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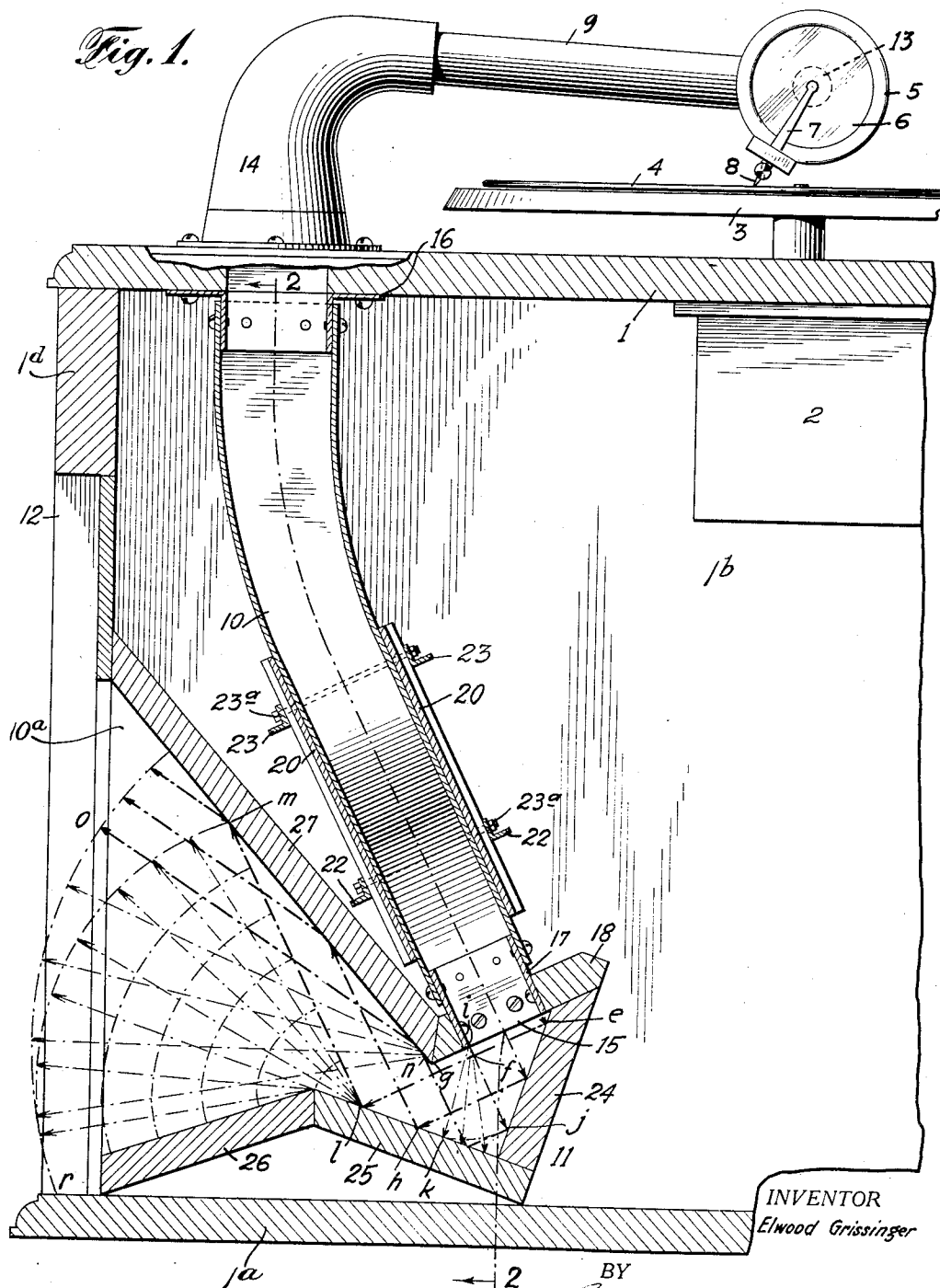
E. GRISSINGER

1,666,057

SOUND PROJECTING APPARATUS

Original Filed July 12, 1921

4 Sheets-Sheet 1



April 10, 1928.

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SOUND PROJECTING APPARATUS

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4 Sheets-Sheet 2

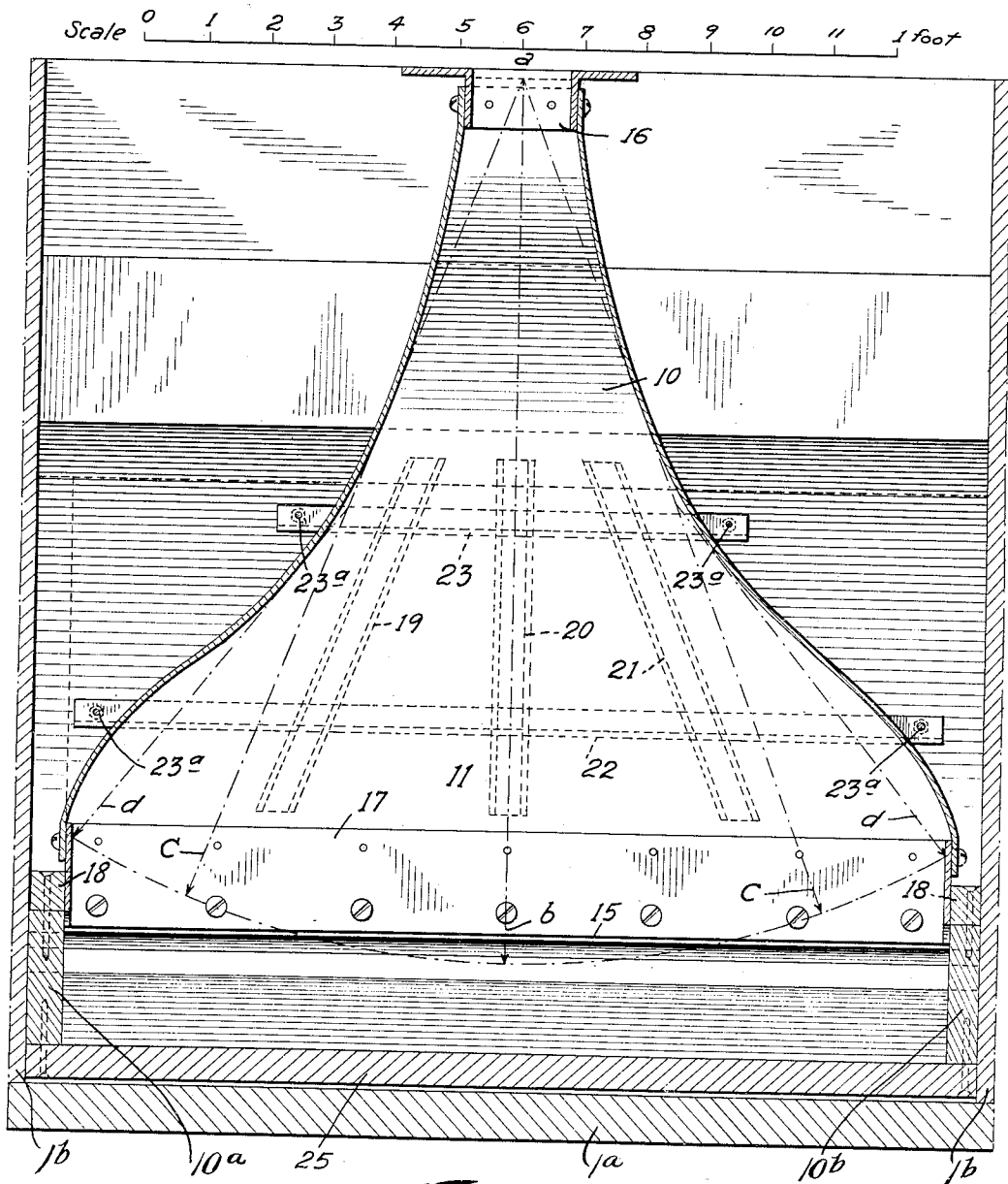


Fig. 2.

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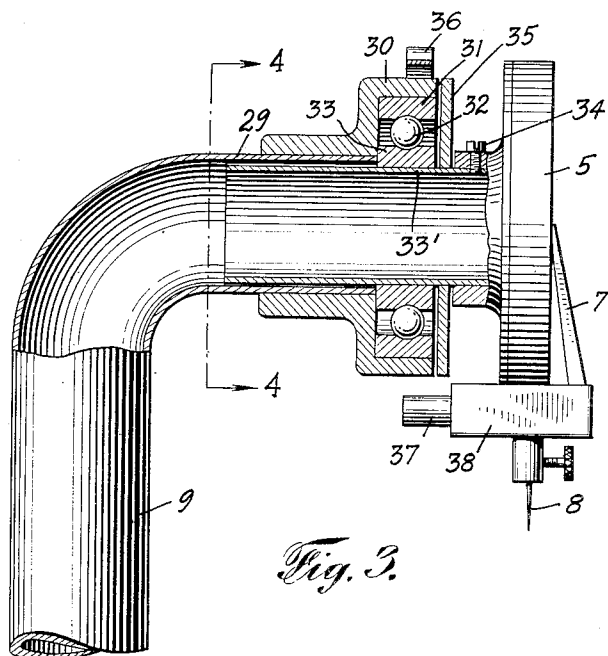
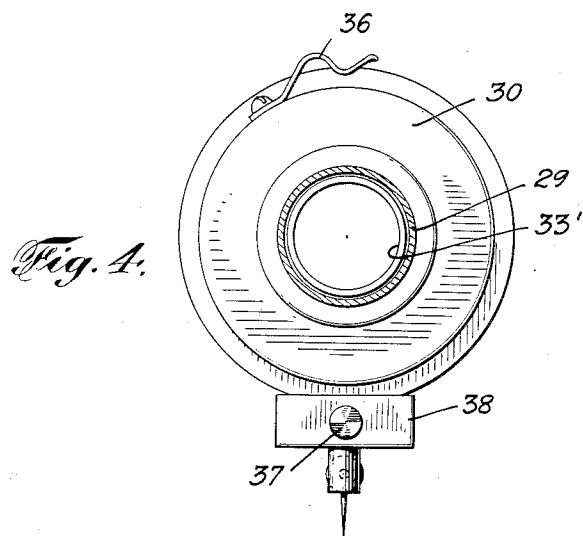
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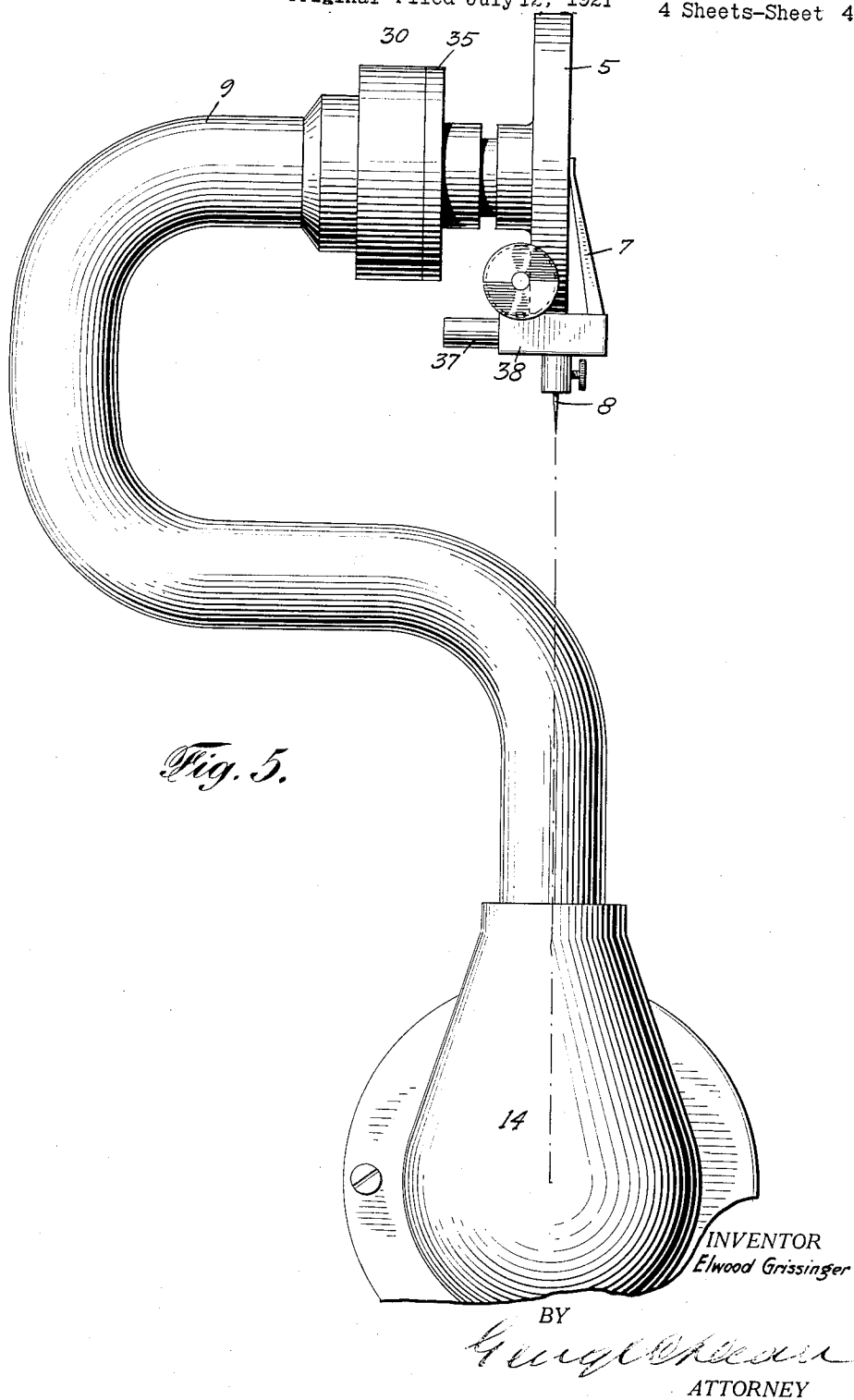
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4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE.

ELWOOD GRISSINGER, OF BUFFALO, NEW YORK.

SOUND-PROJECTING APPARATUS.

Original application filed July 12, 1921, Serial No. 484,240. Divided and this application filed August 18, 1923. Serial No. 658,007.

My present invention relates to cabinets of the type employed for amplifying and projecting sound waves, particularly phonograph cabinets. Its novel features are closely related to and preferably include certain novel features of the projector which is set forth and separately claimed in my companion application Serial No. 484,240, filed July 12, 1921, and which issued as Patent No. 1,477,556 on December 18th, 1923, of which application this is a division. The novel features of the amplifier and projector which make possible the novel cabinet structure herein claimed, are indicated in the drawings and will be described herein to such extent as may be necessary to an understanding of the new and useful features of the cabinet in which it is embodied.

In my cabinet the air column comprises the tone arm, an intermediate portion in which the expansion is mainly or wholly lateral, and a terminal portion in which the expansion is mainly in the other dimension. Of these, the intermediate portion is of extreme practical importance because in cabinet phonographs as now manufactured it is impractical to continue the small diameter conduit around all of the curves which are required because of the limitations of the cabinet makers' art and the necessity of providing a considerable physical length of air column in which the wave front must be gradually expanded to the required large area before projecting it into the open air. This is one of the advantages of my invention. I am able to start the expansion directly at the outlet of the tone arm, but in one dimension only, so that the conduit may be curved to almost any desired extent in the thin direction without danger of serious phase displacement for the short length waves. It is to be noted, however, that curvature either of a small diameter pipe or of a thin layer conduit is not a good thing acoustically. Hence, in the preferred form of my invention, the middle portion of the air column is made fairly straight (downward for the cabinet type of phonograph), and the waves are turned laterally outward through the side of the cabinet, it being permissible to turn them through very wide angles in the direction of thinness of the beam.

part of the air column which is in the tone arm, with an equal or greater length and breadth of widened air column, the otherwise sharply resonant air column in the tone arm tends to function with the widened air column as a composite unit of which said widened air column is a more or less dominant part.

The widened portion may be curved in the direction of its thinness through an arc of 90 degrees or more, provided the radius of curvature be not too sharp, without substantial impairment of its function. Consequently it is quite possible to arrange the projector outlet in the front face of the cabinet and have the intermediate conduit curved as much as may be necessary to bring its small end in receiving relation to the passage through which the tone arm discharges downward.

At the end of the widening conduit, the wide thin sound beam is permitted guided but high angle expansion in a vertical direction. Up to the vertically expanding projecting portion, it seems desirable to keep the main beam as thin as may be practical, without choking the exit of said beam, although this seems to be an energy problem and the desideratum seems to be to have the beam "fill" the throat without choking it.

Another feature of my invention consists in arranging the tone arm outlet at the front of the phonograph cabinet directly over the projector outlet. This makes desirable another feature of my invention which consists in arranging the sound box so that the stylus needle trails toward the vertical axis of the tone arm, on the right hand side of the center of a record, which, as usual, rotates clockwise. This makes it convenient for right-hand manipulation of the sound box to renew the needle or rotate the same into and out of operating relation to the record. A further feature is mounting the sound box upon ball bearings, for rotation about an axis which coincides with the axis of the sound outlet of said box.

The above and other features of my invention may be more fully understood from the following description in connection with the accompanying drawings, in which:—

Figure 1 is a vertical section along the central axis of the sound amplifier and projector showing diagrammatically the path

of the main "beam" and also a part of the forward diffusion thereof near the mouth of the projector.

Fig. 2 is a section at right angles to the plane of Fig. 1 taken along the curved and broken line 2—2 on said Fig. 1, indicating diagrammatically also the lateral expansion and downward curvature of the wave front in this dimension.

Fig. 3 is a detail section showing the mounting of the reproducer on the tone arm.

Fig. 4 is an elevation partly in section on the line 4—4, Fig. 3.

Fig. 5 is a plan view of a modification.

These drawings are intended to indicate approximate sizes as well as the proportions of the parts in one desirable embodiment of my invention. The scale for Figs. 1 and 2 is indicated on Figs. 2, but Figs. 3, 4 and 5 are on a scale twice as large.

In these drawings the invention is shown as applied to a cabinet type of phonograph having a top 1, bottom 1^a, sides 1^b, 1^c and front 1^d. The top 1 carries the motor box 2 driving turn table 3 supporting record 4 in operative relation to sound box 5 having diaphragm 6 operated by a stylus lever 7 through needle 8. These parts may be of any known or desired construction, but as above indicated, the sound box preferably embodies the invention set forth in my application Serial No. 404,860.

The top 1 also carries the tone arm 9 on standard 14; also the primary expansion conduit 10 and the reflecting, secondary-expansion projector 11, which opens through the side 12 of the cabinet.

The diaphragm 6 has its inner face in operative contact through opening 13, with the upper end of the air column which extends continuously through said parts 9, 14, 10, 15 and 11 to the outer air.

The diameter of the air column may be say $\frac{5}{8}$ inch to $\frac{3}{4}$ inch for the length of the tone arm 9, but in the device shown this is enlarged to about $1\frac{3}{4}$ inches in the standard 14. Then for the next 14 inches or through the expansion chamber, the air column has a front-to-rear contraction to say $1\frac{1}{4}$ inches, while the lateral widening in the same distance is approximately 14 inches. The next 4 inches measured along the axis of the main beam, follows the reflection path, and is contained in a portion of the projector which actually measures only about $1\frac{1}{2}$ inches from front to rear. The path of the beam from the end of said reflection path out to the mouth of the projector is about 8 inches to 10 inches though the shortest distance to the mouth is say 4 inches to 6 inches. This is short as compared with lengths of either tone arm or primary expansion conduit. The final expansion in the vertical direction is also limited as to angle, being preferably between top and bottom

walls diverging at angles less than 90°, preferably about 60° to 70°. The horizontal width of the mouth across the face of the cabinet is preferably the same or slightly greater than that of the slot outlet at 15. Usually it will be found convenient and acoustically desirable to make this horizontal width about the same as the practically permissible width of the cabinet.

The entire widening conduit 10, together with the entire reflecting projector 11 might well be embodied in one integral gray iron casting having walls say $\frac{1}{8}$ inch or more in thickness, but as actually constructed by me and as shown in the drawings, the intermediate widened section 10 is made of 16 gauge hard rolled sheet brass the sides being cut to pattern and soldered at the corners. The transverse section is substantially rectangular throughout. At the upper end the sheet brass is firmly screwed and brazed to a square bushing 16 which is in turn screwed to the top 1. At the lower end the slot-like outlet is reinforced by a stiff brass frame member 17 which is in turn screwed to the top board 18 of the reflecting projector. As will be evident from Fig. 2, particularly, the front and rear walls of the widening section 10 are of very considerable area and the sheet brass employed being relatively thin, would be liable to vibration in response to the sound waves. Consequently, I have reinforced and stiffened these flat areas by longitudinal channel bars 19, 20, 21 brazed in place and clamped by superposed cross bars 22, 23, held by tension bolts 23^a—23^b. The channel bars determine nodal lines and the unclamped areas between the bars being narrow but of widely varying widths and highly tensed, amplify slightly and approximately equally for a wide range of the high frequencies. Locating these relatively sensitive vibratory areas in advance of the reflecting projector having relatively insensitive walls, seems to result in better reproduction of the higher frequencies while avoiding all tendency to "metallic" quality. These effects may be modified or eliminated by embedding the vibratory areas or the entire conduit in a plaster of Paris or concrete jacket.

When this part of the device is an integral metallic casting, the interior surface may be continuous and smooth throughout and, if desired, the exterior may be ribbed instead of clamped.

The reflecting projector 11 constituting the secondary expansion element is made of hard elastic material smoothly finished on the inner surfaces, preferably well seasoned birch about $\frac{3}{8}$ inch to 1 inch or more in thickness. The beam being preferably widened in a horizontal direction to the maximum extent before reaching the projector, the end walls 10^a, 10^b of the pro-

jector are parallel and are preferably as wide apart as the width of the cabinet will permit. They are cut to the shape shown in Fig. 1 and have secured thereto by many closely spaced screws, the boards constituting the rear reflector 24, bottom reflector 25, bottom expansion guide 26, roof guide and reflector 27, and the previously mentioned board 18 to which the outlet of the primary expansion conduit 10 is secured. The angle between reflectors 24, 25 is preferably 90 degrees but variations between 80 degrees and 105 degrees have been used.

I find that well seasoned birch of proper variety is highly desirable for this purpose, since it takes a very smooth surface and can be readily stained and polished. Acoustically considered, it is extremely stiff and hard while being elastic in the sense that an ivory billiard ball is elastic. Hence it is almost incapable of absorbing any substantial amount of the sound wave energy and, in the thicknesses and widths above described, is substantially incapable of being objectionably vibrated thereby. The same rigid construction and solid material may be employed for the widening conduit 10, if desired.

The surfaces, particularly the inner surfaces, are stained, polished and varnished with care and the joints are all sealed, as indeed are all other cracks or joints of the entire structure.

Some of the acoustical characteristics of the primary expansion element of the air column will be evident from Fig. 2 taken in connection with Fig. 1. Fig. 1 shows how this portion of the air column is kept thin from front to rear and in this instance actually converging from $1\frac{3}{4}$ inches down to $1\frac{1}{4}$ inches. Fig. 2 shows how it expands laterally. The axial distance down the line $a-b$, is 14 inches, which is the distance traversed by the central part of a wave in reaching the slot outlet at 15 via the line $a-b$. The lines $a-c$ and $a-d$ show the diverging lines of travel of the waves along the edges, and the curved line $d-c-b-c-d$ shows the downward curvature of a wave which necessarily results from equal-speed, equal-distance travel of the waves along said lines $a-b$, $a-c$, $a-d$. For a 14 inch conduit the portions of a wave crest that travel along the side lines $a-d$, $a-d$ are some 2 inches or 3 inches behind the portions traveling along the axial line $a-b$. Thus the successive wave fronts, that is, identical phases of the same wave, cross the slot outlet at different times and at different angles, as and with the results heretofore described. For a 28 inch conduit, the distance of this lag will be 4 inches to 6 inches, thus giving for notes an octave lower, the same phase differences that the 14 inch conduit gives for the higher octave. As the wave continues

its travels its impingement on different portions of the rear reflector 24 will be non-simultaneous both as regards the plane of Fig. 2 and also as regards the plane of Fig. 1; also, the angles of impingement will be different, as regards the plane of Fig. 2; similarly with respect to the second reflection from bottom reflector 25; similarly with respect to the third reflection from top reflector 27.

Fig. 1 also makes it easier to see why front to rear thinness of the slot outlet 15 is a particularly good thing, when employed in combination with a reflecting projector. The more the slot is narrowed and elongated, the less will be the distance which the reflected wave has to travel across the mouth of the slot from e to f , Fig. 1. Moreover, the thinner the main sound beam, the more we may safely decrease the height of the first reflector 24 by raising the second reflector 25 thus vertically narrowing the "throat" at $g-h$ so that the sound can "fill" the projector at this point. If the beam is thick, the diffusion $i-j$, $i-k$ impinging on the bottom reflector 25 will be strong and too much energy will be thus reflected directly back, up the air column.

In Fig. 1 also the dotted lines and arrows indicate in a suggestive though more or less inadequate manner the path of the main beam through the reflecting projector and also with less degree of completeness some of the forward diffusion from the front face $l-m$ of the main beam and also the face $n-o$. The curved lines $m-r$ and $o-r$ represent the wave fronts of these diffusions. These various sets of lines indicate that the main beam and all of the stronger portions of the forward diffusion, cross the plane of the mouth of the projector at comparatively high angles and at different angles and at different times. Thus the curvature of the wave front and its non-simultaneous passage of points where backward reflection might occur exists not only with reference to the dimensions illustrated in Fig. 2, but also with reference to the other dimension illustrated in Fig. 1.

It will be evident that the remarkable performance of the air column above described is contributed to by the characteristic widening of the wave front in one dimension, to a long thin slot outlet, with little or no expansion in the other dimension; this being followed by even more abrupt and shorter distance expansion in the other dimension (vertically) which takes place in the projector; and also so ordering the successive cross-sections of the air column, that the sound pressures can substantially "fill" the cross section; also the curving of the wave front so that the crossing of planes of possible backward reflection is non-simultaneous, for each wave and is at widely dif-

ferent, but mostly sharp angles for different portions of the same front (or phase) of the same wave.

The long, straight-line approach of the sound beam to the first reflector, between substantially parallel walls, seems to parallel the paths of oscillation of the particles, thus giving a sharper more dependable beam for impingement on the reflector.

Furthermore, the preliminary "slot" expansion followed by the secondary expansion in the other dimension and the reflecting projection of the waves, makes possible the following features of construction which are of acoustic as well as structural advantage. The tone arm has its vertical axis at the front of the cabinet, that is, above and near the outlet of the projector which opens through the side of the cabinet. The waves from the tone arm can be carried almost directly downward and whatever curvature is necessary, as for instance that shown in Fig. 1, is in the direction in which the air column is thin. At the same time the air column is being expanded in the other dimension, at a high rate. Frictional losses and particularly attenuation of the high frequencies is very small because the expansion is so free and the distance so short. By the time the waves reach the reflecting projector, the wave front has been expanded so that the distance and therefore the velocity of oscillation of the air particles in propagating the wave, is greatly decreased. As friction decreases much more than in direct proportion to decrease of velocities, the frictional losses are much reduced. Moreover, the propagation of the waves in this part of the air column being by reflection from hard polished surfaces, losses for the higher frequencies are small.

In my projector the waves, without having to traverse any curves after they have been expanded more than two inches in the direction of the curve and without having to turn any corners except by high angle reflection, are enabled to traverse an air column which, as we have seen above, is 36 inches or more in length, yet the main beam emerges from the mouth of the projector not more than 8 inches or 10 inches from the base of the tone arm outlet.

The thus compactly disposed air column affords the desired quarter wave length column for the generation of the long waves of the lowest frequencies necessary for phonograph work, and at the same time, affords a low friction, phase-preserving path for the high frequencies upon which the quality of the reproduced sound depends.

The novel location of the tone arm on the same side of the cabinet through which the sound is projected into the outer air, would require a tone arm and sound box of usual construction, to trail on the left-hand side

of the record which would be awkward and inconvenient in practice. Accordingly my invention includes arranging the sound box to operate on the right hand side of the record with the stylus trailing toward the vertical axis of the tone arm. The preferred construction for this purpose is illustrated in Figs. 1 and 2. The tone arm is curved around through a right angle to form a horizontal terminal portion 29. On this is mounted a housing 30 in which may be fitted an ordinary, ready-assembled roller bearing comprising outer ring member 31, the intermediate balls 32 and the inner ring member 33. The latter has fitted within the same a relatively long sleeve 33', on the outer end of which the sound box is secured by means of screw 34. A face plate 35 closes in and protects the ball race. Outside of the housing 30 is secured a spring 36 adapted to frictionally engage and retain the sound box when turned to the uppermost position for removal or insertion of the needle or for discontinuing operation of the phonograph. The weight of the projection 37 and housing 38 on the sound box may be adjusted to cause the stylus to bear upon the record with any desired degree of force. While this mounting for the sound box is of special advantage in connection with my present invention, it is obvious that any known or desired sound box and any known or desired mounting thereof may be employed.

While I have described in great detail the characteristics of one illustrative form of a composite air column, and the structure whereby all of the various features are practically attainable, it will be obvious that the perfect reproduction obtainable by this invention is contributed by and is the composite result of numerous very novel features localized at various points along the air column, each of which represents careful study, invention and discovery by itself, as well as in relation to the whole. For instance, it is in the nature of a discovery that where the air column is expanded in one dimension only, the expansion may be very rapid, provided the other dimension be sufficiently thin; that preferably this other dimension is less than 2 inches; that when the thinning in of this dimension gets down toward a half inch and less, the length and width of conduit required to give the desired enlargement of wave front may become great, that is, say 24 inches or even 36 inches for a $\frac{1}{2}$ inch slot, and that the limitations on slot thicknesses are of particular importance with reference to the higher frequencies to be reproduced. Another instance is discovery of the desirability for the thinness of main sound "beam" in connection with a reflecting projector, and the desirability of narrowing the "throat" so that the sound may "fill" the same. Another instance is the

discovery, involving more or less of the foregoing, that the best way to expand a wave is to give it primary guided expansion in one dimension, keeping the other dimension small, preferably well below 2 inches until expansion in said dimension is adequate, then affording the wave a guided and limited, but nevertheless rapid secondary expansion in planes at right angles to the primary expansion.

When I speak of expansion in one dimension followed by expansion in another dimension the word "dimension" is not to be taken in a strictly geometrical sense, that is to say, it is the spacing and proximity of the front and rear walls of conduit 10, that is of importance so far as concerns the broader aspects of the invention involved. If the spacing and proximity be preserved these walls could be given a curvature in a direction parallel with the waves. As an extreme illustration, the desired proximity of the walls could be preserved where one wall is a cone and the other wall an inner cone concentric with the first. In this particular case the benefit of a downwardly curving wave front crossing the mouth of the projector at different distances and times and angles, will be lost unless the mouth of the conduit were cut on a plane at an angle to the axis of the cones. This instance is cited merely as an illustration of the fact that some of my discoveries are generic and applicable to geometrical forms of air column quite different from those shown in the drawings.

While the vertical end walls of the projector mouth are above described as parallel, the principal value of this is cheapness of construction. They may diverge or converge provided the angle be not too abrupt. With respect to lateral diffusion of the sound, in the outer air, it will be noted that the 24 inch slot does not sound as loud as the 14 inch slot when in front of the respective instruments, whereas, from an adjoining (side) room, the 14 inch slot will not sound as loud as the 24 inch slot, at least this is so for many kinds of records.

With respect to the length for conduit 10, it will be noted that if a conduit 14 inches by 14 inches by 1 inch makes the edge portions of a given wave front or given wave phase 2 inches or 3 inches behind the axial portion, when passing the mouth 15, then a conduit 28 inches by 28 inches would make this distance 4 inches to 6 inches so that the 28 inch conduit would give the same phase differences for a wave front of frequencies an octave lower than would the 14 inch conduit.

For waves of average phonographic intensity the area to which the conduit 10 widens the wave front, is preferably between 12 square inches and 30 square inches, although inferior but fair results have been obtained with a 14 inch by 14 inch by $\frac{1}{2}$ inch

conduit, the outlet area of which is only 7 square inches. A 24 inch by 24 inch by 1 inch having an area of 24 inches gave almost as good results as a 16 inch by 16 inch by $1\frac{1}{4}$ inch which had an area of 20 inches. The latter is perhaps the most satisfactory instrument of all the instruments I have specifically described.

The mouth portion of the projector wherein the thin beam is thickened to the desired final area is preferably shorter than the axial length of the primary conduit and shorter than the width of the beam projected therefrom.

Fig. 5 shows a tone arm which is bent horizontally in reverse curves, so as to bring the vertical plane of the trailing stylus needle into the same plane with the vertical pivotal axis of the tone arm. The frictional drag of the record on the needle is made to take effect in the plane of the vertical axis and there is less tendency for the needle to jump the groove in the record or to press more strongly on one side of the groove than on the other. In the form shown these reverse curves result in increasing the length of the tone arm several inches, as will be evident by comparison with the form shown in Fig. 1.

While I have shown and described with considerable precision the precise dimensions as well as the shape of one desirable embodiment of my invention, together with illustrative examples of how certain of these dimensions can be varied to advantage, it will be evident that certain of the claims herein define the combinations in such scope as to include different dimensions, proportions and details of construction, such as shown in my patents such as 1,477,553 and 1,553,770; and such claims are intended to cover said combinations whether employed in the sensitive sonorous plate combinations to which said prior disclosures are more specifically directed, or in the non-vibratory wall combinations to which my present application is more specifically directed.

It will be noted that some of the novel features of organization and arrangement of the parts of the phonograph cabinet as claimed herein resemble those disclosed in my prior application Ser. No. 380,492, filed May 11, 1920, now Patent 1,553,770 but I have elected to present the cabinet structure claims in this application and to limit the claims of said prior application to specific features not specifically claimed herein.

While the theories herein stated are such as may prove helpful in the design of other devices embodying various features of my invention, separately or in different combination or relation, the completeness and accuracy of some of them have not been fully verified and applicant reserves the right to withdraw, correct or supplement some of

said theories, in accordance with the facts which may be developed by further study or test.

I claim:

1. A phonograph cabinet having the usual record-supporting and driving means and any known or desired reproducer and tone arm defining a slender air column in operative relation thereto, the vertical axis of the tone arm being located approximately in the central front-to-rear vertical plane of the cabinet and discharging downward, said cabinet being of substantially greater diameter than said record supporting and driving means in combination with a primary expansion conduit communicating directly with the slender part of the air column, said conduit expanding the waves to a relatively wide, thin beam and delivering said beam through a projector discharging through a side wall of the cabinet and having vertically diverging walls adapted to afford limited and guided but rapid expansion of the wave front in the dimension in which the beam is thin, the mouth of said projector having a width approximating the width of said cabinet.

2. In the combination specified by claim 1 the further feature of a curve in the conduit to bring its outlet in desired relation to the projector, said curve being in the direction of the thinness of said conduit.

3. In the combination specified by claim 1 the further feature of deflecting surfaces in the projector whereby the sound beam is deflected through a total arc approximating a semi-circle.

4. In the combination specified by claim 1 the further feature of having the throat or outlet of the widening conduit of a height approximately equal to or less than the thickness of the sound beam where it is projected from the mouth of the conduit.

5. A phonograph apparatus comprising a cabinet, a reproducer, supporting and rotating means for the record, and a tone arm swinging in a horizontal plane, upon the free end of which said reproducer is mounted, but with the reproducer needle trailing toward the front of the cabinet and the tone arm discharging downward at the front of the cabinet, in combination with a conduit in which the waves from the tone arm are expanded laterally, in a length at least as great as the length of the said slender part of the air column and to a width several times its thickness.

6. A phonograph apparatus comprising a cabinet, a reproducer, supporting and rotating means for the record, and a tone arm defining a slender air column in operative relation to the reproducer; the tone arm discharging downward at the front of the cabinet; a sound outlet in the front of the cabi-

net and intermediate means for expanding the waves to a limited extent; then projecting them through said outlet in the front of the cabinet, said outlet having a width approximately that of said cabinet.

7. A phonograph apparatus comprising a cabinet, a reproducer, supporting and rotating means for the record, and a tone arm defining a slender air column in operative relation to the reproducer; the tone arm discharging downward at the front of the cabinet; in combination with a downwardly extending conduit shaped to expand the waves widely in a dimension parallel with the front of the cabinet substantially without expansion in the other dimensions, and means for projecting the thus expanded waves outwardly through the front face of the cabinet near the level at which the tone arm outlet is located.

8. In the combination specified by claim 7, the further feature of plane reflectors in the projector whereby the sound beam is emitted at an upward angle.

9. In the combination specified by claim 7 the further feature of arranging the plane reflectors at right angles and closely adjacent, in the same wall of the projector to direct the emitted sound beam adjacent the roof or upper wall of the projector outlet.

10. A cabinet type phonograph including a cabinet having therein the projector outlet and the tone arm outlet adjacent the same face of the cabinet and in combination with the reproducer and tone arm of such a device, a mounting for the reproducer on the tone arm permitting rotary motion of the reproducer about an axis substantially perpendicular to the center of the reproducer diaphragm, the reproducer stylus trailing toward the vertical axis of the tone arm so as to operate on the right hand side of the center of the record.

11. In the combination specified by claim 10 the further feature of a roller bearing concentric with the axis of the reproducer diaphragm and in which bearing the reproducer turns, in combination with means for yieldingly forcing the stylus toward the record by rotary movement about said axis.

12. A phonograph apparatus comprising a cabinet, a reproducer, supporting and rotating means for the record, and a tone arm defining a slender air column in operative relation to the reproducer; in combination with a projector opening through a wall of the cabinet and an intermediate conduit in which the waves from the slender part of the air column are expanded laterally, to form a thin beam approximately as wide as the projector opening, said projector having walls rapidly diverging vertically to the desired height of the outlet opening.

13. A phonograph cabinet apparatus comprising supporting rotating means for the record, a reproducer, and a tone arm defining a slender air column in operative
5 relation to the reproducer; in combination with a projector having a mouth opening through a vertical wall of the cabinet and an intermediate conduit communicating directly with the outlet of the tone arm, and
10 shaped so as to expand the waves mainly in one dimension to a wide thin beam, said projector having walls permitting wide expansion of said beam in the direction of its thinness.

15 14. A phonograph cabinet apparatus comprising supporting rotating means for the record, a reproducer, and a tone arm defining a slender air column in operative relation to the reproducer; in combination with
20 a conduit communicating directly with the outlet of the tone arm, said conduit having its walls shaped so as to expand the waves to a wide thin cross section, the width of which is several times the thickness.

25 15. In combination with the parts specified by claim 14 two high angle reflectors

arranged to reflect said beam twice in the direction of its thinner dimensions.

16. In the combination specified by claim 14 the further feature of having the wider
30 walls of said conduit approximately parallel for a considerable distance back from the outlet thereof.

17. A method of sound wave amplification comprising expanding the sound waves substantially in one dimension only and then expanding them substantially in another dimension only.

18. A method of sound wave amplification comprising expanding the waves substantially in one dimension only, then deflecting them in the direction of their thinness, and then expanding them in substantially
40 another dimension only.

19. A method of amplifying sound waves
45 comprising causing substantially uni-dimensional expansion only of the waves successively in different dimensions.

Signed at Buffalo, in the county of Erie and State of New York, this 31st day of
50 July, A. D. 1923.

ELWOOD GRISSINGER.