

Sept. 23, 1958

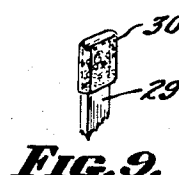
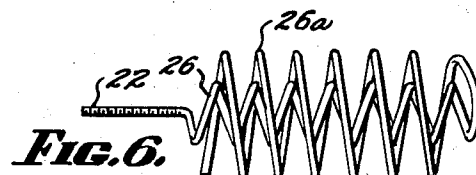
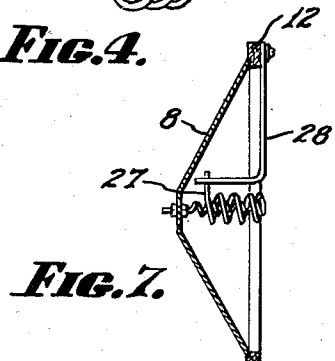
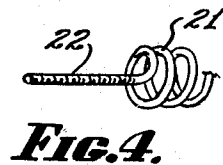
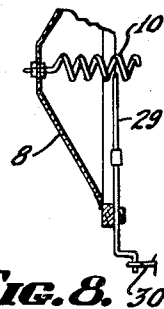
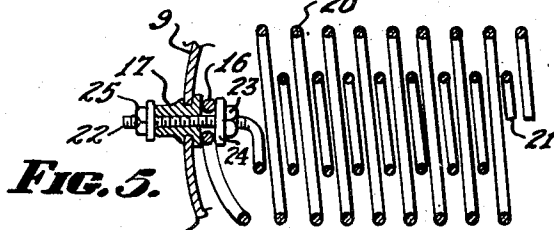
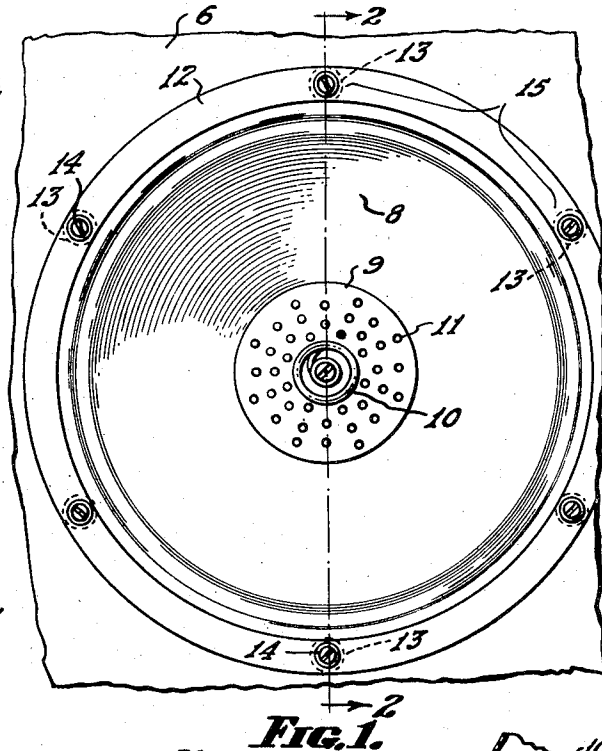
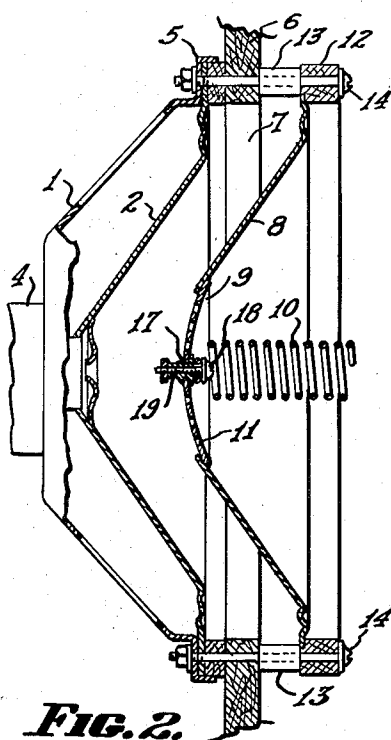
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2,853,145

REVERBERATION LOUD-SPEAKER ASSEMBLY

Filed Sept. 9, 1953

4 Sheets-Sheet 1



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REVERBERATION LOUD-SPEAKER ASSEMBLY

Filed Sept. 9, 1953

4 Sheets-Sheet 2

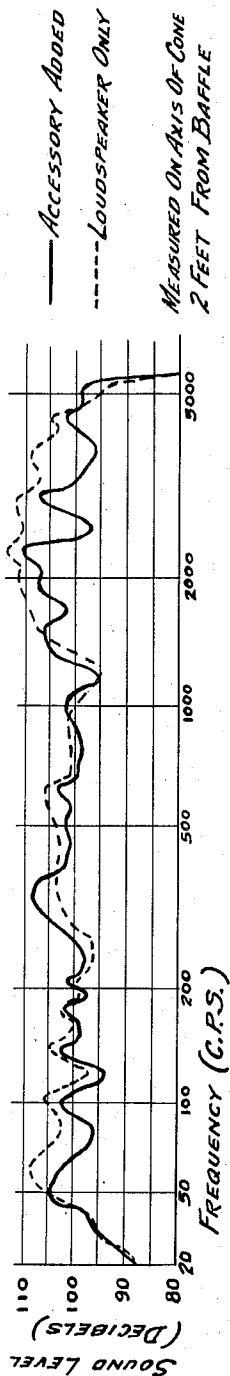


FIG. 17.

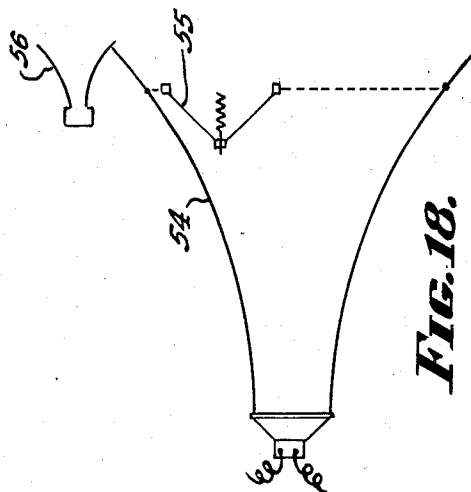


FIG. 18.

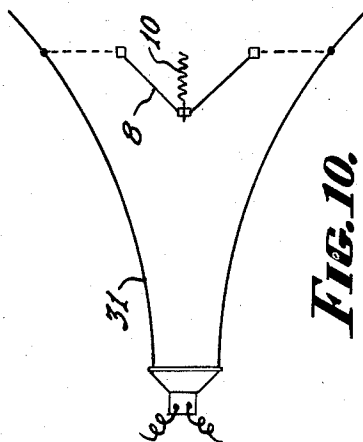


FIG. 10.

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REVERBERATION LOUD-SPEAKER ASSEMBLY

Filed Sept. 9, 1953

4 Sheets-Sheet 3

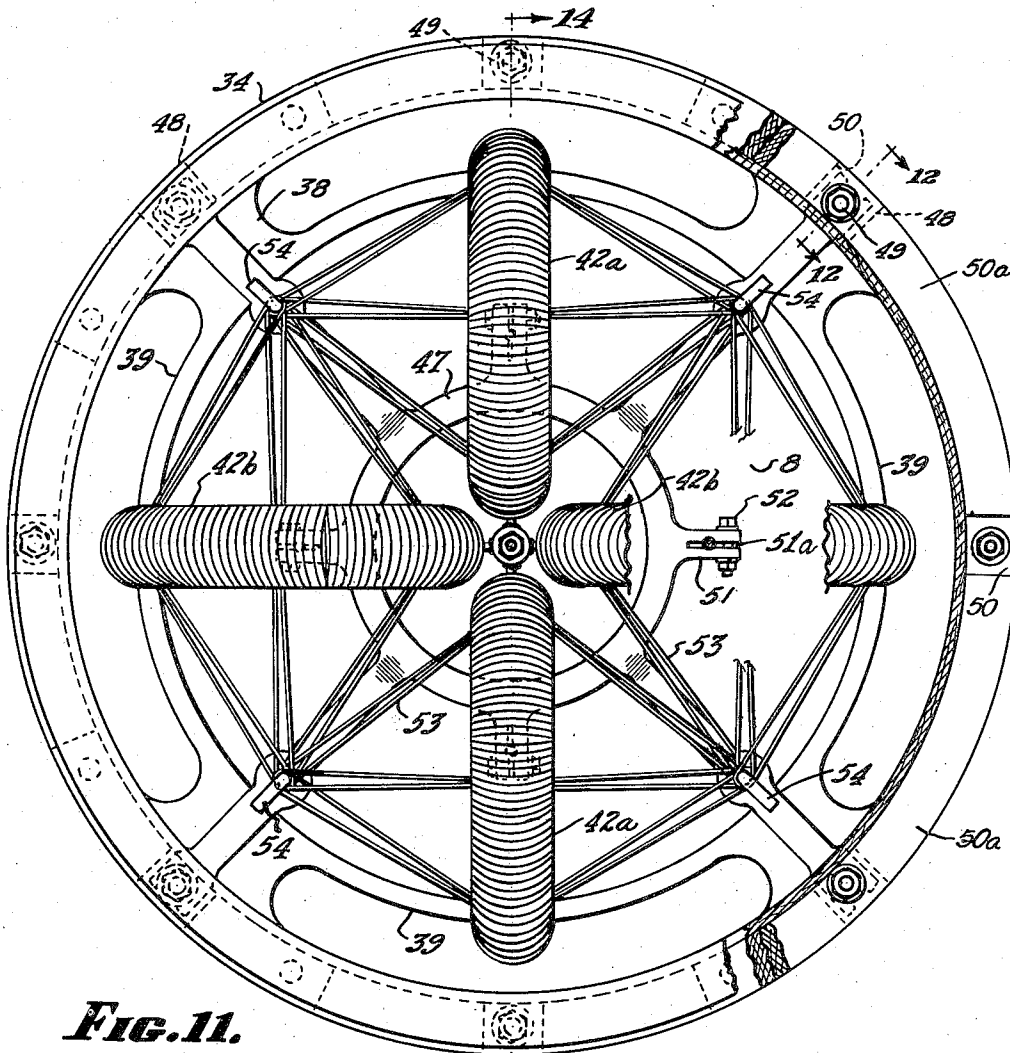


FIG. 11.

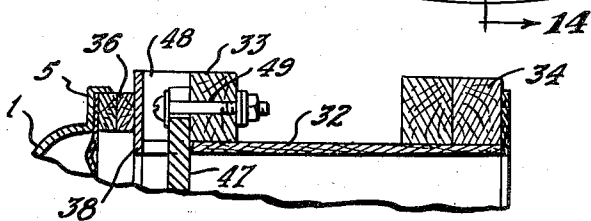


FIG. 12.

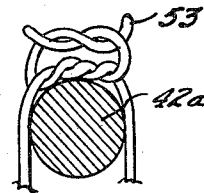


FIG. 13.

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REVERBERATION LOUD-SPEAKER ASSEMBLY

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4 Sheets-Sheet 4

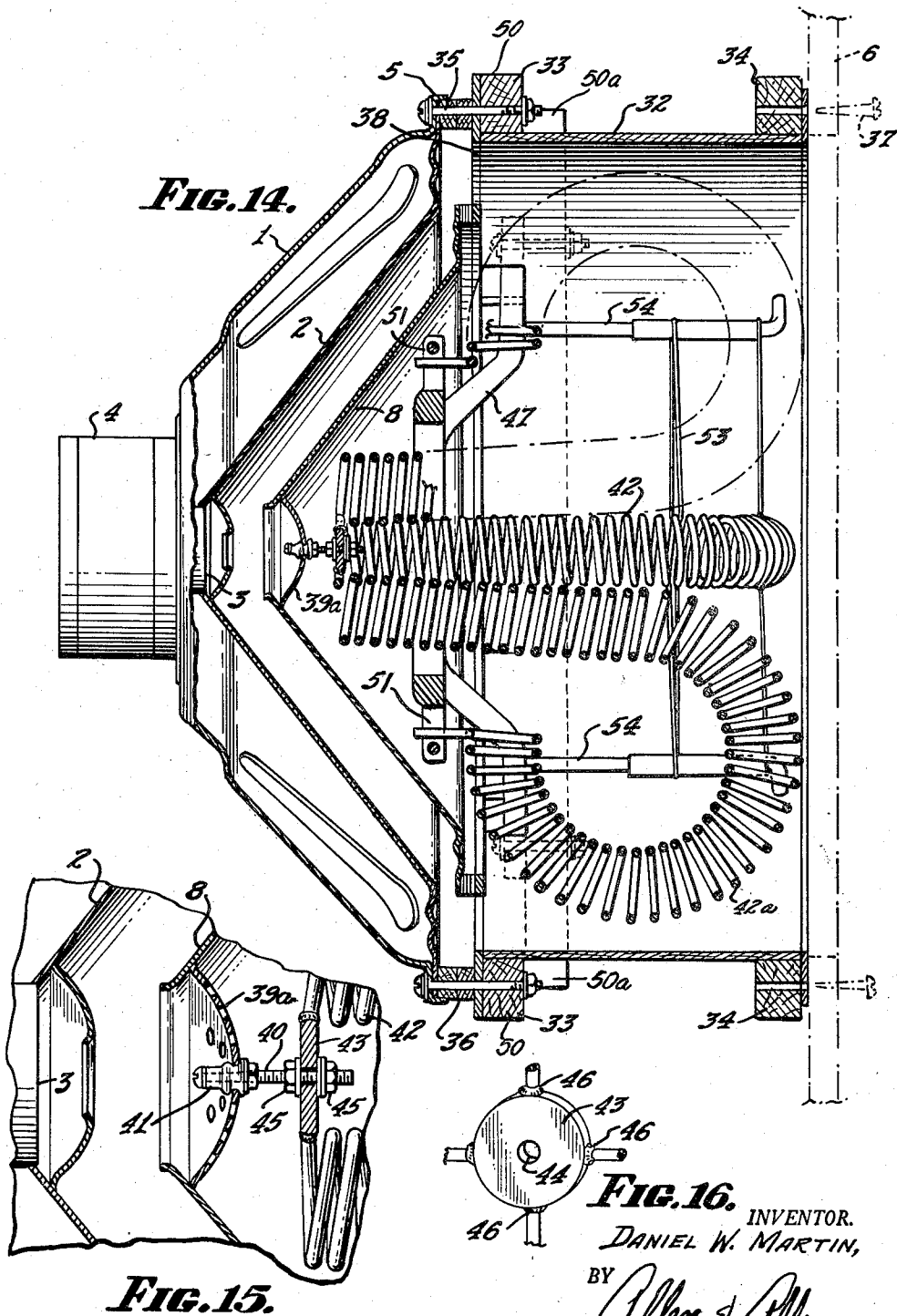


FIG. 16.

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2,853,145

REVERBERATION LOUD-SPEAKER ASSEMBLY

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Application September 9, 1953, Serial No. 379,231

12 Claims. (Cl. 181—31)

My invention has to do with synthesizing sound reverberant effects such as are present in large rooms or auditoriums, and relates more particularly to a reverberation producing loud-speaker assembly which may be employed with electrical musical instruments such as organs, sound amplifying systems, radios, television sets and the like wherein it is desired to introduce reverberation effects.

Added reverberation has been found to be useful for many purposes in sound recording and broadcasting. In recent years organs, which traditionally have been heard in large, reverberant rooms, have been installed rather frequently in small studios and parlors having very short reverberation time or wherein little or no natural reverberation occurs. While systems have heretofore been devised for adding reverberation to sound, such systems have been both complex and expensive and in many cases wholly impractical for the use to which they are put. Such systems have generally employed a driving transducer, a multiple time-relay means, one or more pick-up transducers, and mixing and amplifying circuits, all of which obviously adds materially to the cost of a unit so equipped.

Much of the complication and expense of the systems characterized above has been avoided in the reverberation devices taught by my co-worker, Armand F. Knoblauch, in his co-pending application Serial No. 173,749, now Patent No. 2,768,235, filed July 14, 1950, and entitled Reverberation Devices, wherein he has taught a reverberation device comprising a direct-radiator loud-speaker which is coupled mechanically to one or more resonant helical delay lines mounted in front of the loud-speaker cone. Vibrational energy absorbed by the reverberation coils directly from the loud-speaker voice-coil is transmitted back to the loud-speaker cone and radiated at a later time as reverberant sound. Specifically, the instant application relates to modifications of and improvements in reverberation devices of the type taught in the aforementioned co-pending application.

It is a principal object of my invention to provide a loud-speaker assembly for the production of a reverberant sound in which the assembly is separable from the direct-radiator loud-speaker with which it is associated. In such assembly, reverberation coils are coupled mechanically to a separate cone or diaphragm which is adapted to be mounted in proximity to the loud-speaker cone, thereby providing an acoustical coupling between the speaker cone and the diaphragm which will supply sufficient energy to the reverberation coils for clearly audible reverberant sound to be radiated from the reverberation diaphragm.

It is a further object of my invention to provide a separable reverberation assembly which can be manufactured and shipped independently of the loud-speaker, and easily installed in existing installations by the service technician.

Yet a further object of my invention is the provision of a compact reverberation device which reduces the steady-state output of the loud-speaker with which it is associated by an extremely small amount, thereby enabling me to

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utilize a single loud-speaker for both steady-state output and to drive the reverberation assembly acoustically.

It is a further object of my invention to provide a compact reverberation device which occupies little more space than the loud-speaker to which it is attached, the assembly being such that it may be mounted in both vertical or horizontal position without strain of voice coil supporting members.

It is yet another object of my invention to provide a method and an electro-mechanico-acoustic structure in which electric oscillations are converted into mechanical vibratory energy and thence into acoustic energy, and in which the acoustic energy is partly reconverted into mechanical energy which is stored and thereafter reconverted into acoustic energy in a gradual manner.

A still further object of my invention is to provide a more uniform steady-state acoustical output with respect to frequency.

These and other objects of my invention which will appear hereinafter or which will be apparent to the skilled worker in the art upon reading these specifications, I obtain by those constructions and arrangements of parts and by that procedure of which I shall now describe certain exemplary embodiments.

Reference is now made to the accompanying drawings, wherein:

Figure 1 is a front elevational view of my reverberation assembly as it would be acoustically coupled to a conventional loud-speaker.

Figure 2 is a sectional view taken along the line 2—2 of Figure 1.

Figure 3 is an enlarged partial perspective view of the attachment portion of a reverberation coil.

Figure 4 is an enlarged partial perspective view of another form of attachment for the end of a reverberation coil.

Figure 5 is a partial vertical section illustrating a fitting suitable for the joint mounting of the reverberation coils of Figures 3 and 4.

Figure 6 is a side elevational view of a modified form of reverberation coil.

Figure 7 is a vertical sectional view of a reverberation diaphragm and coil, illustrating the use of a supporting bar for clamping the free end of the reverberation coil.

Figure 8 is a partial vertical section illustrating a damping means for use with my device.

Figure 9 is a partial perspective view of a damper for the reverberation coil.

Figure 10 is a somewhat diagrammatical representation of the use of a reverberation cone and coil in a horn-type speaker.

Figure 11 is a front elevation, with parts broken away, of a modified form of my invention.

Figure 12 is a sectional view taken along the line 12—12 of Figure 11.

Figure 13 is an enlarged fragmentary view illustrating one manner in which mounting cords may be tied to the reverberation coils.

Figure 14 is a sectional view taken along the line 14—14 of Figure 11.

Figure 15 is an enlarged sectional view of a portion of the device illustrated in Figure 14.

Figure 16 is a perspective view of a detail of the construction of the device illustrated in Figure 14.

Figure 17 is a graphical comparison of the sound level of a conventional loud-speaker operating alone and with a reverberation assembly attached.

Figure 18 is a diagrammatical representation similar to Figure 10 showing two horn-type speakers utilizing a single reverberation assembly mounted at the mouth of one of them.

Referring now to Figures 1 and 2 of the drawings, I have therein illustrated a conventional loud-speaker comprising a usual frame 1 supporting a speaker cone 2, a voice coil 3 attached to the cone at its central portion, and a magnetic structure for the voice coil enclosed in the housing 4. The frame 1 terminates outwardly in a peripheral rim or flange 5 by means of which the loud-speaker may be conveniently attached to a supporting surface, such as the wall 6 of the speaker cabinet, the wall 6 being provided with a suitable opening 7 adapted to be surrounded by the frame 1.

Mounted in front of the loud-speaker is a reverberation assembly comprising essentially a cone or diaphragm 8 having a semi-rigid hub 9, which may be dome-shaped or otherwise, attached to the central portion of the diaphragm in the manner illustrated. The hub 9 will be preferably composed of metal such as aluminum of suitable thickness and rigidity so that a reverberation coil structure, indicated generally at 10, may be attached thereto to be vibrated by and to vibrate the hub and the diaphragm 8. As shown, the hub 9 is provided with apertures 11 to permit the loud-speaker to radiate high frequencies through the reverberation diaphragm.

The reverberation diaphragm is preferably mounted on a supporting ring 12 adapted to be secured to the wall so as to position the diaphragm 8 in spaced relationship to the speaker cone 2. As illustrated, this may be conveniently done by using spacing blocks 13 to space the ring 12 the desired distance from the wall 6. As illustrated, elongated bolts 14 may be utilized to attach both the loudspeaker frame 1 and the supporting ring 12 to the wall 6, the bolts passing through the spacing blocks 13.

As will be evident from Figure 2 of the drawings, the reverberation diaphragm 8 and coil 10 are free of mechanical connections to the loud-speaker cone 2. Rather, the arrangement is such that an acoustic coupling is effected between the speaker cone and the reverberation diaphragm, i. e., the spaced apart relationship of the cone and diaphragm is such that the acoustic energy generated by the speaker cone 2 will drive the reverberation diaphragm 8, which in turn will mechanically drive the reverberation coil 10. Vibrational energy thus absorbed by the reverberation coil from the reverberation diaphragm will traverse the coil, be reflected from its far end, and returned to the reverberation diaphragm to be radiated therefrom at a later time as reverberant sound. It will be understood that the distance between the speaker cone 2 and the reverberation diaphragm 8 will vary depending upon their relative sizes, but it will be apparent their relationship must be such that an acoustic coupling will result. As already indicated, the hub 9 of the reverberation diaphragm is perforated to permit high frequency radiations from the loud-speaker to pass directly through the reverberation diaphragm. In addition, the space between the cone and diaphragm is ported peripherally, as in the areas 15 between the spacer blocks 13, to permit direct radiation from the loud-speaker. The reverberation diaphragm and its assembly has been found to present substantially no obstacle effect to low frequency sounds produced by the loud-speaker cone 2. Thus, even though the reverberation assembly is acoustically coupled to the loud-speaker and derives its energy therefrom, the steady-state output of the loud-speaker is not materially reduced in either acoustical output or quality of sound produced thereby.

In this connection, reference is hereby made to Figure 17 of the drawings which shows a graphical comparison of the sound measured on the axis of a conventional loud-speaker (dashed curve) and of the same loud-speaker with my reverberation assembly added (solid curve). It will be evident from the graph that the response at very low frequencies (below 50 cycles per second) is unaffected. There is a slight loss in response from 50–150 C. P. S., a slight gain from 200–400 C. P. S., and little change up to 1500 C. P. S. Above 2000 C. P. S. there

is an average loss in level of five decibels on the axis of the loud-speaker, but this is caused by a general broadening of the conventional directivity of the loud-speaker at high frequencies, which is actually a desirable property in many applications. It will be noted that the curve for the assembly is moderately smooth, and free from the numerous sharp and deep (20 to 30 db) variations in steady-state response which are characteristic of devices employing direct mechanical drive of the reverberation structure.

Since the reverberation assembly does not require direct mechanical connection to the loud-speaker, if either the loud-speaker or the reverberation assembly becomes defective, replacement is independent and may be effected with a minimum of difficulty. Similarly, the reverberation assembly may be provided as an attachment for use with loud-speakers already in service. Thus any organ or the like now in use may be readily equipped with the assembly, in the form of an attachment, for the production of reverberant sound effects.

An important consideration in the provision of reverberant sound in accordance with my invention is the energy storing capacity of the reverberation structure. In other words, the reverberation coil or coils connected to the reverberation cone 8 must have a transit time, i. e. the time of transit of vibratory energy from one end of the coil to the other and return, which is appreciable as compared with the period—time of vibration—of the acoustic energy radiated by the loud-speaker cone. For example, the useful frequency range of the acoustic energy in the production of organ music is approximately 30 to 6000 V. P. S. (vibrations per second), corresponding to a range of periods from about .033 to about .00017 second. In view of this, the reverberation coil structures which I employ should have a transit or transmission time of at least about .01 second in order to produce useful results. Preferably, the reverberation coil will be designed so as to match the mechanical impedance of the loud-speaker with which the reverberation device is to be used.

As illustrated in Figure 2, the reverberation coil may comprise a helically wound spring 10 of galvanized iron wire extending freely outwardly from the hub 9. The inner end of the coil is provided with a tight loop 16, as best seen in Figure 3, which is adapted to be secured to the fitting 17 carried by the hub by means of a bolt 18, the stem or body 19 of the bolt passing through the tight loop 16. In this embodiment, the coil 10 is supported solely at its inner end by means of the fitting 17, the coil extending freely outwardly from the hub 9 with its free end unsupported. Preferably, the length of the spring will be such that it will lie substantially within the confines of the reverberation diaphragm and supporting ring 12. Being of relatively limited length, the fundamental resonance frequency of the spring will be relatively high and the distribution of approximately harmonically related natural frequencies will be rather sparse.

Where a denser distribution of resonance frequencies is desired, the arrangement illustrated in Figure 5 may be employed. As therein illustrated, the reverberation structure comprises an outer coil 20 and an inner coil 21. As in the case of the coil 10, the outer coil 20 is provided with a tight loop 16 by means of which the coil is secured to the fitting 17. In this instance, however, the inner coil 21 is provided with an axially extending threaded portion 22 which extends through the fitting 17 in much the same manner as the bolt 18 described in conjunction with Figure 2. The threaded portion 22 carries a nut 23 and collar 24 which serve to secure the tight loop 16 to the fitting 17, the entire assembly being held together by means of nut 25. It will be evident that due to the differences in size and number of windings of the coils 20 and 21, they will have different series of resonance frequencies. Other than being mutually connected

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to the fitting 17, the coils 20 and 21 are free of attachment to each other and hence free for independent vibration. Instead of being mounted one within the other, the several coils may be mounted side-by-side to the hubby means of separate fittings.

While the reverberation coils just described operate satisfactorily, the timbre and duration of reverberation, generally speaking, is better for long coils than for short ones having the same diameter of wire, number of turns and spacings of the convolutions. This is the result of having a lower fundamental resonance frequency and, consequently, a more dense distribution of resonance frequencies. The longer free path, i. e., reduced number of reflections per unit of time, also reduces the effect of damping. Yet in order to get the size of the reverberation assembly down to a practical minimum in which the reverberation coil will lie within the confines of the reverberation diaphragm and supporting ring, and still maintain the spring driving impedance comparable to the mechanical impedance of the loud-speaker, a longer spring or coil must be contained in a smaller space. Reduction of turn-to-turn spacing is impractical; in fact, if possible, the spacing should be increased in order to reduce the probability of the adjacent turns or convolutions contacting at the large amplitudes of low-frequency resonance. I have found that coils of greater length can be provided by folding the spring back over itself in the manner illustrated in Figure 6 wherein the coil 26 is folded back over itself at a larger coil diameter 26a. I have found that a coil constructed in this manner provides improved response more nearly approximating that of a single coil of uniform diameter and greater length. The diameter change between the coil 26 and the coil 26a will, however, result in a change of impedance with the result that the energy has a somewhat harder time returning to the reverberation cone than it would in a spring of constant diameter. Nevertheless the folded coil has been found to have a relatively wide frequency range. The most satisfactory folded coil has been found to be one in which the outer diameter or coil 26a is spaced as closely as possible to the inner diameter or coil 26. When the two coils or coil diameters are closely spaced, minimum reflection is encountered at the fold. The change in diameter should be smooth and gradual in order to minimize reflection in this region. A multiply-folded coil has also been successfully used.

Under certain circumstances the folded coil structure of Figure 6 has been found to have some tendency, at certain frequencies, to strike the hub 9. This difficulty may be avoided by spacing the turns of the outer diameter or coil 26a well apart and terminating the coil sufficiently short of the dome to prevent the free end of diameter 26a from striking the hub or diaphragm. Where it is found impractical to shorten the length of the outer diameter 26a, a supporting bar 27, as shown in Figure 7, may be connected to the outermost convolution of the diameter 26a. The supporting bar 27 may be conveniently carried on an arm 28 extending inwardly from the supporting ring 12. Where a supporting bar is employed, I have found that the spacing of the convolutions can be reduced in the outer diameter of the coil, thereby yielding a greater number of convolutions which, together with the clamped condition of the end thereof, would yield a lower, denser series of normal frequencies.

Where it is desired to damp the reverberation coil when reverberation is not desired, a device such as that illustrated in Figures 8 and 9 may be employed. I have therein illustrated a flat strip of metal 29 projecting inwardly from the reverberation diaphragm ring 12. The inner end of the strip 29 is covered with felt 30 and is positioned to normally pass between two convolutions of the reverberation coil 10, the strip of metal normally clearing both of the adjacent convolutions. Normally the felt-covered strip will touch the coil only on very large excursions or vibrations of the convolutions, or

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when the strip is rotated by external control means, indicated at 30, which would limit the excursions of the coil and hence introduce damping.

While thus far I have discussed my reverberation assembly as it would be applied to a conventional loud-speaker, it will be readily apparent that the assembly will find utility elsewhere. For example, in Figure 10, I have illustrated diagrammatically the manner in which the assembly could be utilized in connection with a horn-type speaker 31, the assembly being mounted within the horn or at its mouth. As before, the mounting will result in an acoustical coupling between the electro-acoustic transducer and the reverberation assembly, excepting that in this case the coupling is through the medium of the horn which is an acoustic transformer. Obviously a loud-speaker fitted directly with the reverberation assembly, as shown in Figure 14, could be used at the throat of the horn. The mouth location of the assembly, however, has the advantage that in multiple horn systems the horn mouths can be arranged in close proximity, so that the reverberation assembly is actuated to a somewhat lesser degree by sound from the adjacent horns. Thus, as shown in Figure 18, the horn-type speaker 54 has a reverberation assembly 55 mounted at the mouth thereof adjacent the horn of a second speaker 56, which may be a high frequency horn.

In Figures 11 through 15 of the drawings I have illustrated a modification of my invention in which a coil assembly on the order of that taught in the aforementioned Knoblaugh application is acoustically driven without a direct mechanical connection with the loud-speaker moving system. As in the case of the loud-speaker illustrated in Figures 1 and 2, the loud-speaker assembly comprises a frame 1 supporting a speaker cone 2, a voice coil 3 attached to the center of the speaker cone, and a magnetic structure for the voice coil enclosed in the housing 4. The frame 1 again terminates in a peripheral flange 5 by means of which the speaker assembly is secured to a support, which in this case is the housing 32 enclosing the reverberation coils and supporting the reverberation diaphragm. The housing 32 is preferably cylindrical and may be constructed of wood or plywood, and having collars 33 and 34 at its ends. The speaker frame 1 is detachably secured to the housing by means of bolts 35 which pass through the collars 33, spacing blocks 36 being provided to space the speaker assembly from the housing. The housing is, in turn, mounted to the speaker cabinet or other support 6 by means of screws 37 adapted to engage the collar 34.

The reverberation diaphragm 8 is mounted to the housing 32 by means of plate 38 having ports 39 therein arranged to permit the passage of acoustic energy around the reverberation cone and yet through the housing 32. A hub 39a is secured to the central portion of the reverberation diaphragm 8. An outwardly extending screw or stud 40 is secured to the hub 39a by means of a fitting 41; and to the screw 40, at a point displaced outwardly from the body of the hub, I attach the reverberation coil structure, indicated generally at 42, by means of a disc 43 having an opening 44 through which the end of the screw 40 is passed and secured by means of nuts 45.

The coil structure 42 comprises four helical wound coils or springs formed from galvanized iron wire outwardly extending on the concave side of the diaphragm 8. As illustrated, each of the coils is composed of an inner straight portion and an outer curved portion—the latter comprising approximately three-fourths of a circle. The coils are arranged in two planes at right angles, two coils in the one plane being designated 42a with the remaining coils in the second plane indicated at 42b. The inner ends of four coils are preferably joined by brazing, as at 46, to the disc 43, thereby mechanically connecting the inner end of each coil to the hub 39a and the reverberation diaphragm 8.

For securing the respective outer ends of the coils, I

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have provided a spider-shaped metal frame 47, the legs of which are secured to the collar 33 of the housing 32, as illustrated in detail in Figure 12. To this end, the collar 33 may be provided with relieved portions 48 adapted to receive the legs of the spider which are bolted to the collar by means of bolts 49. Alternatively, the collar 33 may be formed of a plurality of overlapping sections, such as the sections 50 and 50a, the sections 50 having their ends in spaced apart relation and connected by the section 50a, thereby providing an integral collar interrupted periodically to provide the recesses 48. As further shown, the inner portions of the coil 42a and 42b extend outwardly through the central ring portion of the frame 47, the coils terminating at their outer ends at integral lug extensions 51 located on the ring portion of the frame intermediate the legs thereof. These lugs 51 contain lengthwise slots 51a (Figure 11) through which holes of suitable size have been bored to receive the coil ends. Respective cross holes have been bored in the lugs near their outer ends, into which bolts 52 have been inserted. By tightening the bolts 52, simple effective clamps for the outer ends of coils 42a and 42b are provided.

Spurious lateral movement of the reverberation coils, both in shipping the structure and in its operation, are prevented by means of strong light-weight textile cords 53 which are laced between the reverberation coils and outwardly extending metal rods 54 which are screwed into the legs of the frame 47. The cords 53 will be tied to the coils intermediate their ends, one mode of attachment of the cords to the coils being illustrated in Figure 13. In addition to inhibiting lateral movements of the coils, the cords prevent sagging of the coils from their normal positions of use.

In the embodiment just described, the housing 32 envelops the reverberation coils, acoustically houses the entire reverberation assembly and adapts it to panel mounting. It will be evident, as in the case of the reverberation assembly described in connection with Figures 1 and 2 of the drawings, that the entire assembly may be shipped as a unit for mounting in an organ or similar device already in use. Similarly, the loud-speaker assembly or the reverberation assembly may be replaced individually as separate units, should the occasion arise.

It will be understood that other modifications may be made in my invention without departing from the spirit of it. Having, however, described my invention in certain exemplary embodiments, what I desire to secure and protect by Letters Patent is:

1. In a device for synthesizing sound reverberant effects, an electro-acoustic translating means, a diaphragm acoustically coupled to said electro-acoustic translating means, said diaphragm acting to translate acoustic energy generated by said electro-acoustic translating means into mechanical vibratory energy, and a reverberation coil having time delay vibration-transmitting and vibration-reflecting characteristics, connected to the central portion of said diaphragm, said diaphragm acting to transmit the mechanical vibratory energy produced thereby to said reverberation coil where it travels the length of the coil and is reflected and returned to said diaphragm where it is translated into acoustic energy at a time later than the initial impression of acoustic energy on said diaphragm.

2. The device claimed in claim 1 wherein said diaphragm includes a perforated hub at its center to which said reverberation coil is connected, and a fitting connecting said reverberation coil to said hub.

3. The device claimed in claim 1 wherein said diaphragm includes a perforated hub at its center to which said reverberation coil is connected, a fitting connecting said reverberation coil to said hub, the inner end of said reverberation coil terminating in a tight loop secured to said fitting and wherein a second reverberation coil of lesser diameter than said first named reverberation coil

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extends axially of and is surrounded by said first named reverberation coil.

4. The device claimed in claim 1 wherein said reverberation diaphragm includes a perforated hub at its center to which said reverberation coil is connected, a fitting connecting said reverberation coil to said hub, the inner end of said reverberation coil terminating in a tight loop secured to said fitting, and wherein a second reverberation coil of lesser diameter than said first named reverberation coil extends axially of and is surrounded by said first named reverberation coil, said second reverberation coil terminating at its inner end in an axially extending portion secured to said fitting, said axially extending portion extending through the tight loop in said first named reverberation coil and including means for securing both coils to said fitting.

5. The device claimed in claim 1 wherein said reverberation coil is folded back over itself to form a second coil portion surrounding said first named coil portion and of a diameter greater than said first named portion.

6. The device claimed in claim 1 wherein said reverberation coil is folded back over itself to form a second coil portion surrounding said first named coil portion and of a diameter greater than said first named portion, said second coil portion having its inner end terminating short of said reverberation diaphragm, a supporting bar, the inner end of said second coil portion being connected to said supporting bar.

7. The device claimed in claim 1 wherein there are a plurality of reverberation coils each connected at one end to said hub, and wherein said coils extend outwardly from said reverberation diaphragm and are reversely bent, said device including a housing supporting said diaphragm, and a spider mounted in said housing to which the reversely bent ends of said reverberation coils are attached.

8. In combination for the purposes described, a loud-speaker having a motor and a speaker cone for translating electrical vibrations into acoustic vibrations, a reverberation diaphragm acoustically coupled to said loud-speaker and adapted to be driven thereby, and a reverberation coil connected to the central portion of said reverberation diaphragm and extending outwardly therefrom, said reverberation coil being adapted to store kinetic energy imparted to it by said reverberation diaphragm and to return the kinetic energy to said diaphragm at a later time for translation by said diaphragm into acoustic energy.

9. The combination claimed in claim 8 wherein said reverberation diaphragm and said loud-speaker are in spaced apart relation, resulting in a generally radially extending opening between the said speaker cone and said reverberation diaphragm, and wherein this opening terminates in a plurality of ports arranged to direct said acoustic vibrations in the direction of the axis of said speaker cone, whereby acoustic vibrations will pass directly from said speaker cone around said diaphragm.

10. In combination with a loud-speaker having a motor and a speaker cone for translating electrical vibrations into acoustic vibrations, a reverberation producing assembly comprising a frame, a reverberation diaphragm mounted on said frame adjacent to said speaker cone so as to effect an acoustic coupling between said speaker cone and said reverberation diaphragm, and a mechanical vibratory means comprising a convoluted member capable of kinetically storing mechanical vibrations connected to said reverberation diaphragm.

11. In combination for the purposes described, an electro-acoustic transducer including a horn and a reverberation assembly including a reverberation diaphragm having a reverberation coil connected thereto, said reverberation assembly mounted in said horn in acoustically coupled relation to said electro-acoustic transducer.

12. The structure claimed in claim 11 wherein said assembly is mounted at the mouth of said horn, and

wherein the horn of a second horn-type electro-acoustic transducer is positioned adjacent the horn of said first named electro-acoustic transducer, whereby sound from said second electro-acoustic transducer will also actuate said reverberation assembly.

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