March 6, 1973 P. R. BARNUM 3,719,782

SYSTEM FOR CHANGING THE OUTPUT RESPONSE CHARACTERISTICS OF AN ACOUSTIC INPUT

Filed Oct. 12, 1971 4 Sheets-Sheet 1

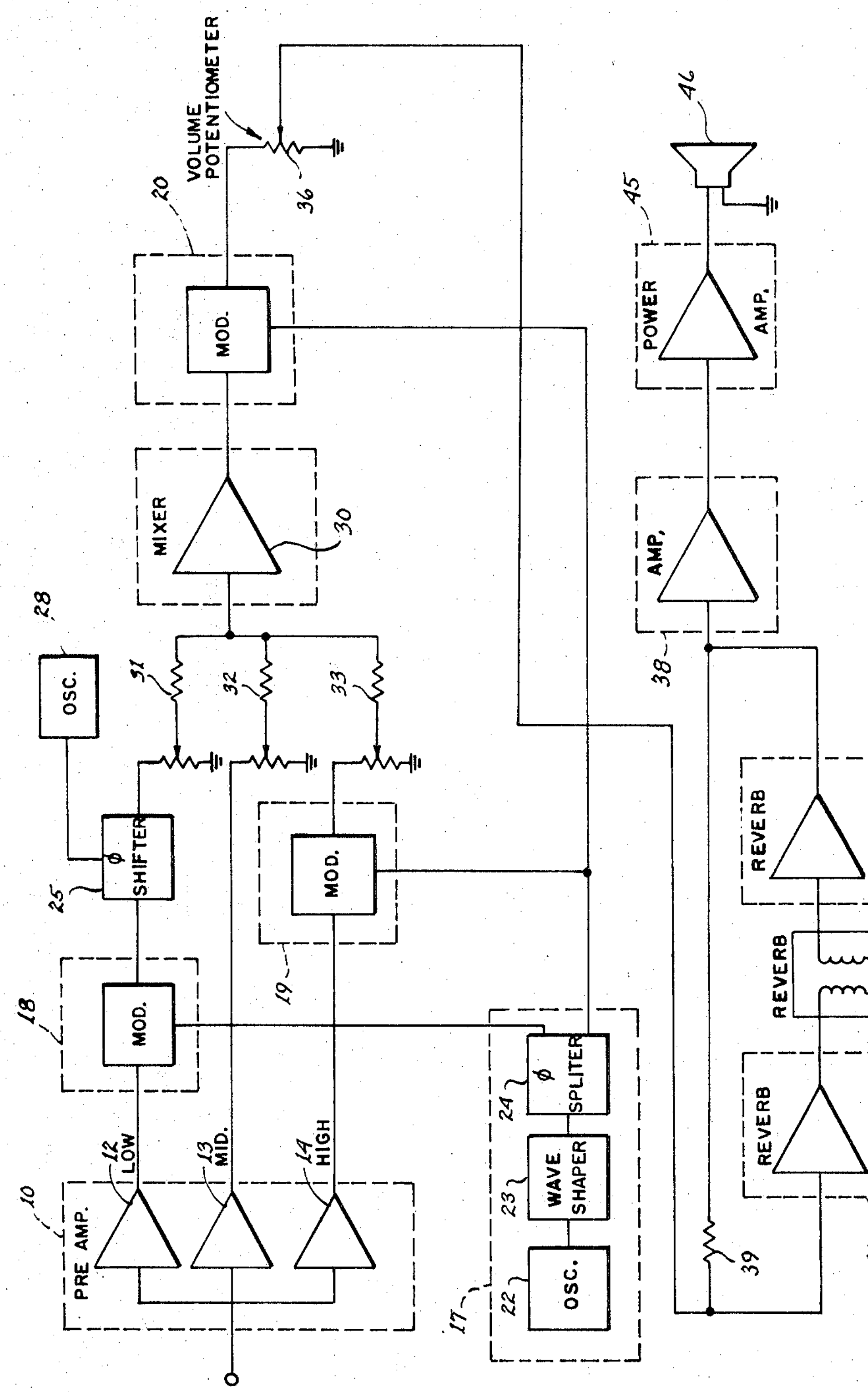


fig. 1

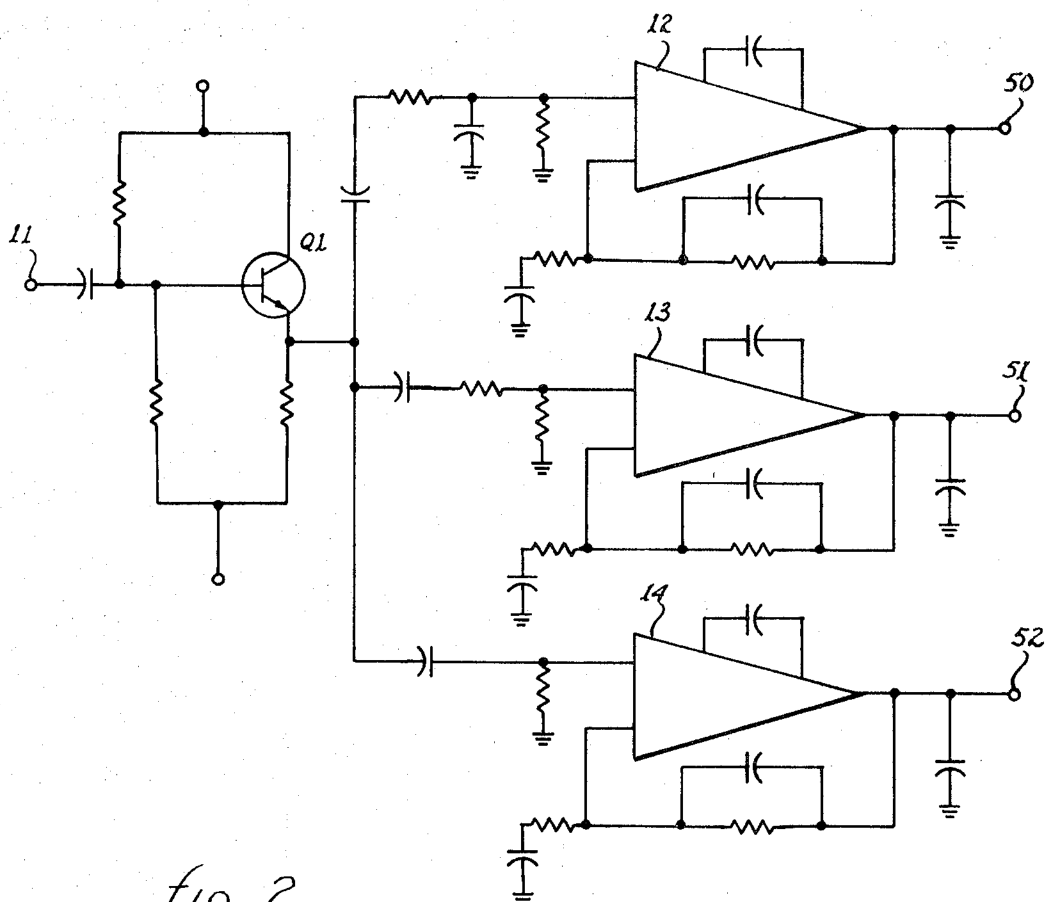


fig. 2

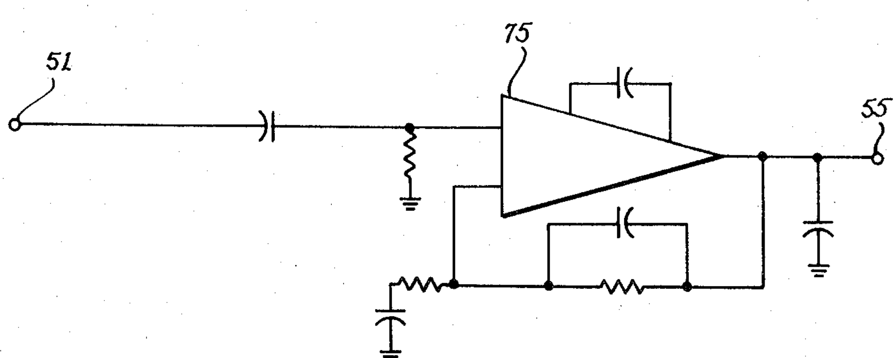


fig. 4

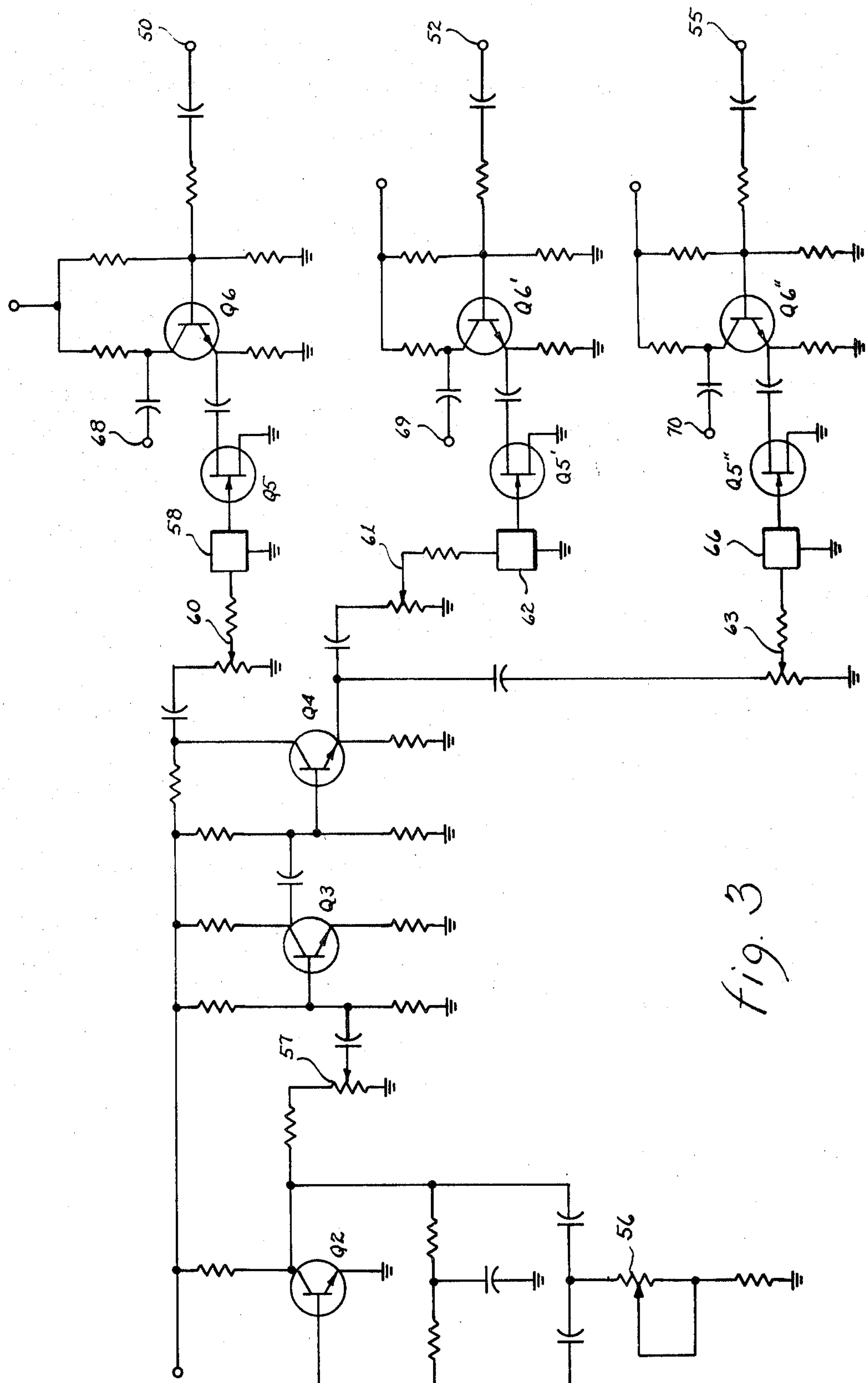


fig. 3

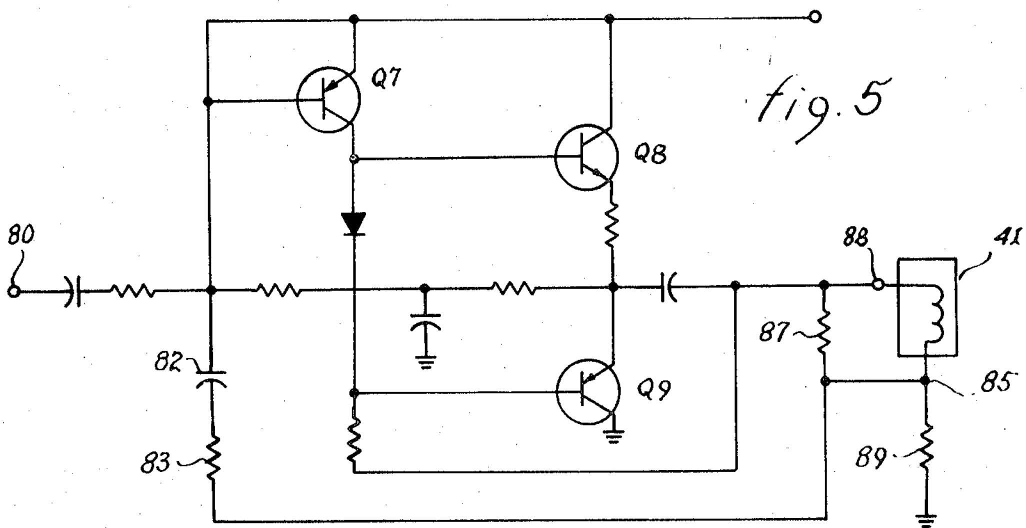
Q7
Q8
Q9
80
82
83
87
88
41
85
89

fig. 5

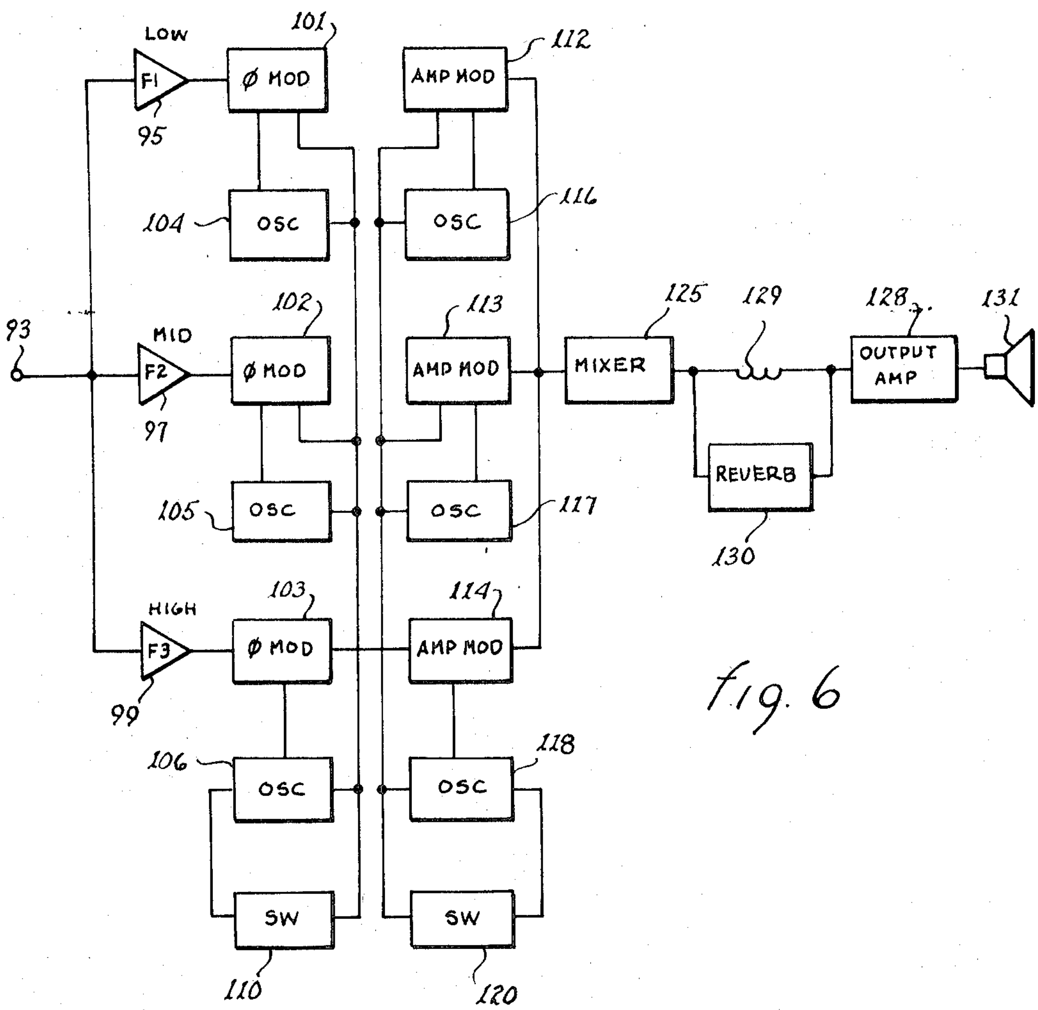
LOW
F1
95
101
φ MOD
AMP MOD
112
104
OSC
OSC
116
93
MID
F2
97
102
φ MOD
113
AMP MOD
125
MIXER
129
128
OUTPUT AMP
131
REVERB
130
105
OSC
OSC
117
HIGH
F3
99
103
φ MOD
114
AMP MOD
106
OSC
118
OSC
SW
SW
110
120

fig. 6

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3,719,782

SYSTEM FOR CHANGING THE OUTPUT RESPONSE CHARACTERISTICS OF AN ACOUSTIC INPUT

Phillip R. Barnum, Mesa, Ariz., assignor to James E. Breene, Chandler, Ariz.

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U.S. Cl. 179—1 J 14 Claims

## ABSTRACT OF THE DISCLOSURE

A sound system is disclosed incorporating a frequency divider for dividing a sound signal into predetermined frequency ranges. Each frequency range is selectively subjected to phase shifting and/or amplitude modulation to produce a desired effect. The modulated frequency ranges are recombined in a mixer and the mixed signal is applied to appropriate amplifying and transducing means through a parallel arrangement of a resistance and a reverb system. Adjustments are provided for altering the inter range phase relationship and for inducing tremolo in selected frequency ranges; tremolo is also selectively provided for the combined and mixed frequency ranges.

## BACKGROUND OF THE INVENTION

The present invention pertains to sound generating systems, and more particularly, to a system for creating desired sound effects when energized by a conventional musical instrument.

The utilization of amplifiers in combination with musical instrumentation is a well developed art; further, special sound effects have been generated through the utilization of oscillators and the like generating tones or sounds to be utilized in combination with an instrument. Embodied in this general prior art are numerous attempts to impart tones and sound effects to a musical instrument to render the sound similar to another instrument. These attempts have, for the most part, been generally unsuccessful in that the sophistication of electronic circuitry required to detect the frequency of the note being played and converting that frequency into the proper tone and harmonic frequencies of the instrument to be imitated has resulted in an extremely complex, cumbersome, and expensive system which is not altogether successful in its simulation of another instrument.

## OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide a sound system that may be utilized to simulate the sound of a desired instrument.

It is another object of the present invention to provide a sound system that is capable of receiving a signal imparted by an instrument and transforming the signal into modified form to render a pleasing effect.

It is still another object of the present invention to provide a sound system incorporating means to separate the frequencies of a detected sound and operate upon the separated frequencies to effect an overall sound change.

It is still another object of the present invention to provide a sound system wherein frequencies of a detected sound are divided and operated upon independently to subsequently be recombined to form a new sound that may simulate an instrument unlike the instrument generating the original sound.

It is still another object of the present invention to provide a sound system wherein a detected sound may be modified to incorporate certain and desirable sound effects, such as tremolo and reverberatory effects.

These and other objects of the present invention will become apparent to those skilled in the art as the description thereof proceeds.



## SUMMARY OF THE CHOSEN EMBODIMENT

The present invention is a sound system incorporating a frequency dividing section wherein an incoming sound signal is divided into three frequency ranges, each range subsequently being operated upon independently of each other range. In a specific embodiment chosen for illustration, the high and low ranges are each subjected to modulation, the frequency of modulation depending upon a desired tremolo effect; the low frequency may further be phase-shifted by an oscillator if it is desired to impose still another effect on the ultimate sound. The three frequencies thus operated upon independently are then mixed and the mixed signal again subjected to modulation of a varying degree, depending on the desired tremolo offect. The mixed signal is then applied to a preamplifier, while a parallel circuit is provided to enable the generation of a reverberatory effect through a delay in recombination of the delayed signal with the original signal. The resulting signal is amplified and applied to an appropriate transducer. The frequency of the tremolo effect is variable and may be preselected to render a desired sound while the phase of the respective frequency ranges may be altered with respect to each other. In the specific embodiment described in detail, the high range frequencies and the mixed frequencies are maintained in phase while the low frequencies are deliberately phase-shifted 180°. This phase shift may be rendered variable by the implementation of a variable phase shifter interposed in series with the low frequency signal.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may more readily be described by reference to the accompanying drawings, in which:

FIG. 1 is a block diagram of a sound system constructed in accordance with the teachings of the present invention.

FIG. 2 is a circuit diagram of a typical preamplifier for use in the block diagram of FIG. 1.

FIG. 3 is a circuit diagram of a tremolo oscillator incorporating a predetermined phase relationship between specific frequency bands and representing certain blocks of FIG. 1.

FIG. 4 is a schematic circuit diagram of a typical mixer for utilization in the block diagram of FIG. 1.

FIG. 5 is a circuit diagram of a unique driver circuit used in the system of the present invention and incorporated in the block diagram of FIG. 1.

FIG. 6 is a schematic block diagram of a modification of the block diagram of FIG. 1 incorporating the teachings of the present invention.

## DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, and particularly to FIG. 1, a preamplifier **10** is provided to receive a signal applied to the terminal **11** from a suitable source. The signal applied to terminal **11** may be derived from any instrument whose sound has been appropriately transduced, such as by a microphone, or through the utilization of other types of transducers, such as contact type, etc. The sound derived from the instrument is transduced to an appropriate electrical signal. The electrical signal thus applied to the terminal **11** is divided into three frequency ranges: low, mid, and high. Each of the respective frequency ranges is amplified in a preamplifier **12**, **13**, and **14**, respectively. Thus, the amplified frequency ranges are each available for manipulation in accordance with a desired sound effect. A tremolo section **17** includes tremolo modulator **18** for the low frequency range, tremolo modulator **19** for the high frequency range, and tremolo modulator **20** for the mixed signal to be described. Each of these modulators **18**, **19**, and **20** derive the tremolo frequency or tremolo "speed" as it is referred to in the art from an oscillator **22**. The signal from the oscillator **22** is appropriately shaped by wave shaper **23** and is applied to a phase splitter **24**, which will be described more completely hereinafter. The phase split tremolo signal is thus applied to tremolo modulator **18**, **19**, or **20**.

The low frequency range may also be utilized as a means to simulate the particular type of sound generated from a speaker known as a "Leslie" speaker. While this phenomena will be described more completely hereinafter, a variable phase shifter **25** may be incorporated in the low frequency range section, the phase shifting of which may be determined by the frequency of an oscillator **28**. The phase shift imposed by the variable phase shifter **25** would result in a frequency shift of the low frequency range of from 20 to 200 hertz. Further, the rate of frequency change would be approximately 6 to 9 times per second. Although it will be obvious that the frequency ranges herein described may vary with regard to the spectrum of frequencies considered within each range, I have found that the usual frequencies considered to be low, mid, or high range are appropriate in working with the sound system of the present invention. Thus, as herein described, high frequencies are considered from 2000 to 10,000 hertz, midrange frequencies are considered from 600 to 2000 hertz, while the low frequencies are generally considered from approximately 40 to 600 hertz.

It may be noted that the low and high range frequencies have been modified while the mid-range frequencies have until now remained unchanged. The separated and modified signals are thus passed to a mixer **30** through potentiometers **31**, **32** and **33** that may be utilized to balance or otherwise alter the relative signal strength among the low, mid, and high freqeuncy ranges. The mixed signal derived from the mixer **30** is applied to the third tremolo modulator **20**. The relationship of the modulation in modulator **20** as compared to the modulation in modulators **18** and **19** will be described more fully hereinafter. The combined signal emanating from the mixer **30** is thus again subjected to the modification of a desired tremolo effect which, of course, may be preselected to be completely inoperative, thus passing the straight signal unmodulated to a volume potentiometer **36**. The signal at **36** is applied to amplifier **38** through a resistor **39** and a reverb effect system paralleling the resistor **39**. This reverb effect system incorporates a reverb driver **40**, a reverb effect unit **41**, and a reverb amplifier **42**. As mentioned previously, the effects of the reverb system provide a delaying effect to the signal applied to the amplifier **38**. Thus, the signal and its delayed counterpart are successively applied to the amplifier, resulting in an echo effect. The output of the amplifier **38** is applied to a conventional power amplifier **45** and subsequently to a suitable transducer **46**.

Referring now to FIG. 2, a typical preamplifier for utilization in the block diagram of FIG. 1 is shown. The input terminal **11** is shown for receiving an input signal as previously described. The signals applied to the base of transistor Q1. The transistor Q1 is connected in an emitter-follower configuration with the output thereof applied to a typical freqeuncy dividing network of resistors and capacitors, each network for passing a predetermined frequency range to a corresponding one of the preamplifiers **12**, **13**, and **14**. The preamplifiers may be of conventional design and may be either discrete circuits or formed of readily available integrated circuits. The outputs of the low, mid, and high freqeuncy preamplifiers **12**, **13**, and **14** appear respectively at terminals **50**, **51**, and **52**.

Referring now to FIG. 3, the tremolo terminals **50** and **52** operate at two of the three inputs to the circuit of FIG. 3. The terminal **55** receives the mixed signal after



the three frequency ranges have been recombined in the mixer **30** (FIG. 1). An oscillator, including transistor Q2, provides the tremolo frequency or "speed" and is variable by adjusting the potentiometer **56**. The magnitude of the modulation to be derived through the utilization of the oscillator may be adjusted through the utilization of the potentiometer **57** from an amplitude of substantially 100% of the total sound amplitude to zero modulation where no tremolo effect is evident. The waveforms derived from the oscillator are amplified through transistor Q3 and applied to the base of Q4; however, it will be noted that both the emitter and the collector electrodes of transistor Q4 are utilized to transmit the amplified waveform from the oscillator to the respective frequency range signals applied at the terminals **50** and **52**. The collector electrode of the transistor Q4 is connected through a manual switch **58** to the control electrode of a Field Effect Transistor (F.E.T.) Q5. A potentiometer **60** provides variable attenuation of the signal applied to the transistor Q5 and may be termed a "depth" control for adjusting the amount of modulating effect imposed on an incoming sound signal.

Similarly, the emitter electrode of the transistor Q4 is connected through a potentiometer **61** (depth control) and a manual switch **62** to the control electrode of F.E.T. Q5'. The emitter electrode of Q4 is also connected through still another potentiometer or depth control **63** and manual switch **66** to the control electrode of F.E.T. Q5''. It may therefore be noted that the signal derived from the transistor Q4 is applied to the three F.E.T.'s Q5, Q5' and Q5''; however, the signal from Q4 applied to Q5 is 180'' out of phase with the signal applied to F.E.T.'s Q5' and Q5''. The low frequency range signal applied to the terminal **50** is connected to the base of transistor Q6 and amplified, while the modulation of the tremolo oscillator is imposed thereon through the connection of the F.E.T. Q5 with the transistor Q6. Similarly, the signals applied to terminals **52** and **55** are applied to the base electrodes of transistors Q6' and Q6'', while the signals amplified therein are modulated by the tremolo modulation signals applied to the respective transistors by F.E.T.'s Q5' and Q5''. Therefore, the low range sound signals applied to the terminal **50** are modulated at the frequency and amplitude determined by the adjustments available at the tremolo oscillator and the resulting modulated signal applied to the low frequency range output terminal **68**. In a similar manner, the high range sound signals applied to terminal **52** and the mixed or tone sound signals, applied to the terminal **55** are each modulated and presented to their corresponding output terminals **69** and **70**. It may be noted that the modulation provided to the low range signals is 180° out of phase with that modulation applied to the high range signals and the mixed signals. This phase differential is fixed in the embodiment shown in FIG. 3; however, it will be understood that a variable phase shift may be imposed between and among the three sound signals being applied to the circuit of FIG. 3 to derive desired sound effects. The switches **58**, **62**, and **66** are each provided to shunt the control electrode of the corresponding F.E.T.'s to ground to enable the operator to remove the tremolo effect from any one or all of the frequency range channels, again to produce a desired effect.

Referring now to FIG. 4, a typical mixer circuit appropriate for utilization in the system of the present invention is shown. The mixer is generally conventional and receives the signals from all the frequency ranges at terminal **51**. The amplifier **75** may take any of numerous well known forms and may, for example, be formed from readily available integrated circuit chips, such as Motorola Mc 1303. The amplified output signal available at terminal **55** is then applied to the circuit previously described in connection with FIG. 3.

As mentioned in connection with the block diagram of FIG. 1, a reverb system including a reverb driver **40**, a reverb unit **41**, and a reverb amplifier **42**, permits the imposition of a delay to the sound resulting in certain desirable sound effects. Reverb units are well known in the art and typically utilize a variety of sonic delay techniques. One such technique incorporates a coiled wire having a transducer at the ends thereof that can be utilized as a sonic delay line to impose a predetermined delay to the signal. Such delay lines are readily available; however, such units generally exhibit the unfortunate characteristic of a variable impedance. The input impedance of such units is a function of frequency and, as shown in FIG. 5, an inductive winding couples the input signal to the reverb unit. The reverb driver of FIG. 5 overcomes the above problems resulting from the variable impedance of such reverb units. The mixed and modulated sound signal is applied to the terminal **80** of the driver and is appropriately amplified by transistors Q7, Q8, and Q9; however, it may be noted that transistors Q8 and Q9 are complementary types. Series connected capacitor **82** and resistor **83** are connected between the base electrode at transistor Q7 and a "summing" point **85** forming one side of the reverb unit **41**. A resistor **87** parallel the reverb unit between a reverb unit input terminal **88** and the summing point **85**; resistor **89** is connected in series with the reverb unit **41** input and is connected between summing point **85** and ground. By proper choice of the resistors **83**, **87**, and **89** as well as a capacitor **82** relative to the power requirements and impedance variation of the reverb unit **41**, a constant current is provided by the driver of FIG. 5 regardless of the impedance variation of the reverb unit **41**. For example, a typical reverb unit presently available on the market will include an impedance variation of from 2 to 22 ohms. Under those circumstances, the following values are typical for the element indicated:

Capacitor **82**=2 microfarads
Resistor **83**=27K ohms
Resistor **87**=20 ohms
Resistor **89**=1 ohm.

The resistor **89** provides negative feedback voltage at the input of the reverb unit **41**. The signal present for feedback is a function of the current through the resistor **89**; at low frequency, the input impedance of the reverb unit **41** appears low, thus resulting in a given IR drop across the resistor **89**. As the frequency of the applied signal increases, the input impedance of the reverb unit **41** appears greater, thus reducing the IR drop across the resistor **89**. The input voltage versus frequency characteristic maintains a constant drive current to the reverb unit **41**; resistor **87** prevents what would otherwise be an open circuit in the event of removal of the reverb unit.

Referring now to FIG. 6, a modification of the system of the present invention is shown incorporating the features of FIG. 1 in a somewhat expanded form. Input terminal **93** receives the original sound signal which is subsequently frequency divided and applied to frequency range preamplifiers **95**, **97**, and **99**. Each of the signals being amplified by one of the amplifiers **95**, **97**, **99** may be phase modulated in a phase modulator **101**, **102**, **103**. Each of the phase modulators **101–103** may be formed using conventional circuit technology and utilizing a continuously variable oscillator **104**, **105**, **106**, respectively, that may be characteristically a zero to 12 hertz oscillator to drive and control the modulation frequency of the respective phase modulator. A switch **110** may be provided to enable all the phase modulators **101–103** to be driven from the oscillator **106** when it is desired that the modulation of all frequency ranges be in phase. The phase modulated signals of the respective frequency ranges are then applied to amplitude modulators **112**, **113**, and **114**. Each of the modulators **112–114** is driven by a corresponding oscillator **116**, **117**, and **118** respectively. The switch **120** is provided to enable all the amplitude modulators **112–114** to be driven from a single oscillator **118**. The single oscillator **118** may be utilized to drive the respective amplitude modulators when it is desired to amplitude modulate all three frequency ranges at an identical frequency. It will be obvious to those skilled in the art that a variety of oscillator configurations may be utilized in the embodiment chosen in FIG. 6 and that under certain circumstances the functions of the phase modulation oscillators and amplitude modulation oscillator may be combined.



The signal originally applied to terminal **93** has thus been divided into frequency ranges, each of which has been independently phase modulated and amplitude modulated. The phase and amplitude modulated signals are then recombined in a mixer **125** and applied to an output amplifier **128** through a resistor **129** and a paralleling reverb unit **130**. The reverb unit may be as described previously in connection with the diagram of FIG. 1; the resulting amplified signal from the amplifier **128** is then applied to an appropriate transducer **131**.

By separating the sound signal derived from an instrument into frequency bands or ranges and phase and/or amplitude modulating signals in these frequency ranges, a great variety of effects can be imposed on the sound. For example, the sound reaching a listener's ear from a mechanically rotating speaker, such as the previously mentioned "Leslie" speaker, is the result of complex interaction of numerous factors, including frequency modulation induced by the Doppler effect of the speaker, beat frequencies, phase and amplitude modulation. By inducing a frequency shift of from 20 to 200 hertz at a rate of approximately 6 to 9 hertz through the utilization of oscillator **28** and phase shift modulator **25** of FIG. 1, coupled with the tremolo modulation afforded by the system of the present invention, the sound of the previously mentioned rotating speaker system can be duplicated. Further, among the great variety of musical sounds that can be imposed on an otherwise unrelated tone, a conventional contact-type microphone can be utilized with a piano to generate organ sounds. It will be apparent to those skilled in the art that many modifications can be made in the system chosen for specific illustration without departing from the scope of the present invention.

I claim:

**1.** In a sound system for manipulating or amplifying an electrical signal corresponding to an acoustical signal, the improvement comprising: a frequency divider connected to receive said electrical signal for dividing said electrical signal into a plurality of range signals, each within a predetermined frequency range; an oscillator for producing a tremolo signal having a predetermined frequency and amplitude; an amplitude modulator connected to said oscillator and connected to receive at least one of said range signals for amplitude modulating said range signal with said tremolo signal; a phase shifting circuit connected to receive said range signals for shifting the phase of at least one of said range signals relative to the other range signals; a mixer connected to receive said range signals from said amplitude modulator and said phase shifting circuit for mixing said range signals to produce an output signal.

**2.** The combination set forth in claim **1**, wherein said tremolo signal is amplified in a transistor having a collector and an emitter, and wherein said collector is connected to amplitude modulate one of said range signals, and said emitter is connected to amplitude modulate another of said range signals whereby said range signals are modulated 180° out of phase with respect to each other.

**3.** The combination set forth in claim **1**, including a second oscillator and wherein said phase shifting circuit is a variable phase modulator connected to said second oscillator for varying the phase of at least one of said range signals relative to the other range signals at a frequency determined by said second oscillator.

**4.** The combination set forth in claim **1**, including a reverb amplifier and an output resistor and wherein said output signal is applied in parallel to said reverb amplifier and said output resistor.

5. The combination set forth in claim 2, including a reverb amplifier and an output resistor and wherein said output signal is applied in parallel to said reverb amplifier and said output resistor.

6. The combination set forth in claim 3, including a reverb amplifier and an output resistor and wherein said output signal is applied in parallel to said reverb amplifier and said output resistor.

7. In a sound system for manipulating or amplifying an electrical signal corresponding to an acoustical signal, the improvement comprising: a frequency divider connected to receive said electrical signal for dividing said electrical signal into high, mid, or low range signals, each within a predetermined frequency range; an oscillator for producing a tremolo signal having a predetermined frequency and amplitude; an amplitude modulator connected to said oscillator and connected to receive said high range signal and said low range signal for amplitude modulating said high and low range signals with said tremolo signal; a phase shifting circuit connected to receive said range signals for shifting said high range and low range signals relative to each other; a mixer connected to receive said range signals from said amplitude and modulator and said phase shifting circuit for mixing said range signals to produce a mixer signal; means connecting said mixer signal to said amplitude modulator for amplitude modulating said mixer signal.

8. The combination set forth in claim 7, wherein said tremolo signal is amplified in a transistor having a collector and emitter and wherein said collector is connected to amplitude modulate said low range signal, and said emitter is connected to amplitude modulate said high range signal whereby said high and low range signals are modulated 180° out of phase with respect to each other.

9. The combination set forth in claim 7, including a second oscillator and wherein said phase shifting circuit is a variable phase modulator connected to said second oscillator for varying the phase of at least one of said range signals relative to the other range signals at a frequency determined by said second oscillator.

10. The combination set forth in claim 7, including a reverb amplifier and an output resistor and wherein said output signal is applied in parallel to said reverb amplifier and said output resistor.

11. In a sound system for manipulating or amplifying an electrical signal corresponding to an acoustical signal, the improvement comprising: a frequency divider connected to receive said electrical signal for dividing said electrical signal into a plurality of range signals, each within a predetermined frequency range; a plurality of oscillators, each corresponding to a different one of said range signals, and each oscillator for producing a tremolo signal; a plurality of amplitude modulators, each corresponding to a different one of said range signals, each connected to a different one of said oscillators and each connected to receive a different one of said range signals for amplitude modulating said range signals with said tremolo signals; a second plurality of oscillators, each corresponding to a different one of said range signals; a plurality of phase modulators, each corresponding to a different one of said range signals, each connected to a different one of said second plurality of oscillators and each connected to receive a different one of said range signals for changing the phase of said range signals relative to each other at a frequency determined by said second plurality of oscillators; a mixer connected to receive said range signals from said amplitude modulators and said phase modulators for mixing said range signals to produce an output signal, a reverb amplifier and an output resistor connected in parallel to receive said output signal.

12. The combination set forth in claim 11, wherein said first plurality of oscillators oscillate at the same frequency and in phase with each other.

13. The combination set forth in claim 11, wherein said second plurality of oscillators oscillate at the same frequency and in phase with each other.

14. The combination set forth in claim 11, wherein said first plurality of oscillators oscillate at the same frequency and in phase with each other and wherein said second plurality of oscillators oscillate at the same frequency and in phase with each other.


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KATHLEEN H. CLAFFY, Primary Examiner

J. B. LEAHEEY, Assistant Examiner

U.S. Cl. X.R.

84—1.24; 179—1 M