

April 18, 1933.

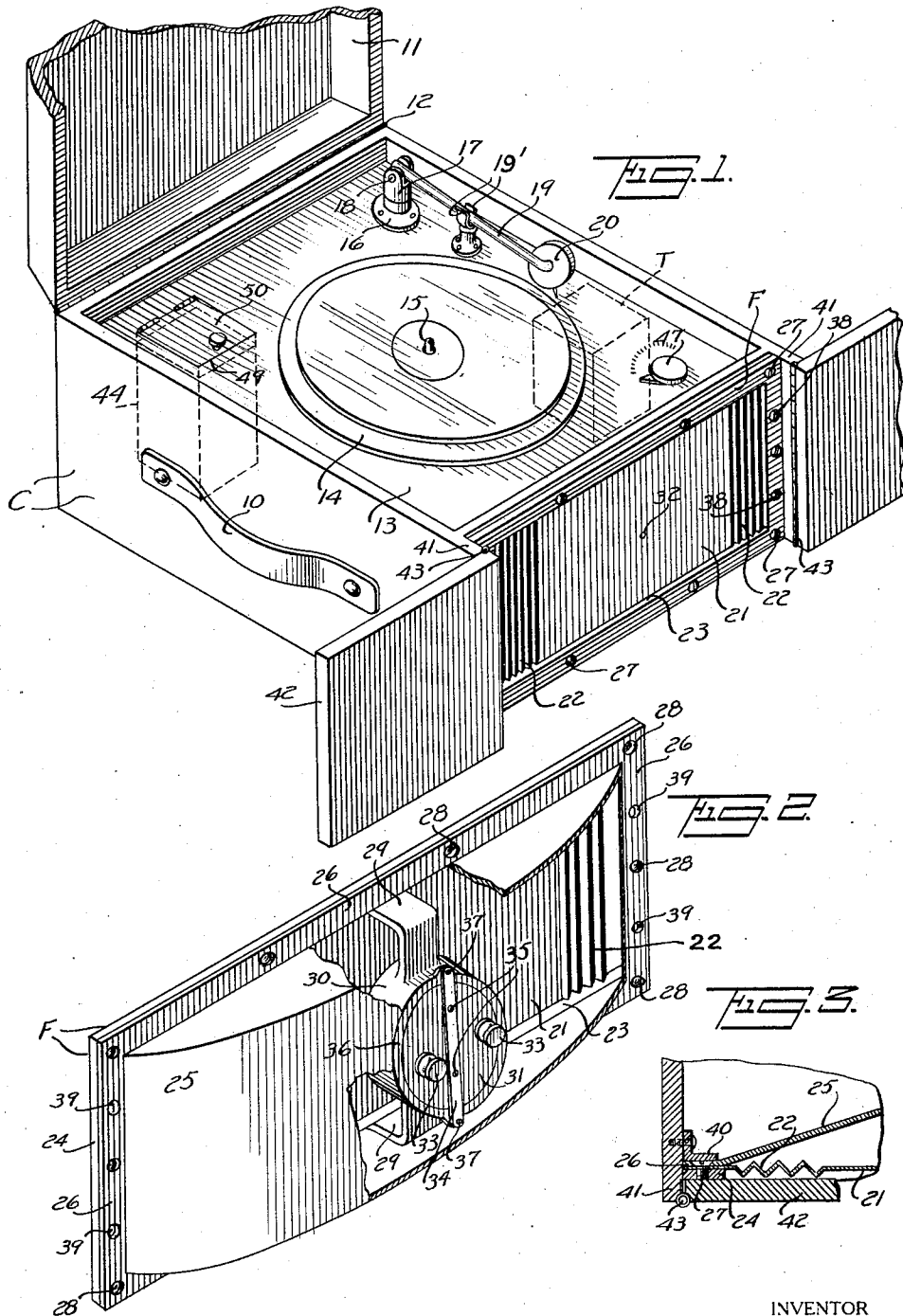
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SOUND REPRODUCING APPARATUS

Filed Dec. 16, 1926

2 Sheets-Sheet 1



INVENTOR

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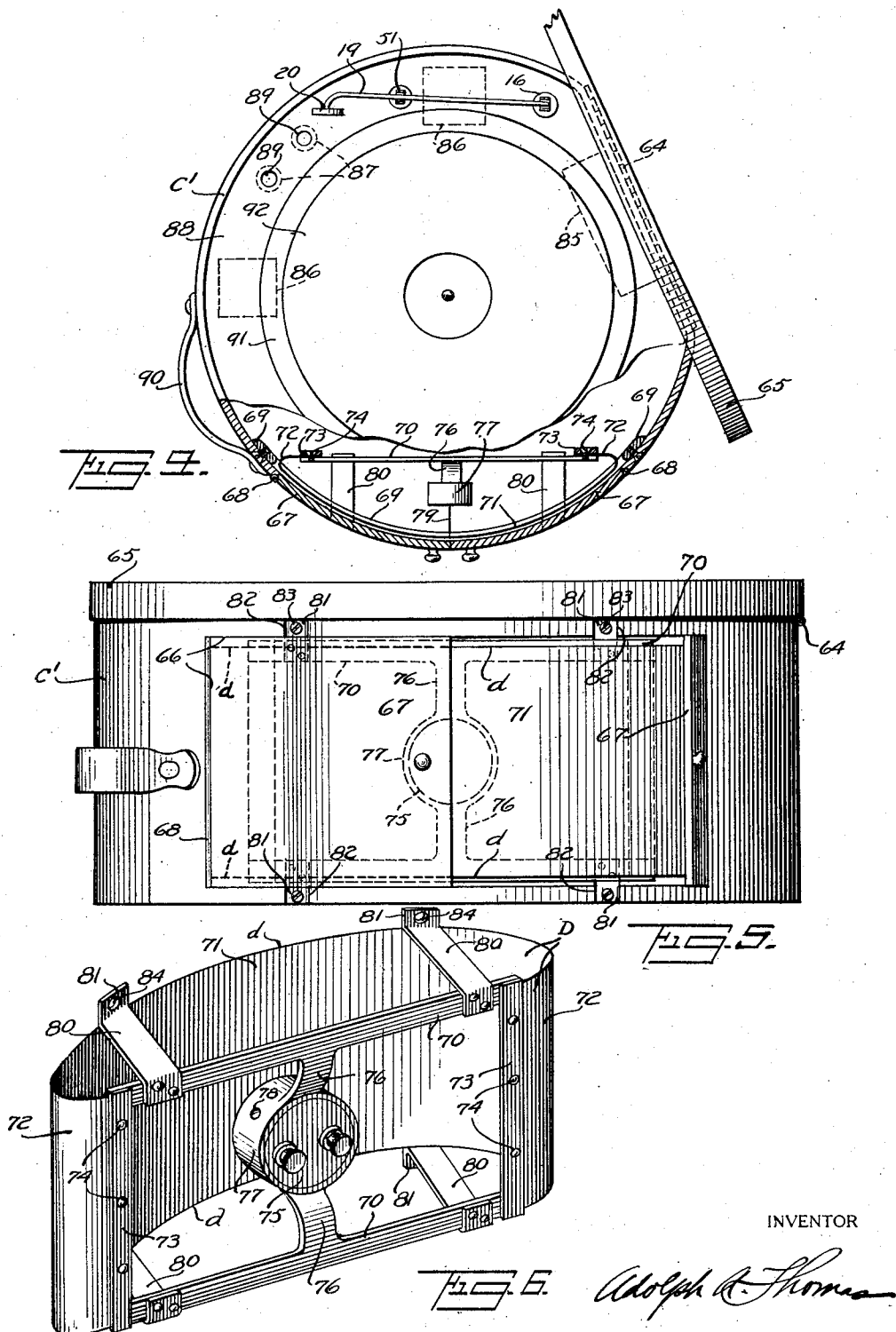
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INVENTOR

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## UNITED STATES PATENT OFFICE

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## SOUND REPRODUCING APPARATUS

Application filed December 16, 1926. Serial No. 155,116.

The present invention is for sound reproducing mechanism of novel construction and improved operation. As will appear later, certain features of this invention are of special advantage in electric phonographs of the portable or table type, although my invention is not limited to that particular class of machine.

One of the characteristic features of my invention comprises a loud speaking diaphragm in the form of an elastic tensioned sheet of thin metal or other suitable material. When this diaphragm is used in phonographs, it is stretched across a large opening in the outer wall of the case or cabinet of the machine. This diaphragm sheet, which is held under constant tension, covers the opening and in effect is part of the outer case structure, so that practically no extra space is required for the diaphragm. This feature is particularly useful in the construction of small light phonographs designed to be easily carried about.

In a preferred form of my invention, the diaphragm sheet is stretched on a frame which also carries the electro-magnetic driving unit for the diaphragm. The frame and all parts carried thereby are inserted as a unitary member into the outer opening of the case or cabinet and readily secured in position from the outside. The diaphragm sheet is generally of rectangular shape, roughly speaking, and the two longer edges are free to permit bodily vibration of practically the entire sheet across the opening. Therefore, a diaphragm of comparatively small area and of a shape fitting into a compact carrying case is capable of giving a reproduction of great volume.

When my invention is embodied in a portable phonograph, the carrying case may have straight sides or it may be cylindrical. The diaphragm sheet referred to is of such a nature that it may be made straight to fit into a rectangular case, or it may be curved to conform to a case of cylindrical shape.

So that my invention may be fully understood by those skilled in the art in order to enable them to practice the same, I shall describe two illustrative embodiments there-

of as shown in the accompanying drawings, in which—

Fig. 1 shows in perspective a portable phonograph equipped with my new loud speaking diaphragm, certain parts being broken away for lack of space;

Fig. 2 is a perspective view of the loud speaking mechanism adapted to be inserted as a unit into the phonograph case of Fig. 1, a portion of the rear housing being broken away to show the parts within;

Fig. 3 is a fragmentary detail view showing how the loud speaking diaphragm is secured along one edge;

Fig. 4 is a plan view of a modification comprising a cylindrical case, the motorboard being partly broken away to show the loud speaking diaphragm;

Fig. 5 is a front view of the construction shown in Fig. 4 on a somewhat larger scale; and

Fig. 6 is a detached perspective view of the loud speaking mechanism adapted to be inserted as a unit in the cylindrical case of Figs 4 and 5.

I shall first describe the construction shown in Figs. 1-3. The entire phonograph mechanism is mounted in a cabinet indicated as a whole by C, which is of rectangular shape and is constructed of suitable material, such as wood, fiber, sheet metal, and the like. A handle 10 secured to one side of the cabinet permits the same to be easily carried about. A lid or cover 11 is hinged at 12 along the rear edge of the case and is held in open position by any suitable means. Above the motorboard 13 rotates a turntable 14, which is mounted on a vertical shaft 15 in the usual way. The shaft 15 is supposed to be driven by a motor mounted beneath the motorboard. As phonograph motors, both mechanical and electrical, are well known in the art, I need not show or describe any motor construction for operating the turntable. There will, of course, be a brake for starting and stopping the turntable, or a switch if an electric motor is used, but I need not show these parts, since they are obvious. On the motorboard 13 is fixed a stand 16 on which is mounted a horizon-

tally rotatable post 17 provided on top with a horizontal bearing 18. A reproducer arm 19, preferably a light tube, is pivoted at the rear end on the bearing 18, and at its front end it carries an electric reproducer 20. The horizontal bearing 18 allows the arm 19 to move vertically, and the swivel post 17 permits it to swing horizontally over a record. Any other practical form of mounting for the reproducer arm 19 may be employed. If desired, a suitable support 19' may be provided for holding the reproducer arm 19 in idle or rest position. The electric reproducer 20 may be of any approved construction, either of the microphone type or the electromagnetic type. Since there are reproducers of both types in the market, I need not show or describe any structural details of reproducer 20, which will therefore be regarded as any practical form of electric phonograph reproducer. The circuit connections from reproducer 20 may conveniently be led through the tubular arm 19 and through the hollow post 17 to the electric transmission devices mounted below the motorboard. As my present invention has nothing to do with circuit connections for electric pickups in phonographs, I need not show or describe any details thereof, particularly since phonographic amplifying circuits are well understood. It is sufficient that in Fig. 1, I have indicated diagrammatically a battery 44 and an amplifying transformer T mounted in the space below the motor board, and a rheostat arm 47 to regulate the volume of reproduction. All parts of the amplifying system may be housed in the cabinet below the motorboard, or they may be mounted in a separate case. To permit ready access to the battery 44 for replacement, the motorboard is provided with an opening 49 closed by a cover 50. The battery is removed and replaced through opening 49 without disturbing any other part of the phonographic mechanism. The electric parts housed within the casing are, of course, properly secured in position, but I do not consider it necessary to show or describe any securing means, since any mechanic would know how to fix in position a battery, transformer, rheostat, amplifying tube, and so on.

Practically the entire front of case or cabinet C is open, and this large opening is covered by a loud-speaking diaphragm 21 of novel construction. This diaphragm consists of a single flat sheet of rectangular shape adapted to fill the open front of the cabinet, so that the diaphragm is in effect a part of the outer cabinet structure. The two side portions of diaphragm 21 are corrugated vertically, as shown at 22, and these corrugations which may be termed regions of special extensibility, act like spring supports for the central section of the dia-

phragm, which is thus held under constant strain or tension in the direction of its length. The upper and lower edges of the diaphragm are free, so that the diaphragm may vibrate bodily. In Figs. 1 and 2 there is a space 23 to indicate that the top and bottom edges of diaphragm 21 are not connected and are free to vibrate. The diaphragm sheet 21 is rigidly connected at its opposite ends to the vertical side bars 24 of a frame indicated as a whole by F, which is preferably constructed of light strong material, such as aluminum and the like. On the rear side of the supporting frame F is mounted a housing 25, which is provided with a rectangular flange 26 arranged to fit against frame F, as best shown in Fig. 2. Screws 27 or other fastening devices pass through aligned holes 28 in frame F and flange 26 to secure the diaphragm and housing 25 on the frame. A pair of bracket arms 29 are provided on the supporting frame F, and these arms terminate in a cylindrical support 30 for receiving an electromagnetic unit 31 which is operatively connected to the diaphragm 21. Electromagnetic driving units for loud speaking diaphragms are well known in the radio art and I do not therefore consider it necessary to show or describe the structural details of such a unit, particularly since they do not constitute part of my invention. It is sufficient to say that the driving unit 31 is properly mounted in support 30 and connected to diaphragm 21 for vibrating the same in accordance with the needle vibrations of reproducer 20. In Fig. 1 the point 32 is supposed to indicate the connection between the diaphragm and the driving unit. The rear face of unit 31 is provided with a pair of binding posts 33 for receiving conductors to connect the unit in circuit, as will later be explained. The casing of driving unit 31 fits snugly in the cylindrical support 30 and is rigidly held in position by any practical means. In Fig. 2, I have shown a strip 34 secured to the back of unit 31, as by screws 35 or otherwise. The ends of strip 34 project into contact with the circular flange 36 of support 30, and are secured thereto by screws 37. It will be observed from Fig. 2 that the rear wall of housing 25 fits snugly around the cylindrical support 30 without covering the rear flange 36 thereof, so that the driving unit 31 may be fitted into place after the housing has been mounted on framework F. It will be clear from the preceding description that the frame F and all parts carried thereby constitute a unitary structure adapted to be inserted as a single member into the front opening of the phonograph case. This permits the correct adjustment of the driving unit 31 and its connection with the diaphragm 21 before the

frame F is mounted in the cabinet of the machine. The frame F is secured in the cabinet by screws 38 passing through holes 39 into a pair of posts or angle-bars 40 fastened to the side walls of casing C, as shown in Fig. 3. Any other practical means may be employed for mounting the frame and its parts in the phonograph cabinet. The sides of the cabinet extend forwardly at 41 to support one or two doors 42 hinged at 43. When the doors 42 are closed, they completely cover the frame F. The front edge of top lid 11 may be provided with suitable means for holding the closed door or doors 42 locked when the lid is closed, as will be understood without additional illustration. The doors 42 are not necessary if the machine is intended for home use only and is not to be carried on trips, but they are useful in protecting the diaphragm against accidental injury when the machine is not used. Also, a pair of hinged doors at opposite sides of the diaphragm may be used as panels to direct or deflect sound waves into the desired direction.

The loud speaking diaphragm 21 is preferably constructed of a single sheet of resilient material capable of giving good acoustic reproduction. Such material may be metallic or non-metallic, and by way of example I may mention aluminum, brass, steel, impregnated linen, paper, celluloid, and the like. The diaphragm shown in Figs. 1 and 2 consists of a flat rectangular sheet having a length equal to at least twice its width. Although I have shown the corrugations 22 as integral with the body portion of the diaphragm, they may be formed as separate sections secured to the central portion of the diaphragm. The corrugated portions 22 perform the double function of holding the central acoustic surface of the diaphragm constantly under tension and resiliently supporting the diaphragm in such a way that it vibrates with substantially equal amplitude over the entire central area. I do not mean to say that the corrugations 22 are necessary in all cases, but they make it easier to hold the diaphragm stretched, and at the same time provide an elastic support for the central portion of the diaphragm. It must be understood that, before the two short ends of the diaphragm sheet are secured to the side bars 24 of supporting frame F, the sheet is pulled and placed under tension, and this tension remains in the supported diaphragm. Any suitable tools may be used to stretch the thin resilient diaphragm sheet before it is attached to frame F. The housing 25 back of the diaphragm prevents sound waves from passing into the dead space below the motorboard. At the same time, this housing serves to deflect sound waves outwardly through the narrow openings 23 along the

top and bottom edges of the diaphragm. In this way, the full acoustic effect of the diaphragm is impressed upon the outer air.

In the construction of Figs. 4, 5 and 6, the outer carrying case C' of the machine is cylindrical, except that it is cut away at 64 to provide a straight hinge edge for the cover 65, and also a flat base on which to set the machine when necessary. The outer case may be constructed of sheet metal, fiber, or other serviceable material. The cylindrical wall of casing C' is provided with an opening 66 adapted to be closed by one or two doors 67 hinged at 68. The edges of the opening 66 may be re-enforced on the inside by strips 69, which may be in the form of a one-piece rectangular frame bent to conform to the cylindrical wall of the outer case. Across the opening 66 is stretched a loud speaking diaphragm D carried by a rectangular frame 70. As shown in Figs. 4 and 6, diaphragm D consists of a main central section 71 and a pair of end sections 72. The central section 71 is curved to conform to the cylindrical shape of the outer case, and the end sections 72 are suitably secured at their edges to the frame 70, as by means of strips 73, which are held in place by screws 74 or otherwise. The upper and lower edges d of the diaphragm are free to vibrate and are therefore slightly spaced from the adjacent portions of case C', as will be seen in Fig. 5. The loud-speaking diaphragm D is constructed of a single sheet of resilient material, which may be of metal or non-metallic, as previously mentioned in connection with diaphragm 21. The end portions 72 of diaphragm D hold the central acoustic section 71 under constant tension and act as a resilient support for the same. In this way the main portion 71 of the diaphragm vibrates with substantially equal amplitude over its entire area.

The supporting frame 70 also carries an electromagnetic unit 75 for operating the diaphragm. Any approved form of driving unit may be used, as explained in connection with driving unit 31. The supporting frame 70 is provided with a pair of cross-arms 76 which terminate in an annular enlargement 77 adapted to receive the casing of driving unit 75. A set-screw 78 or any other practical means holds the unit 75 rigidly in proper position within the annular support 77. The driving unit is operatively connected with the diaphragm D, as by means of a rod 79. If the diaphragm D is made of magnetic material, or is otherwise provided with an armature, no mechanical connection between the driving unit 75 and the diaphragm is necessary. It will therefore be understood that the link or rod 79 of Fig. 4 is intended to represent any operative connection, whether mechani-

cal or electromagnetic, between diaphragm D and driving unit 75.

The supporting frame 70 carries forwardly projecting arms 80, which terminate in vertical lugs 81 arranged to fit into slots or countersinks 82 on case C'. Screws 83 or other fastening means pass through holes 84 in lugs 81 and engage the reenforcing frame 69, whereby the frame 70 and all its parts are insertable into the cabinet and removable therefrom as a unitary structure. The arms 80 and lugs 81 allow closing of the doors 67. In the particular construction shown in Fig. 5, the lugs 81 are visible when the doors 67 are closed, but these doors may be sufficiently wide to conceal all parts of the supporting frame 70.

The construction and mounting of the electric reproducer of Fig. 4 may be the same as those of reproducer 20 in Fig. 1, and I need not therefore repeat that part of the specification. It will be sufficient if I indicate the reproducer mounting of Fig. 4 with the same reference numerals as the corresponding parts in Fig. 1. What I have previously said about the amplifying transmission connections between reproducer 20 and driving unit 31 of Figs. 1 and 2, may be regarded as fully applicable to the reproducer and driving unit of Figs. 4-6. In Fig. 4, I have indicated in dotted outline some of the electrical parts to be used in the amplifying system. Thus, there is a battery 85, two amplifying transformers 86 and two amplifying vacuum tubes 87, such as would be used in a two-stage amplification system. The motorboard 88 of case C' may have openings 89 over the tubes. These various electrical parts are properly mounted in the space below the motorboard, and access to them is attained in any convenient way, either by having openings in the motorboard itself, or by means of doors in the outer wall of the case. If the machine is to be carried about like a piece of hand luggage, it is preferable to have access to the electrical parts through openings in the motorboard so as not to weaken the carrying case by too many openings in its outer wall. The battery 85, being the heaviest part of the equipment, is preferably arranged opposite the carrying handle 90, so as to be at the bottom of the case when the latter is stood on its flat base.

The cylindrical case C' of Figs. 4 and 5 need not be much larger than a twelve-inch record. The turntable 91 shown in Fig. 4 is supposed to be twelve inches across and the record 92 is a ten-inch record. The diameter of the casing need not be more than about sixteen inches, and may even be less.

From what I have said above, it will be clear that I have provided an electric phonograph of simple construction, compact arrangement and capable of giving out

great volume without a horn. The loud speaking diaphragms are so constructed and arranged as to require no additional space; they are practically a part of the outer cabinet wall. The small box or cabinet that houses the entire apparatus may be placed upon a table or chair for playing, and when the machine is not in use, it is easily hidden in a closet, or otherwise disposed of in a small space. A phonograph of that kind is particularly useful in the apartments of city dwellers where the rooms are small and space for furniture is scarce. The loud-speaking diaphragm 21 or D, if properly constructed and operated, will give a reproduction equal (or at least comparable) in volume and tone quality to that of large cabinet phonographs, which many apartment dwellers have to forego on account of lack of space. When in the description and claims I refer to the diaphragm being free at two of its edges, I mean that it is not rigidly attached at those edges, and I do not exclude the idea of using damping means at the free edges, as heretofore employed in free-edged cone diaphragms.

In the broader aspect of my invention, it is not necessary that all the electrical parts constituting the transmission system shall be concealed within the cabinet itself. If the machine is to be used as a portable phonograph to be taken on trips, then of course it will be self-contained; but if the instrument is to be designed as a so-called table machine, which is for use in the home only and not to be carried about like a piece of luggage, then some of the various parts of the electric amplifying system may be mounted outside of the machine cabinet. Although I have shown and described my invention in the form of a phonograph, it is evident that my new diaphragm may be used in other types of sound-reproducing mechanisms.

I do not herein claim per se the particular form of curved diaphragm shown in Figs. 4-6, because a diaphragm of that kind is claimed in my copending application Serial Number 141,692, filed October 15, 1926.

I claim as my invention:

1. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a loudspeaking diaphragm consisting of a one-piece tensioned elastic sheet of metal stretched across said opening and forming in effect a continuation of said wall and a cover for said opening, said tensioned sheet being substantially flat at the center, and a driving unit in said cabinet for operating said diaphragm.

2. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a loudspeaking diaphragm consisting of a substantially rectangular thin elastic sheet stretched across said opening and forming

in effect a cover therefor, means for so mounting said diaphragm sheet that two of its opposite edges are unsecured, resilient means at the other two edges of said sheet

for constantly holding the central portion thereof in a state of tension, and a driving unit in said cabinet for operating said diaphragm.

3. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a frame secured to said cabinet in said opening, a loudspeaking diaphragm consisting of a flexible elastic sheet having end portions secured to said frame so that said diaphragm sheet is stretched across said opening and practically covers the same, said tensioned diaphragm sheet being unattached to said frame between said end portions, and a driving unit carried by said frame for operating said diaphragm, said frame and the parts carried thereby being insertable into and removable from said opening as a single member.

4. In sound-reproducing apparatus, a cabinet having a substantially rectangular opening of greater length than width, a loudspeaking diaphragm covering said opening, said diaphragm consisting of a substantially rectangular elastic sheet having its longer edges unsecured for free vibration of the diaphragm, the central portion of said sheet lying in a plane substantially parallel with the plane of said opening and means for operating said diaphragm.

5. In sound-reproducing apparatus, a case having a substantially rectangular opening of greater length than width, a frame fitting into said opening from the outside and having means for securing it to said case, a loudspeaking diaphragm consisting of a substantially rectangular sheet attached only at its shorter side edges to said frame and unsecured at its upper and lower edges, said rectangular sheet being held under tension and being unattached to said frame between said attached edges, a support carried by said frame at the rear of said diaphragm, and a driving unit mounted on said support for operating said diaphragm, said frame and the parts carried thereby being insertable into said opening as a unitary structure.

6. In sound-reproducing apparatus, a loudspeaking diaphragm consisting of a substantially rectangular sheet of stiff elastic material provided with corrugated end portions which act like a resilient support for the stiff central portion of the sheet and hold the same under constant tension, supporting means engaging the edges of said corrugated end portions, the corrugations of said end portions running substantially parallel with the attached edges of said sheet, the other pair of opposite edges of said

sheet being free to permit bodily vibration of said central portion, and means for actuating said central portion.

7. In sound-reproducing apparatus, a substantially rectangular frame, a loudspeaking diaphragm consisting of a rectangular sheet of stiff elastic material provided with corrugated end portions which act like a resilient support for the stiff central portion of the sheet and hold the same under constant tension, means for attaching the edges of said end portions to the sides of said frame, the other pair of opposite edges of said sheet being free to permit bodily vibration of said central portion, the corrugations of said end portions running substantially parallel with the attached edges of the sheet, a support carried centrally by said frame, and a driving unit mounted on said support for operating said diaphragm.

8. A loudspeaking diaphragm consisting of a single elastic sheet having a rigid central portion and a pair of transversely corrugated end portions of substantially the same width as said central portion, and means for supporting said end portions at their outer edges so that said central portion is held under tension by said end portions.

9. A loud speaking diaphragm consisting of a substantially rectangular elastic sheet having a rigid central portion and a pair of corrugated end portions, means for supporting said end portions at their outer edges so that said central portion is held under tension by said end portions, and means operatively associated with said central portion for actuating said diaphragm.

10. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a loudspeaking diaphragm consisting of a tensioned elastic sheet stretched across said opening and forming in effect a continuation of said wall and a cover for said opening, said elastic sheet being free at two opposite edges and having transversely corrugated end portions which hold the central portion constantly under tension, and means for operating said diaphragm.

11. A loud speaking diaphragm consisting of a flat rectangular sheet plaited transversely and supported under tension at two opposite ends only.

12. A loud speaking diaphragm consisting of a flat rectangular sheet having a length at least twice its width, and means for securing the two shorter edges of said sheet to hold the same tensioned in the direction of its length, said diaphragm being unsecured at the two longer edges and provided with corrugations running substantially parallel with the supported edges of the sheet.

13. An acoustic device comprising a rec-

tangular frame, a direct-acting diaphragm in the form of a substantially flat rectangular sheet supported on said frame, means carried by said frame for operating said diaphragm, and means for tensioning said diaphragm in the direction of its length without substantially varying the normal distance between the diaphragm and its operating means.

14. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a loudspeaking diaphragm comprising a substantially flat elastic sheet supported at said opening and forming a cover therefor, means for operating said diaphragm, and a housing arranged back of said diaphragm to prevent sound waves from passing into the dead space of said cabinet.

15. In sound-reproducing apparatus, a cabinet having an opening in an outer wall, a flat rectangular frame mounted at said opening, a loudspeaking diaphragm comprising a substantially flat elastic sheet supported on said frame, said diaphragm forming a cover for said opening through which the sound passes directly into the outer air, means carried by said frame for operating said diaphragm, and a housing carried by said frame back of said diaphragm to prevent sound waves from passing into the dead space of said cabinet.

16. An acoustic device comprising a direct-acting diaphragm uniformly tensioned to a high degree and having means therein providing regions of special extensibility.

17. An acoustic device comprising a uniformly and highly tensioned diaphragm having regions of special extensibility, said regions comprising corrugations in said diaphragm intermediate its ends.

18. An acoustic device comprising a diaphragm having corrugations transverse to one dimension thereof and stretched to a high degree.

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