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G. SEIBT

APPARATUS FOR THE REPRODUCTION OF SOUNDS

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Fig:1.

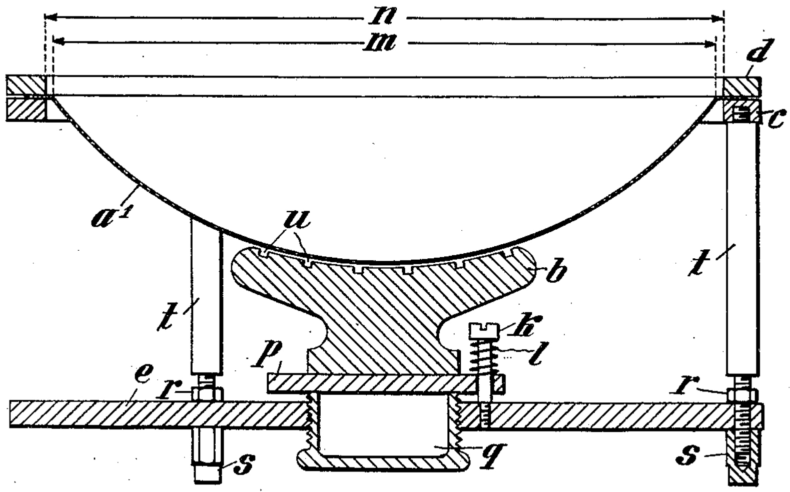
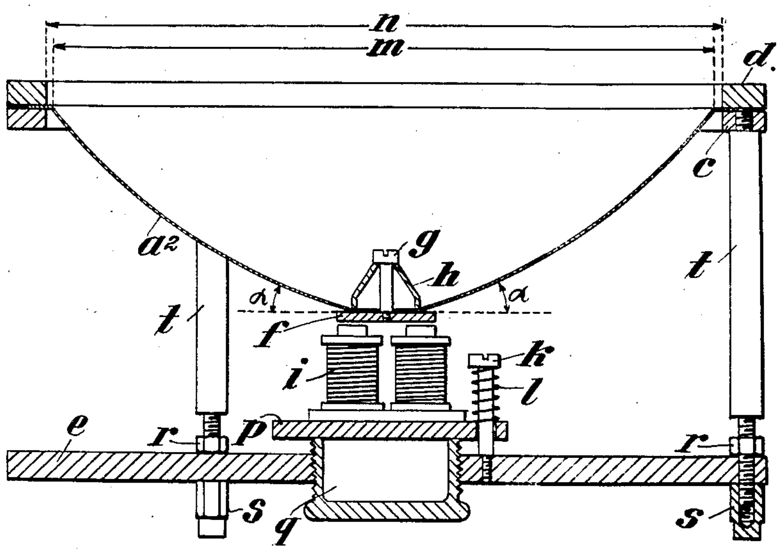


Fig:2.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR THE REPRODUCTION OF SOUNDS.

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To all whom it may concern:

Be it known that I, Georg Seibt, residing at 9 Hauptstrasse, Berlin-Schoneberg, Germany, have invented certain new and useful Improvements in Apparatus for the Reproduction of Sounds, of which the following is a specification.

This invention relates to an apparatus for the reproduction of sounds, and more particularly to an apparatus for the reception or reproduction of speech or music by various means such as mechanical means, as in a phonograph in which the sound waves are impressed on a record and the recorded sound waves are afterwards reconverted into sound waves, or by electrical means, such as a telephone receiver in which electric voice current waves are converted into sound waves, or a microphone by which sound waves are converted into voice current waves. In all cases it is a question of converting energy which fluctuates in the rhythm of the sound waves to be received or produced. In order that this conversion may result in a faithful reproduction of the original sound, i. e. in order that certain tones may not preponderate, or other tones, particularly the upper harmonics which give the timbre of the sound, may not be suppressed, and to prevent disturbing vibrations or fluctuations of energy, which change the timbre and give rise to collateral sounds, from occurring, several requirements must be fulfilled at the same time and certain causes of disturbance must be avoided.

If, as is nearly always the case, a diaphragm is used in a talking apparatus, the origin of a disturbance which interferes with a faithful reproduction of sound or conversion of energy may be the mass of the diaphragm. The disturbing influence of a diaphragm of a too great mass becomes particularly noticeable with high tones and upper harmonics because the resistance to acceleration increases as the square of the frequency, so that for example this resistance at a frequency of 2000 per second is 16 times as great as at a frequency of 500. From this it follows that the weight of the diaphragm must be reduced to the greatest possible extent.

A further requirement is that the energy translated in the reception of sound waves from the air by the diaphragm, or in the production of sound waves by the diaphragm when acting as a reproduction member, should be considerable. To this end it is necessary to make the diaphragm as large as possible and the diaphragm should not only be flexed at its centre, but all parts of its surface should be made to vibrate in phase with each other.

Another requirement to be fulfilled is that the natural rate of vibration of the diaphragm should be as high as possible, because it can only act as an efficient receiver and reproducer of sounds whose frequency is lower than the said rate of vibration.

To prevent the occurrence of collateral vibrations which do not correspond with the frequencies of the sound to be received, recorded or reproduced, provision must be made for preventing any elements of the diaphragm surface from vibrating independently of each other or of the remaining surface of the entire diaphragm.

If the conversion of vibration energy is to be accomplished by electrical means, as by electromagnetic or electrostatic action, it will be found necessary that, to obtain a great effect and at the same time a uniform distribution of stress in the diaphragm, the parts which act upon each other magnetically or electrically, i. e. the oscillating and the stationary co-operating parts will have to be placed as near as possible to each other, i. e. as near as will just leave sufficient gap for the diaphragm to vibrate freely, and on the other hand the surface of the said parts, which are placed opposite to each other and co-operate magnetically or electrically, must be arranged so as to extend substantially at right angles to the direction of vibration of the diaphragm, or in other words their surfaces should lie in perfectly parallel planes.

The object of this invention is to produce apparatus in which all of the above requirements, some of which are contradictory, are all perfectly met. This is accomplished by employing a diaphragm which is much thinner and in itself much stiffer than any that have hitherto been used in talking apparatus and which it has been impossible to manufacture by process known previous to this invention. Although the diaphragm is exceedingly thin, it is formed or arranged to be so stiff that all its parts have to vibrate in phase with each other, i. e. independent vibrations of parts of the diaphragm surface are prevented from occurring. Although all parts of the diaphragm are made to vibrate in phase with each other and although its diameter is comparatively large, it is caused to have a very high natural rate of vibration by being shaped in a certain manner. When the conversion of vibration energy is to be carried out electrically, means are provided to enable the gap between the two opposite surfaces of the co-operating parts to be reduced to any desired extent and to enable this adjustment to be effected without disturbing the exact parallelism of the opposite surfaces.

The invention is shown by way of example in the drawing.

Fig. 1 is a central vertical section of an electrostatic telephone receiver,

Fig. 2 a similar section of an electromagnetic receiver.

Referring to the drawing the diaphragms a^1 in Fig. 1 and a^2 in Fig. 2 consist of thin sheet aluminum or of another light metal or light alloy. The diameter of the diaphragm may range from 8 to 10 cm. or more. The thickness of the diaphragm is only 0.03 mm. or less. Its diameter may be 7 to 10 cm. or more. At a diameter of 10 cm. the thickness of diaphragm may be cut down to 0.03 mm. and at a diameter of 7 cms. to even 0.02 cm. To impart to the diaphragm the required stiffness it is cup-shaped. The walls of the cup are not straight as in the case of a hollow cone or of a body whose generatrix is a straight line, but the said walls are curved so that the diaphragm has the form of a flat cup whose generatrix is arcuate and may be a part of a circle. In the case of diaphragms that are so extremely thin a curved wall cup formation has the advantage over a straight wall cup formation that the former is stiff in all directions, while in the case of a hollow cone the degree of stiffness in the direction of the generatrix is much smaller than in the direction of curvature and this would be the result in parts of the surface of a diaphragm in the form of a cone shaped cup vibrating independently of the other parts of the diaphragm surface.

When a large part of the central portion of the diaphragm surface is subjected to the vibration producing forces as for example the diaphragm a^1 of the electrostatic receiver Fig. 1 which is subjected to the electrical field set up by the spherical concentric immovable electrode b, or when, as in employing a similar apparatus such as an electrostatic microphone, the diaphragm set vibrating by sound waves impinging upon it has to overcome the electrostatic countereffect of the fixed electrode b by a large central portion of its surface, the diaphragm may have the form of a part of a hollow sphere as shown in Fig. 1. But if the forces to be translated to or from the diaphragm only act through a central surface portion of small diameter, as in the case of a gramophone for example in which the energy is translated at the middle of the diaphragm by a style, or in the case of an electromagnetic receiver, as shown in Fig. 2, in which the forces translated from the electromagnet to the iron armature only act through a small connecting part of the armature, it would not do to have a cup shaped diaphragm with curved walls or a spherical diaphragm attached to a tangential energy translating member because there would then be a danger that all parts of the diaphragm would not be vibrated in phase with each other and that the middle central portion due to its approximate flatness or to its extending approximately at right angles to the direction of vibration, would execute vibrations independently of the other parts of the diaphragm. In the case like this the stiffness of the diaphragm is obtained by shaping it in the manner shown in Fig. 2. The cup shaped diaphragm a^2 is shaped in such a way that its cross-section at both sides of the central axis (which passes through the central screw g) has the form of a curve that forms an angle α with the plane or top surface of the fastening member f. The region of the cup shaped diaphragm adjacent and surrounding the fastening member then does not lie in a plane that extends at right angles to the direction of vibration but forms a hollow cone whose central axis extends in the direction of vibration.

Thin diaphragms for talking apparatus which are made in the form of cups with straight walls (hollow cones) or cups with curved walls for the purpose of stiffening the diaphragm are already known in the art. But these known diaphragms are of considerable thickness so that they do not meet the aforementioned requirements. Some of these diaphragms were also not designed so that all parts of the same vibrated in phase with each other, others did not have a sufficiently high natural rate of vibration and a drawback of others was that the annular ring joining the periphery of the diaphragm with the peripheral clamping device did not consist of a single piece of non-perforated sheet metal. If, as has already been proposed, the periphery of the cup shaped diaphragm is only joined to its peripheral clamping device or support by narrow radical strips between sector-shaped or arcuate perforations, a diaphragm which is as thin as that used in accordance with this invention, would be deformed to an unpermissible extent by the operation of stamping out the perforations. If, as has also already been proposed, the stiff cup shaped diaphragm is fixed to a separate thin elastic clamping ring of prepared paper or fabric or the like, a diaphragm of the requisite thinness would also be deformed during manufacture when the apparatus is assembled. A diaphragm thus consisting of two parts (the diaphragm proper and the annular clamping ring) would be liable not to vibrate in unison at all parts of its surface, i. e. different elements of its surface would be liable to vibrate out of phase with each other. In accordance with the invention the rim of the cup-shaped part of the diaphragm joins immediately onto a flat annular non-perforated ring which is adapted to be clamped or held in the peripheral clamping or supporting device. The diameter *m* of the rim (see Figs. 1 and 2) is slightly (1 or 2 mm.) smaller than the inside-diameter *n* of the clamping device which consists of the rings *c* and *d*.

The narrow annular ring between the inside edge of the clamping ring and the edge or bend of the cup-shaped diaphragm has only a width of about ½ or 1 mm. but, due to the extraordinary thinness of the sheet metal of which the diaphragm is made, this narrow annular ring bends sufficiently to and fro to enable the entire cup-shaped diaphragm to oscillate with comparatively larger amplitudes ($\frac{1}{10}$ of mm. and more), and on account of its narrowness the said annular ring gives rise to a very high natural rate of vibration.

In talking apparatus in which the energy of vibration is converted from electric waves into acoustic waves or vice versa by means of cooperating members, it is necessary to be able to adjust the opposite surfaces of the said members so that the gap between them may be reduced to the utmost while the said surfaces remain perfectly parallel to each other.

To this end the ring *c*, which carries the diaphragm of the talking apparatus shown in Figs. 1 and 2, is supported on a base plate *e* which also carries the electrical energy converting device that cooperates with the diaphragm. In the apparatus shown in Fig. 1 the diaphragm a^1, in a form of a spherical cup, is placed opposite to an electrode *b* with a concave spherical surface. In the apparatus shown in Fig. 2 an armature *f* is fixed to a small flat central surface of the diaphragm by means of a hollow cone or cup *h* and a screw *g*. The armature *f* is vibrated by an electromagnet *i*.

In both apparatus the electrical energy converter is fixed on a plate *p* with holes through which three screws *k* pass that are screwed into the base plate *e*. The plate *p* is urged towards the base plate *e* by springs *l* whose one end abuts against the head of their screws *k* and whose other end presses against the plate *p*. The plate *p*, which carries the electrical energy converter, can be raised against the pressure of the springs *l*, so as to approach the diaphragm, by means of a cap *q* with external thread fitting into internal screw threads in the base plate *e*. The cap *q* may be screwed in and out by hand.

The opposite cooperating surfaces of the cooperating members (armature *f* and pole pieces of the electromagnet *i* Fig. 2, or electrode *b* and central portion of the diaphragm a^1 Fig. 1) are adjusted to be perfectly parallel to each other by means of three pillars or staybolts *t* whose bottom threaded ends pass through the base plate *e* and whose effective length can be altered by nuts *r* and counteracting nuts *s*.

To enable the air in the narrow gap between the spherical-shaped surfaces of the two electrodes a^1 *b* of Fig. 1 to move out and in more readily, grooves *u* are provided in the face of the electrode *b*.

Diaphragms which are thin, light and stiff enough and are sufficiently free of internal stresses for the purposes of the present invention cannot be produced by processes of the kind proposed hitherto for similar purposes. Attempts have been made to produce cup-shaped spherical, or curved metal diaphragms by depositing metal upon a surface of wax of the desired shape after making the said surface capable of conducting electricity. Useful results might possibly be obtained with difficulty by this method when employing copper or nickel but when aluminum is employed, which, as is well known, cannot be deposited electrolytically in thin layers, this method is useless. Besides the separation of the thin layer or metal skin from the wax surface is fraught with great difficulties and is thus liable to destroy the skin. Attemps have also been made to produce conical thin aluminum diaphragms by spinning, i. e. by applying pressure by means of a burnisher or the like to the sheet metal while it is rotated in a lathe. This spinning process is applicable with metal of a thickness down to about 0.05 mm. and diameters of about 50 mm. A disk of the sheet aluminum is fixed at its periphery in a chuck rotated by the lathe. During rotation pressure is applied by a blunt tool until the desired shape is produced. This process becomes impracticable when larger diameters or thinner sheet metal are, or is, employed. Besides it will not answer for diaphragms of considerable cavitation. Its greatest drawback is that it gives rise to internal stresses in the diaphragm which result in rattling noises when the diaphragms are used for the reproduction of the voice. These collateral noises are quite insupportable when the talking apparatus is energized with considerable power as in the case of loud speaking telephones or the like.

In accordance with this invention all these disadvantages are avoided by shaping the diaphragm with the aid of a drawing process in which the patrix expands the thin sheet metal quite uniformly. It has been found preferable to use a patrix which has no precisely defined shape but which consists of plastic material such as compressed air.

Aluminum diaphragms as thin as 0.02 mm., of a diameter of 70 mms. and a cavity 14 mms. deep may be produced.

It has already been proposed to shape diaphragms for talking apparatus by means of compressed air, but in these proposals it was not a question of making diaphragms of light metal and extreme thinness and great stiffness, but of producing celluloid diaphragms of unusual elasticity but not conical or cup-shaped and at the same time of a thickness of only a few tenths of a millimeter. Diaphragms of this kind are not in the scope of this invention because they do not enable the desired technical effect be obtained but result in a contrary affect.

I claim:

1. In a sound reproducer, a base plate, a diaphragm supporting ring, means for supporting said ring on said plate and for adjusting it parallel thereto, an extremely thin cup-like diaphragm having a marginal flange whose inner diameter is but slightly less than said ring, a clamping ring to hold said flange on the first ring and electrical vibrating means on said base plate.

2. In a sound reproducer, a base plate, a diaphragm supporting ring, adjustable stay bolts supporting said ring above said base plate, a clamping ring, an extremely thin, dished diaphragm having a flat, imperforate marginal flange, clamped between said rings and whose inner diameter is less than the diameter of the rings, electrical means mounted on said base plate to vibrate the diaphragm and means for adjusting said electrical means to and from the diaphragm.

3. In a sound wave reproducer, a vibratory wave reproducing diaphragm of light metal formed in the shape of a brimmed cup, the cup having a shape generated by a generatrix in the form of a curved line extending obliquely to its axis of rotation, and a clamping ring for clamping the annular brim of the cup, the said brim being nonperforated and integral with the cup-like portion of the diaphragm, and the diameter of the cup-like portion at its widest part being only slightly smaller than the inside diameter of the clamping ring.

4. In a sound reproducer, a vibratory wave-reproducing diaphragm of light metal less than 0.05 mm. thick and formed in the shape of a brimmed cup, the cup shaped portion having a form generated by a generatrix in the shape of a curved line extending obliquely to its axis of rotation; a clamping ring for clamping the annular brim of the cup, the said brim being nonperforated and integral with the cup-like portion of the diaphragm, and the diameter of the cup-like portion at its widest part being only slightly smaller than the inside diameter of the clamping ring; a base plate, members for connecting the base plate to the said clamping ring, means for adjusting the position of the clamping ring relatively to the base plate, and an electrical wave reproducer arranged between the base plate and the diaphragm.

5. In a sound reproducer, a vibratory wave reproducing diaphragm of light metal less than 0.05 mm. thick and formed in the shape of a brimmed cup, the cup-shaped portion having a form generated by a generatrix in the shape of a curved line extending obliquely to its axis of rotation; a clamping ring for clamping the annular brim of the cup, the said brim being nonperforated and integral with the cup-like portion of the diaphragm and the diameter of the cup-like portion at its widest part being only slightly smaller than the inside diameter of the clamping ring; a base plate with a threaded hole therein; members for connecting the base plate to the said clamping ring; means for adjusting the position of the clamping ring relatively to the base plate; an electrical wave reproducer with a supporting plate arranged between the base plate and the diaphragm; a hollow threaded cap with exterior threads fitting in the said threaded hole and adapted to shift the wave reproducer in the space between the base plate and the diaphragm, and springs pressing the supporting plate of the wave reproducer towards the base plate.

In testimony whereof I have signed this specification.

GEORG SEIBT.