E. E. CLEMENT.

ACOUSTIC MULTIPLIER.

APPLICATION FILED MAR. 16, 1912.

1,216,946.

Patented Feb. 20, 1917.

2 SHEETS—SHEET 1.

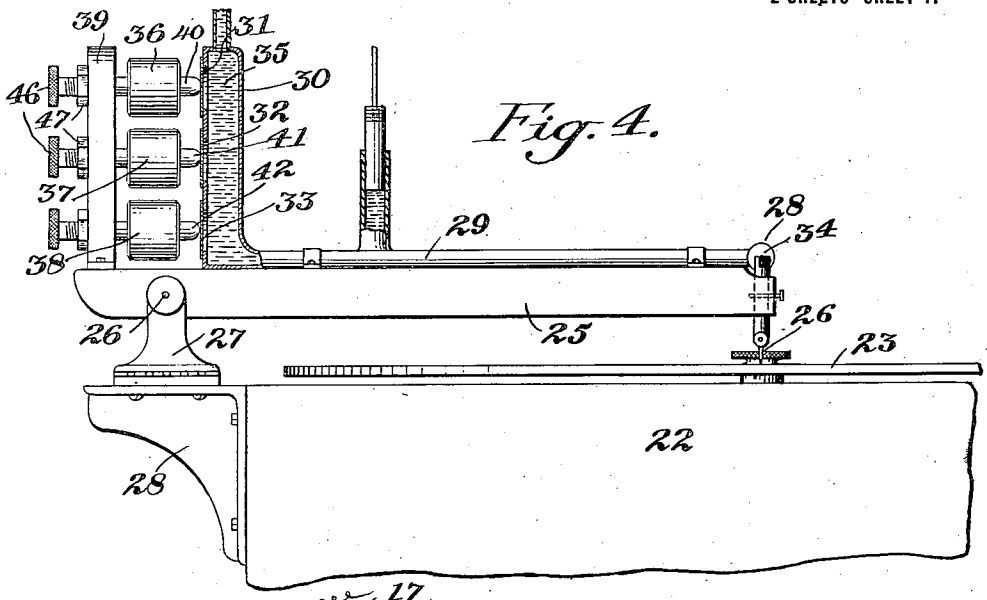


Fig. 4.

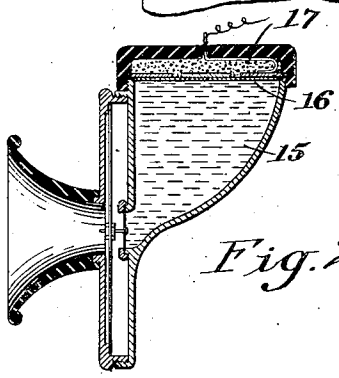


Fig. 2.

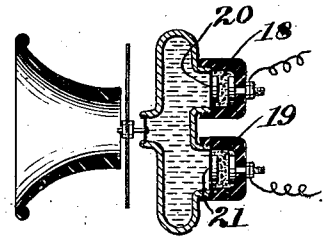


Fig. 3.

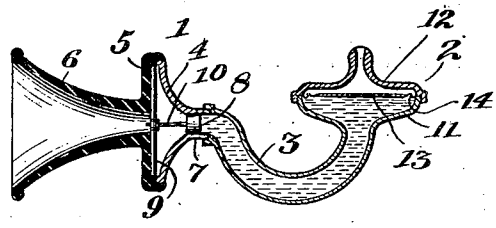


Fig. 1.

WITNESSES

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2 SHEETS—SHEET 2.

Fig. 5.

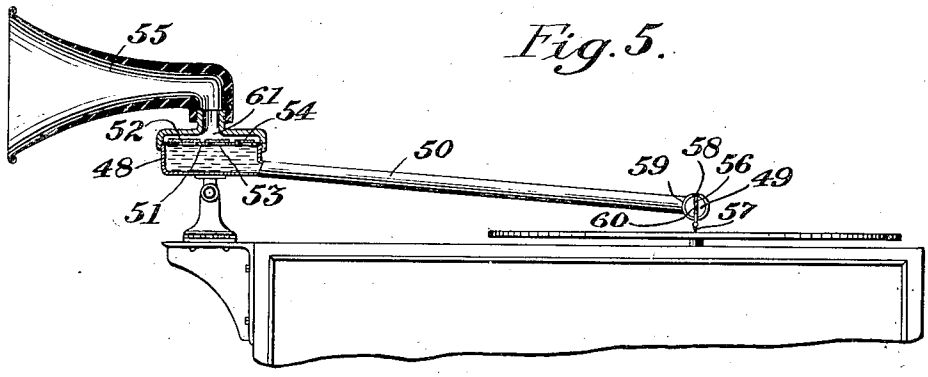
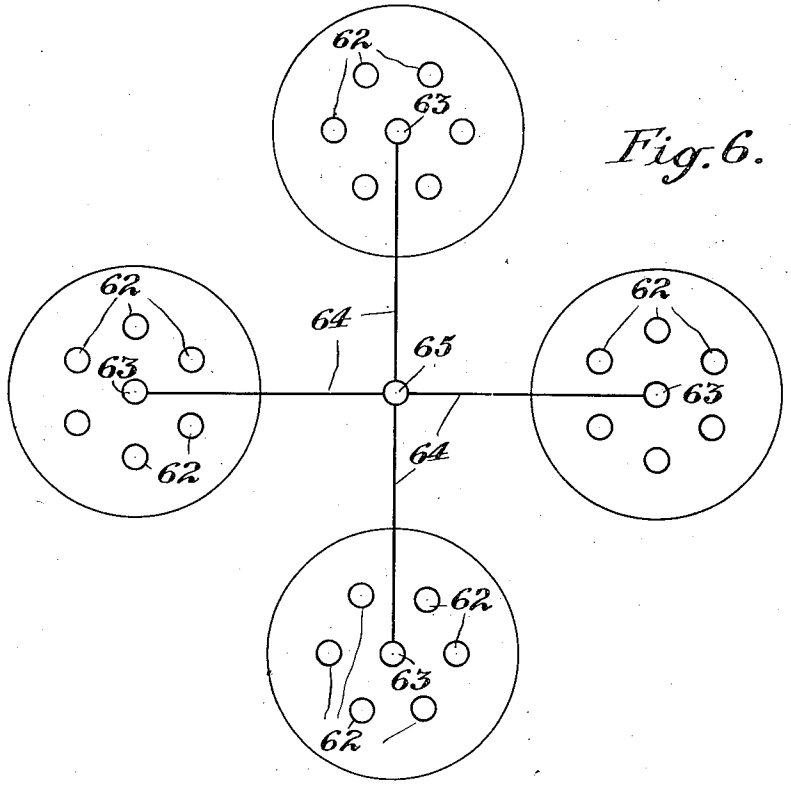


Fig. 6.



WITNESSES

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ACOUSTIC MULTIPLIER.

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Application filed March 16, 1912. Serial No. 684,365.

To all whom it may concern:

Be it known that I, EDWARD E. CLEMENT, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Acoustic Multipliers, of which the following is a specification, reference being had therein to the accompanying drawing.

My invention relates to acoustic apparatus and particularly to means for increasing the clearness and carrying power of sound. The invention is applicable to a number of purposes, such for example as that of improving transmission through an ear trumpet, improving the reproduction of phonographic records, and improving the action of telephonic transmitters. By an inversion, the invention also permits of producing a better synthetic effect in transmission; where a number of sounds of different timbre or character are to be combined in the same record or over the same transmission line.

The principle upon which this invention depends is that expressed in Pascal's law. As the principle is applied, the initial vibrations of the sound to be transmitted or reproduced are communicated to a body of liquid over a unit area, and the pressure waves produced in the liquid are caused to act upon a diaphragm or diaphragms having an area or areas suitably proportioned relatively to the said unit area, to produce the desired effects. Thus in an ear trumpet the initial vibrations are communicated to the liquid through a small surface, and are reproduced against a relatively large diaphragm held in juxtaposition to the ear. The clearness and carrying power of the reproduced vibrations are thereby increased. In other words the efficiency of transmission is greatly increased. In a telephone transmitter, the main diaphragm is connected to a small supplemental diaphragm or plunger, so as to communicate its vibrations to a limited area of liquid. A supplemental diaphragm of larger area is acted upon by the liquid and in turn varies the pressure on granular material or equivalent electrodes. In one form of transmitter it is possible to get a very high resistance by putting a number of resistance buttons in series, and exposing them all to the action of the liquid, or for the purpose of getting volume, a number of buttons may be connected in parallel and all exposed to the action of the liquid. The dimensions of these buttons may be anything desired, but need not vary as regards their exposed area, from those of the initiating diaphragm or plunger. The multiplication in such case is produced by summing the electric effects and thereby the hydrostatic effects. In phonographic reproduction, the reproducing needle is connected to vibrate a very small diaphragm or plunger which acts upon a column of liquid to produce vibrations or waves therein which are transmitted undiminished to one or more diaphragms of larger size, which in turn either directly impart their vibrations to the air or act upon resistance buttons for telephonic transmission.

Synthesis and analysis of sounds of varying pitch and timbre are possible by the use of this invention. For synthesis, especially in phonographic recording, different instruments or groups of instruments may be centered about separate receiving horns supported before diaphragms which communicate their vibrations to columns of liquid, all of which columns converge upon a common diaphragm which works the recorder. For analysis, the reverse procedure would be followed.

It will be obvious after reading the detailed description hereinafter, that in some cases a body of gas or air may be employed as a part or the whole of the pressure transmitting medium.

My invention is illustrated in the accompanying drawings in which—

Figure 1 is a sectional view of an ear trumpet embodying the invention.

Fig. 2 is a similar view of a simple form of a telephone transmitter.

Fig. 3 is a similar view of a telephone transmitter having a plurality of resistance buttons.

Fig. 4 is a side view of a portion of a graphophone, showing the hydrostatic reproducer partly in section, said reproducer acting upon telephonic resistance buttons.

Fig. 5 is a side view of a graphophone also showing the hydrostatic reproducer partly in section and imparting its vibrations directly to the air.

Fig. 6 is a diagram indicating the grouping of instruments or vocalists for synthetic recording.

In Fig. 1 is shown a very simple embodiment of my invention in the form of an ear

trumpet which consists of a special transmitting device 1 and a receiving device 2, connected by a tube 3 having rigid walls. The funnel-shaped casing 4 of the transmitting device is provided with threads on the periphery of its flared end which take into complementary threads in the recessed flange 5 of the mouth-piece 6. The smaller end of the funnel-shaped casing is formed into a short cylinder 7 in which oscillates a small plunger 8. A diaphragm 9 is seated between the front edge of the flared end of the casing 4, and an annular shoulder within the recessed flange 5, the said shoulder maintaining a suitable space or clearance between the diaphragm and the inner face of the flange 5. The plunger 8 is rigidly connected with the diaphragm 9 by the rod 10. At the receiver end, the tube 3 is flared out into a funnel 11 the periphery of the flared end being threaded to take into complementary threads in the flared end of the ear-piece 12. The diaphragm 13 may be of the ordinary type clamped around the edge, or as shown made stiff with a flexible rim 14 by which it is clamped between the mouth of the funnel 11 and ear-piece 12, which affords a uniform vibration of the whole diaphragm without distortion of the same. The tube 3 including the enlarged portion 11 is filled with liquid. This body of liquid occupies the entire inclosed space between the diaphragm 13 and plunger 8, and as said diaphragm is of greater area than the plunger any movement of the plunger will produce a corresponding movement of the diaphragm of less amplitude, but greater carrying power. Thus any sound waves entering the mouth-piece will vibrate the diaphragm 9 and plunger 8 and be reproduced with greater clearness and power at the ear-piece.

Figs. 2 and 3 show the principle as applied to different forms of telephone transmitters, by connecting the main diaphragm to a small supplemental diaphragm, so as to communicate its vibrations to a relatively small area of liquid. In the form shown in Fig. 2 the transmitting liquid 15 acts upon a diaphragm 16 of relatively large area which in turn varies the pressure upon a resistance cell 17 so that variations in pressure in the liquid will act equally upon the whole area of the resistance cell, and as this cell is of low resistance and large area of cross section, slight variations in pressure will produce large variations in the conductivity of the resistance cell. This form is especially adapted for use where a heavy current of low voltage is used.

The form of transmitter shown in Fig. 3 can be used either as a high resistance or low resistance transmitter, according to the grouping of its resistance buttons. In this form, a plurality of resistance buttons or cells such as 18 and 19 are acted upon by the transmitting fluid through their respective diaphragms 20 and 21 and the resistance of the whole instrument can be varied by different arrangements of the electrical connections of said resistance cells. Thus if the cells are connected in series their resistances are added and consequently the variations in resistance are multiplied by the number of cells. On the other hand, if the cells are connected in multiple, the total resistance is divided by the number of cells and the variations in conductivity of each cell will then be multiplied by the number of cells.

The principle as applied to the reproduction of phonographic records is shown in Figs. 4 and 5. In Fig. 4, a portion of the usual phonographic motor box is indicated at 22 on which is carried a record 23. The electro-hydrostatic reproducing means is mounted upon a bar 25 pivoted for vertical movement at 26 upon a post 27 which in turn is rotatably mounted upon a bracket 28 at one side of the motor box, thereby permitting both vertical and horizontal movement of the bar 25. At the free end of the bar 25 a reproducing needle 26 is mounted in the usual manner so as to impart its vibrations to a diaphragm 34. The diaphragm 34 communicates with a small circular chamber 28 which is connected through a tube 29 with a transforming chamber 30 mounted near the pivoted end of the bar 25. In the front wall of the chamber 30 are a number of diaphragms 31, 32 and 33 each relatively larger than the generating diaphragm 34 and of different diameters. The entire space between all the diaphragms 31, 32, 33 and 34 is occupied by a transmitting liquid 35. A number of microphones or resistance buttons 36, 37 and 38 one for each diaphragm are mounted upon a bridge 39. These resistance buttons are of the solid back type with their front electrodes fitted with studs 40, 41 and 42 which bear against the diaphragms 31, 32 and 33 respectively, and are each adjustable toward and away from its diaphragm by the thumb screws 46 and lock nuts 47. In operation, the reproducing needle 26 imparts its vibrations to the small generating diaphragm 34 producing corresponding variations in pressure throughout the whole body of transmitting liquid, which causes the several diaphragms in the transforming chamber 30 to vibrate in synchronism with the generating diaphragm 34 but with amplitude in inverse and power in direct proportion to their respective areas. As already stated, the diaphragms in the transforming chamber are preferably of different sizes, and they may also be made of different thicknesses and different materials so as to respond selectively to vibrations of different character, pitch or intensity. The

vibrations of these diaphragms produce corresponding changes in the electrical resistance of their respective resistance buttons which may be connected either together in one transmission circuit or separately for multiplex transmission. This system is particularly adapted for multiplex transmission where the different transmission lines are of different lengths or resistances, or otherwise vary in their electrical characteristics, in that each resistance button and its actuating diaphragm may be designed according to the characteristics of the particular transmission circuit in which it is to be used, and at the same time have their actuating diaphragms controlled by the same body of transmitting liquid, and mounted in the same transforming chamber. A further advantage of this system in multiplex transmission is, that should any one of the resistance buttons or its transmitting circuit get out of order or otherwise become useless, the stud of the resistance button may be jammed against its diaphragm by means of the adjusting screw, and so prevent the useless diaphragm from absorbing any part of the pressure variations, and maintain the operativeness of the other transmission units.

The structure shown in Fig. 5, is similar to that shown in Fig. 4 except that the mounting bar and resistance buttons are omitted and the sound waves from the transforming diaphragms are projected into the air through a common horn. In this embodiment, the transforming chamber 48 is mounted upon bearings for both vertical and horizontal movement, and communicates with the reproducing diaphragm 49 through a rigid tube 50. An air or sounding chamber 61 is formed above the chamber 48 and separated therefrom by a rigid partition 51, upon which may be mounted one or a number of diaphragms 52, 53 and 54 of different diameters, the upper portion of the sounding chamber communicating with a horn 55. The arm 56 to which is secured the reproducing needle 57 is pivoted at 58 to the rim 59 of the reproducing diaphragm chamber and connected with the diaphragm 49 by a pin 60. In operation, all vibrations of the reproducing needle 57 are transmitted to the diaphragm 49 by way of the arm 56 and pin 60, and thence through the tube 50 to the chamber 48 where the various combined tones and overtones are selectively intensified and recombined in the sound chamber 61, and finally projected into the air through the horn 55. The needle may also be secured directly to the diaphragm 49, without pivoting, as is common in the phonographic art.

Fig. 6 illustrates, diagrammatically, the method of synthetic recording of sounds produced by a number of instruments of different pitch and timbre using for the recorder an instrument similar to that of Fig. 5. The larger circles inclose groups of instruments or vocalists 62 which are thus grouped according to the character of tone which they produce and to each of these groups is delegated a receiving instrument 63 most efficiently responsive to the mean effective tone quality and pitch of that group. The diaphragms of all of these receiving instruments communicate their vibrations to the columns of liquid 64 which converge into a common chamber 65 and upon a suitable common diaphragm not shown but similar to 52, 53 or 54, which works the recorder.

The chamber 65 may be an analyzing chamber such as that shown at 35 in Fig. 4, where the various over-tones are selectively transformed into electrical waves through the segregating diaphragms 31, 32 and 33 and the resistance buttons 36, 37 and 38, respectively. The electrical waves may then be separately transformed or amplified in the usual manner, impressed upon a common line and electrically synthesized into one wave of a single phase in which the over-tones are represented by a complication of the wave form. At the receiving end of the line this complicated wave may be transformed into synthesized sound waves by the usual form of telephonic receiving apparatus, or it may pass through several segregating receivers from which the sound waves are projected into the air through a common horn. The great advantage of this electrical analysis and synthesis is that the various factors of a complicated telephonic current wave or sound wave can be selectively amplified and recombined or synthesized into a single amplified wave in which none of the characteristics of the original are lost or rounded off by the damping effect that a single or common amplifier must needs produce on certain minor characteristics of such a complicated wave in order to be effectively responsive to the mean wave characteristic.

It is further contemplated to provide a suitable pressure regulating means for the body of transmitting fluid such for instance as an adjustable column of liquid connecting therewith and contained in a tube extending vertically from the fluid containing space, or a shorter tube containing a portion of the volume of the transmitting fluid and provided with a weighted or spring pressed piston. Also an adjustable cushioning device may be added.

Having thus described my invention what I claim and desire to secure by Letters Patent is—

1. An acoustic transformer for telephone transmitters comprising an inclosure, a body of fluid therein, an initial vibrator connected to the inclosure and having a relatively

small superficial area exposed to said fluid, and a telephone transmitter with a secondary vibrator connected to the inclosure and having a relatively large superficial area exposed to the fluid therein, whereby initial vibrations of determinate amplitude and power will be impressed upon the transmitter with reduced amplitude and increased carrying power.

2. A telephone transmitter comprising a casing, a single primary vibrator having a fixed determinate area, a plurality of telephone transmitter elements each having a secondary vibrator of an area the same as or greater than that of the primary vibrator, exposed through an opening in the wall of the casing, and liquid filling the casing and adapted to transmit vibrations from the primary vibrator to all of said secondary vibrators and transmitter elements equally and undiminished.

3. A reproducer for an acoustic instrument having a record surface carrying a variable trace corresponding to a series of sound waves, comprising an initial vibrator adapted to be vibrated by said trace on said surface, a secondary vibrator, and a fluid interposed between and connecting said vibrators, said secondary vibrator having a relatively larger area exposed to the fluid than the initial vibrator.

4. An acoustic transformer for graphophones comprising a hollow arm having a primary vibrator of determinate area at one end, and secondary vibrating means having individual area or areas equal to or greater than the area of the primary vibrator at the other end, together with a body of liquid in the arm connecting the two, an element adapted to be controlled by a sound record and itself controlling the primary vibrator, and electrical sound projecting or transmitting means connected to and controlled by the secondary vibrating means.

5. An acoustic transformer comprising a casing containing a body of fluid, and a set of primary and secondary vibrators set into the walls thereof for the transmission and reception of sound vibrations to and from said body of fluid, there being a larger number of secondary vibrators than of the other, and each of said secondary vibrators having an area exposed to the fluid equal to or greater than the exposed area of the primary vibrator or vibrators.

6. An acoustic transformer comprising a casing containing a body of fluid, and a set of primary and secondary vibrators set into the walls thereof for the transmission and reception of sound vibrations to and from said body of fluid, there being a larger number of secondary vibrators than of the other, and the vibrators of the class having the larger number having individually different vibratory characteristics adapting them each for response to vibrations of determinate and special character, and each of said secondary vibrators having an area exposed to the fluid equal to or greater than the exposed area of the primary vibrator or vibrators.

7. An acoustic transformer comprising a casing, a body of fluid therein, a primary vibrator forming part of one wall of said casing and a plurality of associated and correlated secondary vibrators each forming also a part of the confining walls of the said casing, and each having an exposed area equal to or greater than that of the primary vibrator.

8. An acoustic transformer comprising a casing, a body of fluid therein, a primary vibrator forming part of one wall of said casing and a plurality of associated and correlated secondary vibrators each forming also a part of the confining walls of the said casing, each of said secondary vibrators having different vibratory characteristics adapting it to respond to vibrations of a determinate and special character, and each having an exposed area equal to or greater than that of the primary vibrator.

9. An acoustic transformer comprising a casing, a body of fluid therein, a primary diaphragm vibrator the diaphragm of which forms a part of one wall of said casing, and a plurality of secondary diaphragm vibrators, the diaphragm of each of which also forms a part of the walls of said casing, and each having an exposed area equal to or greater than that of the primary vibrator.

10. An acoustic transformer comprising a casing, a body of fluid therein, a primary diaphragm vibrator the diaphragm of which forms a part of one wall of said casing, and a plurality of secondary diaphragm vibrators, the diaphragm of each of which also forms a part of the walls of said casing, the said diaphragms of the secondary vibrators being of different diameters, and each having an exposed area equal to or greater than that of the primary vibrator.

11. An acoustic transformer comprising a casing, a body of fluid therein, a primary vibrator forming part of one wall of said casing and a plurality of associated and correlated secondary vibrators each forming also a part of the confining walls of the said casing and each having an exposed area equal to or greater than that of the primary vibrator, and resistance varying electrodes associated with each of said secondary vibrators.

12. An acoustic transformer comprising a casing having an opening at one end thereof, and a group of openings in proximity to each other at the other end thereof, some of said group having an area equal to or greater than that of the said single open-

ing, a primary vibrator the vibrating element of which closes said first named opening, a plurality of secondary vibrators the vibrating elements of which each close one of said group of openings, and a body of liquid confined in said casing.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD E. CLEMENT.

Witnesses:

E. P. TARBOX,

JAMES H. MARR.