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TWO-PIECE LOUDSPEAKER

Filed Aug. 3, 1964

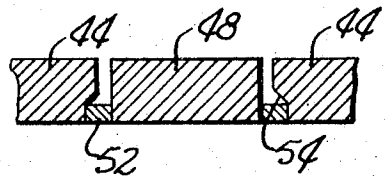
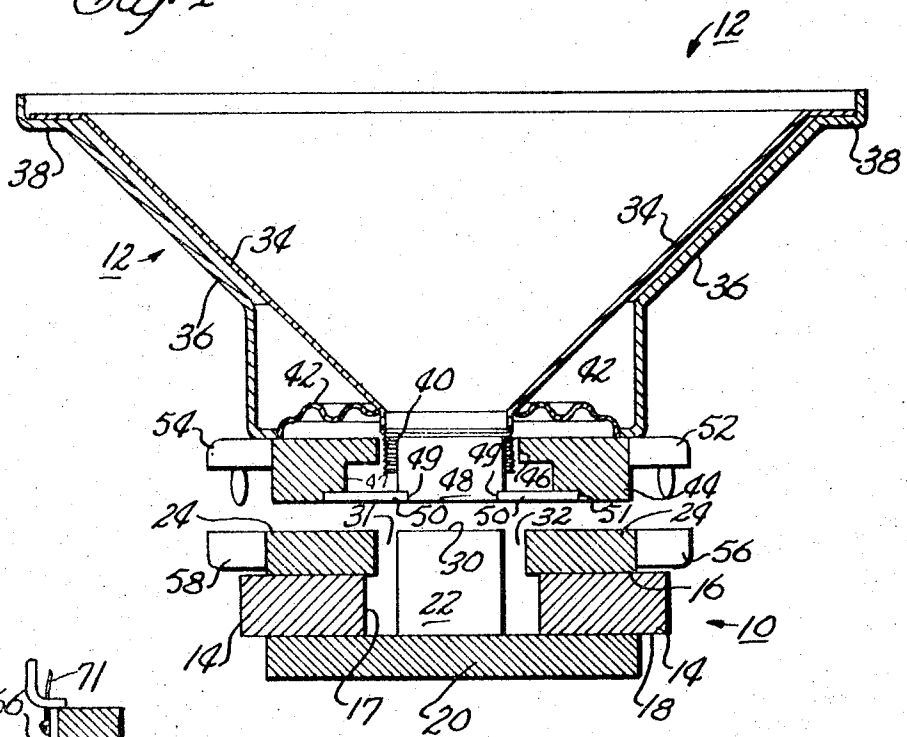


Fig. 2

Fig. 1



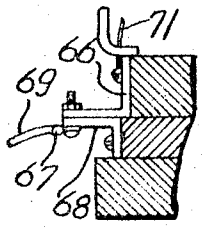


Fig. 6

Fig. 3

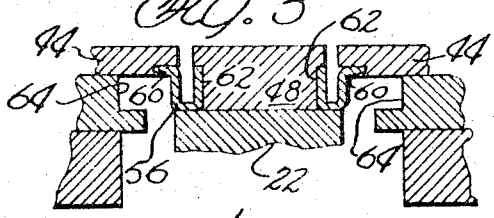


Fig. 4

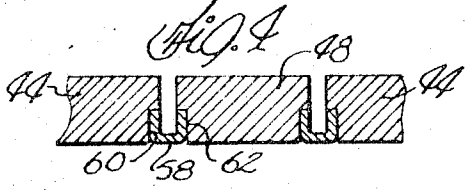
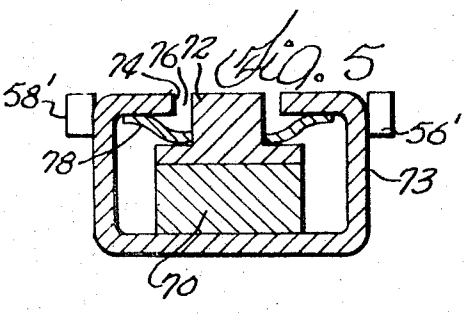


Fig. 5



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TWO-PIECE LOUDSPEAKER

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ABSTRACT OF THE DISCLOSURE

This disclosure concerns a loudspeaker composed of two readily separable sections, one of which incorporates a bracket supporting the cone of the loudspeaker, and the other incorporating a permanent magnet. The voice coil of the cone is disposed in an air gap formed between two ferromagnetic members rigidly mounted on the bracket of the cone section, and air gap and voice coil are enclosed by a nonferromagnetic shield. A complete magnetic flux path including the voice coil and the permanent magnet is formed when the two sections are juxtaposed, the magnet section being provided with ferromagnetic members for this purpose, which contact the ferromagnetic members of the cone section when the loudspeaker is assembled. The design of the magnet section is such as to provide for a minimum flux level for the permanent magnet when the sections are separated, and to lessen the effect of misalignment of the sections on the flux density at the voice coil when the sections are assembled.

This invention relates to loudspeakers, and more particularly to such speakers which are adaptable to being readily disassembled into two separate units.

In the prior art, numerous attempts have been made to design and construct loudspeakers by which the section including the speaker cone and its supporting structure might be removed from the section including the magnet to permit repair of damaged cones, cleaning of the air gap in which the voice coil is disposed, or the like. These attempts have generally resulted in a construction in which one of the sections of the speaker is a speaker cone assembly, having an outwardly projecting voice coil. This approach has proven impractical, however, because in the assembled speaker the voice coil must be in very close concentricity within the air gap in the magnet assembly to minimize any resistance to motion of the voice coil, which would cause distortion. But even slight variations in the sizes or relative positions of the two sections of the speaker assembly, even within manufacturing tolerances, might result in eccentricity. Moreover, the speaker cone, being inherently resilient and yieldable, makes it difficult to manufacture such a cone section with the voice coil always in exactly the same position relative to the other parts of the cone section. These problems do not present any great difficulties when the speaker cone itself is not cemented in place on its bracket until after the bracket is attached to the magnet assembly, as is common in the manufacture of unitary loudspeakers, for slight variations may be equalized on an individual basis by the way in which the cone itself is cemented on the bracket. Where the cone is attached on the bracket prior to assembly, however, the difficulties are vastly greater. In addition, the voice coil itself is very delicate and easily bent out of shape, and great care must be exercised in order to avoid damaging the voice coil while inserting it into the circular air gap of the magnet assembly. Even a light tap on the voice coil may result in its being sufficiently deformed as to encounter substantial resistance to motion within the air gap. These difficulties render impractical speaker constructions which employ the features inherent in prior art two-piece speakers.

Another disadvantage arising from prior art speaker constructions is that the relative positions of the voice coil, and the air gap of the magnet assembly are determined by the screws, bolts, or the like which hold the two sections of the speaker together. Such mechanisms may through wear, vibration or the like eventually loosen their hold between the two pieces of the speaker and permit the same to shift into misaligned positions with respect to each other. This situation becomes even more critical when the preferred size of the air gap is employed, in which there is only about .006" to .007" clearance between the voice coil and the side walls of the air gap. Larger air gaps may minimize these problems, but may not provide the necessary magnetic field strength to provide high fidelity sound reproduction.

Still another disadvantage of prior loudspeakers is that when the parts of the magnet assembly are disassembled, and particularly when parts forming the air gap for the voice coil are disassembled, the magnet assembly becomes substantially demagnetized and must be remagnetized before it can again function effectively as part of a loudspeaker. In the present invention, this disadvantage has been overcome by a construction which permits the complete disassociation of the air gap forming parts from the magnet assembly when the two sections of the speaker assembly are separated, and then reassembled with virtually no loss of magnetization.

Accordingly, it is an object of the present invention to provide a two-piece speaker construction having a cone section and a magnet section, and which overcomes the disadvantages known to such constructions in the prior art.

Another object of the present invention is to provide a speaker construction in which the relative positions of the air gap of the magnet assembly and the voice coil are fixed in one of the two sections of the complete speaker assembly.

A further object of the present invention is to provide a two-piece speaker in which relatively large variations in the relative positions of the cone section and the magnet section do not affect the performance of the speaker.

Another object of the present invention is to provide a two-piece speaker construction in which the cone section is held together with the magnet section primarily by magnetic force.

A further object of the present invention is to provide a two-piece speaker assembly in which the voice coil of the cone section is protected from dust, damage, and the like, prior to assembly with the magnet section.

Another object of the present invention is to provide a two-piece speaker having means to prevent demagnetization when the two sections are separated.

These and other objects and advantages of the present invention will become manifest upon an examination of this specification and the accompanying claims and drawing.

In accordance with one embodiment of the present invention, there is provided a two-piece speaker adapted to be assembled from a cone section and a magnet section. Minor variations in the relative positions of the two sections do not affect the operation of the speaker, and the voice coil and the air gap therefor is entirely contained in the cone section. The voice coil is shielded from exposure to damaging forces, and also from dirt and other foreign matter prior to assembly of the two sections. Upon assembly of the two sections, they are held together in operable association primarily by magnetic force. Upon disassembly and reassembly, the magnet assembly returns substantially to the original flux level without the need for remagnetization.

The principal advantages of this construction are that ready assembly, disassembly and replacement of cone

sections without tedious alignment and remagnetization are made possible, and thus loudspeakers may easily be modified in their response characteristics by substituting another cone section. In addition, damaged cone sections may be easily and quickly replaced, and the undamaged magnet sections need not be discarded when a cone becomes unserviceable.

Reference will now be made to the accompanying drawings, in which:

FIG. 1 is a partially exploded side elevational view, partly in cross-section, of a two-piece speaker constructed in accordance with the present invention;

FIG. 2 is a cross-sectional view of a portion of another embodiment of the present invention;

FIG. 3 is a cross-sectional view of a portion of an alternative embodiment of the present invention;

FIG. 4 is a cross-sectional view of a portion of a further embodiment of the present invention;

FIG. 5 is a cross-sectional view of an alternative magnet section which may be used with the cone section of the present invention; and

FIG. 6 is a side elevational view, partly in cross section, of a portion of the apparatus of FIG. 1 with an alternative connector assembly.

In FIG. 1, there is illustrated a speaker arrangement having two sections adapted to be connected together, which two sections comprise a magnet section **10** and a cone section **12**. The magnet section is provided with a disc ceramic magnet **14** which is toroidal in shape, having a central aperture **17** and relatively flat upper and lower surfaces **16** and **18**. The magnet **14** is polarized in a direction normal to the surfaces **16** and **18**, so that one surface forms a north pole and the other a south pole.

A ferromagnetic bottom plate **20** extends over the entire bottom surface **18** and closes the aperture **17**. The plate **20** serves to form a magnetic circuit between the bottom of the magnet **14** and a ferromagnetic central pole piece **22**, which is in contact with the plate **20**. An upper plate **24** is in contact with the upper surface **16** of the magnet **14**. The upper plate **24** forms a part of the magnetic circuit of the speaker, and is formed of ferromagnetic material to minimize the reluctance of the magnetic circuit. The upper plate **24** has a centrally disposed circular aperture **32** through which the upper portion of the central pole piece **22** extends, such as to form a circular air gap **31** between the periphery of the upper end of the pole piece **22** and the inside surface of the aperture **32**. The function and operation of the air gap **31** will be more fully described hereinafter.

The cone assembly **12** comprises a base plate **44** and a bracket **36**, secured to the base plate **44**, having a flange **38** at its terminal end, to which bracket the edge of a cone **34** is secured by cementing or the like. To the inner end of the cone **34** there is attached a voice coil **40**, and the inner end of the cone **34** is yieldingly held in place by a resilient spider **42** mounted on the base plate **44** and attached to the inner end of the cone **34**. The bracket **36** and base plate **44** form a relatively rigid structure, the cone **34** and voice coil **40** being movable with respect thereto. The base plate **44** has, in the central portion thereof, a circular aperture **46**, into which the voice coil **40** extends. The diameter of the aperture **46** is very slightly greater than the diameter of the voice coil **40**, and the difference between them has been exaggerated in the drawing. A circular recess **47** is disposed in the lower side of the base plate **44**, as illustrated in FIG. 1, in coaxial relation with the aperture **46**, and a second wider diameter circular recess **51** is disposed in the same side in coaxial relation with the aperture **46** and the recess **47**. A washer **50** of aluminum or another paramagnetic material having a low permeability is connected to the base plate **44** within the recess **51** by any suitable means such as adhesive, machine screws, or the like, and supports a ferromagnetic core member **48** having a circular cylindrical shape. The core **48** has a peripheral recess **49** to which the sheet **50** is secured by adhesive or the like, and is adapted to be disposed concentrically within the aperture **46** to form the circular air gap in which the voice coil **40** operates. The diameter of the core **48** is such that when it is concentrically disposed in relation to the aperture **46** in the base plate **44**, an air gap of the required dimension is formed, in which the voice coil **40** is disposed.

When the two sections of the speaker assembly are assembled, the paramagnetic sheet **50** rests on the flat upper surface of the upper plate **24** and the core **48** rests on the upper surface **30** of the central pole piece **22**, the periphery of the base plate **44** rests directly upon the upper surface of the upper plate **24**, and the core **48** is disposed inside the voice coil **40**. There is thus formed a complete magnetic path which includes the magnet **14** and the air gap between the aperture **46** and the core **48**. This path also includes two junctions between the core and magnet sections of the loudspeaker, viz., at the upper surface **30** of the central pole piece **22**, and at the upper surface of the housing **24**. In each of these junctions, the surfaces on both sides are plane and flat so that there is very little increased reluctance in the path due to these junctions.

When the two sections **10** and **12** of the speaker are assembled together, a force exists across the two junctions of the magnetic circuit, due to the magnetic flux flowing therethrough, which holds the ferromagnetic members on opposite side of the junction together. Thus the base plate **44** is forced together with the housing **24**, and this force holds the two speaker sections in assembled relation. The core **48** is also held in position by the force across its junction with the central pole piece **22**. In a speaker having a relatively small cone and bracket assembly, no additional force is required to maintain the sections in assembled relation.

A pair of plug connectors **52** and **54** are attached to the side of the base plate **44** and are adapted to cooperate with receptacle connectors **56** and **58**, attached to the outer surface of the upper plate **24**. The plugs of the plug connectors **52** and **54** are connected to the voice coil **40**, and the contacts of the connectors **56** and **58** are connected to a source of audio signal. By way of these connectors, the electrical connection to the voice coil **40** may be made and/or broken simultaneously with the assembly or disassembly of the cone section **12** with the magnet section **10**.

The plugs **52** and **54** and associated receptacles **56** and **58** are illustrated as being of the familiar banana plug or pin type, which generate a force tending to resist disconnection. This force is added to the magnetic force tending to hold the two sections together, and by properly designing the connectors, the mechanical component of the composite mechanical and magnetic force may be made as large as required. With the high flux densities which are desirable in loudspeakers, however, the magnetic component alone is ordinarily sufficient to hold the sections in assembled relation, and the connectors may thus be designed merely for their electrical function.

For very large speaker sizes, however, or for speakers likely to be subject to great forces and accelerations, it may be desirable to increase the mechanical component of the force or to secure the several parts of the speaker together with machine screws, nuts and bolts, or the like. Suitable flanges (not shown) may be provided on the upper plate **24** and the base plate **44** for this purpose, or angle brackets **66** and **68** (FIG. 6) employed. A lug **67** may be employed to connect a wire **69** to the brackets. A wire **71**, leading to the voice coil, is permanently connected to the bracket **68**.

In the speaker illustrated in FIG. 1, only the connectors **52**, **54**, **56** and **58** affect the positioning of the cone section relative to the magnet section. Manufacturing tolerances in the production of such connectors, and their placement on the cone and magnet sections, may well

give rise to differences in the relative positions of the cone and magnet sections for different speakers. This does not at all affect the operation of the speaker, however, since the air gap and voice coil **40** are fixed, and not subject to errors in misaligning the speaker sections during assembly. As illustrated in the figure, the upper surface of the upper plate **24** is larger in diameter than the lower surface of the base plate **44**, and the diameter of the upper surface **30** of the central pole piece **22** is larger than the diameter of the lower surface of the core **48**. Thus, the entire area of the lower surface of the base plate **44** is directly opposite the upper surface of the housing **24**, and this is true of for a wide variety of relative positions of the speaker sections. Similarly, the area of the junction between the central pole piece **22** and the core **48** also does not change for the same variety of relative positions. Thus, the reluctance of the magnetic path does not change even if the relative positions are changed slightly, and the same flux density therefore exists across the air gap. Thus, the coarse alignment supplied by the connection of the connectors for the voice coil is the only alignment required on assembly.

The paramagnetic sheet **50**, in addition to supporting the core **48**, also operates to shield the voice coil **40** from dirt, and from damage due to something accidentally colliding with the delicate and fragile voice coil. This is an important feature, since the presence of grit or dust within the air gap tends to create friction, resisting the movement of the coil through the gap, and giving rise to distortion in sound reproduction. The sheet **50** is illustrated in FIG. 1 as being a plane shape in the form of a washer, which may be secured to the base plate **44** and the core **48** either by a force fit or by adhesive or the like. As the voice coil **40** is preferably longer than the length of the air gap, the recess **47**, which defines the lower limit of the air gap in which the voice coil **40** is disposed, permits the end of the voice coil to project beyond the end of the air gap without striking the sheet **50**. If the voice coil **40** were limited in its motion by the sheet **50**, the resulting sound reproduction would be severely distorted.

Other embodiments of the invention which use different forms of the sheet **50** are illustrated in FIGS. 2 to 4. In FIG. 2, a ring **52** is employed, disposed in a recess **54** in the base plate **44**. This embodiment is similar to that of FIG. 1, except for the cross-section of the ring **52**. The upper end of the recess **54** is also tapered in cross-section, as shown, instead of being co-planar.

In FIGS. 3 and 4, the sheets **56** and **58** are swaged or otherwise deformed to present the illustrated cross sections. In each of these embodiments, recesses **60** and **62** are provided in the base plate **44** and the core **48**, respectively, and the upper end of these recesses are co-planar, to define the lower edge of the voice coil air gap. Immediately below the air gap, the spacing between the core **48** and the base plate **44** increases markedly, to render the flux pattern across the air gap more symmetrical. In FIG. 3, the core **48** extends below the lower surface of the base plate **44**, while in FIG. 4 they are co-planar.

Referring again to FIG. 1, the aperture **32** formed in the upper plate **24** surrounds the upper part of the central pole piece **22**, and forms an air gap **31** therewith. The function of the air gap **31** is to provide a maximum reluctance for the magnetic circuit when the two sections of the speaker are separated. This establishes a minimum flux density in the magnetic circuit and prevents the magnet from demagnetizing by lowering the flux density to a low value. If the air gap **31** were omitted from the magnet assembly, the flux density might drop as much as 20% to 25% upon disassembly and reassembly of the speaker, even though a relatively high coercivity magnet **14** is employed. To prevent this phenomenon, the air gap **31** is made somewhat wider than the air gap in which the voice coil **40** is disposed, to allow from 5% to 15% of the total flux in the assembled magnetic circuit to pass through the air gap **31**, irrespective of the assembly of the cone and magnet sections. Althtough this reduces the maximum attainable flux density for a given magnet, it does provide a greater flux density after disassembly and reassembly of the speaker, and the value of the flux density remains substantially constant, irrespective of how many times the speaker may be disassembled. The magnet **14** is preferably a high coercivity ceramic magnet, and the presence of the air gap **31** permits the realization of a constant flux density which is greater than 85% of the flux density which might initially be obtained without the air gap **31**. In the embodiment of FIG. 3, a recess **64**, is provided in the upper surface of the upper plate **24**, so that the amount of the leakage flux is substantially independent of whether the two sections of the speaker are assembled or not.

Some of the practical advantages of the present invention may be appreciated in the construction of entertainment systems such as radios, T.V.'s, and the like, where, by the use of the present invention, any possible damage to the cone of the loudspeaker is obviated by supplying such systems only with a magnet section **10** during one of the first stages of a production line, and inserting the cone section **12** only as one of the final steps of the production of the system. In this manner, damaged speaker cones, which have heretofore required the replacement of the entire loudspeaker, are eliminated, up until the last stages of the production line, thereby effecting a savings in manufacturing costs.

Moreover, the present invention may be effectively used by experimenters, hobbyists, or the like, who desire to change the response of their loudspeakers, or to alternately employ cones having differing frequency characteristics with the same magnet section. This is feasible, since the cost of the cone assembly **12** is a minor portion of the cost of an entire loudspeaker.

In addition, in applications which are hazardous for speakers, such as drive-in movie theaters, for example, damaged cones could be repaired by replacing the cone section rather than by replacing the entire speaker. It is contemplated that the cone section of speakers embodying the present invention could be made sufficiently inexpensive as to make disposable cone sections feasible.

In FIG. 5, an alternative magnet assembly is illustrated, in which a cylindrical Alnico magnet **70** is employed. A central circular pole piece **72** is juxtaposed with the top of the magnet **70**, and a housing or shell **73**, having its central portion juxtaposed with the bottom of the magnet **70**, surrounds the magnet and a circular aperture **74** therein is concentric with the central pole piece **72**, forming a circular air gap **76**. A brass ring **78** having a central aperture tightly fitting around the upper portion of the central pole piece **72** maintains the concentricity of the aperture **74** and the central pole piece **72**. Receptacle connectors **56'** and **58'** are mounted on the sides of the housing **73** to cooperate with the plug connectors **52** and **54** (FIG. 1).

In the magnet assemblies of both FIG. 1 and FIG. 5, the interior of the magnet assembly may be filled with a low permeability sealant such as thermoplastic or thermosetting compounds.

The foregoing has described the present invention in sufficiently full and complete terms to enable others skilled in the art to make and use the same and, by applying current knowledge, to adapt the same for use under a variety of conditions of service, without departing from the essential features of novelty involved, which are intended to be defined and secured by the appending claims.

What is claimed is:

1. A two-piece loudspeaker comprising a readily separable cone section and a magnet section; said cone section comprising a bracket supporting a pair of spaced ferromagnetic members forming an air gap, a cone, a voice coil mounted on said cone and extending into said air gap, and a nonferromagnetic closure enclosing said air gap and voice coil on the side thereof remote from

said cone; said magnet section comprising magnet means and first and second ferromagnetic members connecting the poles of said magnet means in a magnetic circuit with said air gap.

2. Apparatus according to claim 1, wherein said pair of spaced ferromagnetic members are coaxial and form a circular air gap, and low permeability means connecting said pair of ferromagnetic members in fixed relationship to each other.

3. Apparatus according to claim 1, wherein said first and second ferromagnetic members are joined directly with said pair of spaced ferromagnetic members to provide a series magnetic circuit including said magnet means, said first and second ferromagnetic members, and said pair of spaced ferromagnetic members.

4. A two-piece loudspeaker comprising a cone section and a magnet section; said cone section comprising ferromagnetic means, a cone, and a voice coil mounted on said cone; said magnet section comprising magnet means and first and second ferromagnetic members connected to the poles of said magnet means; said ferromagnetic members being joined with said ferromagnetic means to form a series magnetic circuit when said sections are assembled together, whereby said sections are held together by magnetic force existing across the junctions of said magnetic circuit.

5. Apparatus according to claim 4, wherein said ferromagnetic means comprises a pair of spaced ferromagnetic members forming an air gap and held in fixed relationship to each other.

6. A two-piece loudspeaker comprising readily separable cone and magnet sections; said cone section comprising a cone and a voice coil mounted on said cone; said magnet section comprising magnet means and first and second ferromagnetic members connected to the poles of said magnet means, said ferromagnetic members forming a series magnetic circuit including a portion at least partially passing through said voice coil when said sections are assembled together, and air gap means connected between said first and second ferromagnetic members to form a leakage flux path other than through the voice coil to establish a minimum value of flux passing through said magnet means when said sections are disassembled.

7. Apparatus according to claim 6, wherein said cone section includes a pair of spaced ferromagnetic members forming an air gap, said pair of members forming part of said series magnetic circuit.

8. A two-piece loudspeaker comprising a cone section and a magnet section; said cone section comprising a bracket, including a ferromagnetic member, a cone mounted on said bracket, a voice coil connected to said cone, and shield means connected to said bracket for enclosing said voice coil, said shield means being connected to said bracket on the side thereof remote from said cone; said magnet section comprising magnet means and a ferromagnetic member connected to a pole of said magnet means and adapted to be directly magnetically connected to said ferromagnetic member.

9. Apparatus according to claim 8, including an electrical connector secured to said bracket and a mating electrical connector secured to said ferromagnetic member.

10. Apparatus according to claim 6, wherein said magnet means comprises a high coercivity ceramic permanent magnet.

11. For use in a two-piece loudspeaker comprising

cone and magnet sections, a magnet section comprising magnet means, and first and second ferromagnetic members connected to the poles of said magnet means, said first member having a projection thereon directed toward said second member to establish a quantity of leakage flux between said first and second members, including an electrical connector secured to one of said members.

12. For use in a two-piece loudspeaker comprising cone and magnet sections, a cone section having a ferromagnetic base plate with an aperture therein, a bracket mounted on said base plate, a cone mounted on said bracket, and a voice coil mounted on said cone and projecting into said bracket, including shield means connected to the side of said base plate remote from said cone and covering said aperture.

13. For use in a two-piece loudspeaker comprising cone and magnet sections, a cone section having a ferromagnetic base plate with an aperture therein, a bracket mounted on said base plate, a cone mounted on said bracket, and a voice coil mounted on said cone and projecting into said bracket, including core means disposed concentrically within said voice coil and means having a low magnetic permeability for connecting said core means to said base plate.

14. For use in a two-piece loudspeaker comprising cone and magnet sections, a cone section having a ferromagnetic base plate with an aperture therein, a bracket mounted on said base plate, a cone mounted on said bracket, and a voice coil mounted on said cone and projecting into said bracket, including an electrical connector secured to said base plate.

15. A two-piece loudspeaker comprising a cone section and a magnet section, said cone section comprising a circular base plate having a circular central aperture therein, a cone mounted on said base plate and a voice coil mounted on said cone and disposed within said central aperture, and a circular ferromagnetic core member within said voice coil coaxial with said aperture; said magnet section comprising magnet means and inner and outer coaxial ferromagnetic bodies of revolution connected to said opposite poles of said magnet means and aligned with said base plate and said core, the outer diameter of said outer member being greater than the diameter of said base plate, the inner diameter of said outer member being less than the diameter of said aperture, and the diameter of said inner member being greater than the diameter of said core, said sections being connected together by juxtaposing said inner and outer members with said core and said base plate, respectively, along a surface normal to the axis of said coaxial members, whereby said sections to be moved relative to each other parallel with said surface without affecting the areas of contact between said coaxial members and said core and base plate.

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