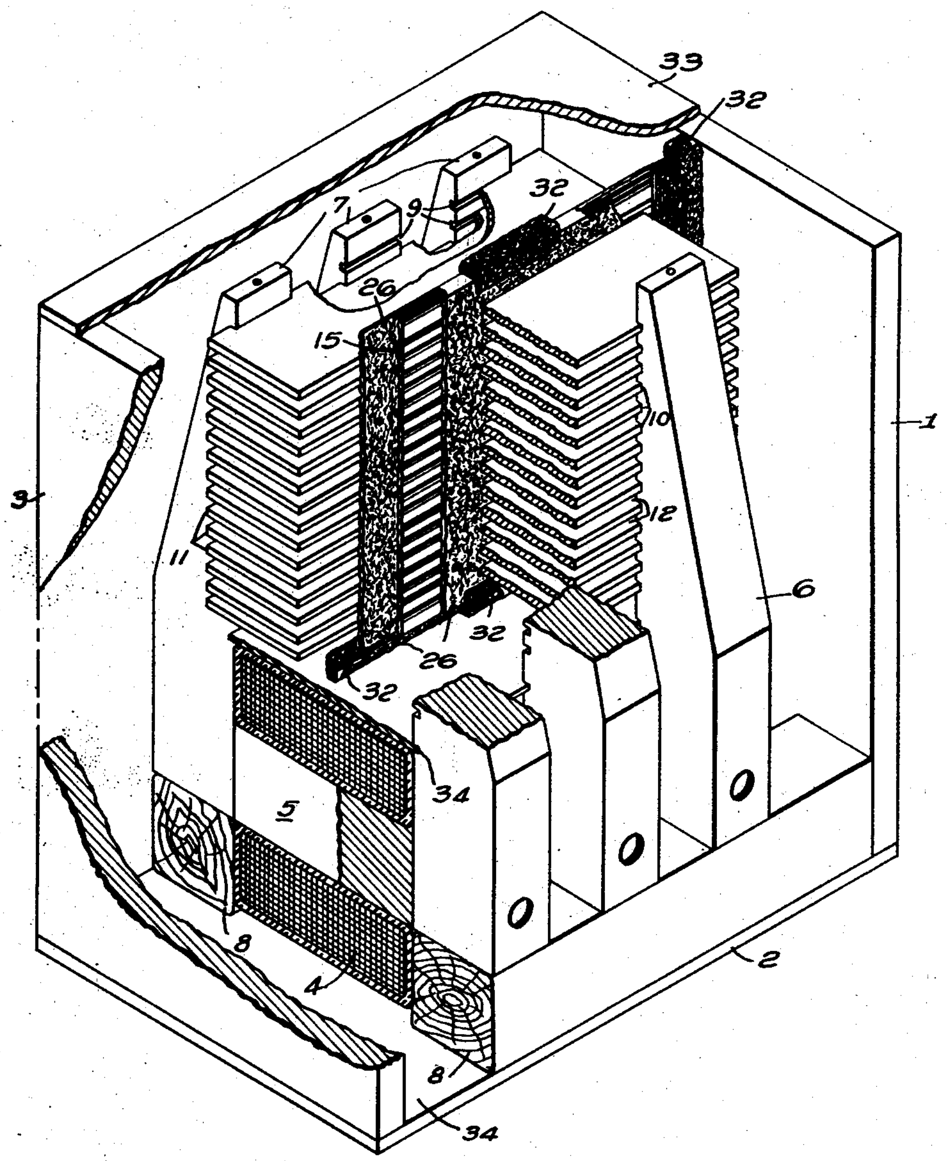
July 21, 1931. J. S. HIGH 1,815,564

TRANSLATING DEVICE

Filed June 13, 1929 3 Sheets-Sheet 1

Fig. 1.



INVENTOR

Jurjen S. High.

BY [signature]

ATTORNEY

July 21, 1931. J. S. HIGH 1,815,564

TRANSLATING DEVICE

Filed June 13, 1929 3 Sheets-Sheet 2

Fig. 2.

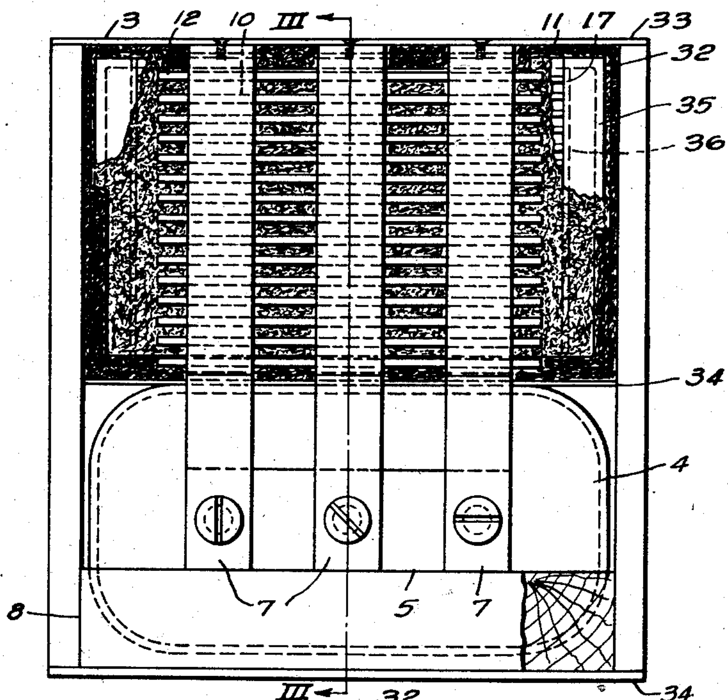


Fig. 3.

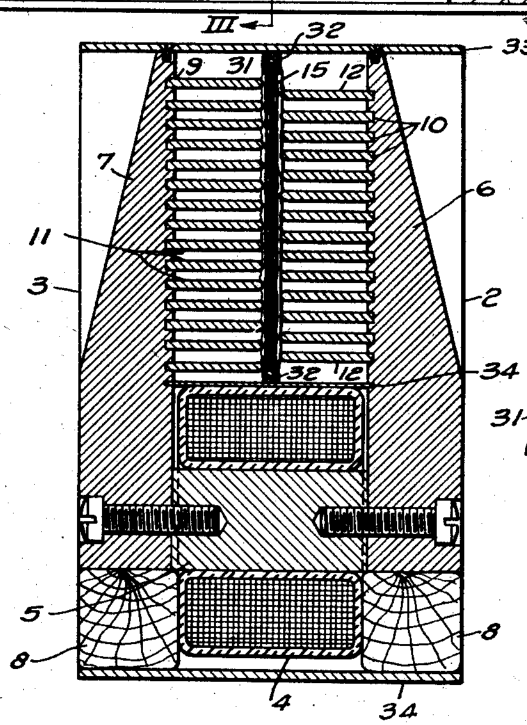
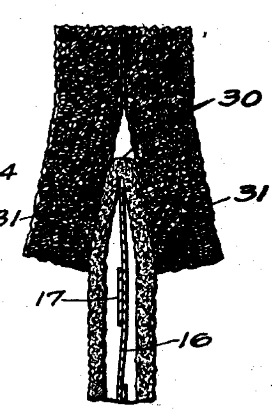


Fig. 4.



INVENTOR

Jurjen S. High.

BY Chesley G. Carr

ATTORNEY

July 21, 1931. J. S. HIGH 1,815,564

TRANSLATING DEVICE

Filed June 13, 1929 3 Sheets-Sheet 3

Fig. 5.

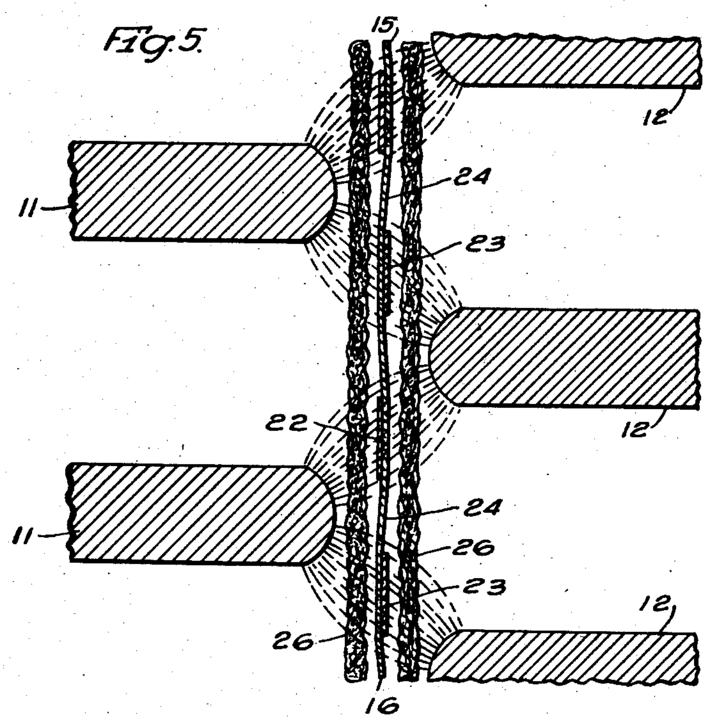
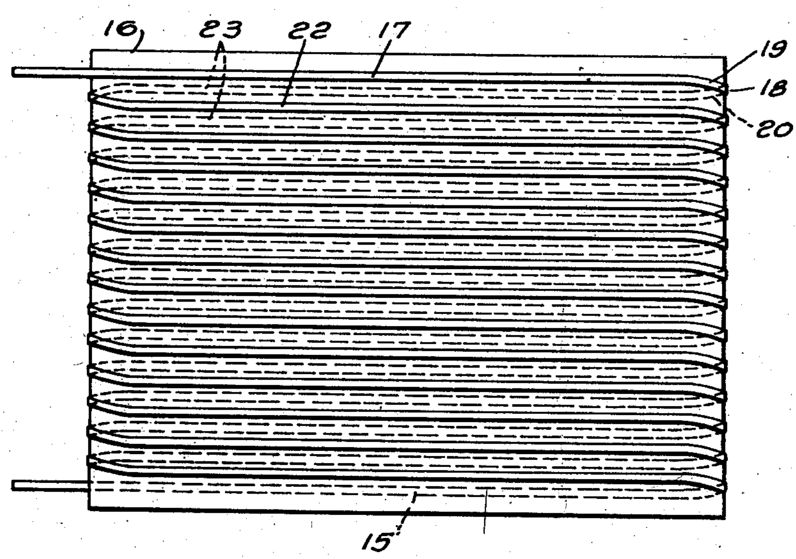


Fig. 6.



INVENTOR
Jurjen S. High.
BY
Wesley G. Carr
ATTORNEY

Patented July 21, 1931 **1,815,564**

UNITED STATES PATENT OFFICE

JURJEN S. HIGH, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

TRANSLATING DEVICE

Application filed June 13, 1929. Serial No. 370,526.

My invention relates to devices, such as microphones and loud speakers, for translating between electrical energy and sound energy.

It is an object of my invention to produce a translating device in which the diaphragm shall be provided, throughout its area, with means for effecting energy translation. When the device is a loud speaker, the force exerted by the electro-dynamic forces is exerted at many points distributed over the diaphragm. Likewise, when the device is acting as a microphone, the diaphragm being moved by the sound pressure, the resistance to the motion presented by the electro-dynamic forces is exerted at numerous points distributed over the diaphragm.

In that form of my invention in which the diaphragm is free to move as a whole, this distribution results in a plunger-like movement of the diaphragm. On the other hand, when the diaphragm is restrained along certain lines or at certain points, the intervening portions vibrate effectively, notwithstanding such restraint, because of the distributed forces.

It is a further object of my invention to provide a means for producing flux through the diaphragm over a very considerable area thereof without causing the magnetic structure to hinder the passage of sound to or from the diaphragm.

It is a further object of my invention to provide a current-carrying conductor which shall be the electrical equivalent of two flat closely adjacent current sheets with their currents in opposite directions.

It is a further object of my invention to so distribute the magnetic flux that it shall co-operate with substantially the whole of each of said current sheets.

I have found it desirable to space apart the individual pole-members which collectively constitute the means for delivering the flux to cooperate with said current sheets. I have likewise found it desirable to space apart the conductors which carry the current, heretofore described as current sheets.

It is a further object of my invention to so locate the individual pole-members that nearly all of the flux will traverse the plane of the double-current sheet in those parts of the plane occupied by the conductors and in such direction that the resultant mechanical force will be effective.

It is a further object of my invention to provide a means whereby rattling noises will be prevented, thereby enabling paper, or other sheet material liable to produce such noises, to serve acceptably as the body of the diaphragm.

A sheet of material of only slight stiffness, such as thin paper, can remain in a vertical position without buckling or otherwise collapsing, provided it is supported on each side against tipping or any large bending movement. It is another object of this invention to take advantage of this property of such sheet material.

Details of the structure and further objects of my invention will be readily understood from the following description and the accompanying drawings, in which

Figure 1 is a perspective view showing the device with parts broken away,

Fig. 2 is a rear elevation of the apparatus shown in Fig. 1,

Fig. 3 is a section on the line III—III of Fig. 2,

Fig. 4 is a view of a support on an enlarged scale, partly in section,

Fig. 5 is a vertical section, on an enlarged scale, through a portion of the diaphragm and the adjacent individual pole-members, and

Fig. 6 is a side elevational view of the diaphragm.

The device is housed in a casing 1 open at the front 2 and back 3. A coil 4 surrounds the central member 5 of the magnetic circuit. The winding of the coil 4 is intended to carry direct current, whereby all of the polar uprights 6, at one side of the coil, are of the same polarity, and all of the polar uprights 7, on the other side of the coil, are of the opposite polarity.

Blocks or bars 8, preferably of non-magnetic material, space the magnetic circuit away from the floor of the casing and provide thereby sufficient room for the coil 4.

The upright pole-pieces 7 are provided

with aligned grooves 9 traverse to the faces of the pole-pieces 7, which are toward the pole-pieces 6, and the pole-pieces 6 are traversed by aligned grooves 10 on the faces thereof toward the pole-pieces 7. The grooves 10 are staggered relative to the grooves 9. Individual pole-members 11, of sufficient length to extend across the whole collection of pole-pieces 7, are fitted in the grooves 9 with a press fit.

If preferred, the joints between the shelf-like individual pole-pieces 11 and the pole-pieces 7 may be welded, the junction being such as to present the smallest possible magnetic reluctance in the joints. Similarly, shelf-like extensions or individual pole-pieces 12 are fitted in the grooves 10 in the upright pole pieces 6 at the front of the apparatus.

Because the grooves 9 are staggered with respect to the grooves 10, the individual pole-pieces 11 occupy horizontal planes midway between the horizontal planes occupied by the individual pole-pieces 12, and the free edges of the individual pole pieces, which are the seats of the several magnetic poles, are in staggered relation, as shown in Fig. 3, and more clearly in Fig. 5.

The diaphragm 15 is located between the individual pole-pieces 11 and 12. It comprises a sheet 16 of drawing-paper or other sheet material upon which a ribbon 17, of aluminum or other conductive material is wound. The ribbon 17 extends the full length of the sheet 16 and, at the edge, is folded, as shown at 18, to extend in the reverse direction the full length of the other side of the sheet.

Adjacent to the fold 18, the ribbon is deflected laterally, as shown at 19, and a similar deflection occurs on the other face of the sheet, as shown at 20. The combined effect of the two deflections is sufficient to locate each length of ribbon upon the reverse side of the sheet, midway between two adjacent lengths of ribbon upon the obverse side of the sheet. Thus, the length 22 on the obverse side of the sheet, as shown in Fig. 6, is midway between two lengths 23 upon the reverse side of the sheet. Preferably, the width of the ribbon is approximately equal to the width of the space between each length and the neighboring length on the opposite face of the sheet.

Any desired way of securing the ribbon to the sheet may be employed. It may be cemented; the metal may be forced into the interstices between the fibres of the sheet by pressure; the combined surface of ribbon and sheet may be varnished, or any other way of insuring that the sheet and ribbon will move as a unitary structure may be employed.

Preferably, the assemblage, comprising sheet and ribbon, is subjected to pressure, whereby the paper is slightly deformed into a zigzag shape, as illustrated at 24 in Fig. 5. As a consequence of this deformation, the successive lengths of ribbon are nearly in one plane.

Upon each side of the diaphragm, a layer 26 of light fibrous material is provided. This material may be oriental silk crepe or loosely woven crinkly silk, but any fabric, the fibres of which are capable of a large amount of movement among themselves and are of relatively small density, will serve the purpose. Very soft loose cotton felt may serve. The silk or other fabric 26 may be supported in place by being folded across the upper edge of the diaphragm, as shown at 30 in Fig. 4. Any other suitable means for supporting the fabric in place may be used, but the fabric need not be cemented to the faces of the diaphragm.

In one form of my invention, a part only of the space between the diaphragm and the ends of the individual pole-members is occupied by the uncompressed volume of the silk. The unoccupied portion of the space between the diaphragm and the ends of the magnetic structure is intended to be sufficient to accommodate the normal movements of the diaphragm. The silk will not be compressed between the diaphragm and the pole-piece in this form of the invention except when extraordinary excursions of the diaphragm occur.

In an alternative form, the fabric is made to fill loosely the space between the diaphragm 15 and the edges of the pole-members 11 and 12. Motion of the diaphragm in this form is largely restricted to the portions between pole pieces.

The upper edge of the diaphragm, together with the folded edge of the silk, is thrust between two pieces of soft felt 31, the upper portion of the adjacent faces of which are glued together. The joined pieces of felt may form a frame extending about the whole periphery of the diaphragm or felt may be used only at certain points, for example, at the corners thereof. At 32 in Fig. 1, several separated portions of the felt are shown and in Fig. 2, the complete frame of felt is illustrated. At the top of the diaphragm, the felt, by loosely engaging the top plate 33 of the casing, permits transverse displacement of the diaphragm.

At the bottom of the diaphragm, similar contact between the felt and a plate 34 of brass or other nonmagnetic sheet material permits transverse movement of the diaphragm.

The plate 34 supports the diaphragm, while the ends of the pole-members prevent it from falling by tipping or buckling. The top plate 33, of the casing, being fastened to the upright pole pieces 6 and 7, takes the thrust set up by the magnetic attraction between pole members 11 and 12.

The diaphragm structure includes, beside the sheet 16 and the winding thereon, an extension at each end of the drawing paper. This extension is shown at 35 in Fig. 2. It is joined to the diaphragm proper by a cemented joint, indicated at 36.

In the operation of the device, current is supplied to the coil 3 to produce unidirectional flux between the individual pole-pieces, as indicated in Fig. 5.

The terminals of the ribbon 17, shown extending toward the left in Fig. 6, are connected to a source of audio-frequency current, in the case of a loud speaker, or to deliver the current produced when the device is acting as a microphone.

In the loud-speaker action, current flows in the aluminum ribbon. Considering the moment at which the direction of the current is into the paper in the lower length 23 of the conductor, as illustrated in Fig. 5, the direction of the current is up from the paper in the length 22 of the conductor in Fig. 5. If the right-hand individual pole pieces in Fig. 5 be regarded as north poles, the left-hand ones will be regarded as south poles. The resulting thrust upon the length 23 of the conductor shown at the bottom of Fig. 5 will be upward and to the right. At this moment, the force exerted on the conductor 22 is downward and to the right. The stiffness of the diaphragm structure is sufficient to prevent the upward component of the force upon the lower length 23 of the conductor and the downward component of the force upon the adjacent conductor 22 from producing any result, but the two components of these two forces toward the right cause a movement of the diaphragm in that direction.

A similar examination of the forces acting upon each length of the conductor will show that, over the whole surface covered by the winding, there is, at the moment under consideration, a uniformly distributed force toward the right. This force is uniformly distributed in the sense that it is equal over many points systematically distributed in a uniform fashion over the area of the diaphragm. It is not meant to assert that the force between two adjacent lengths of conductor is equal to that at the conductors themselves.

In the form of the device in which there is sufficient space provided between the diaphragm and the pole-members, the diaphragm moves laterally without flexing. It produces a plunger-like action faithfully representing the wave-form of the current delivered to the winding. Any tendency for vibration by flexing, with a consequent rattling noise, is prevented by the damping action of the silk.

In the alternative form in which the edges of the pole-members are close to the silk, lateral movement of the corresponding parts of the diaphragm is prevented or partially prevented and the diaphragm vibrates in a system of long narrow strips each of which tends to become arched transverse to its length during each cycle. This zonal vibration is superposed upon the plunger-like movement but the silk still prevents rattling sounds.

The sound radiated from one face of the diaphragm is prevented from interfering with that from the other face by the side-wall and top 33 of the casing and the plate 32. Together, these constitute a frame surrounding the diaphragm, which has much the same result as a baffle-board. This frame must not be too deep or a banel-like effect will result.

When the device is acting as a microphone, the sound pressure causes the diaphragm to move with a plunger-like motion. Each conductor length moves across its respective flux at the same angle and the electromotive forces induced in each add, with the result that the electromotive force produced at the terminals of the winding 17, is of a useful amount.

Both in the loud-speaker action of the device and in its microphone action, it will be seen that the sound reaches the diaphragm through openings provided by expanding the metallic structure of the magnetic circuit into a lattice work. It will also be seen that, in both cases, the movement of the conductors is at an angle approximately 45° to the direction of the flux. This is an advantageous angle that can be obtained with a flat surface and a distributed pole-piece structure.

Many variations of the details of the construction will readily occur to those skilled in the art. The omission of any specific mention of such variations is not intended as a limitation. The only intended limitations are those required by the prior art and expressed in the claims.

I claim as my invention:

1. In a translating device for electric and acoustic energy, a sheet, a winding distributed over both faces of said sheet and flux-producing means cooperating with said winding throughout the major part thereof.

2. In a translating device for electric and acoustic energy, a sheet, a winding distributed over both faces of said sheet and means located on both sides of said sheet for producing flux through said sheet to cooperate with said winding.

3. In a translating device for electric and acoustic energy, a magnetic circuit comprising oppositely located pole-pieces, each pole piece having a plurality of parallel-projecting pole-members spaced from one another and the pole-members on one pole-piece being opposite the spaces between the pole-mem-

bers on the other pole-piece, whereby the pole-members are in staggered relation.

4. In a translating device for electric and acoustic energy, a magnetic circuit comprising a pair of sets of pole-pieces, the sets being located in opposed relation and the members of each set being spaced apart, an open work of magnetic material extending from one set of pole-pieces toward the other, a similar open work extending from the other set of pole pieces toward the first, whereby the adjacent extremities of the open work are on opposite sides of an air gap.

5. In a translating device for electric and acoustic energy, a magnetic circuit comprising a pair of sets of pole-pieces, the sets being located in opposed relation and the members of each set being spaced apart, an open work of magnetic material extending from one set of pole-pieces toward the other, a similar open work extending from the other set of pole pieces toward the first, whereby the adjacent extremities of the open work are on opposite sides of an air gap and the individual pole-members of one open work are opposite the open spaces of the other, whereby the terminals of the magnetic circuit are in staggered relation.

6. In a translating device for electric and acoustic energy, a diaphragm and a magnetic circuit including portions adjacent to said diaphragm on opposite sides thereof, said portions being of lattice work whereby sound may readily pass therethrough.

7. A structure for conveying flux to an area comprising an open-work of magnetic material extending over substantially all of said area and affording passage extending from the exterior of said structure to regions distributed over substantially all of said area.

8. In a translating device for electric and acoustic energy, a sheet, a plurality of conductors secured on said sheet and means for producing a magnetic flux across each of said conductors at an oblique angle to said sheet.

9. In a translating device for electric and acoustic energy, a plurality of magnetic pole-members located on opposite sides of a plane, a winding and means for supporting the winding approximately in said plane.

10. In a translating device for electric and acoustic energy, a plurality of magnetic pole-members located in staggered relation on opposite sides of a plane, those on one side being all of one polarity and those on the other side being all of the opposite polarity, a winding and means for supporting the winding approximately in said plane.

11. In a translating device for electric and acoustic energy, a plurality of magnetic pole-members located in staggered relation on opposite sides of a plane, those on one side being all of one polarity and those on the other side being all of the opposite polarity, a winding and means for supporting the winding approximately in said plane with the individual turns thereof approximately midway between successive unlike poles.

12. In a translating device for electric and acoustic energy, a diaphragm, a magnetic circuit cooperating with said diaphragm and including pole-structures extending over a major portion of the area of the diaphragm on each side thereof and damping material between the pole-structure and the diaphragm.

13. In a translating device for electric and acoustic energy, a magnetic circuit connecting the sides of an air gap and a diaphragm in said air gap, the mid portion of said magnetic circuit being concentrated and the pole portions being of open work whereby the cross-sectional area effective to carry the flux carried by the mid portion is distributed at the pole portions over an area approximately that of the diaphragm.

14. In a translating device for electric and acoustic energy, a diaphragm, means for exerting force transverse to the diaphragm at places distributed over a major part of the area thereof and damping means covering substantially all of said part.

15. In a translating device for electric and acoustic energy, a diaphragm, means for exerting a force transverse to the diaphragm at places distributed over a major part of the area thereof and a connected sheet of material lighter than the material of said diaphragm extending over substantially all of said part.

16. In a translating device for electric and acoustic energy, a diaphragm, means for exerting force transverse to the diaphragm at places distributed over a major part of the area thereof and a connected sheet of material lighter than the material of said diaphragm extending over substantially all of said part and free to move relative thereto.

17. In a translating device for electric and acoustic energy, a magnetic circuit having an air gap in the form of a crevice, a diaphragm in said gap supported only at parts thereof extending beyond the gap and of sufficient stiffness to maintain itself in position within the gap.

18. A diaphragm comprising a supporting sheet and a ribbon of conductive material wound flat on both faces of said sheet.

19. A diaphragm comprising a supporting sheet and a ribbon of conductive material wound flat on both faces of said sheet and forming therewith a structure of sufficient stiffness to support itself against buckling when placed in a vertical plane.

In testimony whereof, I have hereunto subscribed my name this 31st day of May, 1929.

JURJEN S. HIGH.