June 4, 1963 N. I. DANIEL 3,092,792

ELECTRO-ACOUSTICAL DELAY LINE USEFUL FOR PRODUCING REVERBERATION IN ELECTRICAL MUSICAL INSTRUMENTS

Filed July 3, 1961

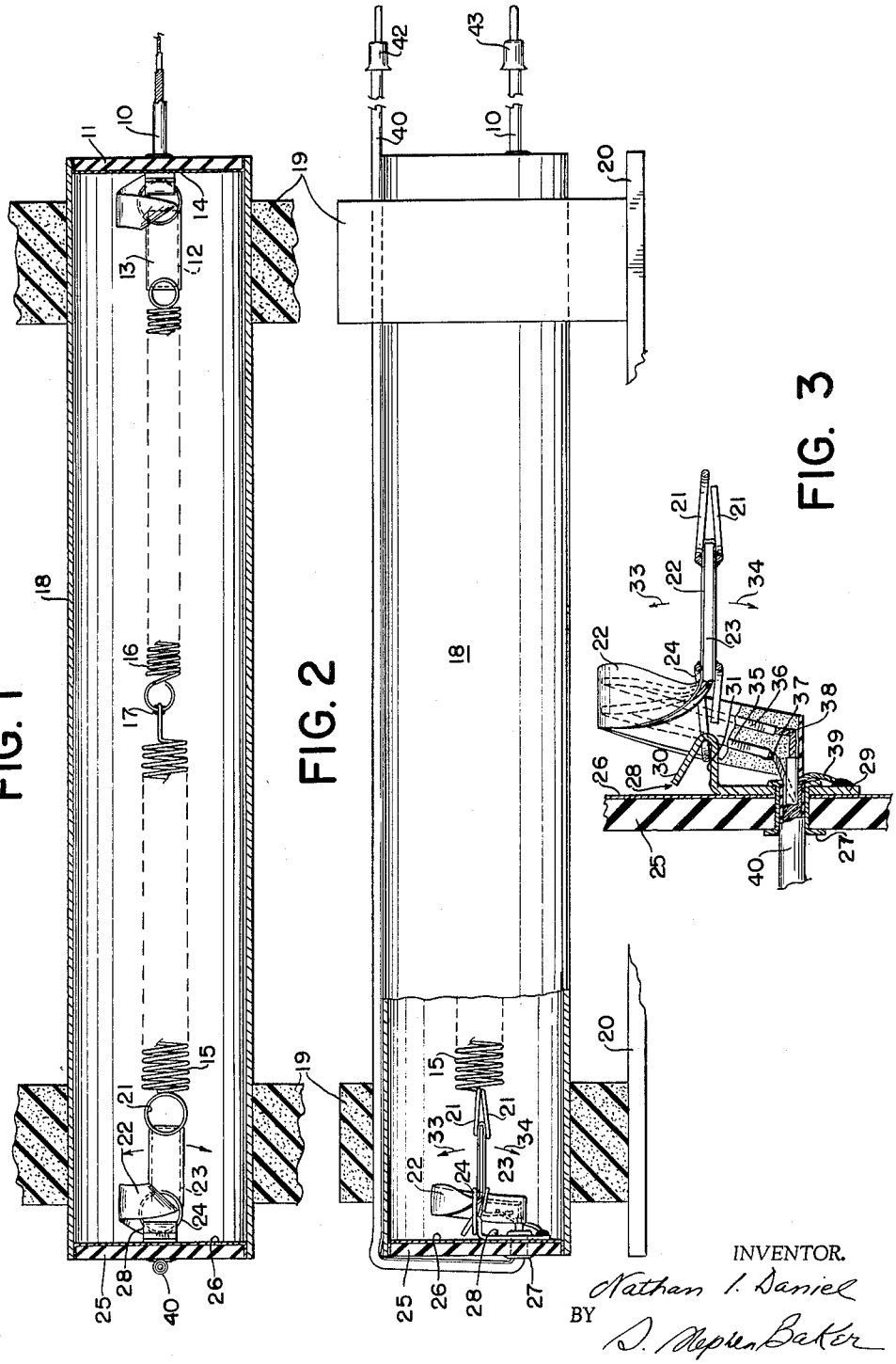


FIG. 1

FIG. 2

FIG. 3

INVENTOR.

Nathan I. Daniel

BY D. Stephen Baker

ATTORNEY

United States Patent Office 3,092,792 Patented June 4, 1963

3,092,792

ELECTRO-ACOUSTICAL DELAY LINE USEFUL FOR PRODUCING REVERBERATION IN ELECTRICAL MUSICAL INSTRUMENTS

Nathan I. Daniel, Wanamassa, N.J.
(207 W. Sylvania Ave., Neptune City, N.J.)

Filed July 3, 1961, Ser. No. 121,431
6 Claims. (Cl. 333—30)

This invention relates to electrical musical instruments and more particularly to an apparatus for producing mechanical reverberation in the transmission of sound signals. The apparatus is, in general, of the type disclosed in Hammond Patent No. 2,230,836, dated February 4, 1941. It was pointed out in the above patent that the apparatus there disclosed was capable of producing tones having reverberation effects which simulated the reverberation characteristics of a large auditorium even though the apparatus was being used in a small non-reverberative room or out-of-doors. This invention also has that objective but it is a considerable improvement in that the character of the reverberation is controlled substantially completely by the tone signals and is not affected by other considerations such as physical vibrations of the apparatus whether originating externally of the unit or produced through sound waves emanating from the speaker.

I have produced a simplified reverberation unit wherein an electrical transducer, such as a piezoelectric crystal functions as a sending element in applying sound vibrations through a coil spring system, the lower end of which system is in turn connected to a piezoelectric receiving transducer which essentially reproduces the sound signals but with a delay caused by the travel of the vibrations along the spring system. Broadly this in itself is old. However, the piezoelectric crystals must be anchored at one end thereof so that the stimulation of the other end mal be translated into physical movement, in the case of the sending transducer, and electrical signals in the case of the receiving transducer.

However, such anchoring has itself caused difficulties in that external physical vibrations would often be introduced into the system so as to produce spurious and undesired reverberative effects. For example, assume that the receiving crystal is physically actuated by the spring to produce reverberative signals. Assume also that an outside effect such as persons dancing in the room would agitate the crystal and produce reverberation effects which were completely unrelated to the sound signals through the apparatus. This results in spurious reverberation effects and, indeed, can even cancel the properly transmitted signals.

With the above in mind, I have provided a reverberation system wherein the transducer crystals are anchored only so far as they must respond to the stimulation of the sound signals through the apparatus. They are, however, free to move in both horizontal and vertical planes in such a manner that they are substantially isolated from external noises and will respond substantially solely to the desired signals. This last description assumes the use of a piezoelectric crystal which responds with or reacts to twisting or torsional effects.

The invention will be further understood from the following description and drawings in which:

FIGURE 1 is a longitudinal cross-sectional view of a reverberation unit constructed according to the instant invention;

FIGURE 2 is an elevational view thereof, partly broken away; and

FIGURE 3 is an enlarged fragmentary view illustrating the connection of the spring system to the end walls.

It will be understood that the reverberation unit herein disclosed translates audio waves or signals into mechanical vibrations, effects a delay in the vibrations, and then translates the vibrations back into electrical audio waves or signals. Accordingly, the unit may be interposed substantially anywhere in the audio amplifier system as will be readily understood. For example, in the above mentioned Hammond Patent No. 2,230,836, such a system was interposed at about the center of the audio channel circuitry whereas in Hannert Patent No. 2,967,447 the signals applied thereto were taken from the voice coil terminations and thereafter amplified after having been mechanically delayed.

In my unit, the electrical audio signals are applied by the usual shielded co-axial cable **10** through an opening in end wall **11** to the conventional flexible metal terminals of a piezoelectric crystal **12**. Crystal **12** is in itself rigid and is preferably of the type which reacts to electrical signals by twisting physically. Such crystals are most commonly used in phonographs where they translate twisting motion derived from the needle into electrical signals. Of course, they also operate in reverse, i.e., they produce a mechanical twisting motion in response to electrical signals applied thereto. Actually, for convenience of mounting and protection of the terminals, I provide a covering of ordinary electrical friction tape **13** over the crystal and its flexible terminals as will be hereinafter described. For grounding purposes, I coat the inner surface of wall **11** with metal foil **14**. The shield of cable **10** is effectively grounded to foil **14** as is conventional and as will be hereinafter more fully explained.

The spring delay system comprises the two coil springs **15** and **16** which are hooked to each other and serially connected together as by solder at their meeting point **17**. The springs are of the type described in the above mentioned patents, it being understood that the springs are largely conventional and are not critical in either length, tension or caliber. As an example, however, it may be noted that in a satisfactory embodiment the smaller caliber spring **16** (about 5/16" diameter) was about 2 inches long, the larger caliber spring (about 7/16" diameter) being about the same length. In such embodiment, the connected springs were extended to about 6 inches, serially. The spring system is enclosed within a metal or other rigid tube **18** which is shock mounted at both ends in foam rubber or plastic blocks **19** which are adhered to a rigid supporting base **20**.

Notwithstanding the mounting of the unit in the highly resilient blocks **19**, the unit is nevertheless subject to external vibrations which produce spurious signals as above described. Accordingly, the connection of the springs to the piezoelectric crystals is of great importance, as I have above set forth.

Referring now to larger spring **15**, the end two coils thereof are bent perpendicularly to the axis of spring **15** so as to form a fastening element **21** comprised of said two end coils. Said fastening element **21** is then glued to the friction tape **22** which embraces the crystal **23**. A firm connection is thus effected which allows no play between the fastener element **21** and the rigid crystal **23**. The glue may be of any common variety which will bond steel coils to the fabric friction tape **22**.

The length of the crystal **23** is about 3/4" as is the crystal **12**. The other end of crystal **23** is similarly adhesively secured to the fastening spring coil **24** which in fact may constitute about 1½ turns. However, a single annulus will suffice. Coil **24** is, of course, of metal as are the springs **15** and **16**. Fastening coils **21** and **24**, although of spring metal, comprise horizontally rigid con-

necting elements capable of transmitting physical movements without losses.

The enlargement of FIGURE 3 best illustrates the connection which forms the subject of this invention. Thus end wall **25** duplicates the structure of the opposite end wall **11**. It includes an inner foil **26** and is formed with an offset hole within which is disposed a tubular rivet **27** serving as a passageway. The rivet further mechanically secures the fastening member **28** to wall **25**.

The construction of fastening member **28** is of importance. It comprises a connecting arm **29** and an end hook **30**. End hook **30** has a planar floor **31**. Coil **24** although being connected firmly by adhesive **32** to the crystal, or rather its tape cover **22**, is pivotally received within hook **30** so that it is free to swing upwardly in the direction of arrow **33** or downwardly in the direction of arrow **34**.

As a result of the foregoing connection, the springs may partake of various motions relative to the tubular casing **18**. Thus, the crystal **23**, which is rigid with respect to the fastening end coils **21** of spring **15**, may swing upwardly or downwardly in a vertical plane in the direction of arrows **33** and **34** and it may also slide perpendicularly thereto in a horizontal plane on floor **31**, all without generating and transmitting electrical signals to its flexible metallic terminals **35** and **36**. Terminals **35** and **36** are the usual flexible Phosphor bronze (or the like) terminals connected to the crystal and which are in turn connected to the wires **37** and **38** of the output co-axial cable **40**, the shield **39** of which is grounded to the arm **29** as illustrated in FIGURE 3.

It will be understood from the foregoing that when the receiving crystal **23** receives a twisting impulse from the springs **15** and **16**, it will produce corresponding electrical signals in its terminals **35** and **36** which are then amplified, although after some delay. However, should the springs be jarred through external vibrations, the described structure will effectively screen out such movements by the connection of the coil **24** to the hook **30** which will produce a response only to twisting of the crystal and not to movement thereof bodily. In other words, by virtue of the construction shown if fastening coil **21** is twisted, then coil **24** will hold fast in hook **30** so as to produce twisting of the crystal and corresponding electrical signals. However, should substantially any other type of motion be applied to the receiving crystal **23**, it will simply move bodily and produce no signals.

The same fact applies to the input transducer or sending crystal **12**, the mounting thereof being identical to that of the output transducer **23**, the fastening member **28** being spaced from its opposed fastening member **41** by the length of tube **18**.

Crystals **12** and **23** comprise flat bodies, the fastening coils **21** and **24** being flatly adhered thereto by having an arc of about 120° thereof adhesively secured to the opposite end portions of the crystal bodies which are rectangular in shape.

Briefly, it may be observed that electrical audio signals translated into sound vibrations by crystal **12** will travel along the length of springs **16** and **15** and will be reflected from the ends thereof as well as from the connection point **17**. The result will be a variety of reflections substantially duplicating or at least simulating the sound reflections or reverberations in a large auditorium. However, outside influences will be screened out as above described.

In the form shown, the output co-axial cable **40** is brought around to the front of the unit for convenience in installation, both cables terminating in plugs **42** and **43**.

There has been shown what is now considered a preferred embodiment of the invention but it is obvious that

changes and omissions may be made without departing from its spirit.

What is claimed is:

1. Apparatus for transmitting sound comprising opposed end supports, a sending piezoelectric crystal and a receiving piezoelectric crystal respectively connected to said supports, both of said crystals having flat bodies, and an elongated spring means connected to and between said flat bodies, the connection of said spring means to at least one of said flat bodies comprising a portion of said spring means fixedly secured to the said one flat body, said spring means consisting of at least one coil spring, said last-named connection comprising an end coil thereof which is adhesively secured to said one flat body and embraces an end portion thereof, a hook having a substantially planar floor on each of said end supports, and a rigid connecting element fixedly secured to the opposite end portion of said one flat body and being rotatably received by said hook and resting on and across said planar floor thereof whereby said rigid connecting element may rotate in the plane of said floor and in a plane perpendicular thereto but is restrained from twisting movement relative to said hook.

2. Apparatus according to claim 1 and wherein said rigid connecting element comprises an annular coil an arc of which is adhesively secured flatly to said flat body while an opposite arc thereof rests slidably on said hook floor.

3. Apparatus according to claim 2 and wherein the connection of each of said flat bodies to said elongated spring means and to said hooks is identical.

4. Apparatus for transmitting sound comprising a pair of opposed fastening members, means maintaining said fastening members in spaced relationship, a piezoelectric crystal slidably connected to each fastening member for slidable movement relative thereto in one plane and rotating movement in a plane perpendicular to said one plane, said crystal being secured against twisting movement relative to said fastening members, spring means disposed between and connected to said crystals for transmitting sound vibrations, one of said crystals being a sending crystal and the other being a receiving crystal, the sending crystal reacting to sound signals by twisting and the receiving crystal reacting to twisting by generating electrical signals, each of said fastening members comprising a hook having a planar floor, said crystals having flat bodies, a rigid connecting element connected flatly to the outer end portions of each crystal and being also slidably connected to said hook and resting on said planar floor thereof, said spring means comprising at least one coil spring and having an end coil thereof fixedly secured to an inner end portion of one of said crystals.

5. Apparatus according to claim 4 and wherein said rigid connecting element comprises an annular coil an arc of which is adhesively secured flatly to the respective crystal bodies while an opposite arc of which rests slidably on the respective hook floors.

6. Apparatus according to claim 5 and wherein said spring means comprises two serially connected coil springs of respectively different calibers.

References Cited in the file of this patent

UNITED STATES PATENTS

1,852,795	Wegel	Apr. 5, 1932
2,001,132	Hansell	May 14, 1935
2,137,852	Nicolson	Nov. 22, 1938
2,211,205	Hammond	Aug. 13, 1940
2,318,417	Phelps	May 4, 1943
2,575,333	Di Toro	Nov. 20, 1951
2,600,870	Hathaway	June 17, 1952