Nov. 21, 1939. O. I. PRICE 2,180,482

SOUND REPRODUCER AND METHOD OF MANUFACTURING THE SAME

Filed Nov. 12, 1937 4 Sheets-Sheet 1

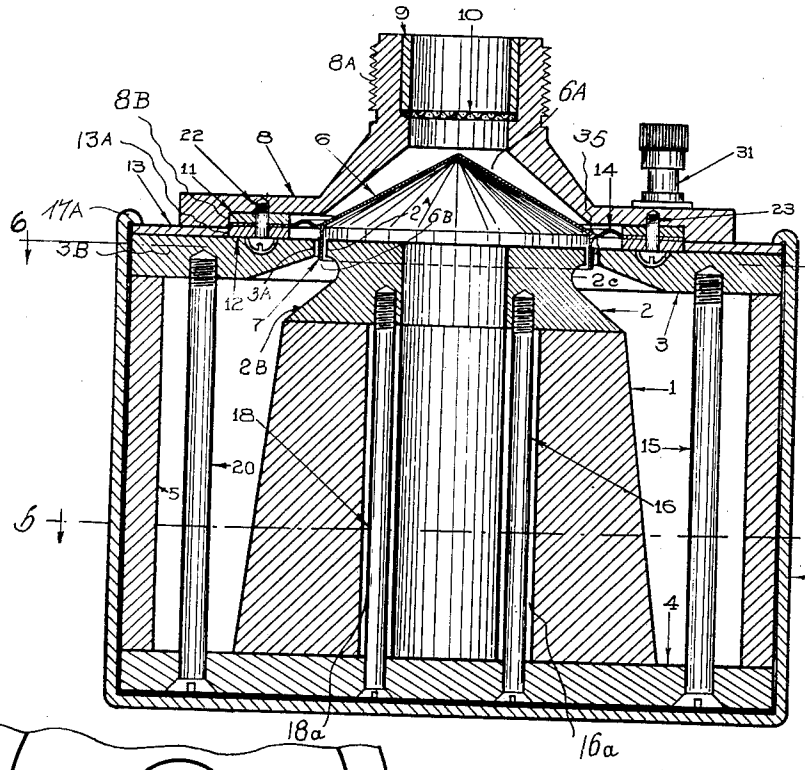


Fig. 1

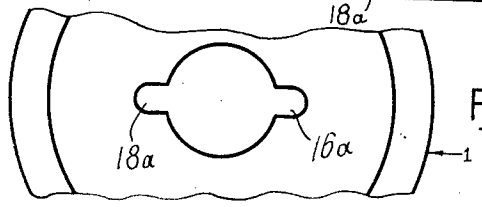


Fig. 2

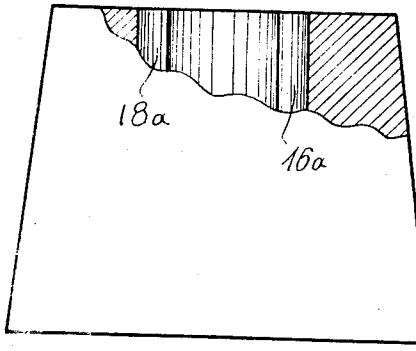


Fig. 3

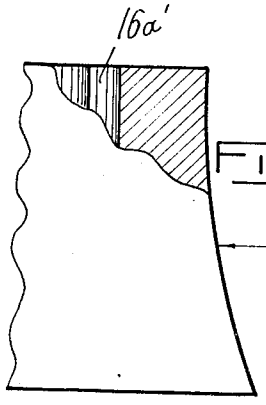


Fig. 4

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SOUND REPRODUCER AND METHOD OF MANUFACTURING THE SAME

Filed Nov. 12, 1937 4 Sheets-Sheet 2

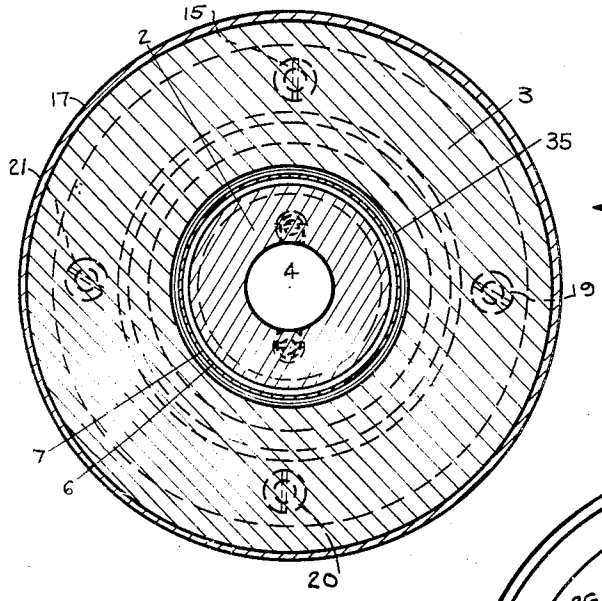


FIG. 6

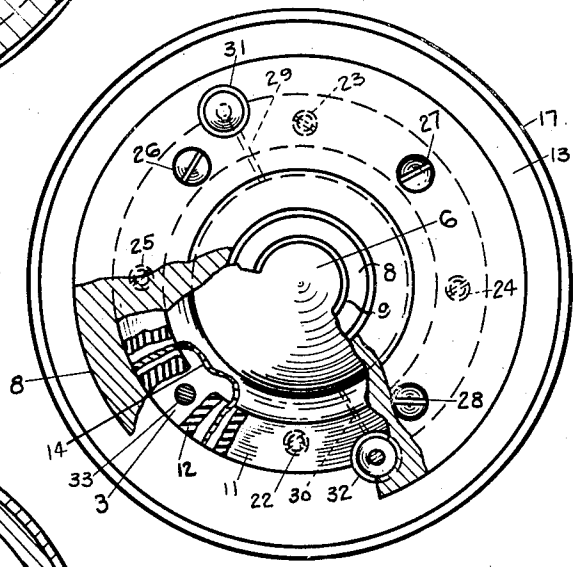


FIG. 7

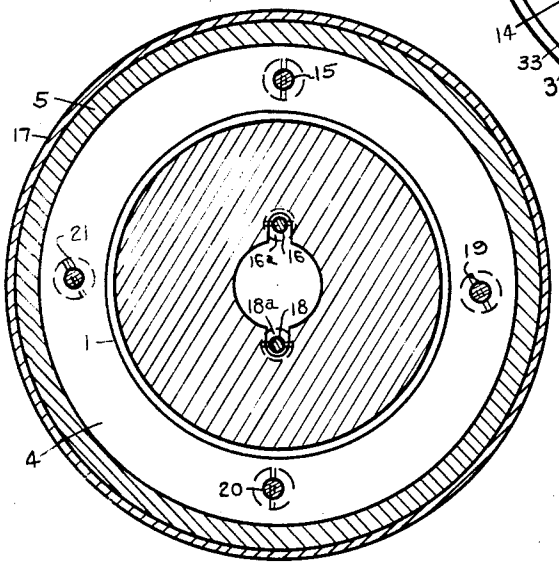


FIG. 5

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SOUND REPRODUCER AND METHOD OF MANUFACTURING THE SAME

Filed Nov. 12, 1937 4 Sheets-Sheet 3

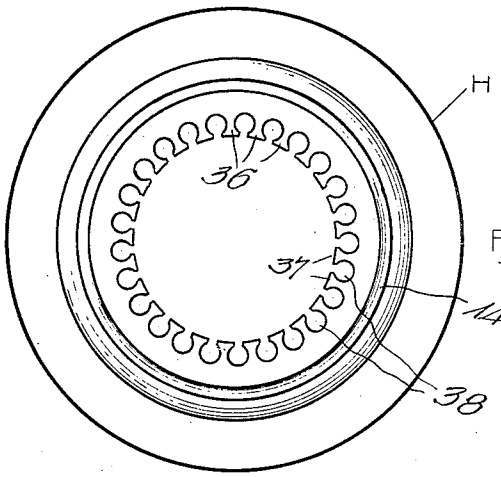


Fig. 8

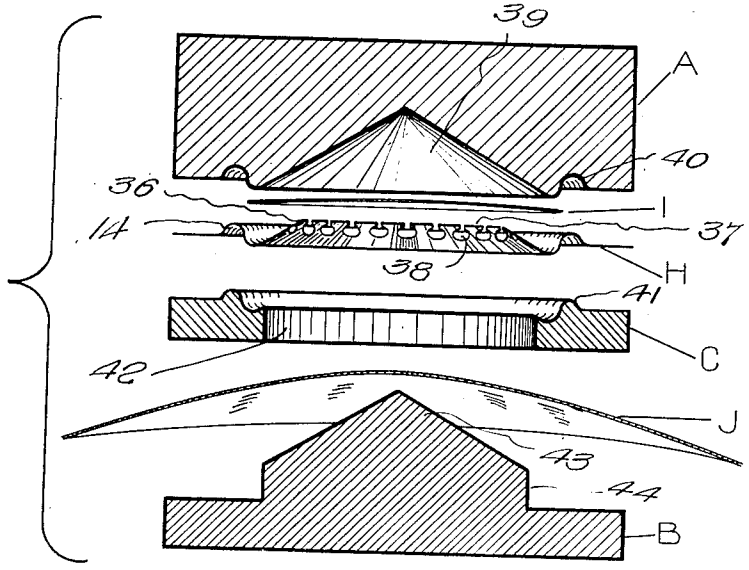


Fig. 9

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SOUND REPRODUCER AND METHOD OF MANUFACTURING THE SAME

Filed Nov. 12, 1937 4 Sheets-Sheet 4

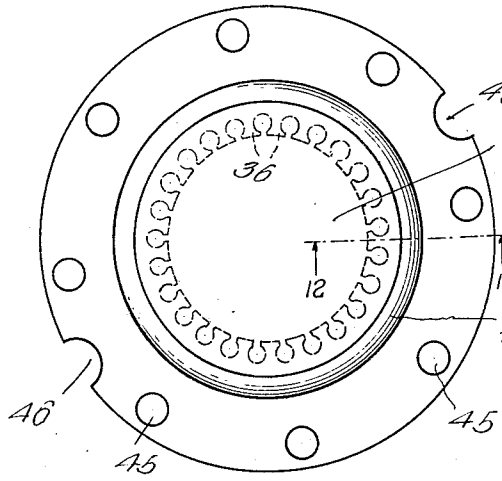


Fig. 10

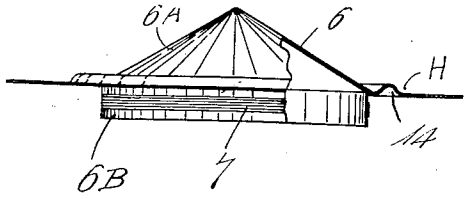


Fig. 11

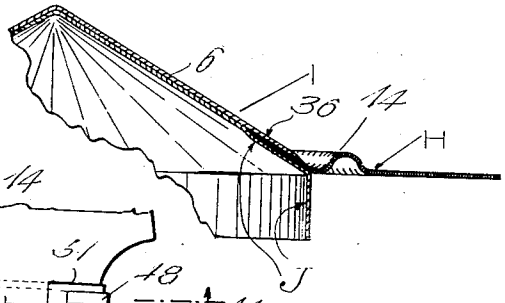
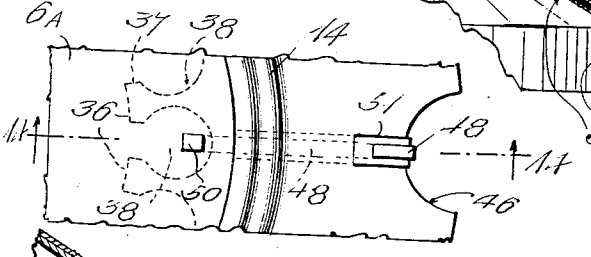


Fig. 12

Fig. 13



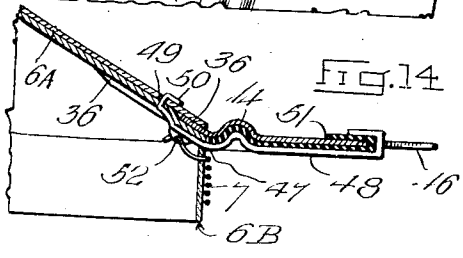


Fig. 14

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Patented Nov. 21, 1939

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UNITED STATES PATENT OFFICE

2,180,482

SOUND REPRODUCER AND METHOD OF MANUFACTURING THE SAME

Osborne I. Price, Frederick, Md.

Application November 12, 1937, Serial No. 174,241

6 Claims. (Cl. 179—115.5)

My invention relates broadly to electrical sound reproducers and more particularly to an improved method of manufacturing an electrical sound reproducer and novel construction of electrical sound reproducer.

One of the objects of my invention is to provide a construction of electrical sound reproducer of the magnetic type having a permanent magnetic field of extremely high flux density.

Another object of my invention is to provide a method of producing a permanent magnet type of electrical sound reproducer wherein a permanent magnetic field of extremely high flux density is maintained continuously across an annular magnetic gap in which a winding carried by a sound reproducing diaphragm is traversed by varying currents and wherein the high flux density is confined to the magnetic path of the sound reproducer per se and substantially shielded against external leakage.

A further object of my invention is to provide a construction of electrical sound reproducer embodying a permanent magnet of toroidal shape terminating in an annular head and coacting with a surrounding magnetic plate providing an annular gap in which a winding carried by a sound reproducing diaphragm and traversed by varying currents is arranged to operate.

A still further object of my invention is to provide a construction of sound reproducer whose characteristics remain substantially constant independently of wide variations in conditions of temperature and humidity while reproducing sound over a wide frequency response characteristic.

Another object of my invention is to provide a method of manufacturing a diaphragm of a sound reproducer from fabric having an integrally connected support for an electromagnetic winding and a flexible metallic rim arranged for supporting the diaphragm.

Still another object of my invention is to provide a method of manufacturing a sound reproducing diaphragm from impregnated cloth under extremely high pressures for producing a sound reproducing portion and a supporting portion operative substantially independently of wide changes in conditions of temperature and humidity.

Other and further objects of my invention reside in the method of manufacturing a sound reproducing diaphragm and in the structure of the diaphragm and parts of an electrical sound reproducer as set forth more fully in the specification hereinafter following by reference to the accompanying drawings in which:

Figure 1 is a vertical sectional view through an electrical sound reproducer embodying my invention; Fig. 2 is a fragmentary plan view of the permanent magnet employed in the electrical sound reproducer of my invention; Fig. 3 is a side elevation partially broken away and shown in cross section of the permanent magnet employed in the electrical sound reproducer of my invention; Fig. 4 is a fragmentary view of a modified form of permanent magnet which may be employed in the sound reproducer of my invention, the view being partially broken away and shown in cross section; Fig. 5 is a transverse sectional view through the electrical sound reproducer taken on line 5—5 of Fig. 1; Fig. 6 is a transverse sectional view through the electrical sound reproducer taken on line 6—6 of Fig. 1; Fig. 7 is a top plan view of the electrical sound reproducer with parts broken away and illustrated in cross section; Fig. 8 is a top plan view of the annular metallic rim and support for the fabric portions of the sound reproducing diaphragm; Fig. 9 is a view showing the method of manufacturing the sound reproducing diaphragm and illustrating the arrangement of forming dies aligned for the manufacture of the diaphragm under extremely high pressures; Fig. 10 is a plan view of the completed sound reproducing diaphragm; Fig. 11 is a side elevation of the sound reproducing diaphragm, partially broken away to illustrate the connection of the coil support with the sound reproducing diaphragm and the rim portion thereof; Fig. 12 is an enlarged sectional view showing the manner in which the supporting rim portion is united with the sound reproducing fabric portions of the diaphragm; and Figs. 13 and 14 are fragmentary plan and sectional views showing the manner of establishing connection between the end of the winding carried by the coil supporting portion of the diaphragm and an external circuit connection for the electrical sound reproducer.

My invention is directed to an electrical sound reproducer capable of functioning under conditions encountered in marine and aircraft operation where the electrical sound reproducer is subjected to wide changes in temperature, barometric pressure and humidity conditions. I have successfully operated the electrical sound reproducer of my invention on shipboard and in aircraft. I have devised a magnetic structure of electrical sound reproducer of my invention with a view of obtaining a permanent magnetic field

of extremely high flux density. I provide a toroidal shaped permanent magnet formed from an alloy of aluminum, nickel and cobalt. The toroidal shaped permanent magnet is magnetized under conditions of high charging current and provides a flux density in the sound reproducer in a range of 10,800 gausses or higher. I dispose the toroidal shaped permanent magnet in a path of soft steel which includes an annular gap within which the winding, supported by the sound reproducing diaphragm and carrying current variations is disposed. I surround the magnetic system with a shield which is so complete that there is substantially negligible magnetic leakage from the magnetic structure. Moreover, the shield is so constructed that the magnetic parts and the diaphragm are substantially protected against dampness, salt water, acid fumes, high pressures and vacuums, whereby the magnetic system and diaphragm operate independently of wide variations in conditions of temperature, barometric pressures and humidity.

The diaphragm in the sound reproducer of my invention is constructed from fabric such as silk, cloth or fine mesh cambric in the nature of parachute cloth, extremely light in weight. The fabric is suitably impregnated so that under conditions of high temperature and extremely high pressures under which the diaphragm is formed when the fabric is united with the flexible metallic rim forming the supporting means of the diaphragm structure, a sound reproducing surface of substantial rigidity is provided. The fabric parts of the diaphragm are pressed into intimate engagement with opposite sides of a light, flexible and resilient metallic rim which serves to suspend the fabric sound reproducing diaphragm and coil support connected therewith and center the coil support in the annular magnetic gap provided in the magnetic circuit. Connection is established with the winding carried by the coil support through means insulated from the flexible metallic rim and upon which there is practically no mechanical strain so that good electrical connection may be made to the winding.

Referring to the drawings in detail, reference character 1 indicates the toroidal shaped permanent magnet employed in the electrical sound reproducer of my invention. The permanent magnet employed is formed from an alloy of aluminum, nickel and cobalt and when magnetized under control of a high charging current, a permanent magnetic field of the order of 10,800 gausses is established. The permanent magnet 1 tapers from a relatively large diameter adjacent its base to a smaller diameter adjacent the top thereof. In Fig. 3 I have shown the permanent magnet with a straight wall, tapered so that the toroidal shaped permanent magnet is substantially frusto-conical. In Fig. 4 I have shown the permanent magnet having a gradual taper 1A from a position adjacent the base to a position adjacent the top of the magnet. The permanent magnet 1 has a central bore extending longitudinally therethrough with diametrically opposite longitudinally extending grooves 16A and 18A for accommodating non-magnetic securing bolts 16 and 18 which pass through the soft steel base 4 and enter the soft steel cap plate 2. The soft steel cap plate 2 has a shaped annular head 2A and an angularly inclined wall 2B connected with head 2A through a curved interconnecting wall portion 2C. The head 2A of the annular cap 2 is aligned with the annular face 3A of soft steel plate 3. The soft steel plate 3 is secured in position with respect to the soft steel base 4 with the cylindrical soft steel case 5 serving as a spacer member between soft steel base 4 and soft steel plate 3 by means of the non-magnetic securing bolts 15, 19, 20 and 21. The cylindrical soft steel case 5 serves as the neutral portion of the magnetic system and provides a path for the magnetic lines which emanate from the permanent magnet 1 and thread through soft steel annular cap 2, head 2A, annular gap 35, annular face 3A and soft steel plate 3, the soft steel case 5 and through the soft steel base 4, returning to the permanent magnet 1.

The sound reproducing diaphragm is indicated generally at 6 having a central sound reproducing portion 6A and winding supporting 6B where the winding supporting portion 6B extends through the annular gap 35 for supporting winding 7 between soft steel annular head 2 and soft steel annular face 3A. The diaphragm is suspended by the annular flexible and resilient metallic rim 14 which is secured between flexible gaskets 11 and 12 by screw members 22, 23, 24 and 25 shown more clearly in Fig. 7. The screw members 22, 23, 24 and 25 pass into the annular plate 8 which forms part of the support for the sound reproducing horn adapted to be connected to the screw threaded cylindrical neck 8A. The plate 8 has an annular recess 8B therein which enables the plate 8 to completely cover the gaskets 11 and 12 and form a tight seal against the entry of moisture, salt water, acid fumes or gases. Plate 8 seats directly against the top 13 of the case. The top 13 may be of aluminum, zinc, brass or other non-magnetic material, and is provided with a central recess indicated at 13A which aligns with the recess 8B in plate 8 allowing a snug fit for gasket 12 when the assembly is inserted in position, thus further presenting an obstructive path against the entry of moisture, salt water, acid fumes, or gases. Top plate 13 also provides a connection means over which the top edge 17A of the non-magnetic protective case 17 is rolled. The case 17 is formed from aluminum or other suitable non-magnetic material and entirely encases the magnetic parts of the sound reproducing system. When rolled over at the top edge 17A, a tight joint is provided with respect to top plate 13. The supporting plate 8 which carries the diaphragm assembly and supports the sound reproducing horn may also be constructed from aluminum or bronze or other non-magnetic materials so that a complete non-magnetic housing is provided around the magnetic system. Not only does this non-magnetic housing aid in confining the magnetic lines of force within the magnetic system, but the casing prevents the undesirable influence which external fields may have upon the magnetic system which tend to realign the molecular structure of the permanent magnet from outside sources. The plate 8 which carries the diaphragm assembly is wholly removable as a unit from soft steel plate 3 so that the diaphragm may be assembled completely within the top plate 8 before insertion with respect to magnetic gap 35. The top plate 3 is provided with recesses 3B aligned with the heads or screws 22, 23, 24 and 25 allowing the assembly to be compactly effected.

While I have referred to plate 8 as being formed from aluminum, I have found that in certain instances that it is desirable to form the plate 8 from soft steel for the purpose of providing a magnetic leakage path for avoiding stray fields where a bronze or aluminum plate would

allow the passage of such leakage fields. I provide a cylindrical collar 9 within the screw threaded terminus 8A and a protective screen 10 within the cylindrical terminus for the protection of the sound reproducing diaphragm 6.

The plate 8 carries binding posts 31 and 32 in insulated position thereon as shown more particularly in Fig. 7. Binding posts 31 and 32 are connected through leads 29 and 30 to opposite ends of winding 7 carried by the coil supporting portion 6B of the sound reproducing diaphragm. The plate 8 is removably secured in position as a complete assembly in itself readily separable from the permanent magnet system by means of screws 26, 27, 28, and 33 which pass through plate 8 and enter the soft steel plate 3 through non-magnetic plate 13 as indicated more particularly in Fig. 7. When plate 8 is formed from soft steel for the purpose of providing a magnetic leakage path, the screws 26, 27, 28 and 33 further serve as a connection to the soft steel plate 3 through which magnetic lines of force thread.

Fig. 3 illustrates in plan view the flexible metallic rim which is employed for supporting the sound reproducing diaphragm. I have designated the metallic rim as H, having the annular flexible suspension 14 and terminating in the inwardly directed tooth-like inner peripheral edge which I have designated at 36. The tooth-like inner peripheral edge 36 is produced by a punch press operation which cuts the thin flexible metal constituting the rim H, to form a series of broadened teeth 37 interconnected by central recesses 38.

In Fig. 9 I have shown the method of making the sound reproducing diaphragm wherein the forming dies A and B, and coacting intermediate die C are all shaped to form the sound reproducing diaphragm and coil support in one operation. The forming die A has a frusto-conical recess 39 therein surrounded by recessed annular groove 40. The intermediate forming die C has an annular projecting portion 41, which coacts with the annular recess 40 in forming the annular suspension 14 in the metallic rim H. The intermediate forming die C also has a cylindrical portion 42 which serves to form the coil support on the diaphragm. The forming die B has a central upwardly projecting frusto-conical portion 43 which coacts with the frusto-conical recess 39, in die A for shaping the diaphragm. Die B also has a cylindrical portion 44 which coacts with the cylindrical portion 42 of the intermediate die C in shaping the coil support with respect to the diaphragm.

The sound reproducing diaphragm 6 is formed by sheets of fabric I and J. The fabric sheet I is interposed between the frusto-conical portion 39 of forming die A and the flexible metallic suspension H. The fabric sheet J is interposed between the intermediate die C and the forming die B. After assembling in this manner, pressure of the order of from 7 to 16 tons is applied after impregnating each of the fabric sheets I and J for forcing the fabric sheets in intimate engagement with each other and on opposite sides of the peripheral edge 36 of the rim H. The closing of the dies A, B and C, with respect to each other with the fabric sheets I and J and flexible suspension H interposed therebetween, results in the structure illustrated in Figs. 11 and 12. The frusto-conical portions 6A of fabric sheets I and J are pressed in intimate engagement. The depending annular skirt 6B constituting an extension of fabric sheet J and which is formed by the coaction of cylindrical portion 42 of intermediate die C with cylindrical portion 44 of die B serves as a support for winding 7. As illustrated in Fig. 12, which is taken on line 12—12 of Fig. 10 the inner peripheral edge 36 of metallic rim H extends intermediate the inclined wall formed by fabric sheets I and J which are pressed into engagement on opposite sides of the inwardly extending teeth 37.

I have illustrated the completed diaphragm in plan view in Fig. 10, containing apertures 45 for the passage of the securing screws which maintain the diaphragm in position between gaskets 11 and 12. The flexible metallic rim is also notched in diametrically opposite positions as indicated at 46 to provide means for conveniently establishing electrical connection with the ends of winding 7 supported by the skirt portion 6B of the diaphragm. The manner of establishing electrical connection with winding 7 is shown more particularly in Figs. 13 and 14. Fig. 13 is a fragmentary plan view of the terminal connection device in which it will be observed that the depending skirt 6B is slitted at 47 for the passage of a flexible metallic connecting strip 48. The metallic strip 48 has one end thereof extending beneath the frusto-conical portion of the diaphragm and through a slot 49 in each of the fabric sheets, being secured over the fabric by means of bent portion indicated at 50. The bent strip passes through the frusto-conical portion of the diaphragm in a position adjacent the edge thereof and along the central axis of one of the circular cut-out portions 38 of the metallic rim 14. Fig. 14 taken on line 14—14 of Fig. 13 shows the manner in which terminal connector 48 is insulatingly supported with respect to the metallic rim 14 by means of insulator strip 51 which is turned over the raw edge of the metallic rim 14 centrally of the recess 46 at one side thereof, allowing terminal strip 48 to be bent over the peripheral edge 14 for mechanical support thereby while being electrically insulated therefrom. The terminal connectors 48 are flexible and introduce only a negligible amount of load with respect to flexible rim 14 of the sound reproducing diaphragm. One end of the winding 7 is soldered to strip 48 as indicated at 52 inside the conical shaped sound reproducing diaphragm as indicated. Connection is made to the binding posts 31 and 32 by a soldered connection to the end of the connection strip 48 which is clinched over the insulator strip 51 in the recess 46 at the edge of the rim 14.

As heretofore observed the complete sound reproducing diaphragm assembly is supported by plate 8 which when secured in position on the casing insures that the coil 7 may be centered in the gap 35 between annular head 2A and annular magnetic face 3A. The winding 7 is connected in the variable current circuit and when energized by variable currents, coacts with the intense magnetic field established across gap 35 for imparting vibrations to the sound reproducing diaphragm 6 which is free to vibrate with respect to flexible suspension H for the reproduction of sound.

The loud speaker of my invention operates to reproduce sound uniformly over a wide frequency range with a high degree of fidelity. The fact that all parts of the structure are protected against variations in temperature, barometric pressure, and humidity, insures permanency in operation of the structure whether in aircraft, on shipboard or under other severe conditions. The fact that the parts of the sound reproducer are

constructed from materials not subject to change under conditions of wide variations in temperature, barometric pressure, and humidity further insures the permanency in operation of the sound reproducer.

While I have described my invention in one of its preferred embodiments I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A sound reproducing diaphragm comprising a flexible supporting rim member, a fabric sheet having a body portion and a coil mounting edge portion thereon, and a second fabric sheet, said second fabric sheet being secured in surface contact with the body portion of said first fabric sheet, with an inner peripheral portion of said rim member interposed therebetween.

2. A sound reproducing diaphragm comprising a flexible annular metallic rim having an inner serrated peripheral edge and fabric sheets coextensively engaging each other and opposite sides of the inner serrated peripheral edge of the annular metallic rim, said fabric sheets being mutually reenforced and constituting a sound reproducing vibratile surface, one of said fabric sheets having a coil supporting portion thereon, and coil connecting terminals insulatingly mounted on said annular metallic rim.

3. A sound reproducing diaphragm comprising a flexible annular metallic rim terminating in an inner periphery formed by a multiplicity of spaced flexible finger elements, fabric sheets inter-connected in surface contact with each other and embracing opposite sides of said finger elements, said sheets extending beyond the plane of said metallic rim and being mutually reenforced for forming a sound reproducing surface, and one of said sheets having a cylindrical coil supporting portion disposed on an axis substantially normal to the plane of said annular metallic rim.

4. The method of manufacturing a sound reproducing diaphragm which comprises forming an annular sheet metal rim, positioning an impregnated fabric sheet on each side of said rim, and applying pressure on the assembled fabric sheets and metal rim for uniting said sheets coextensively with each other and with the portion of the rim therebetween in intimate engagement.

5. The method of manufacturing a sound reproducing diaphragm which comprises shaping an annular metallic rim, arranging fabric sheets on opposite sides of said rim with one of the sheets extending beyond the limits of the rim, shaping and pressing said fabric sheets into mutual engagement with each other and with opposite faces of said rim and forming in the same operations a coil support from the said overextending portion of one of said fabric sheets.

6. In a sound producer, a diaphragm comprising a two-ply fabric vibratible portion having one of the fabric plies thereof extended in substantially cylindrical form to provide an actuating coil supporting portion, a flexible metallic annular rim having a serrated inner peripheral portion thereof engaged between the plies of said vibratible portion, said coil supporting portion being adjacent said rim, and means for leading an electrical connection to said coil supporting portion for energizing a coil thereon comprising a conductive strip member insulatingly mounted contiguous with said rim in a radial line and having the inner radial terminus thereof anchored in the two-ply vibratible portion of said diaphragm intermediate adjacent serrations of the metallic rim secured between the plies.

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