audio frequencies according to claim **2** wherein said switching means comprise mechanical switches closed when an intermittent audio signal is supplied by said microphone.

6. A circuit for eliminating a band of audio frequencies according to claim **4** wherein said switching means comprise a pair of field effect transistors connected between ground and the outputs of said phase shifters and said microphone connected to said pair of field effect transistors to ground the outputs of said phase shifters when an intermittent audio signal is not supplied from said microphone.

7. A circuit for eliminating a band of audio frequencies according to claim **6** including a rectifier and a Schmidt circuit connected between said microphone and said pair of field effect transistors.

8. A sound signal changing circuit comprising:

a. a first means for reproducing a first sound signal in which a vocal component and musical component are contained;

b. a second means for cancelling said vocal component from the output of said first means;

c. a third means for producing a second sound signal containing a vocal component;

d. a fourth means for mixing said second sound signal containing a vocal component with the output of said second means, wherein said vocal components of said first means are stereo signals which are the same level and phase, and wherein said stereo signals are applied to phase-splitters from which output signals opposite in phase and level are derived, said output signals from said phase-splitters with one phase are directly applied to adders, while output signals from said phase-splitters with the other phase are applied through phase-shifters to said adders to cancel vocal components having the same phase and level.

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