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MUSICAL DEVICE

Filed June 12, 1961

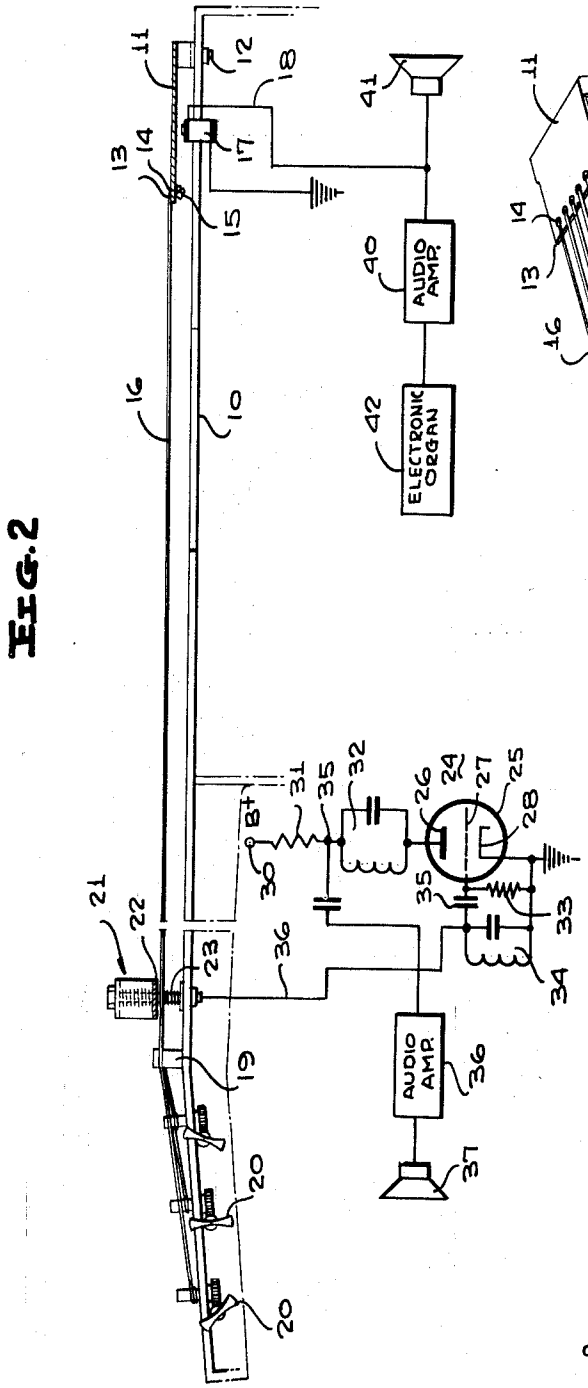


FIG. 2

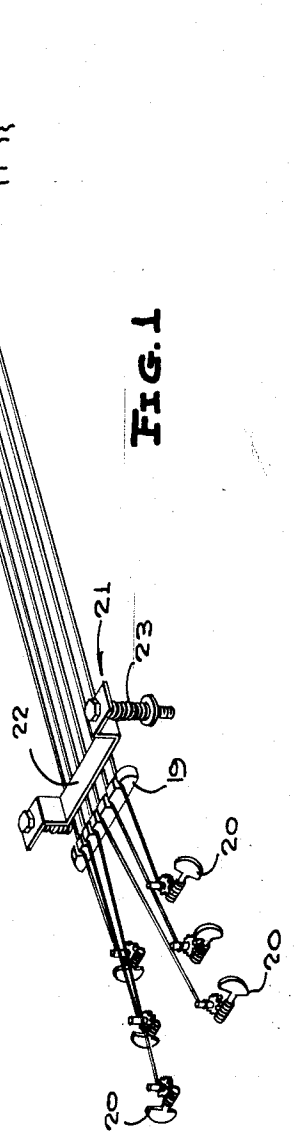


FIG. 1

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MUSICAL DEVICE

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The present invention relates generally to sustain and reverberative devices for musical instruments, and more particularly to sustain and reverberative devices utilizing a plurality of stretched strings resonant to certain musical semi-tones to provide sustain and reverberative effects.

Musical instruments, and particularly electronic organs, can provide enhanced musical effects if the tones provided by the instruments are (1) extended in time in slow decay, or (2) if echo effects are simulated, i.e., if the acoustic effects provided on playing the instrument in a large room or auditorium having acoustic reflective properties are simulated. The former effect is called "sustain" and the latter effect is called "reverberation." It is known to provide such effects by exciting relatively high Q resonant devices in response to electrical wave forms corresponding with music provided by an instrument, and permitting the oscillations induced in the devices to decay, after the tones, as produced by the instrument, have terminated.

In accordance with the present invention, electrical wave forms corresponding with music are caused to induce vibrations in an array of stretched strings. These are tuned to frequencies two semi-tones apart on the musical scales, so that a total of six strings is employed. Since stretched strings vibrate at partial frequencies, fundamental frequencies of the strings may fall within a single octave. The single octave need not be the lowest octave available to the instrument, since the string fundamentals may correspond with second harmonics of the lowest octave of the instrument.

The concept on which the present invention is based is that a single resonant device properly tuned can respond to tones of two nomenclatures, and thus perform double duty. Thereby, six strings can provide complete response to twelve semi-tones, in terms of fundamental and partial responses of the strings, and thus to all the tones of a musical instrument. This result comes about because of the numerical relationship among the frequencies pertaining to the tones, including fundamentals and harmonics, of a conventional musical instrument such as an electronic organ.

Structurally, the system of the invention involves a cantilever magnetic element, to the free end of which the ends of the strings are secured. The cantilever element is electromagnetically vibrated in response to musical tones, thereby vibrating as a whole and at high amplitude those strings which in respect to partial or fundamental responses are tuned to the vibrating frequency.

The strings extend over a bridge to a series of pegs, which are utilized to adjust the tension of the strings, and thereby their resonant frequencies. Adjacent to the bridge is located a capacitive pickup, in the form of a metallic plate coupled capacitively to the strings. The location of the pickup is selected to provide and assure satisfactory response for all partials and for the fundamental of the vibratory responses of the strings.

Utilization of an electromagnetic drive transducer and a capacitive pickup transducer assures that no coupling between transducers can exist except via the strings.

When the strings are tuned precisely with the tones of the instrument, the musical effect is one of sustain, i.e., the strings are set into vibration by the electrical output of the instrument, and due to their Q values continue to vibrate

in a decaying mode after the output of the instrument has terminated.

If the strings are slightly detuned with respect to the tonal frequencies provided by the instrument, the effect is reverberatory, i.e., one of relatively random echoes rather than of uniform decay. It appears that the reverberatory effect occurs because of mutual mechanical couplings among the strings, which leads to cyclic interchanges of energy. In any event, the effect is subjectively clear, and we do not desire to be held to any specific explanation.

It is, accordingly, a primary object of the invention to provide a novel sustain or reverberation generator for musical instruments having musical output.

It is another object of the invention to provide a stringed system responsive to musical tones provided by an instrument to provide a musical effect following in time the termination of notes played on the instrument, wherein a total of six strings is employed which are separated from one another in pitch by two semi-tones.

It is a further object of the invention to provide a sustain or reverberation generator for musical instruments, employing high Q vibratory elements each of which vibrates in tune with frequency components of plural tones of the instrument, within a given single octave.

Still another object of the invention resides in the provision of a stringed device for electrically providing sustain and reverberatory effects, and which employs a total of six essential strings.

Another object of the invention is to provide a stringed device for electrically providing sustain and reverberatory effects by means of a minimum number of high Q strings.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a view in perspective of a stretched string sustain device and reverberator according to the invention; and

FIGURE 2 is a side view of the structure of FIGURE 1, together with a block and circuit diagram of a system incorporating the sustain and reverberator.

Referring now more specifically to the accompanying drawings, the reference numeral **10** denotes a rigid support for the mechanical elements of the system. To the support **10** is secured a cantilever element **11**, as by means of bolts **12**. The cantilever element **11** is provided, adjacent one edge **13**, with six openings **14**, through which extend the knotted ends **15** of strings **16**. The openings **14** are shaped, as in the case of the tail piece of a violin, to retain the knotted string ends **15** even when the latter are under extreme tension. Located immediately under the cantilever element **11** is an actuating electromagnet **17**, supplied with audio signals via lead **18**. The cantilever element **12** is frabricated of magnetic material and accordingly vibrates in response to the magnetic field supplied to electromagnet **17** via lead **18**. The electromagnet **17** is arranged and designed to provide true A.C. motion of the cantilever element **11**, in response to A.C. currents on lead **18**, so that the mechanical vibrations of cantilever element **11** follow with precision the wave shapes of the signal supplied over lead **18**.

The mechanical motion of cantilever element **11**, vertical as seen in FIGURE 1, communicates itself to the strings **16**, which are tuned. The individual strings pass over a bridge **19** to tuning pegs **20** which enable adjustment of tuning of the individual strings, after the fashion of stringed instrument, by adjustment of string tension.

The strings **16** are tuned to frequencies which are two semi-tones apart, and are relatively high Q resonant elements. Typically the strings may have their fundamen-

tals at frequencies corresponding to notes of nomenclature C, D, E, F♯, G♯, A♯, although any other array of values may be selected which, in pairs, are separated by two semi-tones.

Physically adjacent ones of the strings need not be adjacent in musical nomenclature, and in fact it may be undesirable to arrange the strings physically in order of frequency.

Located adjacent to the strings **16**, near the bridge **19**, is a mechanico-electrical transducer **21** in the form of a flat strip of metal **22** extending transversely of the strings. The strip of metal may be adjustably supported by means of studs **23**, secured to rigid support **10**, and provision may be made for adjusting the vertical separation between the strip **22** and the strings **16** by adjusting the studs **23**. It is of importance that the transducer **21** be located adjacent the bridge **19**, so that every harmonic oscillation of the strings will occur at considerable amplitude under the strip **22**.

The strings **16** may be metallic, and may be grounded. The transducer **21** may be insulated from ground, support **10** being insulative. As the strings **16** vibrate vertically, accordingly, the capacity of the strip **22** to ground varies according to the oscillations of the strings.

A vacuum tube oscillator **24** is provided, including a triode **25** having an anode **26**, a control grid **27** and a grounded cathode **28**. Connected between the anode **26** and a B+ terminal **30**, are, in series, a resistance load **31** and a parallel tuned circuit **32**.

A grid leak **33** is connected between the grid **27** and ground, and a parallel resonant circuit **34** is capacitively coupled by condenser **35** between grid **27** and ground. A lead **36** is connected directly (or via a coupling capacitor) to the strip **22**. Thereby, the capacity to ground of strip **22** contributes to the capacity included in resonant circuit **34**, and as the strings **22** vibrate the total capacity of resonant circuit **34** correspondingly varies.

The resonant circuits **32** and **34** are coupled, and are designed to provide self-oscillations. When the strings **16** are quiescent the oscillations are of median strength, the resonant circuits **32** and **34** being relatively detuned. As the strings **16** vibrate the capacity introduced into resonant circuit **34** increases and decreases, with respect to the string-quiescent value, and the resonant frequencies of circuits **32** and **34** are brought alternately more nearly toward equality and farther from equality. The strength of the oscillations accordingly increase and decrease. This is reflected as a change in average D.C. voltage level at the terminal **35** of load resistance **31**.

The signal voltage available at terminal **35** is coupled into an audio amplifier **36**, and the latter drives a speaker **37**. Drive signal for electromagnet **17** is provided by an audio amplifier **40**, which also may drive a speaker **41**, if desired, and which derives its input signal from an electrical musical instrument, such as an electronic organ, **42**.

When the strings are perfectly tuned, the device of the present invention operates as a sustain, i.e. each note or combination of notes played on the organ excites one or more of the strings **16**, which due to their high Q continue to vibrate transiently after the keys of the organ have been released, the vibrations decaying slowly and fairly uniformly. On the other hand, if the strings are slightly detuned from their true pitches the decay assumes a random character, with interchange of energies among the strings, and the decay of the vibrations provides subjectively an echo effect.

It is known to employ stretched strings to provide sustain and reverberative effects, but such devices as were known heretofore have been unsuccessful. Where many strings have been employed the resonance characteristics of the individual strings have overlapped badly so that there has been undue coupling between strings, and consequent ringing at undesired frequencies. To avoid this difficulty the Q factors of the strings have been raised sufficiently to eliminate overlap of the resonance characteristics of the strings. However, the rise times of the string oscillations have then become unduly great, and the musical effects subjectively unpleasant. All attempts to arrive at a compromise as between Q factor and string decoupling have proved unavailing, and must prove unavailing because of the frequency separations inherently present between semi-tones and the rise and decay times required for pleasant listening, both of which are controlled by the same Q factor.

While it is an obvious solution to reduce the number of strings per octave, in some manner, the problem which remains to be solved is, how to reduce this number while retaining sustain or reverberative coverage for the entire gamut of tones. The use of six strings separated in pairs by two semi-tones affords an economical solution since the third harmonic of any fundamental frequency present in a musical tone always corresponds with the fundamental of a different tone. So, the third harmonic of C corresponds with G, the third harmonic of D corresponds with A, and the third harmonic of E corresponds with B, in musical notation. The third harmonics of tones separated by two semi-tones always equal an intermediate semi-tone frequency, so that in terms of harmonic and fundamental response, and recalling that all musical tones include octavely related frequencies and harmonic frequencies, each string of the present invention responds (1) to a given fundamental, and to octaves thereof, i.e., C_1, C_2, C_3 etc. and (2) to certain harmonics, corresponding with G_1, G_2, G_3 etc. for the C fundamental. Thereby, each string performs a sustain function for many frequencies and to tones of two nomenclatures, and a total of six strings is thus capable of providing sustain, or reverberation, for an entire musical instrument.

While we have described and illustrated one specific embodiment of our invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What we claim is:

1. In a system for providing sustain of the gamut of notes of the musical scale, six resonant members tuned to frequencies within an octave, frequency adjacent ones of said resonant members being tuned apart by substantially two semi-tones, and means for simultaneously driving said resonant members electrically in response to a complex musical signal.

2. In a musical system, a source of musical tones comprising electrical tone generators, multiply resonant devices simultaneously coupled to said tone generators, said multiply resonant devices being individually tuned only to notes of nomenclatures separated by substantially two musical semi-tones.

3. In a reverberatory system, a source of a gamut of semi-tones of the musical scale, a plurality of stretched strings having only fundamental resonant frequencies spaced apart by approximately two of said semi-tones, and means coupled to said source for simutlaneously vibrating said stretched strings in response to said gamut of tones.

4. The combination according to claim 3 wherein said means for vibrating is electromagnetic and wherein is provided an electrostatic element coupled to all said strings and responsive to the mechanical vibrations of said strings.

5. The combination according to claim 4 wherein said strings are each slightly detuned with respect to the frequencies of said semi-tones of the musical scale.

6. The combination according to claim 4 wherein is provided an oscillatory circuit coupled to said transducer and tunable thereby over a range of frequencies adjacent to resonance, whereby the amplitudes of output of said oscillatory circuit is a function of capacity of said electrostatic element.

7. A string musical device comprising a cantilever element, a plurality of stretched strings, a bridge, a plurality of pegs, each of said strings extending from said cantilever element over said bridge to one of said pegs, electromagnetic means for vibrating said cantilever element, capacitive means for deriving electrical signals from the vibrations of said strings, said last named means being located immediately adjacent said bridge, a source of complex electrical wave forms representing music, said strings being stretched to respond to selected semi-tones of said music, and means coupling said source to said electrical means for vibrating.

8. The combination according to claim 7 wherein said strings are six in number, and wherein the resonant frequencies of said strings are separated by approximately two semi-tones.

9. The combination according to claim 8 wherein said strings are tuned approximately to one of the sets of notes of musical nomenclature C, D, E, F♯, G♯, A♯ or C♯, D♯, E♯, G, A, B.

10. The combination according to claim 9 wherein the physical order of said strings transversely of said bridge, with respect to the order of the notes is such that strips

of adjacent position are not of adjacent musical nomenclature.

11. The combination according to claim 10 wherein is provided a resonant device, and means coupling said capacitive means to said resonant device in tuning relation thereto.

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