Sept. 8, 1931. J. S. HIGH 1,822,095

ELECTRICAL SOUND PRODUCING DEVICE

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Fig. 1.

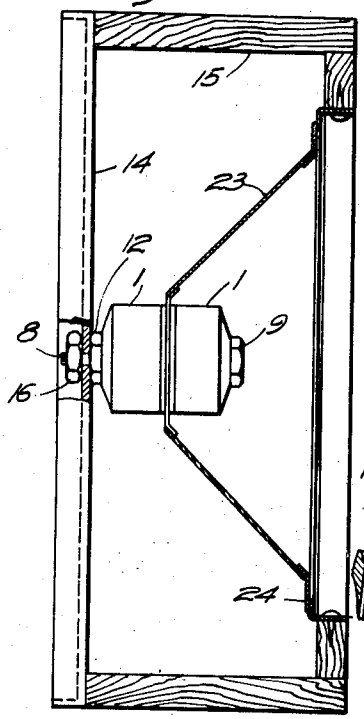


Fig. 2.

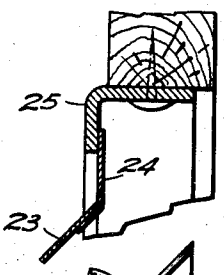


Fig. 3.

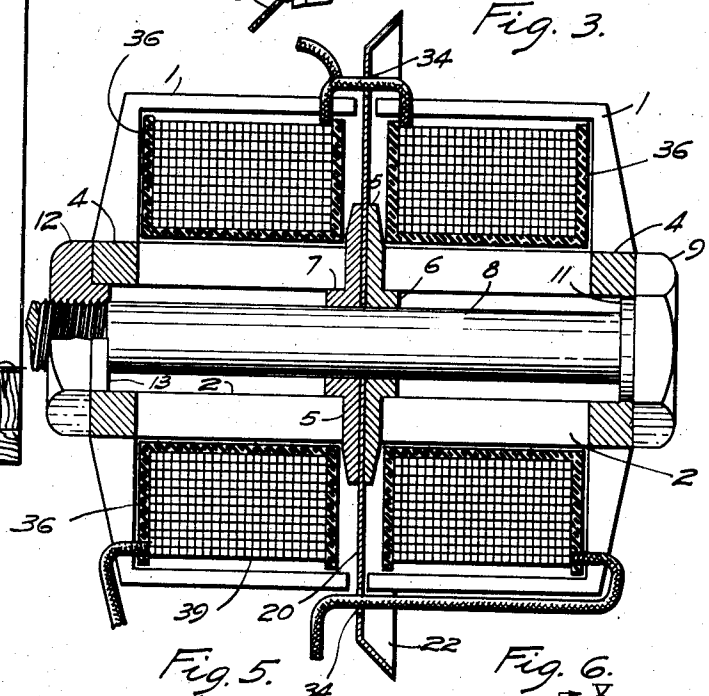


Fig. 4.

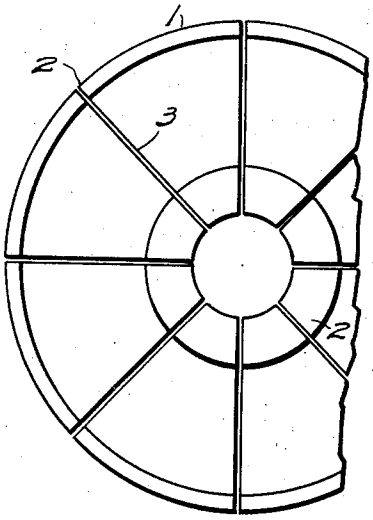


Fig. 5.

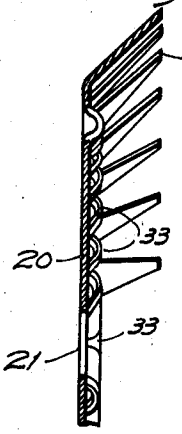
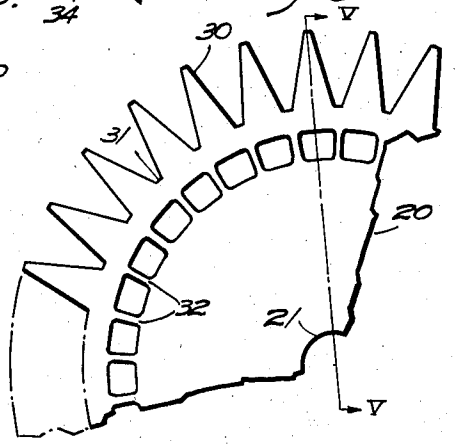


Fig. 6.



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ELECTRICAL SOUND PRODUCING DEVICE

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Fig. 7.

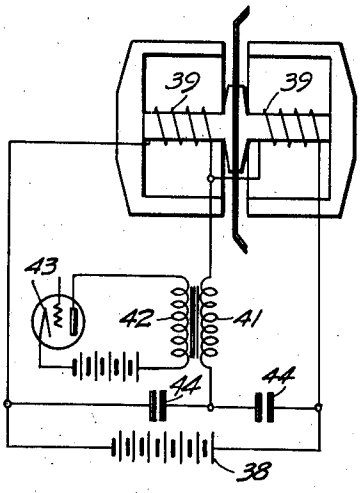


Fig. 8.

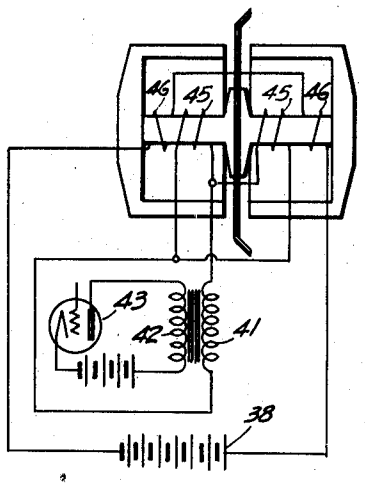


Fig. 9.

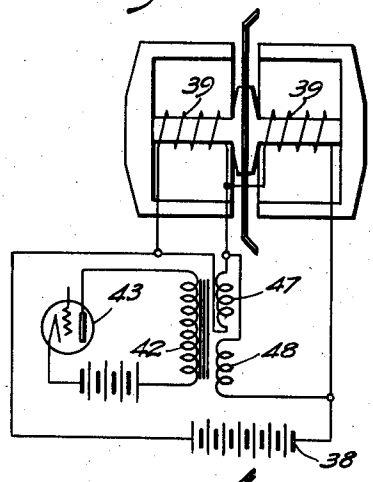


Fig. 10.

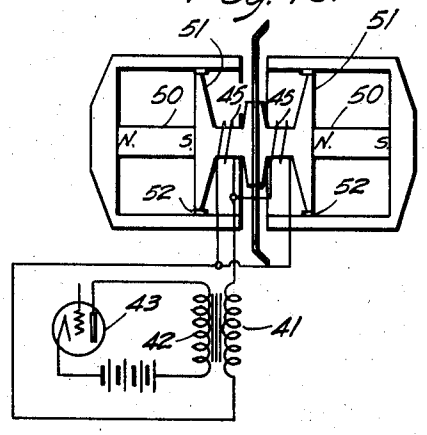
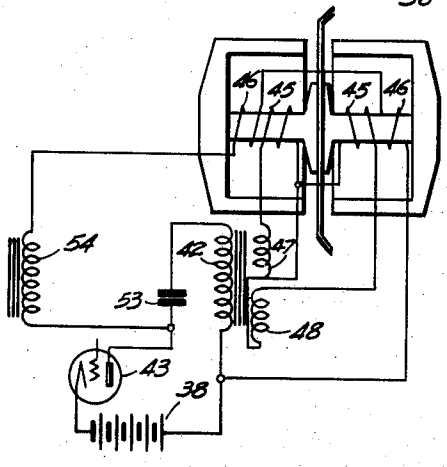


Fig. 11.



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Patented Sept. 8, 1931 1,822,095

UNITED STATES PATENT OFFICE

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ELECTRICAL SOUND PRODUCING DEVICE

Application filed July 11, 1928. Serial No. 291,858.

This invention relates to devices for producing sound from varying electric currents and particularly to devices intended to drive cones for this purpose.

It is an object of this invention to provide an armature capable of vibrating like a reed but which shall have a greater inherent rigidity than a reed of the ordinary straight form.

It is an object of this invention to provide an annular disk with magnetic means for vibrating it and to drive a cone from the moving edge of such disk.

It is a further object of my invention to minimize the effect of the fastening uniting the armature to the cone upon the movement of the armature.

It is a further object of this invention to mount magnetizing coils for producing uni-directional fluxes and coils for producing voice fluxes upon the same member of the magnetic circuit.

It is a further object of my invention to provide means for clamping the diaphragm which shall constitute a part of the magnetic circuit.

Other objects of the invention and details of the construction will be readily understood from the following detailed description and the accompanying drawings, in which

Figure 1 is a side view, partially in section, of one form of the apparatus;

Fig. 2 is a detail sectional view of a portion of the apparatus shown in Fig. 1;

Fig. 3 is a central sectional view of the magnet of the apparatus shown in Fig. 1, on an enlarged scale;

Fig. 4 is an end view of a portion of one member of the magnet shown in Fig. 3;

Fig. 5 is a section; and

Fig. 6 is a front elevation of a modification of the armature, the section being taken upon the line V—V of Fig. 6;

Fig. 7 is a circuit diagram illustrating one arrangement of the means for energizing the flux coils in which the same coils are used both for the uni-directional current and for the voice current;

Fig. 8 is a similar diagram illustrating the use of separate coils for these purposes;

Fig. 9 is a diagram, similar to Fig. 7, in which a modification of the means for dividing the voice current is shown;

Fig. 10 is a circuit diagram illustrating voice coils only, the uni-directional flux being provided by permanent magnets; and

Fig. 11 is a diagram, similar to Fig. 9, but in which separate coils are used for the voice current.

The magnetic circuit includes two members 1 of cup-shape, each of which comprises an outer cylindrical wall and a central column 2 coaxial with the wall. Radial slots, best illustrated at 3 in Fig. 4, separate the outer wall and the central column into segmental parts and divide the floor of the cup into sector-shaped portions. The hub 4, at the junction of the floor and the column, is not slotted and unites the slotted parts into one integral structure.

The central columns are hollow in order to accommodate a bolt for securing the several parts of the magnet together. Annular clamping members 5 of magnetic material are located adjacent the proximate ends of the central columns and are provided with central thicker hubs 6 having shoulders 7 to engage the inner surface of each central column and central openings to accommodate the shaft of the bolt 8. The hubs 6 thus serve as spacing members correctly positioning the several magnetic parts at the center of the unit.

The head 9 of the bolt is provided with an inwardly extending portion 11 constituting a shoulder by means of which the hub 4 and one of the cups 1 are centered correctly. At the end opposite the head 9, the bolt 8 extends through the central openings in the hub 4 of the other cup shape member 1 and is threaded to receive a nut 12. The nut is provided with an inwardly extending portion 13, corresponding to the portion 11 upon the head 9 and positioning the second cup-shaped member.

A thin annular disk 20 of magnetic material is clamped between the two clamping members 5. At the center, the disk has a

hole 21 to receive the shaft 8. At the outer margin, it is provided with means for securing it to a cone. As illustrated in Fig. 3, the securing means is a conical flange 22.

The threaded end of the shaft 8 extends through a supporting bar 14 which is at the back of the frame 15 in which the device is mounted. A second nut 16, upon the bolt 8 on the opposite side of the bar 14, secures the magnet structure in position in the frame. The inner edge of the cone 23 is cemented to the flange 22 or secured thereto in any preferred way. The outer edge of the cone is mounted in the frame 15 as shown at 24, by a flexible annular support. If desired, the member of the frame to which the cone is secured may be of sufficient extent to constitute a baffle board, preventing sound waves radiated from both faces of the cone interfering. The flexible support 24 is secured to the baffle board in any desired way. As illustrated in Fig. 2, a ring 25 is provided which is fastened to the edge of the opening in the baffle board and cemented to the flexible member 24.

Instead of a conical flange, as shown at 22, in Fig. 3, the armature may be provided with radiating projections 30 which, as shown in Fig 5, may be bent out of the plane of the disk and thus caused to fit the cone. The projections 30 are united, at their bases, by a ring 31 Between the ring 31 and the main body 20 of the armature, a circular row of openings 32, separated by strips 33, constitutes a flexible connection. Preferably the strips 33 are arched, as shown in Fig. 5, to obtain more flexibility. The teeth 30, ring 31, strips 32 and main body 20 are all of one piece of sheet material, preferably soft steel or an alloy of iron and nickel.

In the form illustrated in Fig. 3, no such flexibility is provided, because it is expected that, in the ordinary use of the instrument, the deflections will not be large enough to cause the non-symmetrical, cone-fastening arrangement to introduce any undesirable result. The holes 34 are only to accommodate the conductors.

Between the central column and the outer wall of each magnetic member 1, is a spool 36 upon which the windings 39 for the magnetizing current and for the voice current are supported.

As illustrated in Fig. 7, there are but two of these windings 39, one on each column. A battery 38 is connected through the two windings 39 in series. The adjacent ends of the windings 39 are united, and the junction is connected to one terminal of the secondary 41 of a transformer.

The primary of the transformer receives the voice current from any suitable device. This is conventionally illustrated by showing the primary 42 in the output circuit of a vacuum tube 43. The other terminal of the secondary 41 is connected to two condensers 44, which are connected, respectively, to the two separated terminals of the windings 39.

In Fig. 8, the tube 43, primary 42 and secondary 41 perform the same functions as in Fig. 7. The secondary 41 is connected to two windings 45 in parallel. The windings 45 carry only the voice current. Additional windings 46 are connected in series and supplied from the battery 38 to produce the uni-directional flux.

In Fig. 9, the battery 38, the primary 42 and the tube 43 are similar in their functions to the correspondingly numbered parts in Figs. 7 and 8. The windings 39 are connected in series to the battery 38. The voice currents are supplied from two secondaries 47 and 48 connected, respectively, to the two windings 39. A connection, in series, from one terminal of the battery 38 through the windings 47 and 48 may be traced, but it is without effect upon the core of the transformer because the coils 47 and 48 are wound in such directions that, for this current, they produce opposite fluxes in said core.

In Fig. 10, the connections are like those in Fig. 8, except that the battery 38 and coils 46 are omitted, the flux which these coils produce in the other modifications being provided by permanent magnets 50, preferably of cobalt steel. Pole pieces 51 of material like hypernick or silicon steel are placed between the magnets 50 and the armature. The pole pieces form both the spools for the coils 45 and the clamping members for the diaphragm. Rings 52 of non-magnetic material separate these pole pieces from the walls of the cups and prevent the pole pieces from shunting the uni-directional flux from the air gap.

Although the magnets 50 may be short because, being of cobalt steel, they produce sufficient magnemotive force in a small length, they are longer than the cores of windings 39 and 46. Consequently, the cup-shaped members are deeper in this form. Also, these cup-shaped members because they do not carry the alternating flux except through a small portion of the wall, need not be of silicon steel like the other cups but may be of ordinary ingot iron.

In Fig. 11, the connections are like those in Fig. 9 except that, instead of the coils 39, separate coils 45 and 46 are provided, as in Fig. 8, for the voice currents and uni-directional currents, respectively. In order to prevent the production, in the circuit of the battery 38, of currents of voice frequency, a choke coil 54 is inserted. If desired, a similar choke coil may be inserted in the circuit of battery 38 in any of the modifications shown in the other figures.

In the operation of the device, the uni-directional flux established by coils 39 and 46 may be traced in Fig. 3. Starting with

the hub 4 at the right of said figure, the flux is toward the left, through the central column 2 of the right-hand magnetic member 1, the right-hand clamping member 5, the armature 20, the left-hand clamping member 5, the central column 2 of the left-hand cup-shaped member, the left-hand hub 4, the floor of the left-hand cup-shaped member, the outer wall thereof, across the left-hand annular air gap, through the armature, across the right-hand annular air gap, and through the wall and the floor of the right-hand cup-shaped member, to the starting point. It will be observed that the flux crosses the armature twice, but in each case, it is at right angles to the plane of the disk. The flux, therefore, produces no saturation effect upon the armature. Moreover, there is no force exerted upon the armature by the direct flux because there is no uni-directional polarity in the armature.

The alternating or voice flux follows a different course. Considering the moment at which the voice flux is toward the left in the central column of the right-hand cup member, the course of this flux is radially outward, through the armature and through the cylindrical wall of the right-hand cup member, returning through the floor of this cup member and the right-hand hub 4 to its starting point. At this same instant, the voice flux in the left-hand cup member is toward the right in the left-hand central column, radially outward in the armature and toward the left in the left-hand cylindrical wall, returning through the left-hand floor and the left-hand hub 4.

It will, therefore, be understood that the voice flux in the armature, in the case of both coils, is radially outward at this instant. There is, therefore, developed, at this instant, a momentary south-pole effect in the central part of the armature, and a momentary north-pole effect at that portion of the armature in the air gap between the two cylindrical walls. The south-pole effect produces no effect in the movement of the armature, because it occurs at a point where the armature is clamped. The north-pole effect cooperates with the uni-directional flux to produce a movement of the armature toward the right.

When the instantaneous direction of the voice currents and, therefore, of the voice flux is opposite to that just described, there results a south-pole effect at that part of the armature which is in the air gap, and the movement of the armature is, therefore, in the opposite direction. Obviously, the direction of the uni-directional flux could be opposite to that just described and corresponding changes made in the details of the description without changing, in any essential way, the results just stated.

The alternating flux established by the voice currents does not produce eddy currents to any substantial degree because the slots 3 interrupt the circuit in which they would flow.

The movement of the armature is resisted by its rigidity. Elastic forces are developed in the armature, not only by the bending of each radius but also by the compression effect which results from the fact that, when in its disturbed position, the circumference of the armature is smaller. In the disturbed position, the radius of the armature is an element of a cone. The radius of the base of the cone, being the projection of said element on the base, is smaller than the element.

The resistance of the circumference of the armature to said compression results in a tension along each radius. These compression and tension forces are in addition to the bending-moment present in each radial element. The combined effect of these forces is to increase the rigidity of the armature, as compared with the rigidity of an ordinary straight reed. The armature is, in effect, an annular reed. Because of this greater rigidity, the inertia may be made smaller. Both of these circumstances assist in securing better response of the armature at high frequencies.

The conical flange 22 in Fig. 3 or the fingers 30 in Fig. 6 are not symmetrically arranged relative to the plane of the disk 20, but, instead, are all directed toward one side of this plane. This tends to disturb the symmetrical movement of the armature, causing movement in one direction to be resisted to a greater extent than the movement in the opposite direction, particularly at large deflections. In order to avoid such disturbance, the connection between the edge of the armature and the portion thereof in the air gap is made somewhat flexible in order that the unsymmetrical action of the edge may be wholly absorbed in the flexible portion.

In the form illustrated in Figs. 5 and 6, flexibility is obtained by arched strips 32 connecting the edge of the armature and the portion thereof in the air gap. The flexibility provided by this means, while large enough to compensate for the unsymmetrical shape of the margin, is not enough to produce substantial effect upon the response within the frequency range over which the instrument is intended to be used.

With the circuit illustrated in Fig. 7, direct current from the battery 38 establishes a uni-directional flux, through the two central columns which returns through the walls of the cups. Alternating current in the secondary 41, caused by the signal from the tube 43 or other signalling device, divides and passes in opposite directions through the two coils 39, producing flux in opposite directions in the two central columns and thereby producing a radial flux in the armature. The

alterating current returns from the coils through the condensers 44. The connection to the lower terminal of the secondary 41 is effected without short circuiting the battery 38, because of these condensers.

In the form illustrated in Fig. 8, the action of the voice current from the secondary 41 through the coils 45 is the same as that of the current through the condensers 44 in Fig. 7. The battery 38 establishes the uni-directional flux by means of the coils 46. These being separate coils, no provision is needed to prevent short circuiting of the battery 38 by the connections for the voice current.

In the form illustrated in Fig. 9, the battery 38 is permanently shunted by coils 47 and 48, which constitute the secondary of the transformer associated with the signal source. Waste of energy from the battery 38, through these coils, may be prevented by making the resistance of them so great that but small current flows therein. If the increase of this resistance is obtained by increasing the number of turns, this does not result in saturation of the iron of the transformer because the magnetic effect upon the transformer core of the coil 48 is opposed to the effect thereon of the coil 47.

The battery 38 in Fig. 9 establishes a uni-directional flux by means of the coils 39 in the same way as in Fig. 7. The voice current for one coil 39 is supplied from the coil 47 and that for the other coil 39 is supplied from the coil 48. The alternating current from the coil 47 through the battery 38 is equal and opposite to that from the coil 48 through said battery. Consequently, no loss of voice-current energy arises from the connection of the battery across these coils.

In the form shown in Fig. 10, the permanent magnets 50 provide the uni-directional flux. The spools 51 upon which the coils 45 are wound are of magnetically soft material. The path of the flux set up by a coil 45, the right hand coil, for example, is radially through the armature, then to the right across the air gap into the wall of the right-hand cup, through this wall as far as the positioning ring 52 and across this ring which, being of non-magnetic material, presents a second gap, to the spool from which it started. The other coil 45 sets up a similar flux through the other gap and ring. The diaphragm is the only part common to the two paths.

The path of the voice flux includes both the air gap and the gap filled by the ring 52. This tends to make the reluctance of this path greater than that of the path for the voice flux in the other forms, but this tendency is off-set, to some extent, by the circumstance that, in the other forms, the voice flux must go through the full length of the cup-shaped members, while, in the form shown in Fig. 10, it goes through only a short part of the wall.

The increase in the reluctance of the by-pass for the voice flux introduced by the gap 52 is necessary to prevent this by-pass from diverting the uni-directional flux from the air-gap too effectively. The polarity of the edge of the wall of the cup will be like that of the end of the magnet farthest from the spool. A uni-directional flux across the air-gap is thus provided.

In the form illustrated in Fig. 11, the coils 45 are fed from the secondaries 47 and 48 in the way described in connection with Fig. 9. The battery 38 serves both as the plate battery for the tube 43 and as the energizing battery for the coils 46 which are arranged in shunt to the primary 42. In order to prevent the flow of battery current through the primary 42, a condenser 53 is inserted, and, in order to prevent the flow of alternating current through the coils 46, an inductance coil 54 is inserted.

An armature of the annular reed form possesses the advantages over an ordinary reed which have already been explained: namely, it has a better response at high frequencies and may be made with smaller mass. Moreover, the armature is not saturated by the direct flux. The combination of an annular form of reed armature with a cone diaphragm has the advantage that a large junction surface is provided for the union of the armature to the diaphragm. If cement must be relied upon for making this union, the danger of the joint becoming loose or introducing rattling is thereby minimized.

Many variations in the details besides those specifically mentioned will occur to people skilled in the art. The specific description of a few modifications is not to be construed as a limitation, the only limitations intended being those required by the prior art or expressed in the claims.

I claim as my invention:

1. An acoustic device comprising a disk of magnetizable material secured at its central portion, an acoustic loading member attached to said disk at its margin, and electromagnetic driving means cooperating with said disk.

2. An acoustic device comprising a disk of magnetizable material secured at its central portion, an acoustic loading member attached to said disk at its margin, and driving means acting electromagnetically on said disk nearer the margin than the center thereof.

3. A disk, securing means at the inner portion thereof, a load attached at the margin thereof, and driving means acting upon an intermediate portion thereof to flex the disk and thereby move the load.

4. A magnetizable armature for an acoustic device comprising a central portion, a margin, load securing means integral with the margin, and a flexible annular connecting

portion between said margin and said central portion.

5. A diaphragm for an acoustic translating device comprising a cone and an elastic disk of magnetizable material secured at its margin to said cone, said disk comprising a central portion and a flexible connecting portion between said margin and said central portion.

6. An acoustic translating device comprising a disk of magnetic material, clamping means for securing the central portion of said disk, a rigid diaphragm secured to the margin of said disk and a magnetic circuit including said clamping means and an air gap adjacent to said margin.

7. An acoustic translating device comprising a disk of magnetic material, clamping means for securing the central portion of said disk, a rigid diaphragm secured to the margin of said disk and a magnetic circuit including said clamping means and an air gap adjacent to said margin, said disk having a flexible portion between said air gap and said rigid diaphragm.

8. An acoustic translating device comprising two cup-shaped magnetic members and central magnetic members coaxial therewith, an annular armature between said cup-shaped members, clamping means securing the central part of said armature and magnetically integral with said central members, the edges of said cup-shaped members being closely adjacent to said armature near the margin thereof.

9. In a translating device, a magnetic circuit comprising two substantially cup-shaped members each having a central column, a disk-shaped armature between said cup-shaped members, and means magnetically uniting said central columns to the central part of said armature.

10. In a translating device, a magnetic circuit comprising two substantially cup-shaped members each having a central column, a disk-shaped armature between said cup-shaped members and means magnetically uniting said central columns to the central part of said armature, said means spacing said cup-shaped member from said armature whereby an air gap is provided at the edge of the walls of each cup.

11. An acoustic translating device comprising two substantially cup-shaped magnetic members and a central magnetic member united therewith, an annular armature between said cup-shaped members, and clamping means securing the central part of said armature, said central magnetic member comprising said clamping means, the portion of the armature secured thereby and columns integral with each cup-shaped magnetic member, the edges of said cup-shaped members being closely adjacent to said armature near the margin thereof, and load securing means at the margin of said disc exterior to said cup-shaped members.

12. In an acoustic translating device, an annular armature clamped at its inner margin and free at its outer margin, magnetic members on both faces of said armature, and means for establishing a radial alternating flux in said armature.

13. In an acoustic translating device, an annular armature clamped at one margin and free at the other margin, magnetic members on both faces of said armature, means for establishing a radial alternating flux in said armature and an acoustic loading device attached to said armature at its free edge.

In testimony whereof, I have hereunto subscribed my name this 6th day of July, 1928.

JURJEN S. HIGH.