Jan. 8, 1929. 1,698,408

O. JOHNSON

SOUND REPRODUCER

Filed March 10, 1925

Fig. 1.

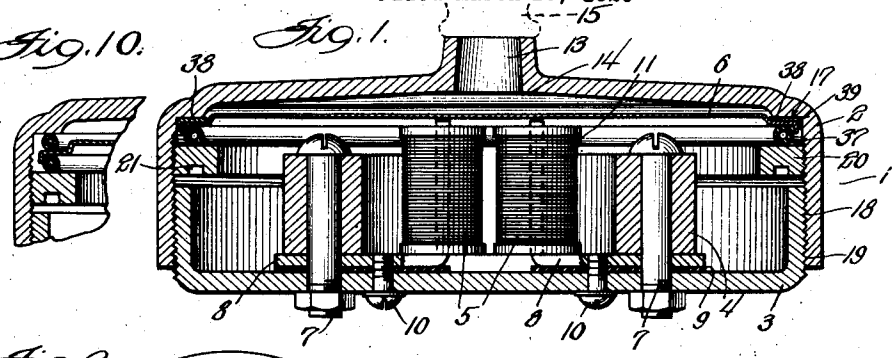


Fig. 10.

Fig. 2.

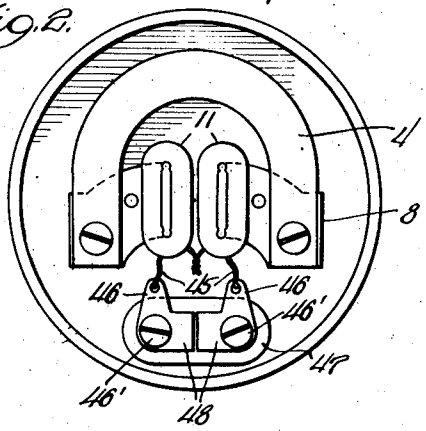


Fig. 4.

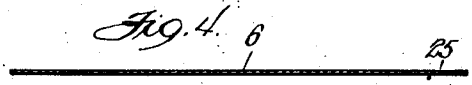


Fig. 5.

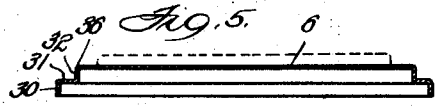


Fig. 6.

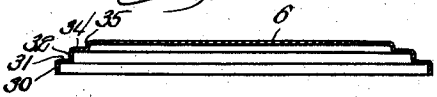


Fig. 7.

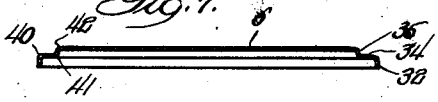


Fig. 8

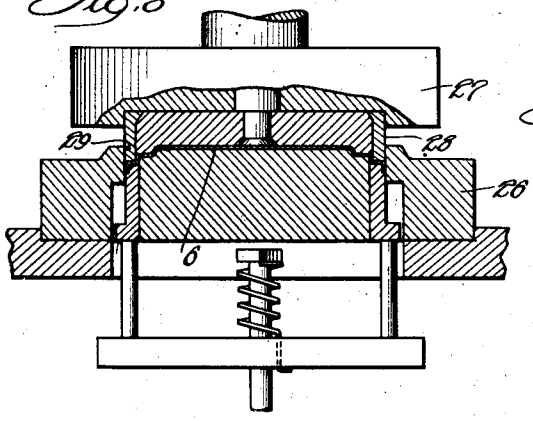


Fig. 9.

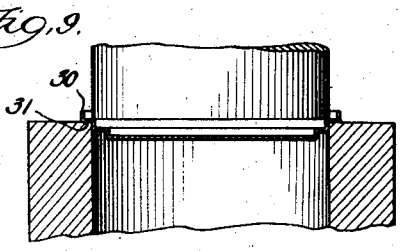


Fig. 3.



Fig. 11.



Witness:
Bertram D. Coltman

Inventor:
OTTO JOHNSON
By Jones, Addington, Ames & Seibold
Attys.

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UNITED STATES PATENT OFFICE.

OTTO JOHNSON, OF BROOKFIELD, ILLINOIS, ASSIGNOR TO BERTRAM J. GRIGSBY AND WILLIAM C. GRUNOW, BOTH OF CHICAGO, ILLINOIS.

SOUND REPRODUCER.

Application filed March 10, 1925. Serial No. 14,486.

This invention relates to the art of reproducing articulate speech, and more particularly to an improved reproducer or "loud speaker" especially adapted for radio reception, although the invention is applicable to other types of electrically transmitted sound reproducing apparatus, such as telephones, or the like.

The difficulties of successfully transmitting articulate speech between two distant points are well known to those skilled in the art, and as a matter of fact known practically to all who are acquainted, in any degree, with radio transmission. With the advent of radio, it was soon found that certain conditions were to be encountered which were not encountered in the ordinary telephone, and that these conditions were so different that the usual telephone receiver failed to reproduce faithfully the sound waves as received at the microphone and transmitted to the receiving apparatus. Compensating for the wide variance in the strength of the signal currents has been the chief difficulty encountered, particularly in designing the sound reproducing unit, for the majority of such units are able to reproduce most efficiently, either with a weak signal, or with a strong signal—but never with both. I have found that the ideal sound reproducing unit is one which is sensitive to a very weak current, and yet capable of carrying a comparatively strong current, without any chattering of the diaphragm against the pole pieces. Improved results both in volume and in tone quality may be obtained, if these above conditions are fulfilled.

I find for example:

(*a*) That tone quality is good when the poles of the operating electromagnets are close to the diaphragm. This is the reason for the tone quality being good on weak signals in many ordinary types of loud speakers, because then the poles are in close proximity to the diaphragm. On the other hand, strong signals received in such instruments require a considerable increase of the air gap as the diaphragm will not hold, and while the volume continues good, the quality decreases as the air gap increases;

(*b*) That, in permanent magnet types, the stronger the magnetic pull is, the greater is the volume, provided magnetic saturation of the diaphragm does not result, this being heretofore avoided to a certain extent by diaphragms of increased thickness;

(*c*) That satisfactory operation can be obtained without increasing the thickness of the diaphragm by providing a stiffness or inherent tension sufficient to balance this magnetic pull;

(*d*) That an ideal diaphragm should be a diaphragm of minimum thickness and preferably maximum stiffness, yet retaining natural elasticity;

(*e*) That heretofore a weak signal required a strong magnetic pull to cause a diaphragm to function and respond to the variations in the voice currents;

(*f*) That the ordinary or usual type of diaphragm has a flat clamping edge and that it is impossible to clamp such an edge uniformly and sufficiently tight to hold its position permanently under an unusually strong magnetic pull and resultant vibration;

(*g*) That many diaphragms operate satisfactorily on weak signals, but are too flexible and will rattle on strong signals.

It has been early recognized in telephonic transmission that not only must the constantly varying rate and amplitude of vibration be faithfully reproduced at the receiving end, but the fundamental tones and all overtones must be reproduced, giving each its proper value and without altering the phrase relations between them. That is to say, after the sound waves have been received at the microphone diaphragm and the signal currents generated and transmitted between antennae and then received, converted and amplified by the receiving apparatus, the telephone units should be able to reproduce the same sound waves, identical in all respects and without any distortion in tone, having perfect timbre, the same pitch and desired loudness.

An object of my invention is to provide a sound reproducing unit including a diaphragm of improved construction, capable of reproducing sound waves which are substantially in all respects the same as those received at the microphone, the diaphragm in its improved form permitting the proper phase relations to be maintained between the

overtones and the fundamental tones, as well as to maintain the proper frequency and amplitude of vibration, so that perfect timbre, the same pitch and decided loudness may be secured.

I have studied the requirements in magnetic sound reproducers and find that the best results can be obtained by the use of a diaphragm under a constant tension, this constant tension being inherent in the diaphragm itself and just sufficent to balance the pull of the permanent magnets.

A principal object of my invention is, therefore, to provide a diaphragm of sufficient stiffness to have this inherent tension. I prefer to form the diaphragm in a manner which, not only retains, but first imparts, natural elasticity to the diaphragm, so that the diaphragm is capable of instantaneously responding to the smallest change in the magnetic field.

A further object of my invention resides in the forming operations employed in the method of manufacturing the diaphragm. A certain predetermined amount of stretching of the material is desirable in order to secure the proper elasticity. By proper elasticity, I means that degree of tension resulting from stretching which will allow the diaphragm to have what might be called a natural vibrating action, analogous to the skin of a drum when stretched across the drum frame.

A further object of my invention resides in the use of a constant tensioned diaphragm in connection with a sound reproducer of the permanent magnet type. A unit is then produced which is sensitive to a very weak signal as well as to a comparatively strong signal. In other words, it is possible to reproduce vibrations of all audible frequencies by means of a single unit and secure good volume and mellow tone quality.

Other objects and advantages of my invention will be apparent from the following detailed description when taken in connection with the accompanying drawings forming a part hereof.

In the drawings:

Figure 1 is a vertical sectional view of a sound reproducing unit embodying my invention;

Fig. 2 is a top plan view of this unit, but with the cap of the unit removed.

Fig. 3 is an enlarged cross-sectional view of a constant tensioned diaphragm formed in accordance with the teachings of the present invention;

Fig. 4, 5, 6 and 7 illustrate the various forming operations employed in the manufacture of this diaphragm;

Fig. 8 illustrates a set of dies that may be used in carrying out these forming operations;

Fig. 9 illustrates a die for cutting a gripping flange from the periphery of the diaphragm, this constituting the final step in the forming; and

Fig. 10 is a detailed sectional view illustrating modified form of mounting the diaphragm.

Fig. 11 illustrates a modification of Fig. 3.

The sound reproducer or receiver 1 is preferably of the magneto or permanent magnet type. It comprises a cap 2 and a cup 3, in which a permanent magnet 4 and coils 5 are carried, and a diaphragm 6 adapted to be seated in cap 2.

Permanent magnet 4 may be secured to the base of cup 3 by means of bolts 7 threading into this base.

This permanent magnet seats preferably on pole pieces 8, spaced from the base of cup 3 by a layer of insulation material 9. These pole pieces 8 are disposed between the permanent magnet 4 and the base of cup 3, but are secured to the latter by means of screws 10 threading inwardly from the under side of the cup. The inner ends of pole pieces 8 are turned upwardly to receive the coils 5 in the usual manner. Coils 5 comprise the ordinary spools about which the winding 11 may be suitably wound.

In my experiments I have found that cap 2 should preferably be of dome shape and that the top wall of the cap 2 adjacent the diaphragm chamber should be at an angle of approximately four degrees. I have further found that at the opening 13, the wall should be sharply terminated as indicated at 14. While such construction is not absolutely essential to the present invention, its use will give better results and not distort the sound waves passing to the horn 15.

As described in my co-pending application, Serial No. 741,275, filed October 2, 1924, the diaphragm 6 is carried in cap 2. The inner wall of cap 2 is provided with a substantial flat shoulder or seat 17 as well as the interior threads 18 which cooperate with exterior threads 19 on the cup 3. An exteriorly threaded diaphragm clamping ring 20 may be provided within the cap 2 for holding the diaphragm 6 upon seat 17. Openings 21 provided on the under side of the clamping ring 20 permit the use of a spanner wrench or like member to adjust this ring, so that the diaphragm may be properly held upon seat 17.

The essence of the present invention, as before pointed out, comprises the use of a constant tensioned diaphragm, preferably in connection with a sound reproducing instrument of the permanent magnet type. By this arrangement, it is possible to reproduce efficiently the weak signals as well as the strong signals, that is to say, it is possible to care for the wide variance in the strength of signal currents, and to reproduce vibrations

of all audible frequencies by means of one unit, without sacrificing volume or tone quality, as has been heretofore sacrificed.

Figs. 4 to 7, inclusive, illustrate the manner of forming the diaphragm. Blank 25 is first cut out of a stock strip. This stock strip is placed upon the female member 26 of the die directly in the path of the male member 27. When male member 27 advances toward the female member 26, the punches 28 function to cut the stock strip at 29. As soon as the cutting is accomplished, continued downward movement of male member 27 immediately results in the formation of flanges 30, 31 and 32, these flanges being firmly gripped by the die members upon being formed. The third step in the forming is illustrated in dotted lines in Fig. 5 and in full lines in Fig. 6. The die members are arranged so that after the flanges 30, 31 and 32 are formed and gripped, the flat portion of the blank 25 is stepped once more so as to result in the formation of flanges 34 and 35. It will be noted that, during the latter operation, a stretching of the material is effected, which stretching takes place beginning at the point or shoulder 36 in Fig. 5 and extending toward the center of the diaphragm. This stretching will, of course, vary and will be greater near the periphery of the diaphragm. As an example, I have found that the best results can be accomplished when this stretching reduces the diaphragm about one-tenth of its original thickness at a point somewhere near one-third of the distance toward the center. The final step comprises trimming off the flanges 30 and 31, as illustrated in Fig. 9. To prevent a substantial bowing of the flat vibrating portion of the diaphragm, the punch o he male member 28 is arranged to give t. liaphragm a final blow after the flange forn. g operations are accomplished, so that this vibrating portion will maintain its flatness when the diaphragm is removed from the dies.

Flange 34 of diaphragm 6 is held against the seat 17 by the clamping ring 20. A rubber tubing 37 is preferably interposed so as to provide a resilient or soft contact between the diaphragm clamping ring 20. A washer 38, which may be made of paper, or other suitable material, is interposed between the flange 34 and the seat 17, this washer 38 being turned down at 39 to extend around and down over the flange 32 of the diaphragm. This separates the diaphragm from direct contact with the cap 2.

Flange 34 may slope slightly upwardly and good results may be obtained if the shoulders 40, 41 and 42 are formed slightly rounded.

In Fig. 1, it will be noted that the diaphragm 6 is positioned in close proximity to the poles of the magnet. The air gap between the poles and diaphragm may be quickly and easily varied by relative movement between the cap 2 and the cup 3. In practice this is usually accomplished by extending a lever outwardly from the base of cup 3. If the vibrating portion of the diaphragm 6 is slightly bowed as the result of the stretching when forming flanges 34 and 35, proper adjustment of the clamping ring 20 will eliminate the bow after the diaphragm has been mounted.

It will be understood, of course, that it is preferable to eliminate the bow when permanent magnets are employed.

By providing diaphragm 6 with such elasticity, the diaphragm may be made to respond to the fullest extent to signals over the entire range of voice current flowing through the coils 5. The diaphragm will respond to the very weak signals and at the present time this is attributed to the fact that the magnetic pull of the permanent magnet and the stiffness of the diaphragm approximately balance one another, so that the entire force of a weak signal immediately causes vibration of the diaphragm. Likewise, on the strong signals, the constant tensioned diaphragm is such that it can withstand the blasting tendency due to the heavier power.

To prevent the coils 5 from burning out on an overload in the circuit, I have connected the ends 45 of windings 11 to terminals 46 mounted by screws 46′, to which the line conductors may be attached. These screws 46′ pass through a strip of insulation 47, serving to space the terminals 46 from the base of cup 3. Terminals 46 have opposed terminal lugs 48 spaced a predetermined distance apart, so that normally the current will not be able to jump the air gap therebetween. The air gap is, however, of a distance which offers a shorter path for an overload in the circuit than the windings 11, thereby protecting the windings in the event of an overload and saving considerable trouble which would be otherwise necessary to replace the coils.

As before mentioned, it is desirable to provide a mounting for the diaphragm which will allow the diaphragm to have the entire benefit of the natural elasticity given it when tensioned during the forming operations. I have previously mentioned that difficulty is experienced in holding the periphery of a flat diaphragm tightly seated. In the present instance I have overcome this difficulty by the provision of flanges 32 and 34, the second being slightly sloped which causes a considerable binding action between itself and seat 17, and the first being turned downwardly which tends to overcome any lateral shifting of diaphragm. In other words, the diaphragm is firmly held upon a soft seat and prevented from shifting about during vibration all of which does not affect the elasticity it has obtained by being stiffened or stretched. I find such a mounting of importance in the present case, because so far as I am able to determine, at the present time, it tends to hold the diaphragm in a

manner permitting its stiffness or tension to balance the magnetic pull of the permanent magnet 4.

In Fig. 10, I illustrate, however, a similar type of mounting wherein rubber tubing is used on both sides of the periphery of the diaphragm.

While it is desirable to provide flange 32 which seems to function primarily to prevent lateral shifting of the diaphragm while seated, I wish it to be understood that this flange may be omitted. This has been illustrated in Fig. 11. The slope of the flange 34 provides a binding engagement against the seat 17 and a diaphragm of this type does not ordinarily tend to shift about in the same manner as a diaphragm having a flat clamping surface.

Many other forms in which this invention may be embodied will occur to those skilled in the art, and the fact that I have specifically illustrated and described but one of them is not intended as a limitation.

I claim:

1. A sound reproducing unit comprising a permanent magnet carrying one or more coils at its poles, and a diaphragm mounted in proximity to said poles having a normal increased elasticity and a tension capable of balancing the magnetic pull of said permanent magnet.

2. A sound reproducing unit comprising a permanent magnet carrying one or more coils at its poles, and a diaphragm mounted in proximity to said poles having a normal tension capable of balancing the magnetic pull of said permanent magnet.

3. A telephone instrument comprising in combination, a casing, a magnet in said casing, a coil for each pole of said magnet, and a diaphragm mounted for operation by the signal current flowing through said coils, said diaphragm being so formed as to balance the pull of said magnet thereby permitting the force of the signal current in said coils to cause an immediately responsive movement in said diaphragm.

4. A telephone instrument comprising in combination, a magnet, coils for the poles of said magnet, and a diaphragm inherently tensioned to balance the normal magnetic effects of said magnet.

5. A diaphragm adapted for use in a sound reproducing device having a tensioned vibrating portion of varying thickness caused by stretching the diaphragm during formation

6. A diaphragm adapted for use in a sound reproducing device having a stiffened vibrating portion of a varying thickness resulting from stretching the diaphragm.

7. Telephonic apparatus comprising a diaphragm having its vibrating portion provided with a flange which is slightly inclined with respect to the plane of its seat whereby to provide a binding engagement therewith when the diaphragm is seated, and a peripheral flange formed about said inclined flange for preventing lateral shifting of the diaphragm.

8. The method of forming a diaphragm for use in a sound reproducing instrument comprising cutting the blank to a size slightly larger than the diameter of the diaphragm, second, holding said blank about its periphery by gripping surplus material, third, operating on the blank adjacent to the periphery to form a flange about the blank by stretching an adjacent intermediate portion of the blank and placing it under an inherent tension, and finally, trimming the surplus material from the periphery of the blank.

9. The method of forming a substantially flat diaphragm for use in sound reproducing instruments which comprises forming a flange about the periphery whereby to tension a limited portion of the diaphragm.

10. The method of tensioning a portion of a diaphragm for use in sound reproducing instruments which comprises drawing the metal outwardly from the center of the diaphragm by forming a flange about the periphery thereof.

In witness whereof, I have hereunto subscribed my name.

OTTO JOHNSON.