March 20, 1945. G. E. GUSTAFSON 2,371,820

METHOD FOR MAKING SOUND REPRODUCING UNITS

Original Filed April 23, 1943

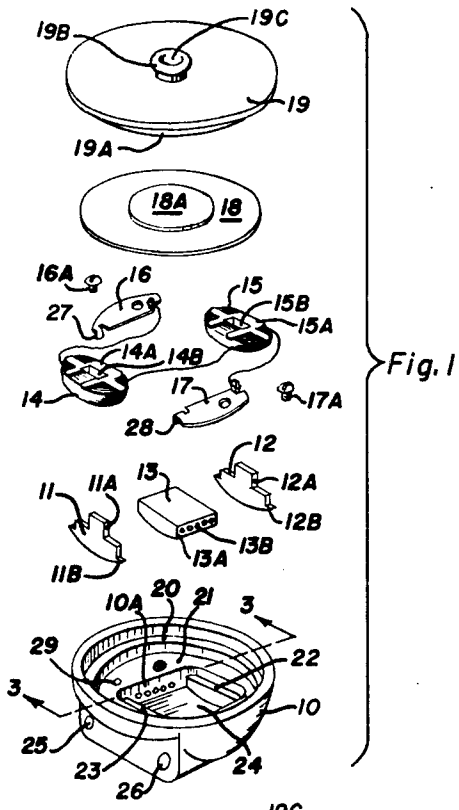


Fig. 1

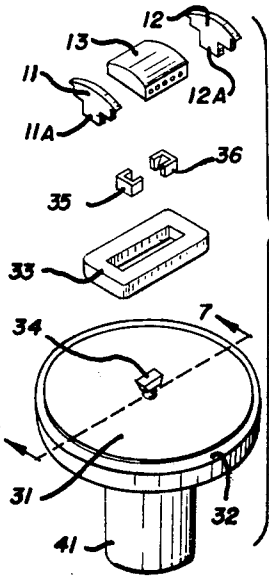


Fig. 4

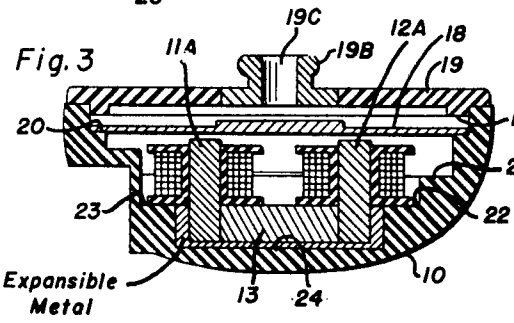


Fig. 3

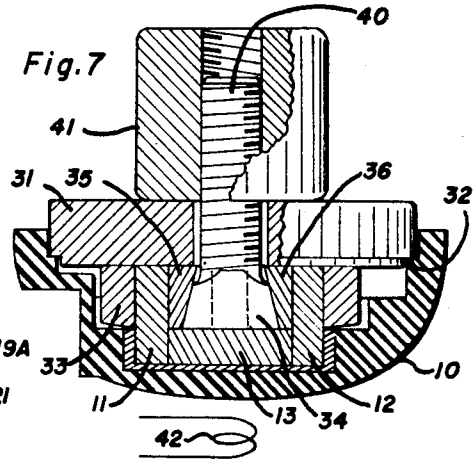


Fig. 7

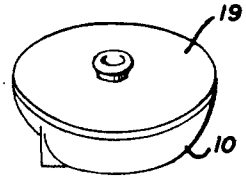


Fig. 2

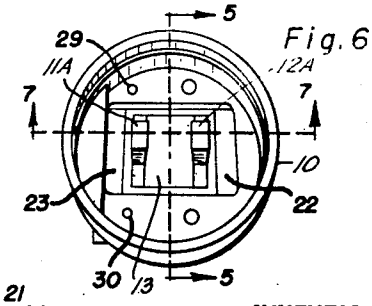


Fig. 6

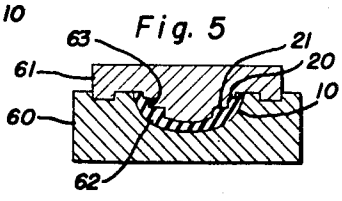


Fig. 5

INVENTOR.
GILBERT E. GUSTAFSON
BY David M. Harris
HIS ATTORNEY

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METHOD FOR MAKING SOUND REPRODUCING UNITS

Gilbert E. Gustafson, River Forest, Ill., assignor to Zenith Radio Corporation, a corporation of Illinois

Original application April 23, 1943, Serial No. 484,153. Divided and this application March 11, 1944, Serial No. 526,094

9 Claims. (Cl. 22—204)

This invention relates to sound reproducing devices and a method for making the same.

In many sound reproducing systems, and especially in hearing aid apparatus, it is essential that the sound reproducing unit be of small size, inexpensive and of sturdy construction. Heretofore these desirderata were not always attained, because much skill and time were required to provide the correct air gap distance between actuating magnets and the associated movable diaphragm, because the parts of the system were of small dimensions, and because there was a large number of parts making up the composite sound reproducing unit.

It is therefore an object of this invention to provide an improved method for making a small, compact, inexpensive and sturdy sound reproducing unit especially suitable for use in hearing aids.

Another object of this invention is to provide a new and improved method for making a sound reproducing unit in which there is provided an air gap between actuating magnets and associated diaphragm of accurate dimension, which gap is maintained fixed with a high degree of stability.

Another object of this invention is to provide an improved method for making a small, compact, sturdy sound reproducing unit having a minimum number of parts.

Another object of this invention is to provide a new and improved method for assembling the parts of a sound reproducing unit which lends itself to mass productiton and yet insures a constant and stable air gap distance between actuating magnets and diaphragm.

This is a division of my application, Serial No. 484,153, filed April 23, 1943, on "Sound reproducing unit and method for making the same" and assigned to the same assignee as the present application.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

Figure 1 is an exploded view of one embodiment of my invention;

Fig. 2 is a perspective view of the assembled embodiment of Fig. 1;

Fig. 3 is a sectional view taken substantially on line 3—3 of Fig. 1 when all of the elements shown in Fig. 1 is mounted on base 10;

Fig. 4 is an exploded view of a jig for use in practicing the method of my invention to produce a unit as illustrated in Fig. 1;

Fig. 5 is a sectional view showing apparatus for moulding the base of the unit shown in Figure 1, the section through the base being taken substantially on line 5—5 of base 10 in Fig. 6 in the absence of pole pieces 11A, 12A and yoke 13;

Fig. 6 is a perspective view of a partially assembled unit as illustrated in Fig. 1;

Fig. 7 is a view partly in elevation and partly in section showing the assembled jig of Fig. 4 mounted with a partially assembled unit as illustrated in Fig. 6 arranged to practice the method of my invention, the sectional part being taken on a line corresponding to lines 7—7 of both Figs. 4 and 6 when the elements shown in Fig. 4 are assembled and disposed in base 10.

Referring to Fig. 1, the sound reproducing unit comprises a base 10, pole pieces 11 and 12, permanent magnet yoke 13, magnet coils 14 and 15, terminals 16 and 17, diaphragm 18 and cover 19. The base 10 is of insulating material, such as Bakelite or the like, and has an inner circular ledge 20 upon which the diaphragm 18 normally rests. The base 10 has also a second lower inner ledge 21 upon which the terminals 16 and 17 are fastened (preferably by means of screws 16A and 17A or the like), and still lower oppositely disposed ledges 22 and 23 (see Fig. 6) upon which the magnet coils 14 and 15 rest. The base 10 has also a centrally located recess 24 in which the pole pieces 11 and 12 and yoke 13 are snugly received and in which they are fastened by means to be described later. The base 10 has two parallelly extending and integrally formed portions 25 and 26 in each of which is a hole adapted to receive a rod shaped electrical contact member (not shown), so that such electrical contact members, when inserted in the portions 25 and 26, make electrical connection with the terminal portions 27 and 28 of terminals 16 and 17, which portions 27 and 28 extend through base holes 29 and 30 (see Fig. 6) into the portions 25 and 26 of the base 10.

The base 10, of Bakelite or other similar material capable of being molded in suitable form and shape to form the various ledges and recesses and integrally formed projecting portions, is formed between a pair of cooperating dies 60 and 61 in Fig. 5, the inner surface 62 of die 60 being of the same shape as the outside surface of base member 10 and the outer surface 63 of die 61

having the same contour as the inner portion of base member 10.

In the manufacture of base member 10, a predetermined amount of unheated Bakelite, resin or similar material is placed in die 60, the die 61 is then placed in cooperating relationship with die 60 with the Bakelite or similar moldable material therebetween, and the Bakelite is caused to solidify by applying heat thereto in well known manner, with the result that when the dies 60 and 61 are separated from each other and from the solid Bakelite, base member 10 is produced. Terminal holes are then drilled by conventional means in base portions 25 and 26 for a purpose described later.

The yoke 13 is of magnetic material, preferably Alnico, an alloy of iron, aluminum, nickel and cobalt in such proportions that the alloy has great permanence and coercive force. It abuts against and holds the pole pieces 11 and 12 in spaced relationship.

The magnet coils 14 and 15 are wound on bobbins 14A and 15A which have rectangularly shaped hollow cores 14B and 15B which may be pressed over the smaller portions 11A and 12A of pole pieces 11 and 12 which extend therethrough.

The diaphragm 18 comprises a thin disc having concentrically mounted thereon a smaller disc 18A sufficient to increase the central thickness of the diaphragm 18 so that it can carry the magnetic flux from yoke 13 and coils 14 and 15 without undesirable saturation.

The cover 19 has a circular shoulder 19A (see Fig. 3) adapted to engage tightly against the inner wall of base 10 but not of sufficient vertical extent to bottom against diaphragm 18. It also has an extending tubular portion 19B adapted to receive a sound transmitting element. In operation, the cover 19 is substantially stationary and the sound impulses generated by movement of diaphragm 18 are transmitted through cover opening 19C.

The pole pieces 11 and 12 and yoke 13 are cemented in and to the base 10 by a suitable material such as an alloy as shown in Fig. 3. One suitable low melting point alloy includes bismuth and lead. Its melting point is 255° Fahrenheit, and its casting temperatures range from 270° to 310° Fahrenheit. Instead of shrinking on solidifying, it expands slightly. Materials similar to this alloy, and which may be used in the cementing operation, are described on pages 184 and 185 of "Materials Handbook," by George S. Brady, published by McGraw-Hill Book Company, Inc., 1940.

In the assembling operation, some of the alloy material is placed in recess 24 and on base ledges 22 and 23. The alloy material is then heated, preferably by induction heating (see coil 42 in Fig. 7), and, when the alloy cools, the yoke 13 and pole pieces 11 and 12 are held firmly in place in and on the insulating base 10. The bobbins 14A and 15A supporting coils 14 and 15 are then pressed onto pole tips 11A and 12A, and terminals 16 and 17 are then fastened on ledge 21, preferably by screws or rivets, with the terminal projecting portions 27 and 28 extending into the base portions 25 and 26, whereby electrical contact may be made with them when rod shaped electrical conducting members (not shown) are inserted into the holes in base portions 25 and 26. The diaphragm 18 is then placed on base ledge 20 and is held thereon due to the action of the magnetized pole pieces 11 and 12. The cover 19 is then placed on the base and is frictionally held in place thereby, the assembled unit appearing as in Fig. 2.

The parts cemented preferably have prepared surfaces thereon so as to increase the area of the cemented surface and so as to provide a finished structure having increased strength. That is, for this purpose, the pole pieces 11 and 12 are provided with notches 11B and 12B respectively, the yoke 13 is provided with surfaces 13A having indentations 13B therein, and the base 10 is provided with indentations 10A therein which may partake of a grooved surface.

In order to make the sound reproducing unit heretofore described in mass production and with a predetermined constant distance between pole pieces 11 and 12 and diaphragm 18, the jig shown in Fig. 4 is utilized. It is important to realize that in small hearing aid reproducing units the pole pieces 11 and 12 are mounted approximately .01 inch below base ledge 20 upon which diaphragm 18 rides; and the diaphragm and outer pole piece surfaces must be substantially parallel with their separation tolerances in the order of a few percent.

The jig of Fig. 4 comprises a circular base plate 31 of such outer diameter as to be frictionally held by the upper inner curved wall of the base 10. Shoulder 32 on base plate 31 serves to limit the movement of base plate 31 into base 10. In the exploded view, Fig. 4, the rectangular shaped collar 33 is adapted to contain snugly within its hollow portion the wedge 34, the pair of channel shaped wedge members 35 and 36, and parts 11A and 12A of the pair of pole pieces 11 and 12.

In order to assemble the parts on the jig, the channel shaped wedge members 35 and 36 and parts 11A and 12A of pole pieces 11 and 12 are mounted on the base plate 31 within the rectangular ring 33, with channel shaped wedge members 35 and 36 in abutting relationship to the downwardly extending portions 11A and 12A of pole pieces 11 and 12. Then the screw 40 (Fig. 7), having wedge shaped head 34, is drawn against the cooperating channel shaped wedge members 35 and 36 by turning the nut 41. As nut 41 is tightened on screw 40, wedge shaped head 34 is drawn into engagement with cooperating wedge surfaces on channel members 35 and 36, and the resulting outward movement of channel members 35 and 36 causes parts 11A and 12A of pole pieces 11 and 12 to be firmly held in the encircling rectangular shaped ring 33. Magnetic yoke 13 is then placed on ring 33 between the downwardly extending portions 11A and 12A of pole pieces 11 and 12, its magnetism holding it securely between pole pieces 11 and 12.

The assembled jig is of such dimensions that when it is inserted in the base 10, containing the elements of the sound reproducing unit (such assembly being shown in Fig. 7), the shoulder 32 abuts the upper ledge 20 of base 10 (Fig. 6) with the pole pieces 11 and 12 and yoke 13 inserted in base recess 24 in predetermined spaced relationship to the base ledge 20 after the alloy material disposed between base 10 and yoke 13 and pole pieces 11 and 12 melts.

It is noted that the alloy material initially placed in base 10 prior to inserting the jig therein is usually in powdered form thus causing shoulder 32 to be separated a small distance from the upper ledge 20 of base 10 when such jig is inserted into the base. But, when and as such powdered alloy melts, shoulder 32 approaches its position on the upper ledge 20 of base 10 either due to gravity forces acting on the composite jig or due

to other forces applied between base 10 and the jig. Ultimately, shoulder 32 rests on the upper ledge 20 of base 10 and is held in that position when and as the alloy later soldifies due to gravity forces acting on the composite jig or due to an external force applied between the jig and base member 10.

When high frequency current is applied to the coil 42 (Fig. 7) the low melting point alloy (or another suitable material), which was initially placed in base member 10 around pole pieces 11 and 12 and yoke 13 melts. Then, as the alloy material cools and solidifies after coil 42 is deenergized, the alloy material expands slightly while shoulder 32 is firmly held on the upper edge 20 of base member 10 and, when the alloy material solidifies entirely it firmly holds the pole pieces 11 and 12 and yoke 13 to the base 10 with the faces of pole pieces 11 and 12 in a predetermined spaced relationship with respect to the base ledge 20 upon which the diaphragm 18 is subsequently placed.

It is also noted that when the expansible metal alloy is heated by high frequency currents flowing in coil 42, eddy currents flowing in such expansible metal produce a magnetic shielding effect on pole pieces 11 and 12 and magnetic yoke 13 whereby less heat is generated in pole pieces 11 and 12 and yoke 13 due to high frequency currents in coil 42 than that produced when the expansible metal is absent. This feature is of particular importance since the magnetic state of pole pieces 11 and 12 and yoke 13 is disturbed much less when eddy currents flow in the expansible metal than is the case when such expansible metal is absent. After the pole pieces 11 and 12 and yoke 13 are thus cemented to the base 10, they are disengaged from the jig by loosening nut 41 on screw 40.

In the preferred embodiment of this invention, the pole pieces are cemented to the insulating base 10 by alloy material which is heated by high frequency induction heating apparatus.

It is also apparent that the alloy material may be heated by means other than by the preferred use of electrical induction heating apparatus and this invention is not necessarily limited to the preferred heating apparatus.

The fact that the preferred alloy material has a low melting point, is metallic and expands as it solidifies makes it a desirable cementing agent in this application. The fact that the material is metallic in nature allows the use of induction heating apparatus and the surrounding parts need not be unnecessarily heated because of the eddy current shielding effect produced by currents flowing in such material. Of importance is the fact that, since the alloy material expands as it solidifies, the pole pieces 11 and 12 are pressed and tend to move outwardly, thus assuring predetermined spacing of the pole pieces 11 and 12 with respect to base ledge 20. In order to achieve this particular feature, it is of course necessary to place a sufficient quantity of such alloy material between the base 10 and pole pieces 11 and 12 in the assembling operation, such sufficient quantity being of a thickness greater than the thickness present in the finished product, heating such material above its melting point and constraining the flow of such material to a degree as it solidifies such that the pole pieces 11 and 12 are firmly pressed and tend to move outwardly against the force of gravity or other external forces which act to maintain shoulder 32 in abutting relationship to the upper edge of base 10, thus assuring predetermined spacing of the pole pieces 11 and 12 with respect to base ledge 20. It is noted that since the base recess 24 snugly receives the pole pieces 11 and 12 and yoke 13, a small clearance exists between the walls defining recess 24 through which the material may pass with appreciable resistance as it solidifies and consequently a relatively large force is exerted by the expanding material between base 10 and pole pieces 11 and 12. This expanding force is utilized in accordance with the present invention to avoid voids and to establish an accurate air gap distance.

In the assembled jig, the parts 11A and 12A of pole pieces 11 and 12 abut the base plate 31 and are of predetermined height, so as to assure their correct spacing in the fabricated sound reproducing device, the height of shoulder 32 on base plate 31 of the jig being just right to assure such correct spacing.

The cementing process described herein is accomplished by making use of the adhesive or binding properties of materials which set in cementing relation between the parts to be cemented whereby those parts can be placed in predetermined spaced relationship, as in a jig, and held in such relation when the cement sets. The cementing process is preferably carried out by using a low melting point material having the property of expanding as it cools, and in which the material adheres to the parts being cemented in the insulating base.

Furthermore, it is noted that since pressure is applied to the expansible alloy when and as it solidifies it is reasonable to believe that such alloy is in a somewhat stressed condition after the complete solidification process.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In the process of manufacturing sound reproducing apparatus having a magnetic structure and a diaphragm supported in spaced relationship in a base, the steps of placing a low melting point material of more than a desired thickness and having the property of expanding as it solidifies on said base, heating the material above its melting point and then allowing the material to solidify whereby the material tends to expand to said more than a desired thickness, and limiting movement of said material in the direction of its thickness and allowing the material to flow in at least one direction other than in the direction of its thickness as it solidifies to limit the thickness of said material to said desired thickness, said diaphragm and magnetic structure being supported on said base in desired spaced relationship by reason of the limited thickness of said solidified material.

2. In the process of manufacturing sound reproducing apparatus having a magnetic means disposed in a base for actuating a diaphragm, the steps comprising disposing said magnetic means in said base with a metallic cement between the base and magnetic means, said metallic cement having the property of expanding as it solidifies, heating said cement above its melting point, allowing said cement to solidify, whereby said ce-

ment disposed between said base and magnetic means tends to move said magnetic means relative to the base, and limiting the movement of said magnetic means produced by the expansion of the cement to a predetermined position with respect to the base.

3. In the process of manufacturing sound reproducing apparatus having a magnetic means disposed in a base for actuating a diaphragm, the steps comprising inserting the magnetic means in said base with a low melting point metallic material having the property of expanding as it solidifies disposed between the base and magnetic means, heating the metallic material above its melting point, then allowing the metallic material to solidify whereby the magnetic means tends to move relative to the base, and limiting the movement of said magnetic means produced by the expansion of the metallic material to a predetermined position with respect to the base.

4. In the process of manufacturing sound reproducing apparatus having a magnetic means disposed in a base for actuating a diaphragm, the steps comprising disposing the magnetic means in said base with a low melting point material having the property of expanding as it solidifies disposed between the base and magnetic means, inductively heating the metallic material above its melting point, then allowing the metallic material to solidify whereby the magnetic means tends to move relative to the base, and limiting the movement of said magnetic means produced by expansion of the metallic material to a predetermined position with respect to the base.

5. In the process of manufacturing sound reproducing apparatus having a magnetic means disposed in a base for actuating a diaphragm, the steps comprising inserting the magnetic means in said base with a low melting point metallic material having the property of expanding as it solidifies disposed between the base and magnetic means, inductively heating the metallic material above its melting point, said metallic material being so disposed as to utilize an eddy current shielding effect for preventing said magnetic means from being unduly heated, then allowing the metallic material to solidify whereby the magnetic means tends to move relative to the base, and limiting the movement of said magnetic means produced by the expansion of the metallic material to a predetermined position with respect to the base.

6. The process of manufacturing a sound reproducing device having a base portion supporting a diaphragm which is actuated by a magnetic means, which process includes the steps of shaping a portion of the base to receive the magnetic means, placing between the magnetic means and the shaped base portion a cement which is a low melting point metallic material having the property of expanding as it cools, heating the cement above its melting point and then allowing the cement to cool while maintaining the magnetic means against the expansion of said cement in predetermined spaced relationship to the diaphragm supporting base portion of said device.

7. The process of manufacturing a sound reproducing device having a base portion supporting a diaphragm which is actuated by a magnetic means, which process includes the steps of shaping a portion of the base to receive the magnetic means, placing between the magnetic means and said shaped base portion a cement which is a low melting point metallic material having the property of expanding as it cools and which is placed between the magnetic means and the base to more than the thickness necessary to a predetermined spaced relationship of the magnetic means to the diaphragm supporting base portion of the device, heating the cement above its melting point and then allowing the cement to cool while maintaining the magnetic means against the expansion of said cement in said predetermined spaced relationship to the diaphragm supporting base portion of said device.

8. The process of manufacturing a sound reproducing device having a base of which a portion supports a diaphragm which is actuated by a magnetic means, which process includes the steps of shaping a second portion of the base to receive the magnetic means, placing between the magnetic means and shaped second base portion a cement which is a low melting point metallic material having the property of expanding as it cools, heating the cement by eddy currents induced therein above its melting point and then allowing the cement to cool while maintaining the magnetic means against the expansion of said cement in predetermined spaced relationship to the diaphragm supporting portion of said base.

9. The process of manufacturing a sound reproducing device having a base having a portion supporting a diaphragm which is actuated by a magnetic means, which process includes the steps of shaping a portion of the base to receive the magnetic means, placing between the magnetic means and the shaped base portion a cement which is a low melting point metallic material having the property of expanding as it cools and which is so disposed as to produce shielding against eddy currents to prevent the magnetic means from being greatly heated, heating the cement inductively by eddy currents above its melting point and then allowing the cement to cool while maintaining the magnetic means against the expansion of said cement in predetermined spaced relationship to the diaphragm supporting portion of said base.

GILBERT E. GUSTAFSON.