March 12, 1963 C. R. EVANS 3,080,785

ELECTROACOUSTIC TONE MODIFYING SYSTEMS FOR STRINGED MUSICAL INSTRUMENTS

Filed Aug. 25, 1958 5 Sheets-Sheet 1

Fig. 1.

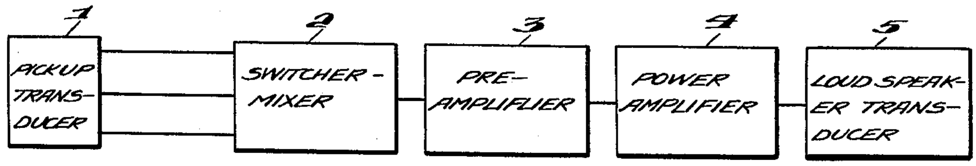

Fig. 2.

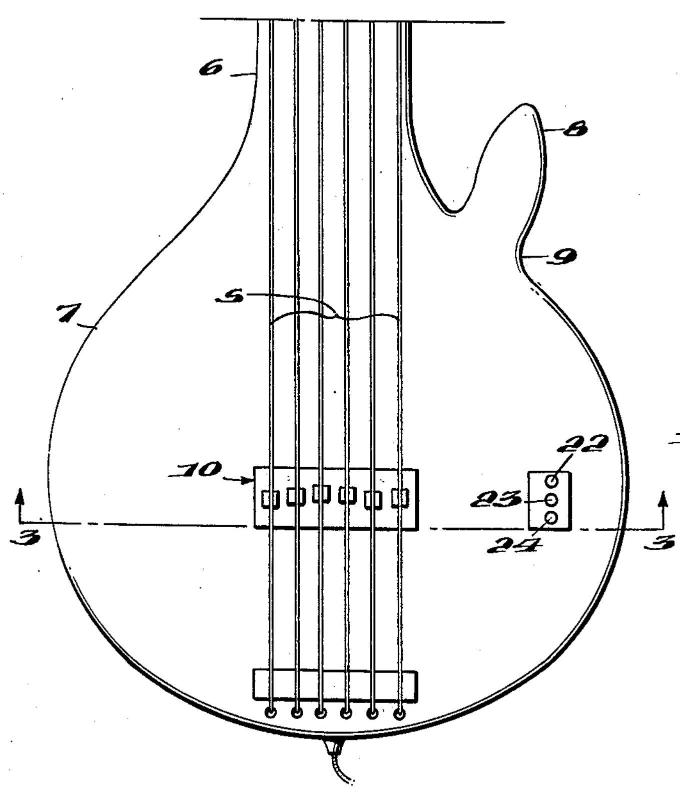

Fig. 4.

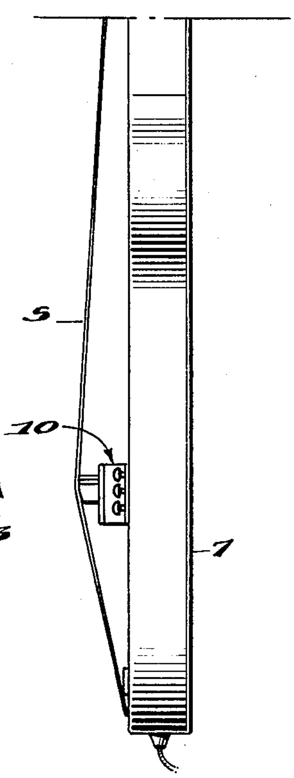

Fig. 3.

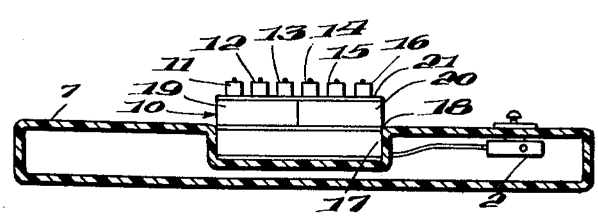

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Fig. 5.

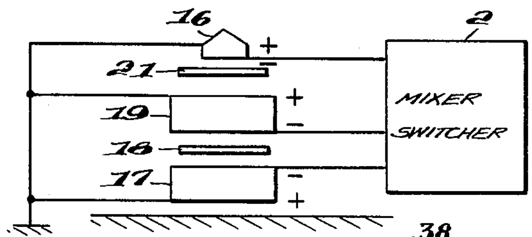


Fig. 6.

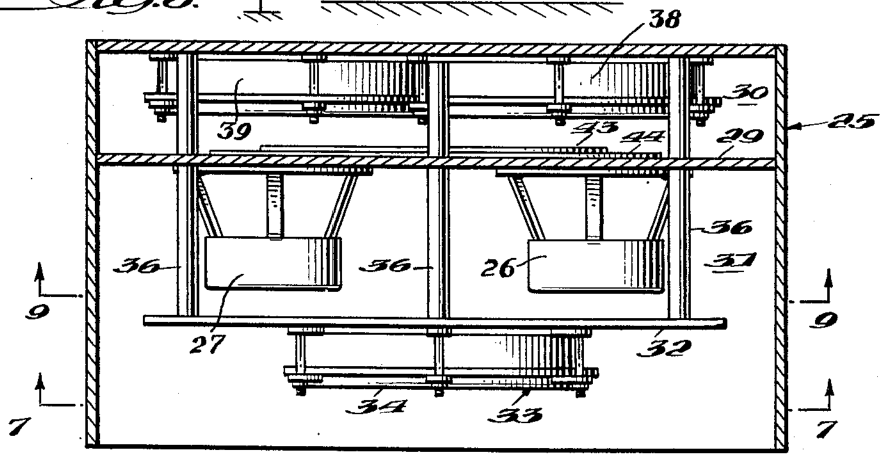
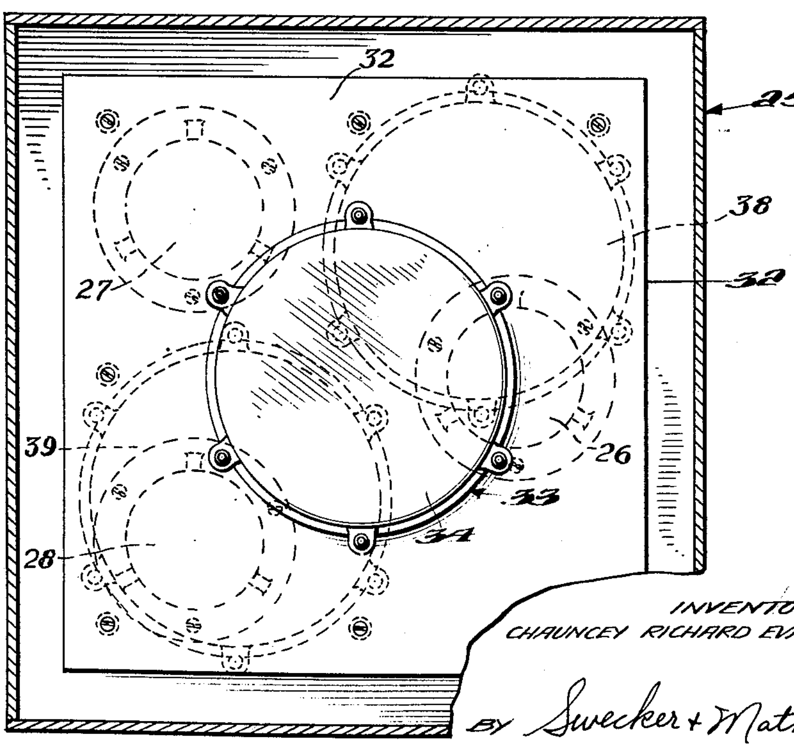


Fig. 7.



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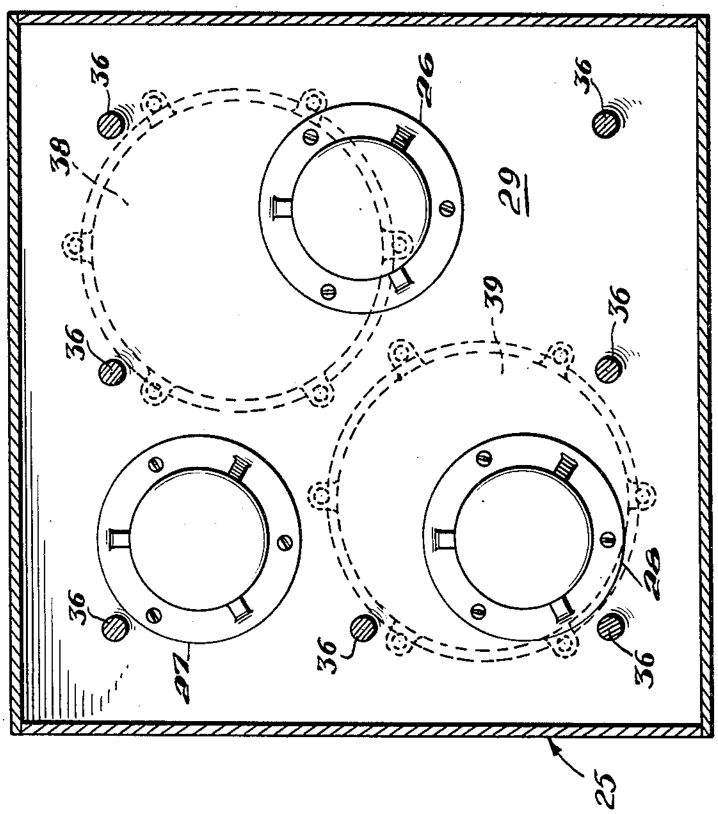

Fig. 9.

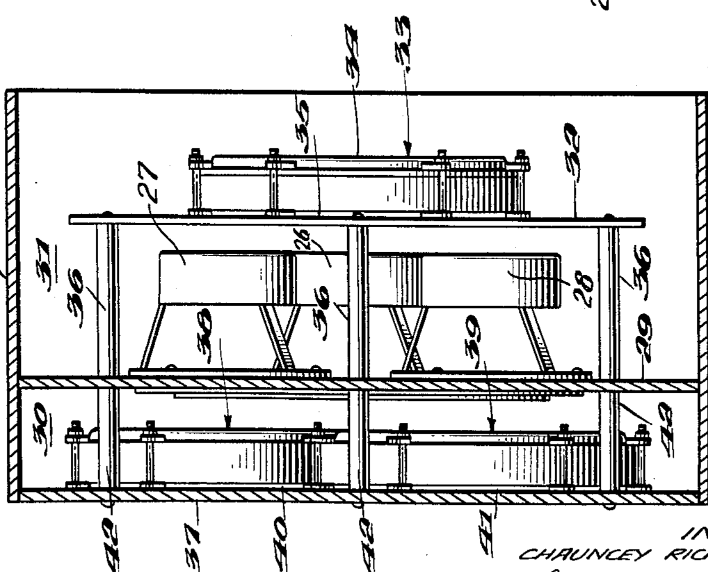

Fig. 8.

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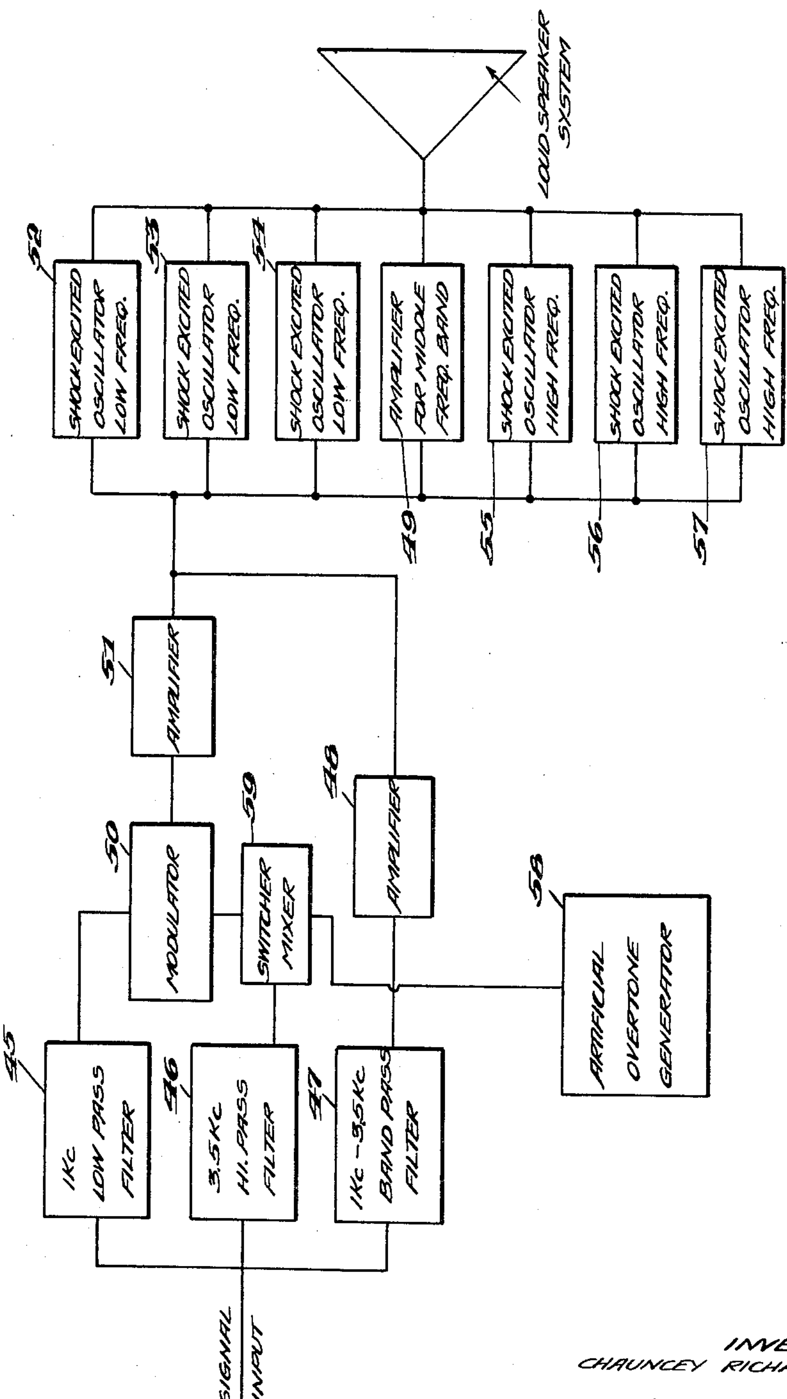

Fig. 10.

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ELECTROACOUSTIC TONE MODIFYING SYSTEMS FOR
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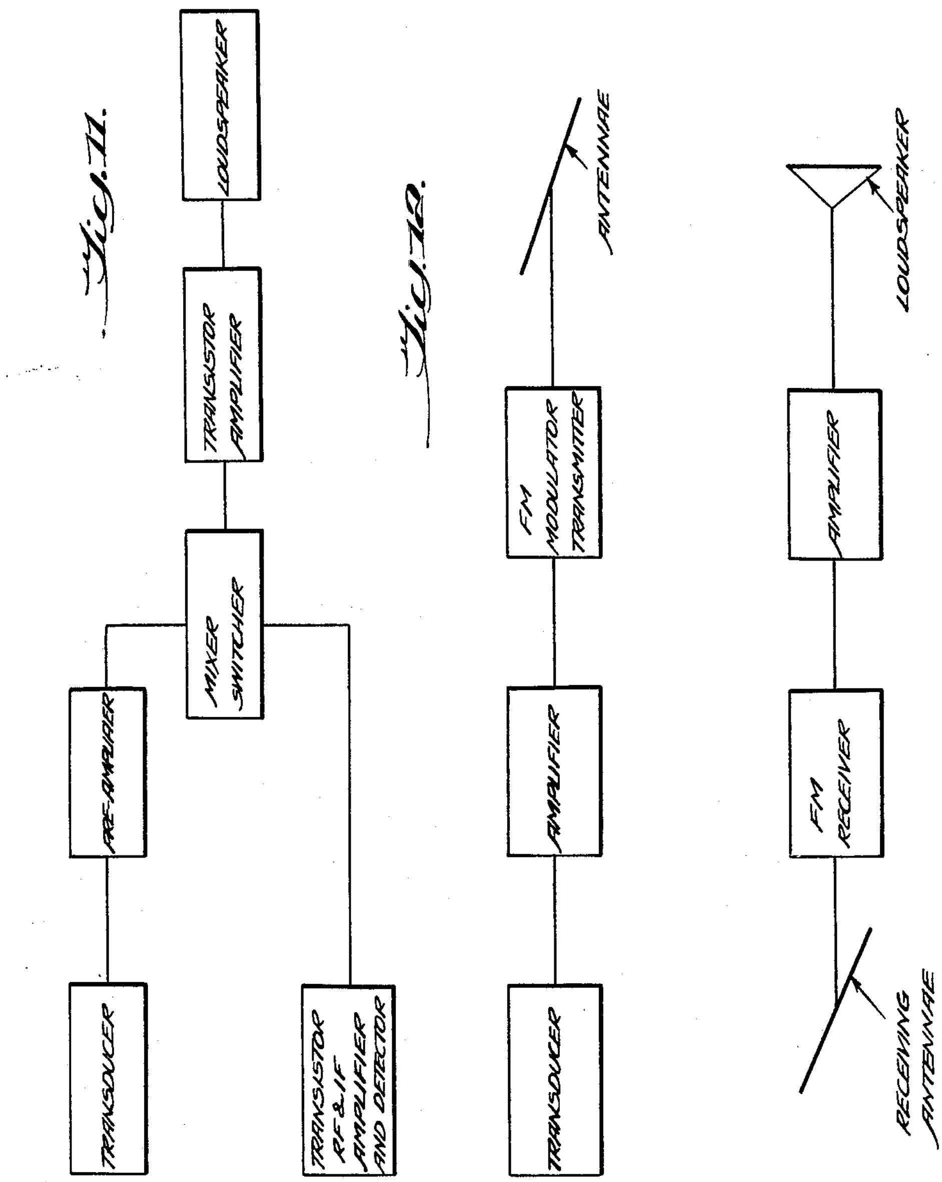

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United States Patent Office

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ELECTROACOUSTIC TONE MODIFYING SYSTEMS FOR STRINGED MUSICAL INSTRUMENTS

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1 Claim. (Cl. 84—1.16)

This invention relates to electroacoustic systems and more particularly to systems in which the output of an electromechanical energy transducer is modified in various ways to produce certain predetermined acoustic effects which are deemed pleasing and desirable.

Musical instruments of the string family have long been noted for the tonal beauty and intimate quality of their music. The musical tones in these instruments are produced by an acoustic resonator or tone chamber which is energized by the vibrations of strings activated by the performer. The quality or characteristics of the music thus produced is determined by the design of the acoustic resonator which forms the tone, and consequently, this element of the instrument is usually regarded as being the most critical in design. Master craftsmen such as Stradivari, Amati, and Guarneri produced instruments of such rare tonal beauty as to become famous throughout the world.

With the present day advent of electronics, various attempts have been made to produce stringed instruments having improved tonal characteristics and higher levels of sound intensity. A conventional electromechanical or electromagnetic sound transducer, used in conjunction with a vacuum tube amplifier and loudspeaker, is capable of giving any level of sound intensity desired, but the tonal quality of such instruments cannot compare with those of the old world craftsmen. This is undoubtedly due to the fact that a faithful reproduction of the vibratory frequencies of the strings will not necessarily produce musical sounds having the desired characteristics.

The beautiful tones which emanate from the acoustic instruments made by these master craftsmen are the result of the string vibrations plus the modulation and added overtones introduced by the acoustic resonator. With this fact in mind, it is readily seen that, in order to duplicate or improve upon these acoustic instruments in an electroacoustic device, it is necessary either to provide a system capable of modifying and introducing certain desired characteristics into the electrical output from the vibrating strings, or capable of modifying, in a predetermined manner, the acoustic energy produced by the loudspeaker, or capable of doing both.

Accordingly, it is an object of this invention to provide an improved electroacoustic system for producing music from stringed instruments.

Another object of this invention is to provide an electroacoustic system in which the musical tones produced from vibrating strings are modified in such fashion as to enhance their aesthetic effect.

Another object of the invention is to provide a novel electromechanical transducer for stringed instruments.

Another object of the invention is to provide a composite electromechanical transducer having variable frequency characteristics.

Another object of the invention is to provide an improved loudspeaker system for stringed instruments.

A further object of the invention is to provide a loudspeaker system for stringed instruments in which the acoustic energy produced by the loudspeaker is enhanced by virtue of modifying the harmonic and overtone content of such energy.

A further object of the invention is to provide an im-

proved formant circuit for modifying the waveform of an electrical signal.

A further object of the invention is to provide a portable self-contained electroacoustic instrument of the stringed variety.

A still further object of the invention is to provide a self-contained electroacoustic instrument capable of receiving radio broadcasts and enabling the instrument to be played in conjunction with such radio broadcasts.

A still further object of the invention is to provide an electroacoustic instrument requiring no physical connection with its associated loudspeaker system.

In accordance with these objects, the system of this invention comprises an electromechanical transducer of piezoelectric material which is used as the bridge element for any conventional stringed instrument. The mechanical vibrations of the strings are translated into electrical energy which in turn may be either (1) modified by appropriate formant circuits and reproduced through a conventional loudspeaker system, or (2) amplified in a conventional manner and reproduced through a specifically loudspeaker system to add the desired tone coloration.

This preferred embodiment of the invention, together with certain modifications thereof, is illustrated in the accompanying drawings in which:

FIG. 1 is a block diagram of the basic system of the invention;

FIG. 2 is a plan view of a classic guitar body showing the bridge element of the instant invention together with the controls therefor;

FIG. 3 is a cross section taken along the line 3—3 of FIG. 2;

FIG. 4 is a side elevation of the guitar body;

FIG. 5 is a diagrammatic view showing the electrical connections to the bridge element;

FIG. 6 is a horizontal cross sectional view of the loudspeaker system of the present invention taken just below the top of the cabinet;

FIG. 7 is a cross section view in elevation taken along line 7—7 of FIG. 6;

FIG. 8 is a vertical cross section with parts in side elevation of the loudspeaker system;

FIG. 9 is a cross section view in elevation taken along line 9—9 of FIG. 6;

FIG. 10 is a block diagram of a formant circuit in accordance with the instant invention;

FIG. 11 is a block diagram of a self-contained musical instrument; and

FIG. 12 is a block diagram of a music system having no interconnecting wires between the instrument and loudspeaker.

The operation of the basic system of the invention may be easily understood by making reference to FIG. 1 of the drawings which is a block diagram of the system. The pickup transducer 1, which has three separate outputs, feeds into a switcher-mixer 2 which provides the functions of selectively switching in and out all three of the pickup transducer outputs and electronically mixing the selected outputs.

The output from the switcher-mixer is fed through a preamplifier stage 3 and an amplifier stage 4 to provide the necessary increase in level, and the resulting amplified signal is fed to a loudspeaker transducer 5 which, in addition to reproducing the electrical signal, adds certain desired tonal colorations by means of a unique baffling structure hereinafter described.

While the invention is adaptable to any form of string instrument, the classic guitar, a plan view of which is shown in FIG. 2, has been selected for the purpose of this description. The neck 6 of this guitar extends far enough into the body portion to enable the player to properly finger the fretboard (not shown) even at its extreme end where it is joined to the main body portion 7 of the guitar. A projection 8 on the guitar body provides a convenient recess 9 for support of the guitar on the player's knee and yet does not interfere with the fingering of the fretboard.

The guitar strings generally designated by the letter S extend over bridge member 10, as is more clearly seen from FIGS. 3 and 4.

The bridge member 10 is constructed in three tiers or layers of piezoelectric material, preferably of a ceramic titanate such as barium titanate. The bottom transducer layer consists of a single ceramic titanate element 17. Placed on top of element 17 and providing a zone of separation is a layer 18 of resilient material having a high degree of compliance, such as neoprene. The second transducer layer comprises two ceramic titanate members 19 and 20, and on top of these members is located a second layer of high compliance material such as neoprene.

The top layer of the transducer is comprised of six individual ceramic titanate elements 11 through 16, each of which has a string of the instrument mounted thereon.

The individual transducer elements of the various layers, while different in shape, are all similar in construction. Each element is constructed of the same material, barium titanate, and has its top and bottom faces metalized with a suitable plating to provide means for making electrical contact therewith.

FIG. 5 is a diagrammatic view of the electrical connections to the bridge member, showing the polarity observed in connecting to the individual transducer members. A separate output is taken from each transducer layer and each transducer layer is designed to have a different frequency response characteristic so that by selective switching and mixing in the switcher-mixer 2, an endless variety can be obtained in the response characteristics of the bridge output.

In contrast to the conventional acoustic instrument which requires a carefully designed resonator body, the body 7 of the classical guitar shown in FIG. 2 serves no purpose other than the conventional one of providing support for the strings, etc., and in no way contributes to the tone quality. The output of the instrument is derived solely from the bridge transducer 10. For this reason, it is possible to fabricate the guitar body by such simple techniques as molding, and the body itself may be made of inexpensive plastic material. Using such techniques greatly reduces the cost of the instrument, without in any way affecting its performance or attractiveness.

The molded body 7, here illustrated, is conveniently made hollow and contains the switcher-mixer 2 which is controlled by individual adjusting knobs 22, 23, 24, which switch in and out the three separate layers of the bridge transducer 10 and also control the amplitude of the individual outputs.

The switcher-mixer 2, preamplifier 3, and power amplifier 4, may be of any conventional design well known in the art, which is adapted for the particular requirements of the instrument involved.

The construction of the loudspeaker system of the instant invention is seen by making reference to FIGS. 6 through 9 of the drawings. The enclosure 25 which is generally rectangular through any cross section contains three loudspeakers, 26, 27, 28, securely mounted on baffleboard 29 which divides the enclosure into two compartments, 30 and 31. As seen from FIG. 9, the only openings in the baffleboard 29 are the three cut-outs for the speakers 26, 27, and 28.

Mounted in compartment 31, on a second baffleboard 32, which is rectangular in shape as shown in FIG. 7, is a diaphragm assembly generally designated by the numeral 33. This diaphragm assembly is of a construction similar to conventional drumheads and consists of a flexible diaphragm 34 held in taut condition by conventional mounting rings and tightening assembly. Since such structure is well known in the field of drums and forms no part of this invention, it is not believed necessary to describe its construction in detail.

In mounting the diaphragm assembly 33 on the baffleboard 32, a cut-out is provided in the baffleboard 32 of a diameter slightly smaller than the diaphragm assembly 33, and the assembly 33 is mounted in spaced relation to the baffleboard 32 in such a manner that a small circumferential slot 35 is provided between the assembly 33 and the baffleboard 32. The composite structure thus produced is mounted on the baffleboard 29 and spaced therefrom by spacer members 36. The rear of compartment 31 behind the diaphragm assembly 33 is left open.

Mounted in the compartment 30 on the baffleboard 37 which forms the front of the enclosure 25 is a pair of diaphragm assemblies 38 and 39 which are similar in construction to the assembly 33 previously described. The assemblies 38 and 39 are spaced from the baffleboard 37 by circumferential slots 40 and 41. Spacer members 42 extend between the baffleboards 29 and 37 to add rigidity to the structure and to additionally serve the purpose of preventing undesired resonances from occurring in the compartment 30.

To further improve the frequency response of compartment 30, a series of terraces 43, 44, are provided in built-up fashion on the face of the baffleboard 29. It will be understood by anyone skilled in the art that variations in the response characteristics of the enclosure can be effected by changing the volume of the enclosure and the relative locations and dimensions of the diaphragms and baffleboards. The important consideration in any modification is that the diaphragm and loudspeakers remain in acoustically coupled relation.

The loudspeaker system thus described has important differences over conventional so-called high fidelity enclosures is not to give a faithful acoustic reproduction of the original electric signal, but rather to add certain tone colorations to the acoustic energy developed by the loudspeakers. This effect is achieved by virtue of the diaphragm assemblies and their mounting.

Each of the diaphragm assemblies is chosen to resonate at a different frequency, and these frequencies are selected to reinforce certain desired fundamental tones and produce modulations of the high overtones with the fundamental tone generated by the vibrating string of the instrument. When a string of the instrument is vibrated, the diaphragms are excited by the acoustic energy from the loudspeaker and vibrate in their normal resonant modes. The diaphragms in turn are coupled either to compartment 30 or 31, and excite these compartments at their resonant frequencies, such as to amplitude modulate the high overtones.

Excitation of the diaphragms occurs with each intonation of the strings regardless of the resonant frequency of the diaphragm and the effect thus produced greatly enhances the beauty of the generated tone. For example, when the high frequency strings are vibrated, the diaphragms tuned to lower frequencies will be excited and then decay in transient fashion to produce a "head" or intonation effect on the high frequency tones. This increases the body or depth of tone in contrast to the bare sound of the high frequency tone containing no lower tones, such as is produced by a conventional system having no diaphragm assemblies.

The tone variations thus produced are found to be most pleasant and are superior to those produced by a conventional loudspeaker system.

It will be realized by those skilled in the art that it is possible to accomplish electrically what the loudspeaker system just described can accomplish acoustically. FIG. 10 shows an appropriate formant circuit for generating an electrical signal which may be reproduced in a conventional loudspeaker to give the desired result.

The incoming signal is fed to a series of filters 45, 46, 47, which are designed to pass the low frequencies, high frequencies, and middle frequencies, respectively. The middle frequencies are amplified by amplifier 48 and further amplified by amplifier 49, and reproduced by the loudspeaker system without having their waveform electrically modified in any fashion. The high and low frequencies are fed into modulator 50, where the high overtones are modulated by the fundamental frequencies, and the resulting signal is amplified by amplifier 51 and fed to a series of shock-excited oscillators 52 through 57. These oscillators are tuned to separate frequencies in the high and low bands and adjusted in such manner that when shocked, the oscillator produces a damped oscillation at the frequency to which it is tuned. The duration of this damped oscillation may be varied to produce the result desired. The outputs of each of these shock-excited oscillations, together with the unaltered middle frequency band, is fed to the loudspeaker system, and the result produced is most pleasant.

To create additional effects, an artificial overtone generator 58 may be provided to mix with the high frequencies from filter 46 in mixer 59 before modulating with the low frequencies in modulator 50.

FIG. 11 is a block diagram of a musical instrument incorporating a broadcast tuner such that the transducer bridge output may be mixed with the broadcast signal and the resultant acuostic effect be that of actually performing with the regular broadcast. This embodiment is made possible by the use of transistors and other miniaturized components. An additional input is added to the mixer switcher to mix the broadcast signal and instrument signal, and the output of the mixer switcher is amplified and reproduced by a transistor amplifier and a loudspeaker which are also contained in the instrument. The same principle explained in connection with the loudspeaker embodiment of FIGS. 6 to 9 may be employed in the self-contained instrument, although on a much reduced scale.

FIG. 12 is a block diagram of a wireless embodiment of the invention in which the musical instrument contains a transmitting oscillator, thus requiring no interconnecting cables between the instrument and the reproducing system.

The signal generated by the transmitting oscillator located in the musical instrument is received and amplified at a remote point and reproduced through the loudspeaker system of the invention.

It will be appreciated from the above description that by means of the instant invention it is possible to achieve, in an inexpensive instrument, tonal qualities which formerly have been realized only in the expensive instruments made by master craftsmen. By using a larger or smaller number of the diaphragm assemblies, it is possible to increase or decrease the variety of tonal effects available, and such variation is controlled only by the limitations of cost and space.

While the invention has been illustrated and described in certain embodiments, it is recognized that variations and changes may be made therein without departing from the invention set forth in the claim.

I claim:

In a stringed musical instrument, the combination comprising piezoelectric transducer means for converting the energy of the vibrating strings into electrical energy; amplifier means operatively connected to said transducer means for amplifying the electrical energy; and a loudspeaker system operatively connected to said amplifier means for converting the electrical energy into acoustic energy, said loudspeaker system including an enclosure having a top wall, a bottom wall, opposed side walls, and a front end wall, a vertical baffleboard mounted within said enclosure to divide the enclosure into two separate compartments, said baffleboard having three ports therein, three loudspeakers mounted on said baffleboard in covering relationship with respect to said ports, said front wall of said enclosure having two ports therein, a pair of separate auxiliary diaphragms mounted on said front wall within the enclosure and adjacent said ports in said front wall, and a third auxiliary diaphragm in said enclosure rearwardly of said loudspeakers.

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