Aug. 5, 1969 V. L. CARBONARO 3,460,080

ARMATURE MOUNTING ASSEMBLY FOR AN ELECTROACOUSTIC TRANSDUCER

Filed April 28, 1967 2 Sheets-Sheet 1

Fig. 1.

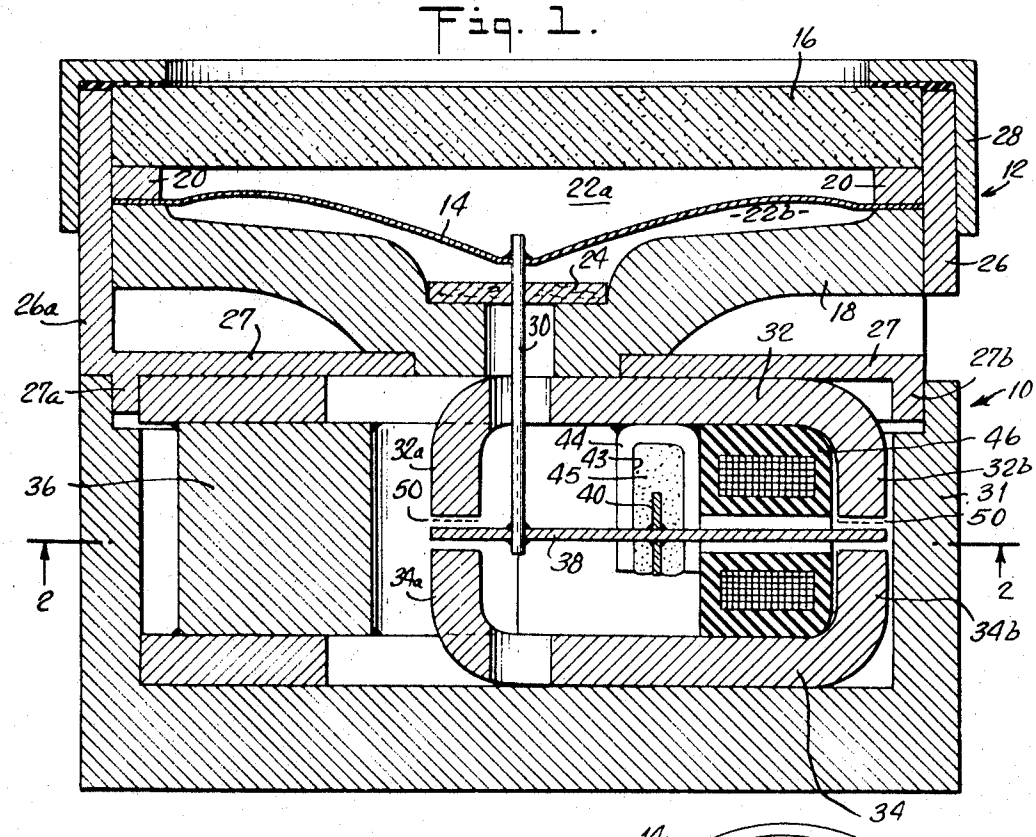


Fig. 2.

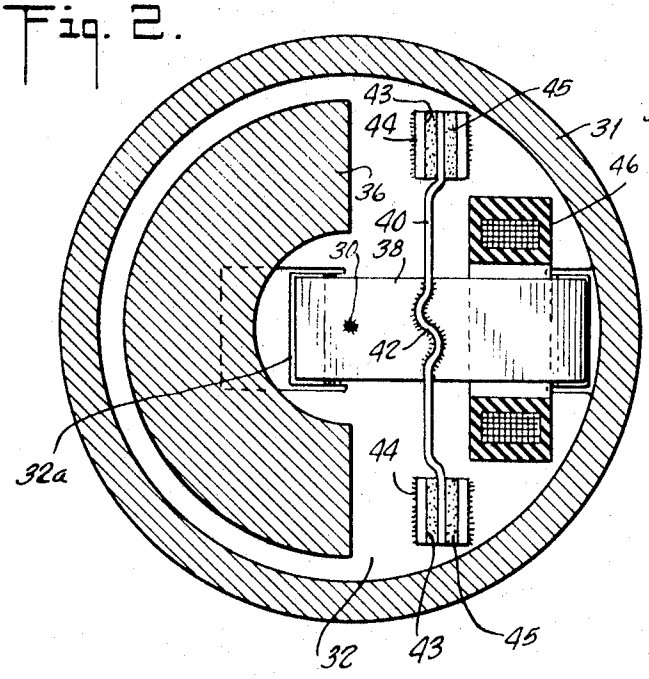
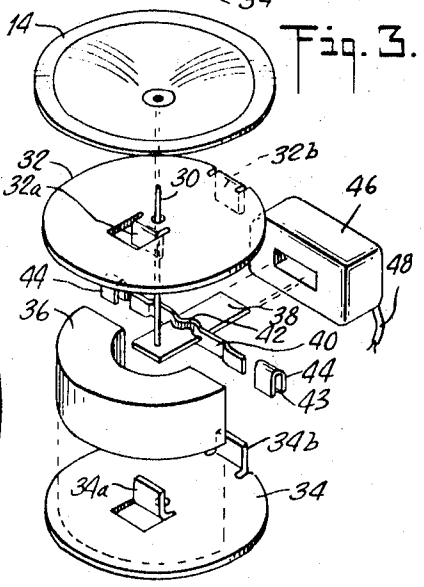


Fig. 3.



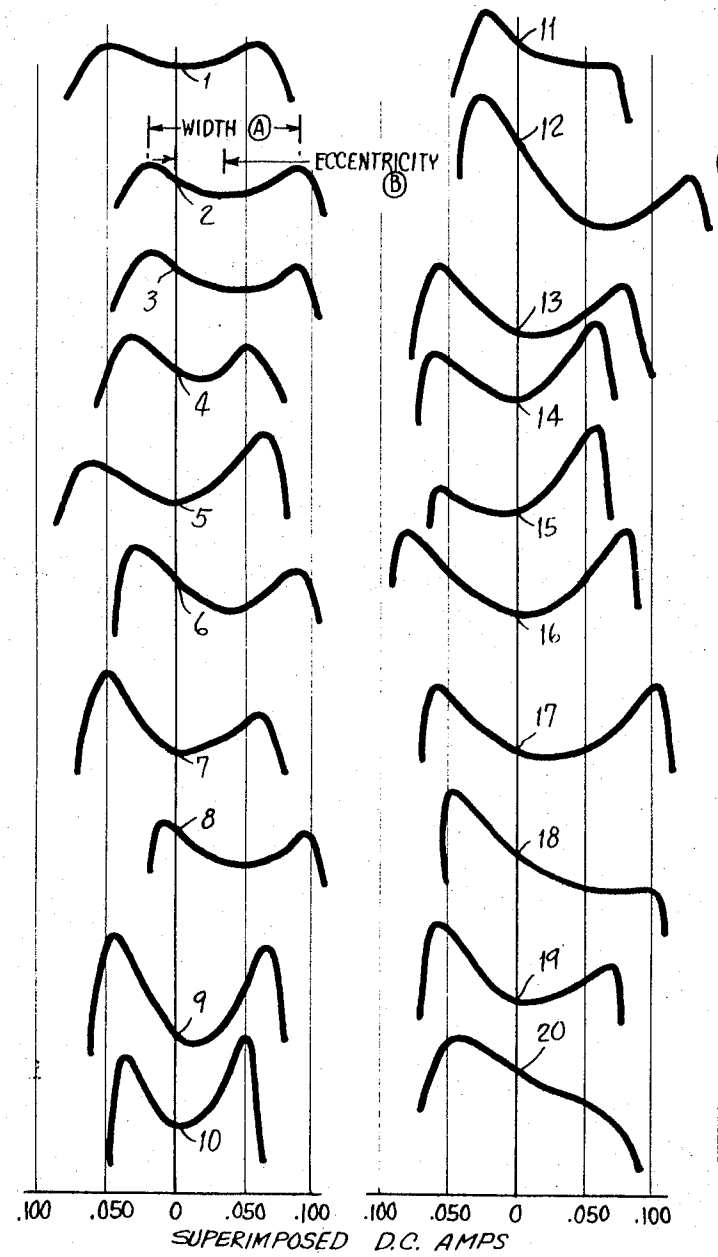
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ARMATURE MOUNTING ASSEMBLY FOR AN ELECTROACOUSTIC TRANSDUCER

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Fig. 4.



NO.	Ⓐ WIDTH OF SUPERIMPOSED D.C. FLAT-TOP (AMPS)	Ⓑ ECCENTRICITY (AMPS)	Ⓒ PERCENTAGE ECCENTRICITY	400 CPS RESPONSE LEVEL - db	RESONANT FREQUENCY CPS
1	.115	.0075	6.5	118.5	1540
2	.110	.035	32.	116.9	1500
3	.110	.035	32.	118.3	1530
4	.090	.010	11.	119.2	1500
5	.130	0	0	117.4	1530
6	.120	.030	25.	119.0	1550
7	.117	.0075	6.5	120.0	1520
8	.105	.0425	40.	119.6	1550
9	.110	.010	9.	119.6	1500
10	.090	.005	5.5	119.1	1500
11	.095	.0225	24.	119.0	1500
12	.115	.0525	34.	118.0	1500
13	.135	.0125	9.5	118.4	1510
14	.120	0	0	118.4	1510
15	.115	.0025	2	119.1	1520
16	.160	0	0	116.0	1490
17	.165	.0225	13.5	116.0	1525
18	.145	.0275	19.	117.0	1525
19	.125	.0075	6.	116.6	1555
20	.120	.015	12.5	118.5	1500
AVE.	.122	.0173	14.4	117.6	1523
MAX.	.165	.0525	40.	120.	1550
MIN.	.090	0	0	116.	1490

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3,460,080

ARMATURE MOUNTING ASSEMBLY FOR AN ELECTROACOUSTIC TRANSDUCER

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Int. Cl. H01f 7/08; H04r 13/00
U.S. Cl. 335—231 8 Claims

ABSTRACT OF THE DISCLOSURE

A technique of so clamping the armature in a balanced armature transducer to achieve accurate centering in air gaps of the ends of the armature w/o the need for further adjustment. According to the technique, epoxy cement, or similar material, holds the armature support in a manner to avoid straining any of the sensitive parts.

This invention related to an electroacoustic transducer, and more particularly, to a type of transducer known as the balanced armature type. Such a transducer is capable of serving as the active element in either a transmitter or a receiver.

The present invention is particularly concerned with the mounting of the armature in a balanced amature type of transducer and the invention provides a unique method of positioning and securing the support means for the armature.

Within the compass of the designation, balanced armature, there happen to be a number of slightly different transducers. One of these is termed a reed armature and basically consists of an armature which is clamped at one end and is free to vibrate at the other end in a magnetic field. Typically this armature is produced in an E-shape although a U-shaped may also be used. Considering the E-shape armature, the central or middle arm of the E is the vibratable arm. This reed armature type of transducer may be appreciated by reference to the patent to Carlson 3,111,563. In the transducer described in that patent the clamped end of the armature forms the spring which supplied the restoring force to the central vibratable arm when it is deflected from its rest position.

The other basic type of balanced armature transducer is one which is designated "rocking armature" in which the armature is supported by a spring located, for example, at the middle of the armature. It is this type of balanced armature transducer which forms the context or ambience in which the technique of the present invention is most judiciously exploited. In order to furnish background material for a complete appreciation of the present invention, reference may be made to the patent to Blount 2,267,808 in which there is described a rocking armature electromagnetic transducer.

In the rocking armature transducer, both ends of the armature are free to vibrate in the magnetic fields and the spring which supplies the restoring force is not necessarily of the same material as the armature. Thus, comparing the two types the rocking armature type (or 4-air gap structure) as described in the Blount patent, has the stiffness of its dynamic elements supplied by a spring material which has good elastic properties, while in the reed armature type as described in the Carlson patent, the spring stiffness is supplied by the armature itself, and hence is usually supplied by a material having poor elastic properties. In addition, the output of the rocking armature type is, at least theoretically, 6 db greater than for the reed armature type.

It will be apparent from the preceding discussion that

the rocking armature type of electromagnetic transducer is almost ideally suited for application to, for example, hearing aid receivers or other tiny head phone devices where extremely small sized elements having large acoustical outputs are required. Of course, this is not to say that balanced armature electromagnetic transducers are not also suited for microphone applications, that is, in the reversed sense of translating from an acoustical input to an electrical output. However, it can be appreciated that in a hearing aid application it is necessary to supply acoustical outputs which are equal to, or greater than, a threshold of feeling, and this must be accomplished with a diaphragm having a very small area. In order to give some idea of the small sizes involved, one of the most widely used, present day, miniature transducers fits into a case whose outside dimensions are ⅜" x ⅜" x .160'.

Since the armature of a miniature electro-acoustic transducer must vibrate with significantly large amplitudes to provide the aforenoted large output, there must of necessity be incorporated in the design a very low spring stiffness for the armature. This is precisely the advantage and justification of the rocking armature type of transducer. In other words, the dictated requirement of producing large amplitude vibrations is very easily satisfied by the rocking armature structure in which the armature support, being of a totally different material from the armature itself, can be used to keep the spring stiffness at a very low value.

The fly in the ointment of the incontestably straightforward approach is the fact that proper functioning of a rocking armature rests on the need for precision adjustment of the armature so as to equalize the reluctance of the air gaps. In general, this condition is realized when the air gaps are dimensionally equal. Since this is a condition which is difficult to obtain with reasonable dimensional tolerances on all of the small parts involved, the traditional method in the art has been to mechanically equalize the air gaps after assembly. Such an adjustment has been accomplished, for example, by mechanically bending the spring support for the armature or by bending the bracket to which the support is attached. Also, such adjustment has been effected by slightly bending the pole pieces; this technique being the one adopted in the Blount Patent 2,267,808 previously referred to. In any event, such mechanical adjustment in whatever form is difficult to achieve, and results in undesirable strains on the members involved, whether it be the spring support, the armature, or the magnetic members.

Accordingly, it is a fundamental object of the present invention to improve upon the rocking armature electromagnetic transducer, particularly by simplifying the adjustment of the air gaps therein.

Another object is to insure the dimensional accuracy of the air gaps with elimination of the strains on the sensitive members involved.

Another object is to achieve precise centering of the armature during its initial positioning in the air gaps so as to obviate the need for any subsequent adjustment.

The above objects, in one way or another, are fulfilled in accordance with several features of the present invention. Broadly stated one of these features resides in the precise initial clamping of the armature spring support by virtue of the fact that the armature spring support is held in place by an epoxy or an epoxy-like cement. The reference to "epoxy" is not necessarily restricted to that class of materials which includes specific chemical compositions commonly known as "epoxies." The term "epoxy" is used here to describe any adhesive and/or encapsulating material which will change from a liquid or semi-liquid state to a solid state without excessive shrinkage, either by its own self-cure properties or by externally applied influence. A feature related to the

foregoing is the specific technique of centering the armature in the air gaps by placing the ends of the armature spring support in over-sized slots provided in the spring support brackets. The required air gaps are initially defined by the use of shims which are later removed. While the shims are in position, the spring support is clamped in its brackets by the use of an epoxy or an epoxy-like cement which is flowed into the over-sized slots and allowed to harden thereby retaining the ends of the spring support.

It will be appreciated that by the aforedescribed technique, there is no strain imposed upon the armature or its spring support, and further, that once set in an unstrained position there is nothing more to do to realize precise centering of the armature.

It should be emphasized that, although in the later description of preferred embodiments of the present invention, reference will be made to specific locations for the spring support and its associated bracket, it must be borne in mind that it is the unique clamping of the armature spring support that is at the heart of the present invention. However, this is not to say that applicant's inventive principle is simply that of substituting one means or technique of securing or clamping the armature spring support for another means or technique. Rather, the viable principle is this notion of totally or substantially eliminating the need for mechanical adjustment of the gaps between the armature and the pole tips which is a necessary consequence of the use of other prior known arrangements or techniques.

To make the above point abundantly clear, particular reference should be made to FIG. 3 in the Blount Patent 2,267,808 in which it will be noted that the armature support brackets are adapted to receive screws or bolts that are threaded into the brackets. These screws or bolts retain the spring supports and the spring supports in turn serve to hold the armature such that its ends are disposed in the air gaps. This technique, of course, imposes a strain on the ends of the spring support with a consequent slight shifting in the intended position for the armature, thereby necessitating the adjustment after assembly that is discussed in the Blount patent. Another way of looking at the Blount technique is that it requires an extremely fortuitous conjunction of fine tolerances and of exact tensioning of the several parts to achieve the requisite centering of the armature. In other words, there must be an unusual combination of circumstances to arrive at perfect centering of the armature in Blount, and hence, it is almost always necessary to make a final adjustment.

On the other hand, with applicant's technique, as will be made apparent, there is only the need for reasonably close tolerances on the distances between the confronting pole tips in order to get exact centering of the armature.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

FIG. 1 is a side view in section of a rocking armature transducer illustrative of one embodiment of the present invention.

FIG. 2 is a sectional view taken on the line 2—2 in FIG. 1.

FIG. 3 is an exploded view in perspective illustrating the construction of the magnetic system and the dynamic elements of the transducer.

FIG. 4 is a graph and an accompanying table showing the results of tests of typical microphone assemblies which were fabricated according to the technique of the present invention.

Referring now to the drawings, the electroacoustic transducer shown in FIGS. 1–3 is illustrated in its application as a microphone, and more particularly, as a microphone of the noise-cancelling variety. By noise-cancelling is meant, of course, that type of microphone in which the diaphragm is capable of discriminating against those incoming sound waves from a number of directions, which are typical of ambient noise, while reproducing desired sound.

The transducer illustrated in the figures comprises two basic parts, that is, the electromagnetic system designated **10** and the acoustic device **12**. The acoustic device here is, in the form of a diaphragm **14** which is in a separate enclosure entirely outside the enclosure containing the magnetic or generator elements. The enclosure for the diaphragm **14** comprises front and rear plates **16** and **18** and the diaphragm **14** is clamped at its periphery by these two plates **16** and **18**. The annular sealing ring **20** abuts the periphery of the diaphragm **14** to form a moisture-proof joint between the diaphragm **14** and the plates **16** and **18**.

The enclosure for the diaphragm constituted by the aforesaid plates is of sintered material, preferably of stainless steel or the like. By this construction minute openings are provided for the passage of sound waves so that sound can enter into either the front or rear chamber i.e. chamber **22***a* formed by the upper plate **16** and the diaphragm **14**, or chamber **22***b* is also defined by a separate acoustic damping element **24** having its axis coincident with thet axis of the transducer. The housing constituted by the sintered material also furnishes acoustic resistance to the system. Moreover, the sintered material provided moisture proofing for the transducer. Thus, in spite of the fact that sound waves can enter the chambers **22***a* and **22***b*, the housing is of such a nature that entry of water or other moisture at reasonable pressures will be resisted. The unique feature of having the housing furnish acoustic resistance and also act to prevent moisture penetration forms, per se, no part of the present invention but constiutes a salient feature of the invention disclosed and claimed in copending application Ser. No. 634,573, assigned to the assignee of the present invention.

The plates **16** and **18** are secured together by means of a suitable clamping ring **26** surrounding the plates. The ring **26** includes a web-like portion **26***a* which connects with a horizontal diaphragm seating ring **27**. The seating ring **27** has downwardly projecting flanges **27***a* and **27***b* which meet with the inner surfaces of the casing for the electromagnetic system to provide a tight enclosure. A cap or cover **28** fits over the entire assemblage and has a suitable opening for entry of sound waves. If desired, the cap or cover **28** may be permanently secured to the top of the ring **26** by the use of cement or the like.

Movement between the diaphragm and the armature is transmitted by way of a linkage in the form of a connecting pin or drive rod **30** which is affixed to the center of the diaphragm and typically is attached thereto by means of an epoxy cement or similar material. The drive rod **30** extends through an opening provided by acoustic resistance **24** and beyond that through an opening defined by the inner periphery of the plate **18**, and further through an opening in the magnetic member.

The diaphragm acts upon or conversely is acted upon by an electromagnetic system which is contained within the casing **31** and together with the casing forms the part **10** of the transducer. The electromagnetic system includes a magnetic member in the form of a pair of substantially identical pole pieces **32** and **34** and a permanent bar magnet **36**. Each of the pole pieces **32** and **32**, as illustrated particularly in FIG. 3 includes a pair of pole tips or flanges, **32***a*, **32***b*, and **34***a*, **34***b* respectively. The pole pieces **32** and **34** are, of course, in contact with the permanent magnet means **36** so that a complete magnetic circuit is established. The pole pieces **32** and **34** are spaced in such a way that the pole tips **32***a* and **34***a*, and also **32***b* and **34***b*, are aligned and confront each other so as to form identical air gaps.

The pole pieces **32** and **34** are securely clamped by siutable means against the permanent magnet. One means of so clamping the pole pieces would be by means of bolts (not shown) fitted in the permanent magnet. Extending between the pole tips is a magnetic armature **38** having its ends located in the air gaps between the pairs of confronting pole tips **32***a*, **34***a*, and **32***b*, **34***b*, so as, in effect, to define with these pole tips four separate air gaps. The armature **38** is pivotally mounted at its center in a spring support **40**. Preferably the armature **38** passes through a slot **42** in the support **40** and is secured therein by means of solder. The support **40** is typically constituted of bronze material and the ends of armature support **40** are fitted within slots **43** in brackets **44**. The ends are clamped in these slots, in accordance with the basic feature of the present invention. The brackets **44** are affixed to the pole piece **32** by any suitable means. Preferably, these brackets are formed in integral fashion as part of the pole piece **32**.

The drive rod **30** which extends down into the magnetic member has its lower end secured to the armature **38**, illustratively at a position which is ¼ of the distance from the left end of the armature as seen in FIG. 1. It will be appreciated that the location of the drive rod can be varied and that it is not essential to the concept of the present invention that the position shown in FIG. 1 be selected. Alternatively, for example, the end of the drive rod **30** could be fastened to the end of the armature **38** and the same essential operation would be obtainable.

The armature **38** is entirely surrounded at one point by a coil **46** carried by an insulating form or bobbin. This coil may be held in place by the use of cement or the like. Here, again, although a single coil is depicted in the drawing it will be understood that a number of coils can be provided to surround the armature. The conductors **48** establish electrical connection to the coil **46** and these conductors are taken out through a suitable opening provided at the bottom of the casing.

The technique in accordance with the present invention is particularly directed to the clamping of the ends of the armature support **40** in the slots **43** formed in the brackets **44**. Such clamping is achieved without strain and is carried out during the assembling of the several parts of the transducer. Thus, the magnetic pole piece **32** is affixed relative to the seating ring **27** and is secured thereto by any suitable means. The pole piece **32** is usually so fabricated that the brackets **44** are formed as an integral part thereof. The armature support **40** holds the armature **38** within its slot **42**. The armature and its support are brought up to the pole piece **32** and, in an inverted position from that shown in FIG. 1, gap-defining means in the form of shims **50**, shown dotted in FIG. 1, are placed against the ends of the pole tips **32***a* and **32***b*. Epoxy cement is flowed into the slots **43** in the brackets **44**, and the ends of the support **40** are embedded in the quantity of epoxy cement **45** contained within slots **43**. The ends of the armature **38** are brought just up to contact the shims **50**. After the epoxy cement has cured, the shims **50** are removed. As a consequence the air gaps are precisely defined and the armature is centered and precisely fixed in its final position. It remains only to bring the other pole piece **34** into proper position so that its pole tips **34***a* and **34***b* are aligned and confront their respective opposite pole tips **32***a* and **32***b*.

The above-described clamping technique may, of course, be carried out with a number of different assembling operations as desired. Generally, however, it is preferable that the electromagnetic system be assembled before the acoustic device **12** is connected therewith.

Although the present invention is not limited to the following detailed set of specifications, these are provided herewith in order to give one versed in the art a handy guide and prescription for practicing the concept and technique of the present invention. As one example, the diaphragm is formed of an aluminum-Mylar laminate and is approximately .600 inch in diameter. The permanent bar magnet **36** is of Alnico VIII. The pole pieces **32** and **34** are ferro-nickel alloy (50% nickel) and the armature **38** is constituted of ferro-nickel alloy (80% nickel). The armature spring support **40** is of beryllium copper and the drive rod **30** is of the same material. The armature **38** is soldered at the slot **42** to the support **40**. As noted in the previous description, the drive rod **30** is solder-attached to the armature **38** and is attached by epoxy cement to the diaphragm **14**.

The epoxy cement used for the herein described purposes has a composition as prepared by the Marblette Corp. It is termed Maraset Epoxy Resin #617A with hardener #617C. Essentially it is an epoxy resin system possessing a very high heat resistance of 450° F. (Heat Distortion Point 380° F.).

Typical dimensions for some of the components are as follows: The armature **38** is .200 inch long by .007 inch wide by .010 inch thick; the air gaps are .004 inch to .005 inch long.

The test results which follow illustrate the effectiveness of the aforedescribed epoxy clamping feature.

Several transducer assemblies with epoxy-clamped armature support springs were fabricated with slots which were .015 inch wide. Better results were obtained using suspension brackets with slots which were .030 inch wide. Superimposed DC tests made on these assemblies showed excellent centering of the armature in the air gaps.

It is possible to compute and plot curves showing the resonant frequency vs. stiffness relationships pertaining to static stiffness, system stiffness and negative stiffness from experimental data of the type taken. As a practical test of the effectiveness of the epoxy clamping, 20 microphone assemblies were adjusted to have a resonant frequency of approximately 1500 c.p.s. The curves which were obtained for the 20 assemblies are shown in FIG. 4, along with an accompanying table which is a summary of the superimposed DC characteristics of these assemblies.

The data shown in FIG. 4 were taken during the assembly of the microphones before the front resistance (i.e. the plate **16**) was in place. There was also some variation in the acoustic resistance used behind the diaphragm. These characteristics were taken with the microphones operating as receivers on a 2 cc. coupler.

It is apparent that the characteristics of FIG. 4 do not have the ideal flat tops desired. This is caused by the Hy Mu "80" armature material which saturates at low DC flux densities. It does, however, have very high AC permeability and is used for this reason. The "spikes" in the curves are caused by the combination of these magnetic characteristics. They are somewhat damped when the transducer has its acoustic circuits completed.

As shown on the summary table in FIG. 4, the resonant frequency range is 1523 c.p.s. average, plus 1.8%, minus 2.2%; and the average width of the superimposed DC flat top is .122 amp, plus 35%, minus 26%. This somewhat large range in width represents the summation of all the dimensional variations in the parts which control the system stiffness, and it is also a function of the quality of the materials which form the magnetic circuit.

The parameter of most interest in the amount of eccentricity of the flat top center line with respect to the zero superimposed axis.

A convenient way of showing this is to express the eccentricity as a percentage of the total width, which means that the output from the transducer will rapidly increase when the eccentricity is greater than 50%. To insure that all transducers maintain their maximum output under all the environmental conditions to which they might be subjected, it is desirable to set a limit on this eccentricity to a value below the 50% value. Referring to the curves of FIG. 4, it is regarded as reasonable to set this limit at 30%.

The average percentage eccentricity for the group of 20 transducers as shown in the table of FIG. 4 is 14.4%. Setting a 30% limit on the percentage eccentricity results in a 17% rejection rate for the transducers measured. These experiments, therefore, indicate that the epoxy method of clamping the ends of the armature support spring would result in making approximately 80% of the transducers acceptable. This result is substantially better than the results that would be obtained by complete dependence on dimensional tolerances. B ysuitable mechanical adjustment those transducers which fall outside of the acceptable limit can be brought within this limit.

Accordingly it will be appreciated that the technique of the present invention eliminates the normal strains imposed upon the armature or its spring support when these elements have been set into their unstrained position, precise enough centering of the armature is achieved so that the yield of acceptable transducers is exceptionally high.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to the preferred embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. An electroacoustic transducer comprising a magnetic member having confronting pole tips defining an air gap, a permanent magnet associated with said magnetic member, an armature extending into said air gap, an elongated spring support for said armature having its ends fitted in slots in mounting brackets, said ends being held in said brackets by epoxy cement.

2. A device as defined in claim **1** wherein said magnetic member comprises pairs of pole tips, each pair defining a separate air gap, the ends of said armature extending into said respective air gaps.

3. A device as defined in claim **1** wherein said armature support comprises a thin spring having a slot for engaging said armature, said support being disposed at right angles to the longitudinal axis of said armature.

4. A device as defined in claim **3** further comprising a drive rod affixed adjacent one end of said armature, a coil disposed along the length of said armature and completely surrounding same.

5. A rocking armature transducer comprising a magnetic member having two pairs of confronting pole tips, each pair defining an air gap; a magnetic armature having its respective ends extending into said air gaps; means for pivotally mounting said armature at its center, said means including a pair of brackets and an elongated spring support for said armature secured within slots in said brackets; and means contained within the slots in said brackets for clamping the ends of said armature support to center the ends of said armature at the time of assembling said transducer.

6. The rocking armature transducer as defined in claim **5** wherein the means contained within the slots in said brackets consists of epoxy cement.

7. The device as defined in claim **6** wherein said armature support comprises a thin spring having a slot therein for engaging said armature, said support having its ends clamped in said brackets so that said support is disposed at right angles to the longitudinal axis of said armature.

8. The device as defined in claim **7** further comprising a drive rod affixed adjacent one end of said armature, and a coil disposed along the length of said armature and completely surrounding same.

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U.S. Cl. X.R.

179—114