April 10, 1928. 1,666,059

E. GRISSINGER

SOUND PROJECTOR

Filed Dec. 12, 1923 2 Sheets-Sheet 1

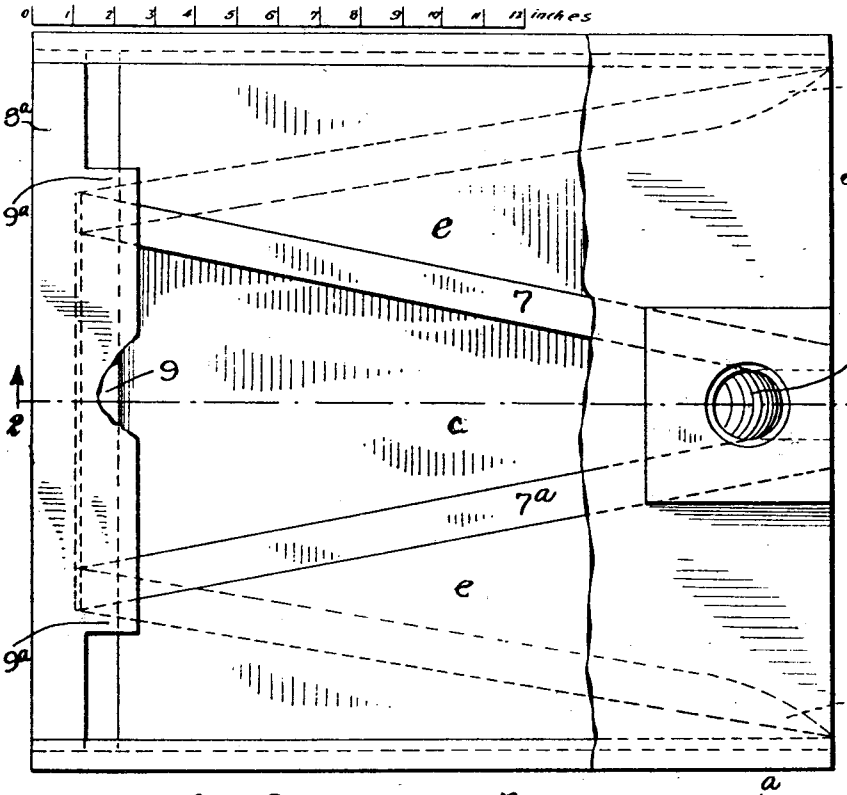


Fig. 1.

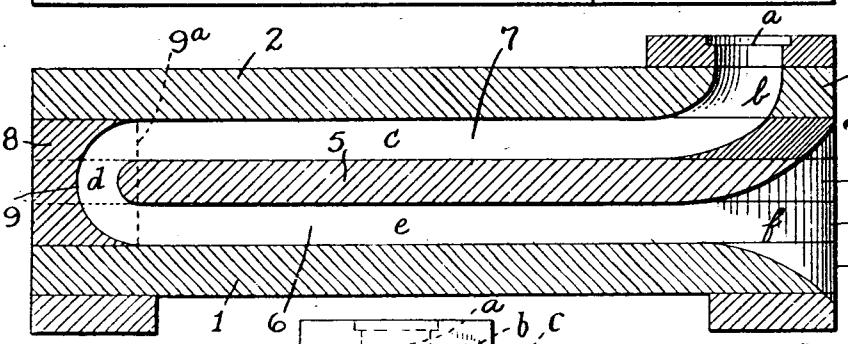


Fig. 2.

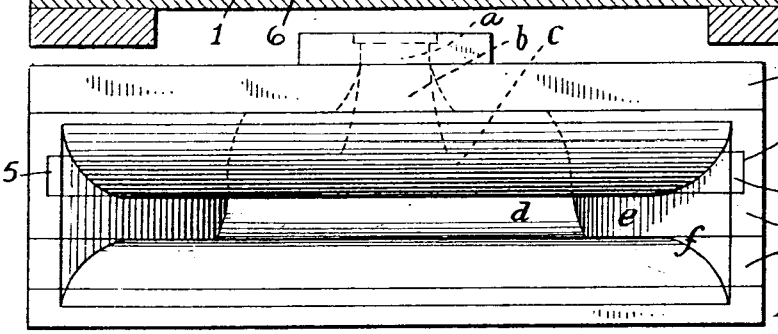


Fig. 3.

INVENTOR
Elwood Grissinger

BY
Gerald Dean
his ATTORNEY

April 10, 1928. 1,666,059

E. GRISSINGER

SOUND PROJECTOR

Filed Dec. 12, 1923 2 Sheets-Sheet 2

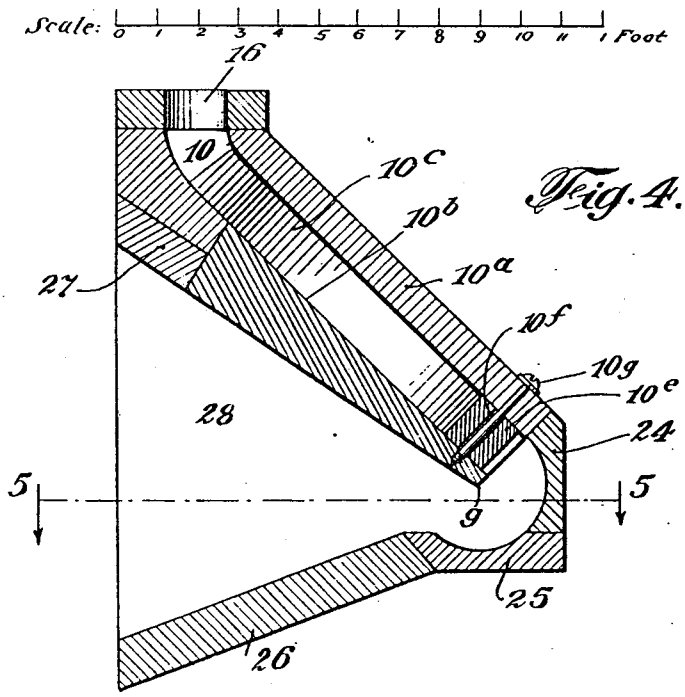


Fig. 4.

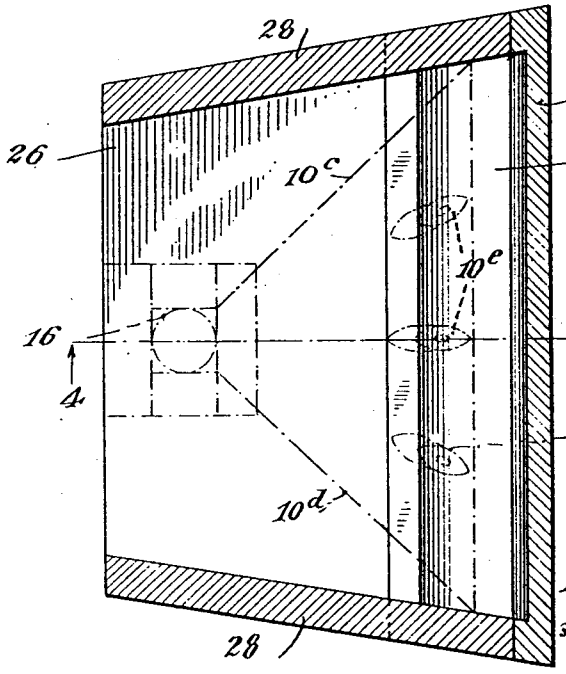


Fig. 5.

INVENTOR

Elwood Grissinger

By G. C. Dlean

his ATTORNEY

Patented Apr. 10, 1928. 1,666,059

UNITED STATES PATENT OFFICE.

ELWOOD GRISSINGER, OF BUFFALO, NEW YORK.

SOUND PROJECTOR.

Application filed December 12, 1923. Serial No. 680,091.

My present invention is closely related to that claimed in my copending application Serial No. 484,240, filed July 12, 1921. This invention is embodied in a special form of sound projector peculiarly adapted to serve the purpose of an amplifier for phonographs but certain features of the projector will be found useful in connection with radio and other telephone receivers and other vibratory sound producers and also in connection with other sources of sound, particularly where, as in the case of human speech and music, the sounds comprise a wide range of frequencies, and particularly where it is desired to faithfully reproduce a multiplicity of sets of waves or complex waves of many frequencies, simultaneously.

A specific object of my invention is to provide an air column associated at one end with the diaphragm of the phonograph reproducer and at the other end communicating with the open air, in which the air column will be a suitable medium for development, expansion of wave front, and projecting into the open air, sound waves having a wide range of physical lengths, including sound waves of which the quarter wave length is long and requires great length of air column, and also short waves of the higher frequencies, the quarter lengths of which may be two inches or less.

In my device, the waves from the tone arm or other source, are first propagated directly into and are partially expanded in a one-dimension-expansion conduit having opposite walls that are approximately parallel and may be slightly converging, provided only that they prevent substantial expansion in one dimension, while other opposite walls are substantially diverging to afford guided expansion in the other dimension to the desired extent. As explained in my prior patent, the parallels or expansion preventing walls of this part of the conduit are of best effect when not too far apart, that is, less than 3 inches and preferably less than 2 inches. Propagation through such a one-dimension-expansion conduit seems to prepare the waves for deflection at right angles to the direction of expansion, that is, deflection in the direction of thinness of the air column. When the deflection is in this direction, there is less energy loss and phase displacement than where the deflection is in the direction of the expansion. Consequently curves or other deflecting surfaces, deflecting the sound beam in the direction of its thinness, may be employed, and this makes possible a close folding and a massive integral construction for the device, which is a feature of my present invention.

In both of the forms herein shown, the amplifier or projector is thus folded in two or more reversely extending lengths and has deflecting surfaces for substantially reversing the direction of the waves from one length into the reversely extending portion. In the first described form, the deflector deflects the sound waves from the primary one-dimension expander into a second portion that is in effect a mere continuation of the preceding, the continuation having opposite walls parallel with each other and with the parallel walls of the primary portion and its other walls diverging similarly to those of said primary portion; but in the second described form, the deflector turns the waves into a projector portion permitting wider angle expansion and this expansion is in the direction of the thinness of the primary conduit. In other words, both forms constitute what may be called folded horns, but in the first form one of the parallel walls of one fold is adjacent and constructed integrally with a parallel wall of the next fold, whereas in the second form it is one of the divergent walls of one fold that is adjacent one of the parallel walls of the other fold. The latter form is analogous to that shown in my application Ser. No. 679,911, filed Dec. 11, 1923, in that the widening conduit has its outlet portion curved in the direction of its thinness to discharge at any desired angle into a well developed projector portion, the arrangement being preferably so ordered that the main beam crosses the plane of the vertical mouth of the projector at a sharp angle. This abrupt turning is in the direction of the thinness of the sound beam and is guided by semicylindrical surfaces curving through an arc of approximately 180 degrees. Moreover, the widening conduit may be curved in the direction of its thinness through a less arc of 90 degrees more or less, if desired.

The above principles are capable of embodiment in many specifically different forms, but I have selected for illustration

herein a form in which all of the walls are very thick and are of dense stiff wood, preferably spruce. For faithful reproduction of the record such thick, stiff, non-vibratory walls are preferable.

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:—

Fig. 1 is a plan view of one form of the device with the top plate broken away.

Fig. 2 is a vertical section on the line 2—2, Fig. 1.

Fig. 3 is a front elevation.

Fig. 4 is a view showing another form in vertical section along the central axis of the sound amplifier and projector on the line 4—4, Fig. 5.

Fig. 5 is a section on the line 5—5, Fig. 4, showing in dotted lines certain parts above the plane of the section.

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 is indicated at the top of each sheet.

In these drawings the invention is shown as adapted for a cabinet type of phonograph and in the first form the projector is adapted to form a solid base for such cabinet. In both forms a tone arm or other source of sound is supposed to discharge downward at the front of the cabinet. However, it is plain that by adding another fold to the form shown in Figures 1 and 2, the inlet to the projector would locate at the rear of the cabinet.

Referring to Figs. 1, 2 and 3, particularly Fig. 2, it will be seen that the device is mainly a widening conduit. The air column comprises an inlet portion *a*; a downwardly extending portion *b*, in which the air column is prevented from expansion in one dimension and may or may not be slightly decreased in thickness; a horizontally extending portion *c*, in which two opposite walls are parallel; a downwardly curving portion *d*, in which the walls are concentric semi-cylinders; a reversely extending horizontal portion *e* terminating in an outlet *f*. The inlet *a* may be of suitable diameter for receiving sound waves from a suitable conduit and this may be a phonograph tone arm or a telephone receiver, say, one inch and three-quarters to two inches in diameter and preferably not more than three inches in diameter. While the contraction in the portion *b* is not essential, it is desirable to have it where compactness is desirable, since that makes possible the reduction of thickness of the beam in *c* to less than two inches, and if this thickness is preserved throughout the partial expansion portion *c*, deflecting portion *d* and reversely extending portion *e*, the total size of the device for given length of air column, is proportionately reduced. The outlet *f* is a more or less rudimentary mouthpiece whereby the transition from the widening conduit to the outer air is rendered less abrupt.

Referring to Fig. 1 it will be seen that the other two walls of the conduit widen practically uniformly from the inlet to the exit, the angle of divergence as shown being about 10 or 12 degrees. Preferably the length of the air column is 40 to 50 inches and the width of the outlet 14 to 18 inches.

By thus limiting substantially all of the expansion of the wave front to a single dimension, I am able to get an adequate expansion of wave front and a length of air column (three or four feet or more) in a very compact space, the width of the device being but slightly greater than the width of the outlet, the length hardly greater than one-half the length of the air column and the height only five or six times the thickness of said column. Obviously the bends in the direction of the thinness of the conduit may be repeated so that the conduit will be disposed in three or more lengths extending alternately in opposite directions and the bends may be greater or less than 180 degrees. The outlet width as well as the total length of the conduit may be greater or less than shown as may also the angles of divergence of the walls 6, 6ª, 7, 7ª. Moreover the cross section may be somewhat elliptical instead of rectangular, provided the thinner dimension be kept within the desirable limits, preferably about 2 inches.

A widening conduit projector having the above characteristics may be constructed in a variety of ways. The simplest way would be to build it up from boards each cut to the proper shape, piled one on top of the other and glued under heavy pressure. As shown, however, the device is somewhat lightened by building it from two heavy boards forming the bottom 1, and top 2, together with an intermediate spacer 3 having a fore and aft groove 4 in which slides an intermediate board 5. Between baseboard 1 and intermediate board 5 are heavy spacer strips 6, 6ª forming the divergent walls of the outlet half of the conduit while the divergent walls 7, 7ª may be similar strips primarily secured to the top board 2. The inner end of the middle board 5 being formed on a semi-cylindrical convexity having a diameter of, say, 1 inch, the outer wall of the bend may be completed by block 8 having a corresponding inwardly directed semi-cylindrical cavity 9 carried by a cross-piece 8ª the ends of which slide in the grooves 4. In the present case this cross-piece is shown as longitudinally recessed to projecting portions 9ª, 9ª, embracing the ends of the divergent walls 6, 6ª, 7, 7ª. All of

these parts are carefully dimensioned and fitted as to thickness and are glued under pressure to form a substantial integral structure. If desired, the structure could be made integral in any other desired way as by molding or casting.

Referring to the form shown in Figs. 4 and 5:—

The top of the cabinet which carries the tone arm and other operating parts of the phonograph also carries the primary expansion conduit 10 with the semi-cylindrical outlet at 24, 25 and the secondary-expansion or projector portion 26, 27, 28, which opens through the side of the cabinet.

The tone arm or other source of sound discharges at 16 directly into the upper end of the air column which extends continuously through the primary and secondary expansion conduits to the outer air.

The conduit walls are all of very thick spruce, including the walls 10^a, 10^b, 10^c and 10^d of the widening conduit. These are all at least one inch thick except the wall 10^b, the lower end of which is made thin in order to bring the upper wall of the projector in proper relation to the discharge from the curved end of the widening conduit. Vibration of this thinner portion, however, is prevented by providing piers 10^e, preferably of wood. These are firmly glued between 10^b and 10^a, the surfaces being drawn into most intimate engagement while the glue is wet by means of tension screws 10^f. These screws, preferably pass freely through holes 10^g in piers 10^e without engaging the sides of said holes. This leaves the end surfaces of the piers freer to take and maintain the desired position under the clamping stress of the screw; also unequal lateral expansion or contraction of the wood cannot take effect directly on the screw. Similar piers may be used for the free edge of the middle wall in Figs. 1, 2 and 3, but is less necessary because it is easier to make this wall as thick as may be deired.

The terminal portion of the conduit is also one inch spruce. The length of the lower plate 26 is such that it must be very thick and stiff in order not to vibrate under the acoustic stresses set up by proper functioning of the projector as a whole. Hence I prefer to make the thickness of this plate greater, say 1¼ inch. The same tendency to vibrate is found in the roof plates 27 and 10^b, but these are so massively backed in the present construction that vibration is minimized, if not eliminated.

The waves emerging from the conduit 10 are diverging on a spherical wave front and the angle is considerable. It results that when the end walls of the terminal portion of the conduit are parallel, as in my said application Serial No. 484,240, a substantial part of each flank of the main beam will impinge upon said walls and will be thence reflected out of the mouth of the projector. In most cases the thus deflected flanks of the beam will tend to converge toward crossing points far beyond the mouth of the projector and practically the angles are insufficient for effective lateral diffusion of the sound on each side of the direct beam. While such arrangement may be employed for my present construction, I have found that improved acoustic effects, accompanied by greater lateral diffusion may be obtained by converging the end walls as shown in Fig. 5. There seems to be a further advantage due to confining the waves laterally (a sort of reversal of flank diffusion), particularly where the vertical expansion permitted in this part of the conduit is extremely rapid. The convergence of the side walls may be small, not more than, say 10° anywhere toward the axis for each wall and, as before stated, the walls may be parallel.

For undistorted amplification I find that the walls of the widening conduit as well as of the projector should be very stiff and at the same time very light, so that tendency to sympathetic vibration will be avoided and such as may occur will be of the higher frequencies. To this end the quality of the material used should be very stiff and light as to quality, while the construction should be as solid as possible. For this purpose the best material which I have been able to find up to the present time, is boards or timbers of well seasoned spruce. Probably the thicker the timber is the better it would be, but experience shows that the above named thickness of an inch or two is practically sufficient for the walls of the widening conduit, and also for the projector.

While I have shown the semi-cylinder at 24, 25, struck from point g as the center for turning the waves emerging from the slot outlet of widening conduit 10, through angles totaling 180 degrees, it will be found that other curved, or partly curved and partly plane deflectors can be used. Curved surfaces of less angular arc or less radius or struck from a more remote center, may be desirable. Where the conduit 10 is vertical, instead of inclined at a 45 degree angle, a single reflector may be used to turn the waves through the 90 degree angle, instead of two reflectors for the 180 degree angle, and such single reflector may be either plane or curved, or partly plane and partly curved. These and other similar modifications are based on my above explained principle that propagation of the waves between opposite approximately parallel walls which prevent expansion in one dimension, with other outlet walls diverging to permit guided expansion in the other dimension, seems to prepare the sound waves for deflection, so that the conduit may be curved in the direction of

its thinness with less energy loss and phase displacement than where the deflection is in the other dimension.

My invention does not depend upon the correctness of my theories with reference to it and in so far as I have stated theories, it has been for the purpose of indicating or accounting for novel results. Whether correct or not, they will be found useful as hypotheses to assist those skilled in the art when seeking to apply one or more of my novel principles to new conditions or purposes.

Regardless of theory, it will be evident that both forms of the device shown in the drawings are generically the same in that each embodies my novel combination of the following features: Each embodies a massive-walled conduit affording an air column for amplifying and projecting speech waves, which is folded upon itself as compactly as may be desired.

Thus, Figs. 2 and 4 are merely different illustrations of how by my invention, successive portions of the conduit may have oppositely extending conduits or walls folded adjacent each other without danger of distortion and confusion by sympathetic vibration effects such as result where the vibrations of the air column of one part of a conduit are permitted to strike through the adjacent wall into another part of the air column, where the phase relations are entirely different.

In Fig. 4, the mouth or projector portion starts much further back in the conduit than in Fig. 2, but the broad idea is the same and, as stated above, the deflecting curves or bends in the direction of the thinner dimension of the conduit may be repeated to dispose any desired length of conduit in three or more lengths extending in opposite directions, as in Fig. 2. Similarly, the projector of Fig. 2 may have the wider area expansion and even the design of the projector portion of Fig. 4.

In all forms of the device, it is highly important to have all surfaces of the wood (preferably well seasoned spruce) filled and worked down to a very smooth hard finish. This is one reason why both forms are shown as of sectional construction. That of Figs. 1, 2 and 3, particularly, is adapted for complete finish of the interior surfaces before being assembled for final gluing or otherwise securing together of parts. The layers may be built up one at a time from the bottom, each interior surface being polished before it is covered by the next layer, or the building may progress from top and bottom plates simultaneously.

I claim:

1. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising walls arranged to permit wide expansion of the wave front in one dimension along widely diverging lines and other walls approximately parallel with each other, arranged to guide said waves in the other dimension, said conduit being curved in the direction of its thinness approximately midway of its length.

2. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising walls arranged to permit wide expansion of the wave front in one dimension along widely diverging lines and other walls approximately parallel with each other, arranged to guide said waves in the other dimension, said conduit being curved in the direction of its thinness through an arc sufficient to cause a wall of the conduit in advance of the curve to constitute a wall for a portion beyond the curve.

3. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising walls arranged to permit wide expansion of the wave front in one dimension along widely diverging lines and other walls approximately parallel with each other, arranged to guide said waves in the other dimension, said conduit being curved in the direction of its thinness through an arc of approximately 180 degrees.

4. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising walls arranged to permit wide expansion of the wave front in one dimension along widely diverging lines and other walls approximately parallel with each other, arranged to guide said waves in the other dimension, said conduit being curved in the direction of its thinness through an arc of approximately 180 degrees approximately midway of its length.

5. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising walls arranged to permit wide expansion of the wave front in one dimension along widely diverging lines and other walls approximately parallel with each other, arranged to guide said waves in the other dimension, said conduit being curved in the direction of its thinness through an arc of approximately 180 degrees approximately midway of its length a wall of conduit beyond the curve being parallel and integral with a wall of a portion in advance of the curve.

6. A sound amplifying conduit for expanding the wave fronts of complex sound

waves, said conduit being solidly constructed of thick, stiff material, and comprising a primary portion having walls arranged to permit guided and limited but rapid expansion of the wave front in one dimension along widely diverging lines and other walls nearly parallel with each other, arranged to guide said waves in the other dimension, thereby forming a thin sound beam with widely divergent flanks and a deeply curved wave front; the outlet end of said primary expansion being curved in the direction of its thinness and discharging into a projector portion having walls diverging at an angle permitting guided but rapid expansion of said beam in said second dimension.

7. A sound amplifying conduit for expanding the wave fronts of complex sound waves, said conduit being solidly constructed of thick, stiff material, and comprising a primary expansion portion having walls arranged to permit guided and limited but rapid expansion of the wave front in one dimension along widely diverging lines and other walls nearly parallel with each other, arranged to guide said waves in the other dimension, thereby forming a thin sound beam with widely divergent flanks and a deeply curved wave front; the outlet end of said primary expansion portion being curved in the direction of its thinness, through an angle of approximately 180 degrees and discharging in the direction of a divergent wall of a projector portion having walls diverging at an angle permitting guided but rapid expansion of said beam in said second dimension.

8. A sound amplifying conduit for expanding the wave fronts of complex waves, said conduit being solidly constructed of thick, rigid material and being reversely folded upon itself to form successive, adjacent lengths or folds extending in opposite directions, adjacent surfaces of adjacent folds being oposite surfaces of the same wall of thick, rigid material; said folds including a primary expansion portion having opposite divergent walls arranged to permit guided expansion of the wave front in one dimension and other opposite walls nearly parallel with each other arranged to confine said waves in the other dimension, thereby forming a relatively thin sound beam comprising waves projected along lines widely diverging in the first dimension but with little or no divergence in the second dimension; and the fold into which said primary expansion portion discharges embodying a reversely extending projector portion having walls widely diverging in said second dimension and one of which is the same wall of thick, rigid material that forms a wall of the adjacent primary expansion portion; and the primary expansion portion being connected with the projector portion by a deflector which is thick, rigid material and has deflecting surfaces curved in the direction of thinness of the sound beam to substantially reverse the direction of said beam.

9. A sound amplifying conduit for expanding the wave fronts of complex waves, said conduit being solidly constructed of stiff material and being reversely folded upon itself to form successive, adjacent lengths or folds extending in opposite directions, adjacent surfaces of the first of said folds being flattened to afford partial expansion of the waves, much greater in one dimension than in the other, adjacent folds being opposite surfaces of the same solid wall of stiff material, and successive opposite folds being connected by a deflector which is of stiff material and has deflecting surfaces curved in the direction of a thin dimension of the conduit.

10. A sound amplifying conduit for expanding the wave front of complex waves, said conduit being solidly constructed of stiff material and being reversely folded upon itself to form successive, contiguous lengths or folds extending in opposite directions, and embodying a primary expansion portion having two opposite sides approximately parallel and two other sides substantially diverging, the successive oppositely extending folds being connected by a deflector, the deflecting surfaces of which operate by lateral deflection in the direction of the thin dimension of the conduit, to substantially reverse the direction of the sound waves for propagation through a projector having divergent walls permitting expansion in the direction of such deflection.

11. A sound amplifying conduit for expanding the wave fronts of complex waves, said conduit being solidly constructed of rigid material and being reversely folded upon itself to form successive, contiguous lengths or folds extending in opposite directions, said folds including a primary expansion portion having opposite divergent walls arranged to permit guided expansion of the wave front in one dimension and other opposite walls nearly parallel with each other arranged to confine said waves in the other dimension, thereby forming a relatively thin sound beam comprising waves projected along lines widely diverging in the first dimension but with little or no divergence in the second dimension; and the fold into which said primary expansion portion discharges embodying a reversely extending projector portion having walls widely diverging in said second dimension; and the primary expansion portion being connected with the projector portion by a deflector, the deflecting surfaces of which operate in the direction of thinness of the sound beam to substantially reverse the direction of said beam.

12. An amplifying conduit for guiding, expanding and projecting complex waves into the atmosphere, said conduit being solidly constructed of stiff material and reversely folded upon itself, with the adjacent walls of adjacent, oppositely extending folds laterally united as a massive integral structure, so as to minimize sympathetic vibration; said conduit including a conduit section, for partial one dimension expansion of the waves, having opposite walls that are substantially parallel to substantially prevent expansion in one dimension and other opposite walls substantiallly diverging to permit expansion in the other dimension; also another conduit section, for further one dimension expansion of the waves from the first section, having opposite walls to prevent expansion in one dimension and other opposite walls to permit the expansion in the other dimension; also including deflecting surface arranged to deflect the partially expanded waves from said first mentioned conduit section in the direction of the thinner dimension thereof.

13. An amplifying conduit for guiding, expanding and projecting complex waves into the atmosphere, said conduit being solidly constructed of stiff material and reversely folded upon itself, with the adjacent walls of adjacent, oppositely extending folds laterally united as a massive integral structure, so as to minimize sympathetic vibration; said conduit including a conduit section, for partial one dimension expansion of the waves, having opposite walls that are substantially parallel to substantially prevent expansion in one dimension and other opposite walls substantially diverging to permit expansion in the other dimension; also another conduit section, for further one dimension expansion of the waves from the first section, having opposite walls to prevent expansion in one dimension and other opposite walls to permit the expansion in the other dimension; also including smoothly curving deflecting surface arranged to deflect the partially expanded waves from said first mentioned conduit section in the direction of the thinner dimension thereof; the laterally united walls of adjacent folds comprising one of the parallel or non-expansion walls of one fold and one of the divergent expansion walls of another fold.

14. An amplifying conduit for guiding, expanding and projecting complex waves into the atmosphere, said conduit being solidly constructed of thick, stiff material and reversely folded upon itself, with the adjacent walls of adjacent, oppositely extending folds laterally united as a massive integral structure so as to minimize sympathetic vibration; said conduit including a conduit section formed for partial expansion of the waves in one dimension more than in the other; another conduit section formed for further expansion of said waves from the first mentioned conduit section in the direction of the thinner dimension thereof; and including also deflecting surface arranged to deflect the partially expanded waves from said first mentioned conduit section in the direction of said thinner dimension.

15. An amplifying conduit for guiding, expanding and projecting complex waves into the atmosphere, said conduit being reversely folded upon itself, the adjacent, oppositely extending folds having the inlet end of the wall of one fold and the outlet end of the next fold laterally united as a massive integral structure so as to minimize sympathetic vibration; said conduit including a conduit section formed for partial expansion of the waves in one dimension more than in the other; another conduit section formed for further expansion of said waves from the first mentioned conduit section in the direction of the thinner dimension thereof; and including also intermediate deflecting surface arranged to deflect the partially expanded waves from said first mentioned conduit section in the direction of said thinner dimension.

Signed at Buffalo in the county of Erie and State of New York this 10th day of December, A. D. 1923.

ELWOOD GRISSINGER.