

April 27, 1948.

W. E. GILMAN

2,440,439

PERMANENT MAGNET ELECTRODYNAMIC TRANSDUCER

Filed July 4, 1942

2 Sheets-Sheet 1

FIG. 1.

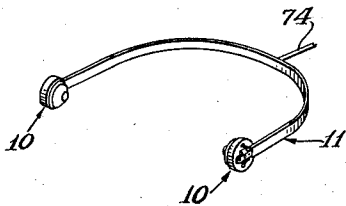


FIG. 2.

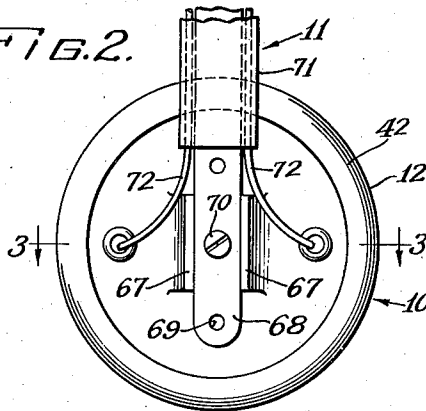


FIG. 3.

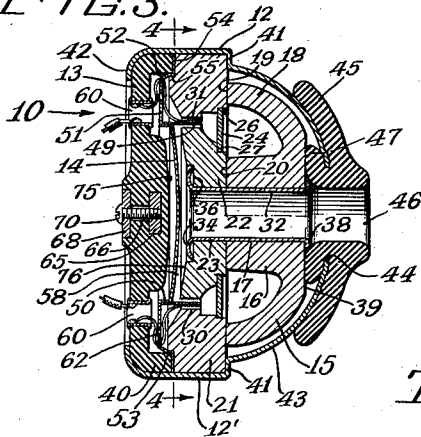


FIG. 4.

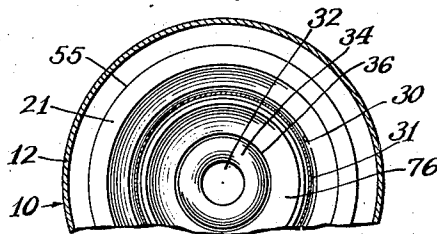


FIG. 5.

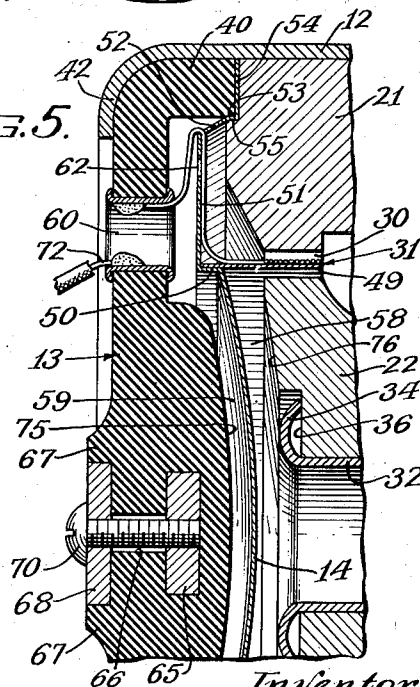
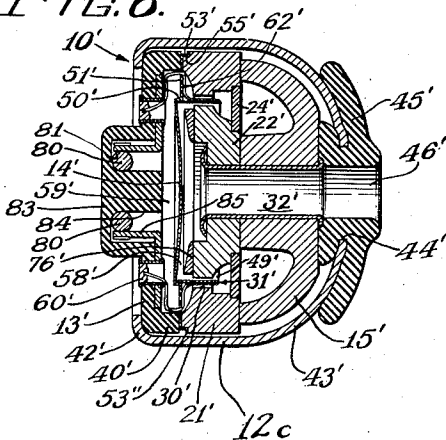


FIG. 6.



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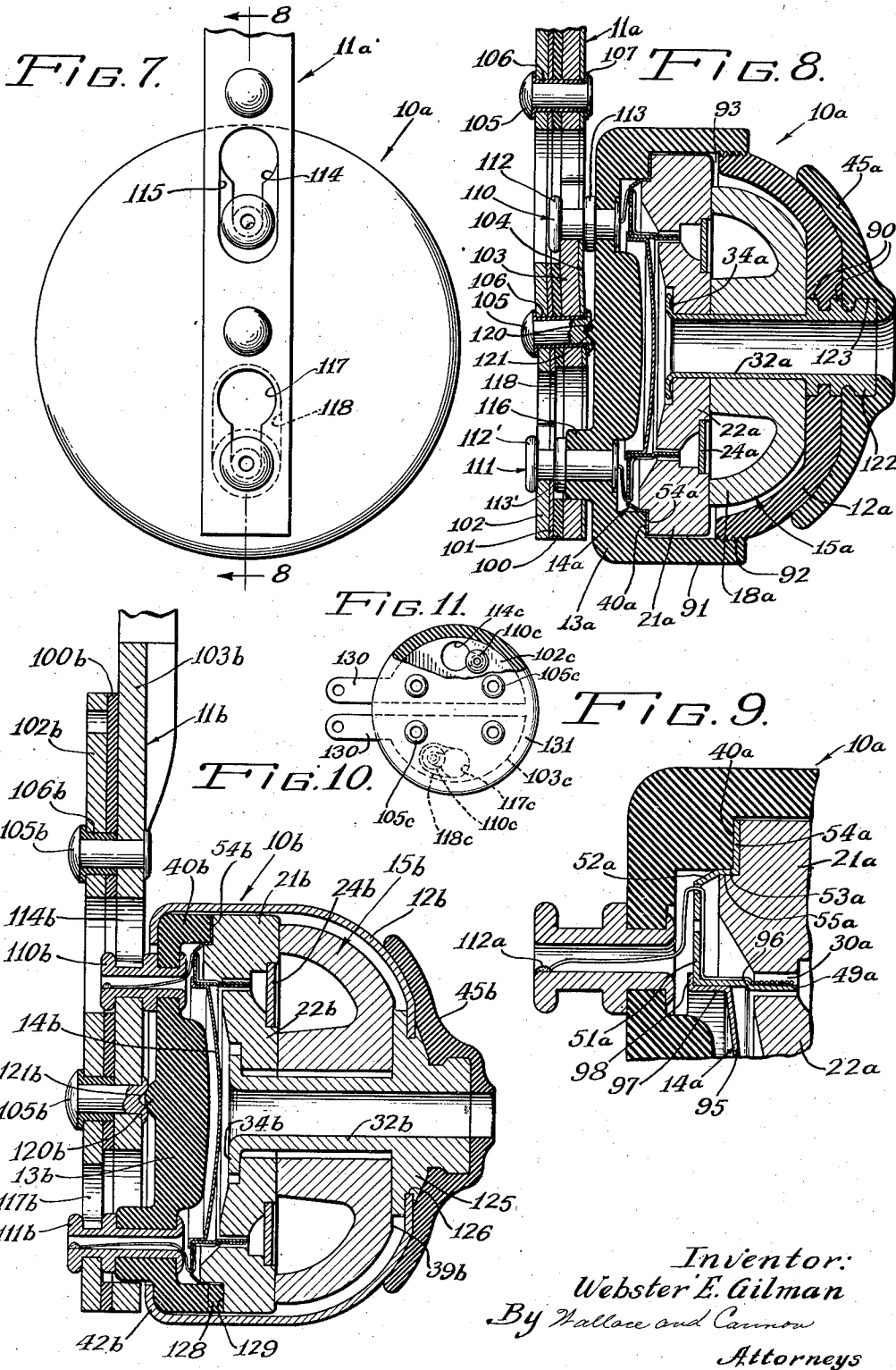
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PERMANENT MAGNET ELECTRODYNAMIC TRANSDUCER

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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PERMANENT MAGNET ELECTRODYNAMIC
TRANSDUCERWebster E. Gilman, Maywood, Ill., assignor to
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Application July 4, 1942, Serial No. 449,767

2 Claims. (Cl. 179-115.5)

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This invention relates to transducers and particularly to the dynamic type as contrasted with the magnetic type thereof.

Transducers of the dynamic type may, of course, be employed either as speakers or as microphones, and in either of these uses the fidelity and range of frequency response is in a large measure dependent upon the accuracy of formation, location and relationship of the various elements thereof, and is particularly dependent upon the accuracy of location of the voice coil structure in the magnetic gap of the transducer. While it has been possible, through the exercise of great care and skill, to obtain the desired operational characteristics in prior dynamic transducers, the difficulties involved have often resulted in wide variations of construction and performance, and to enable such difficulties to be overcome in a simple and expeditious manner is an important object of this invention.

The aforesaid difficulties of producing the desired performance characteristics in prior dynamic transducers have, of course, been encountered in transducers of various sizes and designs, but where such transducers have been of a relatively small size, the reduced tolerances and the reduced size have further increased the difficulties involved in producing a satisfactory dynamic transducer, and a further object of this invention is to enable fidelity and wide frequency response to be readily and uniformly attained particularly in dynamic transducers of relatively small size. Further objects related to the foregoing are to so form and arrange the elements of the magnetic circuit in such transducers as to assure accuracy of size and location of the magnetic gap; to simplify the location and mounting of the diaphragm; to insure accurate location of the diaphragm relative to the magnetic gap; to enable the voice coil to be readily located in an accurately determined position on the voice coil support; and to so form and interrelate the pole pieces of the magnetic circuit and the diaphragm and the voice coil structure that uniformity and accuracy of relationship are invariably attained in the finished transducers.

In dynamic transducers constructed in accordance with prior practice the provision of the desired magnetic circuit from the magnet to the pole pieces has required assembly and accurate mounting of a relatively large number of parts, and by reason of the number of parts and number of accurate connections involved the cost of production has been relatively high. Moreover, in those instances where the proper degree of

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skill and care has not been exercised in assembling the numerous parts, the quality of performance has been relatively low in transducers of the aforesaid character. It is, therefore, another object of this invention to simplify the production of the magnetic circuit of dynamic transducers and the like; and further objects related to the foregoing are to so form and relate the elements of the magnetic circuit of dynamic transducers that accuracy of relation of the elements thereof is attained as an incident to the assembly of such elements; to enable a permanent magnet used as a part of the magnetic circuit in such a transducer to function in producing proper interrelation of the other parts; to reduce the number of parts employed and the number of connecting operations required in the production of such magnetic circuits; to enable both poles of a permanent magnet for use in such magnetic circuits to be engaged in a magnetic sense with their respective pole pieces in a similar manner to thereby simplify the interconnection of the engaged parts; and to provide a permanent magnet of novel and advantageous form for use in the magnetic circuits of such dynamic transducers.

In the use of transducers, whether they be embodied as microphones or as speakers, it is customary to provide a separately formed supporting mounting member which not only acts as a carrier for the transducer but also serves as a carrier for the connecting leads which are to be electrically associated with the voice coil of the transducer. The facility with which transducers may be associated with such a carrier or mounting means is often an important factor in the use of equipment of this character, and it is a further object of this invention to enable transducers to be so mounted upon a headband or other support in a simple and effective manner, and a related object is to accomplish this end by means of a simple and novel character. Other objects related to the foregoing are to enable the desired electrical connections to the transducer to be established as an incident to the mounting of such a transducer on a support such as a headband; and to enable a headband for such use to be simply and economically produced.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show preferred embodiments and the principle thereof and what I now consider to be the best mode in which I have contemplated ap-

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plying that principle. Other embodiments of the invention embodying the same or equivalent principle may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

In the drawings:

Fig. 1 is a perspective view illustrating the invention as embodied in a headset having relatively small dynamic speakers at opposite ends of the head band;

Fig. 2 is an elevational view of the outer end of one of the speakers;

Fig. 3 is a cross sectional view taken substantially along the line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken substantially along the line 4—4 of Fig. 3;

Fig. 5 is an enlarged fragmental view showing a part of the structure illustrated in Fig. 3;

Fig. 6 is a view similar to Fig. 3 and illustrating another embodiment of the invention;

Fig. 7 is a view similar to Fig. 2 and illustrating still another embodiment of the invention;

Fig. 8 is a cross sectional view taken substantially along the line 8—8 of Fig. 7;

Fig. 9 is an enlarged fragmental view showing part of the structure illustrated in Fig. 8;

Fig. 10 is a cross sectional view similar to Fig. 8 and illustrating a further embodiment of the invention; and

Fig. 11 is an elevational view similar to Fig. 7 and showing another manner of mounting.

While the present invention relates to transducers and may be utilized in both microphones and speakers with equal facility, it is herein disclosed as particularly applied to speakers, and in the form shown in Figs. 1 to 5 of the accompanying drawings, the invention is embodied in a relatively small dynamic speaker 10 adapted for mounting on a head band 11 or the like so that the speaker 10 may be held in close association with an ear of the user. The speaker 10 is generally cylindrical in cross-section and has a housing 12 closed at its outer end by a mounting plate 13 made from an insulating material such as a synthetic resinous product and through which the speaker is adapted to be mounted on the head band 11. In accordance with the present invention the speaker 10 embodies a diaphragm 14 located within the housing 12 relatively close to the outer or larger end thereof, and means for actuating and controlling the diaphragm 14 are disposed within the housing 12 between the diaphragm 14 and the inner or output end of the speaker and are so formed that a loading passage or cavity extends therethrough to efficiently transmit the sound created by the diaphragm to the passages of the ear of the user.

The magnetic circuit of the present speaker includes a permanent magnet 15 having a central hub 16 with a central bore 17 formed axially therethrough, and at one of its ends the hub 16 has an annular skirt 18 which projects radially therefrom and then extends endwise to terminate in an annular face 19 which is preferably located in the plane of the annular end face 20 of the hub 16. Thus the annular face 19 of the skirt and the annular face 20 of the hub 16 constitute the opposite poles of the permanent magnet 15. Concentric annular pole pieces 21 and 22 made from soft iron or like material are disposed in abutment with the annular pole faces 19 and 20 of the permanent magnet, the inner pole piece 22 having a central bore or opening 23 formed therein in alignment with the bore 17 of the perma-

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nent magnet. A locating or centering ring 24 made from a non-magnetic material such as brass is disposed with its opposite edges seated with a press fit in annular rabbeted grooves 26 and 27 formed in the adjacent annular corners of the pole pieces 21 and 22, and hence the spacing ring 24 acts to locate the opposed annular faces of the pole pieces 21 and 22 in accurately spaced relation, thereby to define an annular magnetic gap 30 within which the voice coil structure 31 associated with the diaphragm 14 may operate.

The central pole piece 22 is held in an accurately determined relation to the central hub 16 of the magnet by a tubular eyelet 32 which extends with a relatively snug fit through the openings 23 and 17 in the pole piece 22 and the hub 16. At one of its ends the eyelet 32 is outwardly flanged as at 34 into a socket 36 which is countersunk into the outer face of the pole piece 22 concentric with the axis of the bore 23, while at its other end the eyelet 32 is flanged outwardly at 38 to engage the end face 39 of the magnet 15. Since the spacing ring 24 has a press fit with respect to the two pole pieces 21 and 22, the eyelet 32 acts through the spacing ring 24 to hold the pole piece 21 firmly against the annular face 19 of the magnet, and if desired the spacing ring 24 may be made a slightly coned form and may be so disposed in the grooves 26 and 27 that the ring is drawn toward a flat form as the eyelet 32 is flanged into place. Through such an arrangement a firm engagement of the outer pole piece 21 with the annular face 19 of the magnet 15 is invariably assured.

The diaphragm 14 has its outer or bordering edge clamped between an annular border flange 40 on the mounting plate 13 and an opposed clamping face provided on the pole piece 21, and this is accomplished by so forming the housing 12 that it exerts the requisite clamping action between the pole piece 21 and the mounting plate 13. Thus, as shown in Fig. 3 of the drawings, the housing 12 has a cylindrical portion 12' which surrounds the pole piece 21 and the peripheral edge of the mounting plate 13, and the housing is offset inwardly to form an annular shoulder 41 facing endwise toward the outer end of the speaker 10 and engaging the face of the pole piece 21 which is remote from the diaphragm 14. The desired clamping action is obtained by spinning the end edge of the cylindrical portion 12' of the housing radially inwardly to form a flange 42 which overlies the face of the mounting plate 13 and holds the same in firm abutment with the pole piece 21. Beyond the shoulder 41 toward the inner end of the speaker the housing 12 is formed so as to be rounded inwardly as at 43 and this rounded portion of the housing 12 terminates in an opening 44 which is substantially concentric with the axis of the eyelet 32. The opening 44 in the housing is somewhat larger than the central opening of the tubular eyelet 32, and a protecting member 45 which is generally in the nature of a grommet is inserted into the opening 44 so that its central opening 46 forms a continuation of the central opening of the eyelet 32. The inner flange 47 of the grommet 45 extends radially outwardly into the space between the surface 39 of the permanent magnet and the inner surface of the housing 12, while the outer portion of the grommet 45 extends for a considerable distance radially outwardly and about the rounded surface 43 of the housing 12. Thus the grommet 45, which is preferably made from a resilient material such as rubber, may be pressed

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into the external auditory canal of a user so that the bore 46 of the grommet and the central opening of the eyelet 32 cooperate to form a loading cavity extending from the diaphragm 14 to the external auditory canal of the user. From this it will be appreciated that the speaker is illustrated in enlarged scale in the drawing accompanying this application since the external portion of the grommet 45 is, in practice, sized to fit into the entrance to the external auditory canal of the average adult male and the other parts of the speaker are related in size to this grommet. The inner flange 47 of the grommet is of such a thickness that when it is inserted between the face 39 of the magnet 15 and the portion of the inner surface of the housing 12 which borders the opening 44, the flange 47 exerts a resilient force upon the magnet 15 to thereby cooperate with the eyelet 32 and the press fit connection between the two pole pieces to insure firm contact of the pole face 19 with the annular pole piece 21.

The voice coil structure 31 comprises a coil of wire that is wound upon the outer surface of the cylindrical supporting form 49 made from a relatively stiff material such as impregnated paper or the like, and the voice coil structure 31 is so mounted on the diaphragm 14 that the voice coil structure may extend from the diaphragm 14 in an axial direction into the annular magnetic gap 30. It is recognized that fidelity and accurate response throughout a wide frequency range are in a large measure dependent upon accurate location or spacing of the voice coil structure in the annular magnetic gap, and in accordance with the present invention the diaphragm 14, the voice coil structure 31 and the diaphragm supporting means are constructed and related in a novel manner which insures the desired accuracy of relation and location of these elements with respect to each other and with respect to the magnetic gap 30.

To this end the diaphragm 14, which is preferably formed from paper impregnated with a material such as a synthetic resin of phenol-aldehyde type, is molded or otherwise formed to embody lateral positioning means adapted to cooperate with complemental means on the voice coil structure 31 to interlock the voice coil structure in a predetermined and preferably concentric relationship with respect to the diaphragm. In the embodiment of the invention illustrated in Figs. 1 to 5 of the drawings, this end is attained by molding the diaphragm 14 with an offset cylindrical wall section 50 of such a diameter as to fit snugly within the cylindrical coil supporting form 49, and the coil supporting form 49 is secured in position about the cylindrical wall 50 by adhesive or other suitable means. Radially outwardly of the cylindrical wall 50 the diaphragm 14 is molded or otherwise formed to provide a readily bendable and relatively flat annular portion 51, which at its outer edges is merged with an annular connecting portion 52 disposed at an angle to the flat portion 51. The connecting portion 52 merges with a relatively short or narrow cylindrical wall section 53 which, in turn, joins with an outwardly projecting edge flange 54 disposed in a plane parallel to the portion 51 and perpendicular to the axis of the diaphragm. The cylindrical portion 53 is adapted to function in attaining accurate positioning of the diaphragm 14 and the voice coil structure 31 in a concentric relation to the annular magnetic gap 30, and this end is attained through the provision of a coop-

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erating annular shoulder 55 formed on the pole piece 21 so as to face radially outwardly and adapted to fit snugly within the cylindrical locating wall 53 of the diaphragm. The shoulder 55 is formed so as to be concentric with the annular magnetic gap 30, while the cylindrical locating wall 53 is so formed on the diaphragm 14 as to be concentric with the annular cylindrical wall 50 and the voice coil structure 31, and hence when the wall 53 is fitted over and about the shoulder 55, the diaphragm 14 is accurately centered and the voice coil structure 31 is disposed in the desired concentric relation in the annular magnetic gap 30. As a further aid in producing accurate and uniform assembly of the speaker, the flange 40 of the outer wall 13 is so formed as to fit snugly about the cylindrical positioning wall 53, thereby to locate the outer wall 13 of the speaker in an accurate and concentric relation with respect to the other parts of the speaker. Undesired stress on the wall 53 of the diaphragm is avoided by making the shoulder 55 of a height considerably greater than the thickness of the diaphragm flange 54, and hence the flange 40 of the wall 13 is in effect interlocked in a lateral sense with the shoulder 55 and may apply stress to the cylindrical wall 53 of the diaphragm merely in compression.

With the structure as thus described, it will be evident that the space between the diaphragm 14 and the inner pole piece 22 constitutes the sound chamber 58 of the present speaker, while the space between the diaphragm and the outer end of the wall 13 constitutes a back chamber 59. The back chamber 59 may be vented by eyelets 60 which are extended through the wall 13 at diametrically opposite points, and these eyelets 60 serve as terminals to which the ends or leads of the voice coil may be connected. Thus the ends of the wires which form the voice coil are extended along opposite sides of the outer face of the cylindrical form 49 to the portion 51 of the diaphragm and are led in opposite directions along the portion 51 to diametrically opposite points adjacent the annular portion 52 of the diaphragm, at which points the ends of the wires are extended through the diaphragm and are led radially inwardly along the portion 51 and are connected to the respective eyelets 60 as by soldering. For clarity of disclosure the ends of the wires are in some instances shown as being spaced from the cylindrical coil support 49 and from the face of the portion 51 of the diaphragm, but in practice these wires are secured to the surface by adhesive. On the surface of the portion 51 of the diaphragm which is adjacent to the eyelets 60, the ends of the wires may be free of the diaphragm portion 51, thereby to permit free movement of the diaphragm. The space which is included between the annular pole piece 21 and the portion 51 of the diaphragm is also vented or placed in free communication with the back chamber 59 by a plurality of openings 62 formed in the annular portion 51 of the diaphragm. It is to be understood in this connection that in some instances the eyelets 60 may be closed by means such as a plastic sealing compound, for by so doing the frequency response of the diaphragm may be modified or damped to meet the demands of some types of work.

The speaker 10 which is thus provided may be mounted upon a head band 11 or other suitable support in different ways, but as shown in Figs. 1, 2 and 3 such a mounting is attained through the mounting of a nut 65 within the wall 13 and

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centrally thereof. The nut 65 is accessible through a bore or passage 66 in the wall 13, and on opposite sides of the bore 66 a pair of ribs 67 are moulded or otherwise formed upon the outer side of the wall 13. The head band 11 is formed from a relatively flexible strip 68 of a metal such as steel, and the strip 68 is of such a width that it may fit snugly between the two ribs 67. The strip 68 has a plurality of openings 69 formed therein at longitudinally spaced points, and a screw 70 may be inserted into a selected one of the openings 69 and may be threaded into the nut 65 to hold the speaker 10 and the head band 11 in an assembled relation. The head band 11 as shown in Fig. 1 includes an insulated covering 71 extending relatively close to the ends of the strip 68, and the connecting leads or wires 72 are moulded into the covering 71 along the opposite side edges of the strip 68. The extending ends of the wires 72 are connected as by soldering to the respective eyelets 60 and an electrical circuit is thereby established from the leads 72 to the voice coil of the speaker. The wire 72 may be extended from the covering 71 of the headband at any desired point as, for example, centrally of the headband as indicated at 74.

The portion of the diaphragm 14 which is located radially inwardly of the cylindrical wall 50 constitutes the active portion of the diaphragm, and this portion of the diaphragm is shaped to provide a slightly dome-like form, and the inner face of the wall 13 is extended to provide a similar dome-like form 75 to provide a back chamber of substantially uniform depth and thereby attain a uniform loading of the rear face of the diaphragm. The other or active face of the diaphragm 14 is also arranged to be substantially uniform loaded during operation of the diaphragm, and this end is attained through the formation of a sloping annular surface 76 on the adjacent face of the pole piece 22. The slope of the annular surface 76 is preferably such that the sound chamber 58 has its smallest longitudinal dimension at the radially outer edge of the sound chamber. Thus the spacing between the diaphragm 14 and the surface 76 gradually increases toward the axis of the speaker.

In the speaker which is thus provided, the vibration of the diaphragm 14 in response to variations in the intensity of the voice current impressed on the voice coil results in the creation of sound waves within the sound chamber 58, and such sound waves are effectively transmitted to the loading cavity of the speaker and hence to the ear of the user. The mounting and arrangement of the diaphragm 14 are such that the diaphragm has a high fidelity of response over a wide range of frequencies, and hence the present speaker, even in an exceptionally small size in which the diameter is somewhat less than one inch, has been found to be effective to reproduce speech and other sounds with greater intelligibility than prior speakers of a corresponding size.

The structure illustrated in Figs. 1 to 5 of the drawing whereby the present invention attains the desired accurate location of the voice coil structure in the annular magnetic gap may be varied in different respects, as for example, in the manner illustrated in Fig. 6 of the drawing which illustrates an alternative form of the invention. In this form the invention is embodied in a speaker 10' wherein the major elements are of the same general form and are disposed in a generally similar relationship as in the form of

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the invention disclosed in Figs. 1 to 5, and hence specific description as to such parts and relationships will be confined mainly to those aspects where differences of form or relation are found. The speaker 10 has a housing 12c closed at its larger or outer end by a disk-like wall 13' which is held in place by an inwardly turned flange 42. The housing 12c has a cylindrical portion similar to the portion 12' and this cylindrical portion merges directly with the inwardly curved portion 43' rather than through a shoulder such as the shoulder 41. Thus in this form of the invention the resilient grommet 45' which is inserted in the end opening 44' is relied upon to act between the portion 43' of the housing and the end surface 39' of the permanent magnet 15' to hold the magnet 15', the pole pieces 21' and 22', the diaphragm 14' and the outer wall 13' in firmly clamped relation to each other endwise of the speaker and against the end flange 42'.

The diaphragm 14' has a flat annular portion 51' disposed between the edge surface of the flange 40' and the opposed flat annular surface of the pole piece 21' so as to be clamped therebetween. Accurate location of the diaphragm is assured through the provision of a cylindrical locating wall section 53' formed in the diaphragm 14' about the outer edge of the flat portion 51' in such a position and relation as to embrace a cylindrical locating surface 55' afforded by the radially facing surface of a rabbeted groove formed in an annular corner of the pole piece 21'. A flange 53'' preferably extends from the cylindrical locating wall section 53' to impart stiffness to the wall section 53'.

Another cylindrical locating wall section 50' is also formed in the diaphragm 14' to enable accurate mounting of the cylindrical coil supporting form 49' on the diaphragm, and in this instance the wall section 50' extends from the annular portion 51' away from the magnetic gap 30', and the diameter of the wall section 50' is such that the coil supporting form 49' may extend snugly within the wall section 50'; and the parts are secured in position by adhesive or other suitable means. In the assembly of the parts, the location of the coil supporting form 49' within the wall section 50' with the end of the form 49' engaged with the portion of the diaphragm radially inwardly of the wall section 50' insures that the voice coil structure 31' is concentric with the axis of the diaphragm 14', and hence in the assembled speaker the voice coil structure is located accurately in the annular magnetic gap 30'.

The pole pieces 21' and 22' are held in properly spaced relation by a nonmagnetic spacing ring 24', and the magnet 15' and the pole pieces are held together by a central or axial eyelet 32' in substantially the same manner as in the other embodiment of the invention, but as shown in Fig. 6, the sound chamber 58' is defined on one side thereof by an annular baffle plate 76' fixed concentrically on the pole piece 22' and affording a sloping surface similar to the surface 76 and bordering the flanged end of the eyelet 32'.

The back chamber 59' may be vented if desired by metal eyelets 60' extending through the outer or mounting plate 13', and the ends of the wires from the voice coil are led through the portion 51' of the diaphragm 14' and are connected to the respective eyelets 60' in a manner similar to that employed in the structure of Figs. 1 to 5. Vent openings 62' in the portion 51' of the diaphragm 14' connect the space adjacent

the pole piece 21' with the back chamber 59' to insure free flexure of the diaphragm in response to voice or signal currents impressed on the voice coil.

The speaker 10' is arranged for association with a headband 11' having projecting conductors 80 which extend slidably through spaced parallel bores 81 formed in a boss 83 molded on and as a part of the wall 13'. Thus the recesses 84 open into the back chamber 59', and angular contact brackets 85 are disposed in suitable grooves in the inside face of the wall 13' so that one arm of each bracket 85 is held in place by one of the eyelets 60' while the other arm of each bracket 85 extends into the adjacent one of the recesses 84 and engages the side of the conductors 80. Thus the contact brackets 85 are electrically connected to opposite ends of the voice coil, and the arrangement is such that when the conductors 80 are projected through the bores 81, an effective frictional engagement of the conductors 80 with their respective contact brackets 85 establishes the desired electrical circuit to the voice coil. The frictional engagement of the contact brackets 85 with the conductors 80 is such that the speaker 10' may be adjusted on the headband 11' merely by movement of the speaker along the conductors 80.

In the embodiment of the invention shown in Figs. 7 to 9, inclusive, the present invention is embodied in a speaker 10a which is adapted for more convenient mounting upon a headset band 11a of a headset, and in addition, this embodiment of the invention includes a diaphragm and voice coil assembly whereby accurate assembly of the parts of the speaker is facilitated. The embodiment of the invention disclosed in Figs. 7 to 9 includes a magnetic circuit wherein the elements are formed and related in substantially the same manner as in the previously described embodiments of the invention, there being an inner pole piece 22a, and an outer pole piece 21a separated by a spacing ring 24a, and the two pole pieces are held in an operative relation with respect to a permanent magnet 15a by a tubular member 32a which forms a loading chamber in the same general manner as the member 32 disclosed in the embodiment of the invention shown in Fig. 3. The tubular member 32a, however, is permanently associated with one element 12a of a sectional housing, the element 12a of the housing being molded from a moldable insulating material such as a cellulose plastic, and the tubular member 32a is molded in the end wall of the casing section 12a with an interlocking means such as spaced flanges 90 engaged with the material of the casing section 12a.

The other section 13a of the casing includes a wall portion generally similar to the wall 13 of the other embodiments of the invention, and a flange 91 is molded about the edge of this wall to provide screw threads as at 92 to engage complementary screw threads formed on outer periphery of the open end of the casing section 12a. The casing section 13a has an annular shoulder 40a formed interiorly of the flange 92 to engage an annular clamping portion 54a of a diaphragm structure 14a to clamp the diaphragm structure against the outer pole piece 21a. This clamping action is attained when the two sections of the casing are screwed together, it being noted that clearance is provided at 93 between the pole piece 21a and the end of the casing section 12a, thereby to insure proper clamping of the diaphragm between the shoulder 40a and the outer

pole piece and proper clamping of the pole pieces against the magnet 15a.

In this embodiment of the invention the diaphragm and voice coil structure is formed in a novel manner which facilitates the attainment of the desired accuracy of relationship between the operative elements of the transducer. To this end the diaphragm and voice coil assembly is constructed in two separately formed parts which are so formed and related that they may be readily placed in the desired accurate relationship with respect to each other. To this end the mounting portion 54a, the flexing portion 51a and the cylindrical voice coil support 49a are moulded as an integral unit which is completed by mounting of a loading portion 95 thereon in a closing relation to one end of the voice coil support 49a. The arrangement is such that the clamping portion 54a merges with a short cylindrical locating wall portion 53a which in the assembled speaker is located in a snugly surrounding relationship with respect to an annular shoulder 55a formed on the outer pole piece 21a. The wall section 53a merges with an angularly disposed portion 52a which is in turn connected to the flexing portion 51a of the diaphragm, and at its inner peripheral edge of the flexing portion 51a is joined integrally to one end of the cylindrical voice coil support 49a. Thus it will be clear that the voice coil support 49a and the locating wall 53a may be molded or otherwise formed so as to be concentric to each other, and through the formation of the shoulder 55a on the outer pole piece 21a in an accurate concentric relationship with respect to the annular magnetic gap 30a, the desired interrelationship of the operative parts of the speaker may be attained in every instance as an incident to the assembly of these parts.

In the formation of the cylindrical voice coil support 49a, the material thereof is molded to provide an annular shoulder 96 which acts as a guide for locating the voice coil on the voice coil support, and thus, since the voice coil support is molded in a predetermined relation to the flexing portion 51a and the mounting portion 54a of the diaphragm, this construction insures that the voice coil will be normally located in the desired relation to the magnetic gap 30a.

With the voice coil support 49a formed integrally with the flexing portion 51a of the diaphragm, the loading area or central section 95 of the diaphragm may be readily and easily located in the desired relation to the voice coil, and this end is preferably attained through the formation of a cylindrical wall section 97 at the other edge of the loading section 95 so that the cylindrical section 97 may be telescoped snugly within the voice coil support 49a. Uniformity of relationship may be assured by the formation of an outwardly projecting flange 98 at the end of the cylindrical wall 97, and in the assembly of the parts the loading section 95 is forced inwardly into the voice coil support 49a until the flange 98 engages the flexing portion 51a of the diaphragm, and the parts are secured in this relation by means such as adhesive.

The leads or wires from the opposite ends of the voice coil are extended along the outer surface of the voice coil support 49a toward the flexing section 61a of the diaphragm and are then extended outwardly and through the flexing section 51a adjacent to the outer edge thereof so that the leads may be connected to suitable terminal means. In the embodiment of the in-

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vention shown in Figs. 7 to 9 these terminal means are constructed and arranged for co-operation with a novel mounting and connecting device whereby the speaker 10a may be quickly and easily associated with the connecting device so as to establish the desired electrical circuit to the two ends of the voice coil. The connecting device as herein shown is in the form of a headband 11a which has the two conductors included therein. Thus the headband 11a comprises a central insulating strip 100 against one side of which a conductor strip 101 made from a material such as silver is positioned. A resilient strip 102 made from a material such as Phosphor bronze is positioned on the other face of the conductor strip 101. A second flexible strip 103 made from a material such as Phosphor bronze is disposed on the other face of the insulating strip 100 while a second conductor member 104 made from a material such as silver is disposed on the other face of the resilient strip 103. The several strips which are thus used to form the headband 11a are held together by a plurality of rivets 105 which extend therethrough and are insulated therefrom by insulating sleeves and washers 106 and 107 respectively.

The terminal means employed in this embodiment of the invention are arranged to be quickly and easily associated with the headband 11a, and to this end the terminals 110 and 111 are in the form of headed studs which extend through the end wall of the casing 13a and are riveted in position as shown in Fig. 9. The headed studs 110 and 111 are preferably tubular in form so that the leads from the voice coil may be extended therethrough and may be soldered thereto at the exposed outer ends thereof as indicated at 112a.

The terminal 110 is formed with spaced annular flanges 112 and 113 thereon, the spacing of these flanges being substantially equal to combined thickness of the resilient strip 103 and the conductor strip 104, and these two strips are formed with aligned keyhole slots 114 therein so that the flange 112 may be passed through the large end of the keyhole slot 114 and into an enlarged clearance opening 115 which is formed in the strips 100, 101 and 102. After this has been done the head band 11a may be moved endwise so as to engage that portion of the stud or terminal 110 which lies between the flanges 112 and 113 with the narrow portion of the key hole slot 114. Thus the headband is secured to the terminal 110 against separating movement away from the speaker 10a, and as an incident to the establishment of this relation, the conductor strip 104 is engaged with and electrically connected to the flange 113 of the terminal 110.

A generally similar connection may also be established between the terminal 111 and the other conductor strip 101 of the headband, and in accomplishing this result the terminal 111 is mounted on an outwardly projecting boss 116 formed on the casing section 13a. Thus the flanges 112' and 113' of the terminal 111 are disposed in different planes than the corresponding flanges on the terminal 110, and are adapted for operative association with a keyhole slot 117 formed in the resilient strip 102 and the connector strip 101. A clearance slot 118 is formed in the strips 100, 103 and 104 opposite the keyhole slot 117, this clearance slot being arranged to receive the boss 116 and the flange 113'. The spacing of the flanges 112' and 113' is such that after the flange 113' of the terminal 111 has been inserted through the large end of the keyhole slot

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117, the headband 11a may be shifted in an endwise direction to engage the narrow portion of the keyhole slot 117 with that portion of the terminal 111 which is located between the two flanges. This establishes an electrical connection between the strip 101 and the terminal 111, and in addition, the flange 112' holds the headband 11a against movement away from the speaker 10a. To hold the headband 11a against endwise movement, thereby to maintain the small ends of the keyhole slots in engagement with the terminals, a releasable latching means is provided which acts between the headband and the speaker 10a. The latching means as herein shown is afforded by a rounded boss 120 formed on the end wall of the casing section 13a intermediate the terminals 110 and 111 in position to engage a recess 121 formed in the end of one of the rivets 105. This engagement is, of course, resilient, due to the material from which the headband 11a is formed, and hence as the headband 11a is shifted longitudinally to effect the desired engagement of the keyhole slots with the terminals 110 and 111, the recess 121 snaps into engagement with the boss 120. It will be clear, therefore, that the headband is effectively connected with the terminals of the speaker in a simple and effective manner, and that as incident to this connection, the proper electrical connections are established to the voice coil. The headset is then ready for use, and if desired, a resilient guard member 45a may be associated with the output end of the speaker, this being attained through the provision of a flange 122 on the tubular member 32a in position to be engaged with a groove 123 formed in the inner periphery of the guard member 45a.

In the embodiment of the invention shown in Fig. 10, the speaker 10b is adapted to be associated with a headband 11b, and in this headband the voice current is transmitted through resilient strips made from Phosphor bronze rather than through separate conductor strips as in the other embodiment of the invention. In the speaker 10b the magnet 15b, the inner pole piece 22b, the outer pole piece 21b and the spacing ring 24b are substantially the same as hereinbefore described in connection with the other embodiments of the invention. In this embodiment of the invention, however, the central tubular member 32b is associated with the casing 12b formed from a non-magnetic material such as brass, and this is accomplished by the formation of a flange 125 on the outer end of the tubular member 32b. The opening at the smaller end of the casing 12b is arranged about a flanged shoulder 126 and the material of the flange 125 is peened over the outer face of the casing 12b to hold the casing in place on the tubular member 32b. The inner end of the tubular member 32b is flanged at 34b so as to engage the inner face of the inner pole piece 22b, while the flange 125 engages the flat face 39b of the magnet 15b. Thus the formation of flange 34b on the inner end of the tubular member 32b serves to hold the elements of the magnetic circuit in the desired assembled relation within the casing 12b. The outer end of the tubular member 32b is extended beyond the flange 125, and is flanged at 122b to hold a resilient guard member 45b in position to engage the ear of a user.

In this embodiment of the invention the casing section 12b is utilized to hold the mounting wall 13b in position on the outer pole piece 21b and the mounting wall 13b has a flange 40b which is adapted to engage the mounting portion 54b of

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the diaphragm 14b. The diaphragm 14b may be formed as disclosed in Figs. 1 to 5, or may be formed as illustrated in Figs. 8 and 9, but in this embodiment of the invention the mounting flange 54b of the diaphragm has a slot formed therein through which a relatively narrow tongue 123 formed on the flange 40b of the wall 13b may pass into a corresponding slot 129 formed in the outer pole piece 21b, thereby to hold the diaphragm 14b and the mounting wall 13b against rotative movement relative to each other and relative to the elements of the magnetic circuit. With this construction, the edge of the casing 12b may be easily flanged inwardly as at 42b to hold the mounting wall 13b securely in position in the desired clamping relation to the diaphragm 14b.

In this embodiment of the invention similar terminals 110b and 111b are provided on the mounting wall 13b, and these terminals are adapted for association with the headband 11b in substantially the same manner as in the embodiment shown in Figs. 7 to 9. In the embodiment of the invention shown in Fig. 10, however, the headband is formed from a strip of insulating material such as cellulose plastic on opposite sides of which a pair of resilient strips 102b and 103b are fixed by means such as rivets 105b. Those portions of the rivets 105b which might engage with the conductor strip 102b are insulated therefrom by means such as fibre eyelets or sleeves 106b. Thus, in this embodiment of the invention, the resilient strips 102b and 103b, which are made preferably from a material such as Phosphor bronze, are relied upon to serve as conductors, and the spacing of the flanges on terminals 110b and 111b is so arranged that the desired electrical connection is established between the conductor strips and their respective terminals when the keyhole slots 114b and 117b in the headband 11b are engaged with the respective terminals 110b and 111b. Such engagement is maintained by the resilient latching action of a recess 121b formed in one of the rivets 105b and engaged with a rounded boss 120b formed on the mounting wall 14b.

In the embodiment of the invention shown in Fig. 11, the two terminal studs 110c are of the same form as the stud 110 and are mounted with the corresponding flanges thereof in the same plane. In other words, the boss 116 is eliminated in this form of the invention, thereby to reduce the thickness of the speaker as a whole. With this arrangement the two conductors which are to be connected to the respective terminals 110c are disposed in the same plane and are provided by two semi-circular metal plates 102c and 103c having connecting arms 130 extending therefrom so that lead wires may be soldered to the arms 130. The two plates 102c and 103c are mounted on or recessed into one face of a circular plate 131 of insulating material so that the straight edges of the two plates are spaced slightly from each other, and the plates are secured in such positions by rivets 105c similar to the rivets 105. The plates 102c and 103c have keyhole slots 114c and 117c, respectively, formed therein at diametrically opposite points in such a relation that the heads of the two terminal studs 110c may be inserted through the large ends of the two keyhole slots. The small ends or extensions of the slots are extended in opposite directions and are concentrically related so that the speaker may then be rotated about its axis to engage the reduced portions of the studs 110c with the narrow portions of the slots

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114c and 117c. In such movement the heads of the studs pass into clearance openings 115c and 118c formed in the insulating plate 131, and the two studs are electrically connected to the studs 102c and 103c as in the embodiments of the invention shown in Figs. 7 to 10. This engagement of the parts is maintained by latching engagement of the recessed end of one of the rivets 105c with a boss such as the boss 120b appropriately positioned on the outer wall of the speaker. In this form of the invention the plate 131 may be mounted on a headband, or may serve merely as a connecting means for connecting the lead wires to the voice coil. In this latter instance, a molded ear-piece of conventional design is fastened on the flanged end 122 or 125 of the speaker so that the ear-piece may be inserted into the passages of an ear of the user to act as a support for the speaker.

From the foregoing description it will be apparent that the present invention enables transducers of the dynamic type to be produced in such a manner as to insure fidelity of performance and accuracy of response over a wide range of frequencies. The relationship of the parts is such that transducers may be produced over a wide range of sizes, including exceedingly small sizes, and in all instances the mere assembly of the component parts of the transducer results in the desired accuracy of relationship of these parts, and hence the desired excellence of performance is invariably attained. Where the present invention is embodied in a speaker it will be evident that the particular arrangement of the elements of the magnetic circuit is such that all space within the speaker casing is efficiently utilized, and as a result exceptionally good performance characteristics may be embodied in a relatively small speaker. The novel form of permanent magnet which is provided by the present invention contributes in a great measure to the simplicity and efficiency of the transducer, whether such transducer be embodied as a speaker or as a microphone, and moreover, this novel form of permanent magnet enables the other elements of the magnetic circuit to be accurately related to the magnet and to each other in such a manner as to produce accuracy of size and form in the magnetic gap.

It will also be evident that the present invention, through the provision of a novel diaphragm, has simplified the manner of assembly of dynamic transducers, and this simplification is attained in such a way that the elements of the transducer when assembled are invariably located in the desired relationship to each other. Moreover, the formation of the voice coil support integrally with the mounting flange of the diaphragm contributes in a substantial degree to the attainment of the desired location of the voice coil with relation to the magnetic gap, and through the formation of a guiding shoulder on the voice coil support, the manufacture of this portion of the transducer is materially simplified. The present invention also enables speakers to be embodied as parts of a headset in an exceptionally simple manner such that the desired electrical connections are established as an incident to the mounting of the speakers upon the headband.

Hence, while I have illustrated and described preferred embodiments of my invention, it is to be understood that these are capable of variation and modification and I therefore do not wish to be limited to the precise details set forth, but

desire to avail myself of such changes and alterations as fall within the purview of the following claims:

I claim:

1. In a speaker adapted for use in a headset, means forming a magnetic circuit including inner and outer annular pole pieces concentrically located and spaced to provide an annular magnetic gap therebetween, a diaphragm mounted on said outer pole piece and having a voice coil structure carried thereon and extending into said annular magnetic gap, said diaphragm being spaced from one face of said inner pole piece to define a sound chamber, means defining a back chamber on the side of said diaphragm opposite from said sound chamber, a permanent magnet forming part of said magnetic circuit and comprising a centrally bored hub having one end engaging said inner pole piece and having an annular skirt extending outwardly from the other end of the hub and then in an endwise direction in spaced relation to said hub and into contact with said outer pole piece, and a tubular fastening member extending through the bore of said hub and operatively engaged with said magnet and said inner pole piece to hold the same together, said tubular fastening member opening into said sound chamber to afford a passage through which sound may travel from said sound chamber.

2. In a diaphragm for use in a transducer or the like, a sheet of flexible yet relatively stiff material formed to provide an outer annular mounting portion and an integral flexing portion extending inwardly therefrom, said sheet of material also being formed to provide a central load-

ing portion offset from said flexing portion and having a relatively short cylindrical wall portion joining said loading portion and said flexing portion, and said mounting portion and said flexing portion being joined by an integral and relatively short cylindrical wall section located concentrically with respect to the cylindrical wall section which joins said flexing portion and said loading portion.

WEBSTER E. GILMAN.

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