July 9, 1935. L. J. ANDERSON 2,007,749

ACOUSTIC APPARATUS

Filed Dec. 6, 1933

Fig. 1

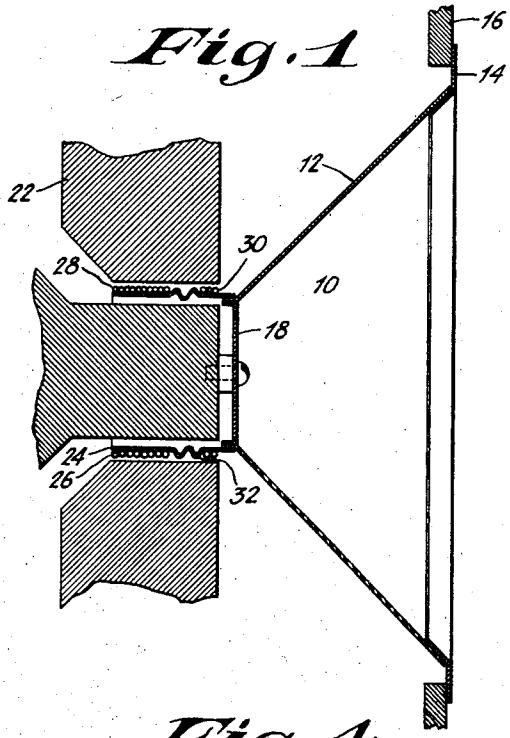


Fig. 2

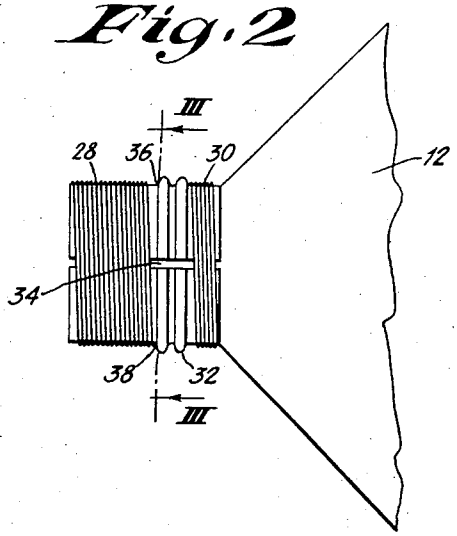


Fig. 4

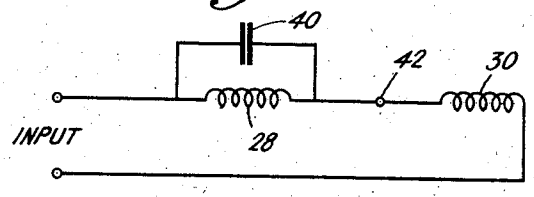


Fig. 3

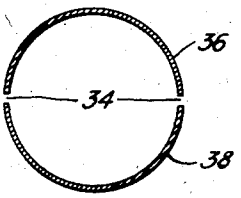


Fig. 5

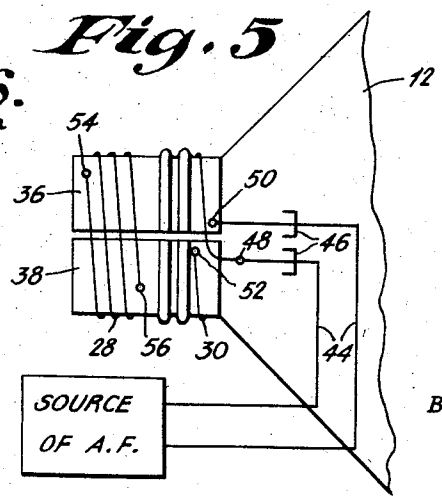


Fig. 6.

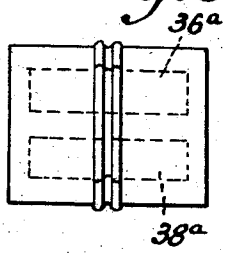
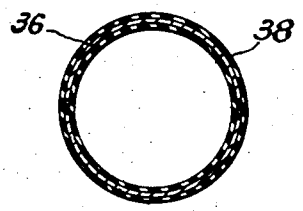


Fig. 3.a



INVENTOR
LESLIE J. ANDERSON

BY H. S. Sawyer
ATTORNEY

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ACOUSTIC APPARATUS

Leslie J. Anderson, Westmont, N. J., assignor to Radio Corporation of America, New York, N. Y., a corporation of Delaware

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16 Claims. (Cl. 179—115.5)

This invention relates to acoustic apparatus. More particularly, it relates to the electrodynamic or moving coil type of acoustic apparatus in which the moving coil is divided into a plurality of windings adapted to be energized by different bands of frequencies within the audible spectrum.

In the copending applications of Abraham S. Ringel S. N. 661,237 filed March 17 1933 and Harry F. Olson S. N. 673,823 filed June 1, 1933, electrodynamic acoustic apparatus is disclosed in which the moving coil is divided into a plurality of sections adapted to be energized at different frequencies. When the moving coil is divided into only two sections, one section is adapted to be energized at high frequencies and the other section is adapted to be energized at low frequencies or, in some instances, one winding only is energized at high frequencies and both windings are energized at low frequencies. The two windings are arranged on the voice coil form with the high frequency winding adjacent the diaphragm and the low frequency winding spaced therefrom by compliant coupling means. The coupling means is adjusted so as to be relatively flexible at high frequencies and relatively rigid at low frequencies. Leads from the low frequency winding extend over the compliant coupling to the high frequency section.

It is found that in some instances breakage occurs in the leads extending over the compliant coupling due to the relative movement between the high frequency winding and the low frequency winding. This is most noticeable when the connections cross the compliant coupling either over it, under it or through slots cut in the coupling in a direction longitudinal of the coil form. This difficulty has been overcome to some extent as shown in the aforementioned Olson application, by arranging the connecting conductors so that they cross the compliant coupling at an angle thereto. However, this arrangement has not proved entirely satisfactory.

It is the object of this invention to provide conductors for supplying energy to the winding spaced from the diaphragm by the compliant coupling, which will not break when the two windings of the voice coil are vibrated relatively to each other, and which will function satisfactorily as electrical conductors as long as the remainder of the vibratile system remains in operative condition. This object is attained by using conducting material for the compliant coupling and by dividing the compliant coupling into a plurality of longitudinally extending sections, electrically isolated or insulated from each other, and by connecting the terminals of the winding spaced from the diaphragm by the compliant coupling to different sections of the coupling member and using each section as a conductor. The longitudinal sections of the conducting member are connected at other points to the circuit for energizing the winding.

The broad idea of the invention is also adaptable to other uses as will be set forth more clearly in the following specification and appended claims. More specific objects of the invention will also become apparent upon reading the specification and claims.

The invention is illustrated in one of its modifications in the accompanying drawing in which,

Fig. 1 is a cross sectional view of the vibratile system of an electrodynamic loudspeaker of the double voice coil type,

Fig. 2 is a detailed view illustrating how the invention is applied to the loudspeaker,

Fig. 3 is a sectional view on the line III—III of Fig. 2,

Fig. 3*a* is a sectional view of a modification of the device shown in Fig. 3.

Fig. 4 is a circuit illustrating an approved form of the connections for the voice coil windings of Fig. 2, and

Fig. 5 illustrates the manner in which the windings of Fig. 2 are connected to the source of energy.

Fig. 6 is a plan view of a modification of the coil form shown in Figs. 2 and 5.

In the apparatus illustrated by Fig. 1 the vibratile system of the loudspeaker is indicated generally at **10**. It consists of the diaphragm **12** and the driving coil attached thereto. The diaphragm is frusto-conical in shape and is supported at both bases by suitable supporting members. The larger base of the diaphragm **12** is supported, for example, by means of an annular rim of flexible material **14** secured to a suitable supporting member **16**. The smaller base of the diaphragm is supported by a spider member **18** in the manner well known in the art. The spider member **18** may either be secured to the inner pole piece **20** of the magnet system as shown in Fig. 1 or it may extend externally of the diaphragm and be secured to the outer pole piece **22**. A coil form **24** having a voice coil **26** wound thereon is secured to the smaller base of the diaphragm. The coil form is secured to the diaphragm in such a manner that the voice coil **26** extends within the air gap between the central and outer pole pieces **20** and **22**. When the coil **26** is energized with audio frequency variations the flow of current

through the coil causes movement thereof and consequently of the diaphragm 12 in the manner well known in the prior art.

In accordance with the aforementioned Ringel and Olson inventions, the voice coil 26 is divided into two windings 28 and 30. These windings are separated from each other by a compliant coupling 32 formed in the coil form 24. The compliant coupling is preferably formed by providing annular corrugations in the coil form. The winding 30 comprises the high frequency winding of the voice coil and the winding 28 comprises the low frequency winding. Means are provided for energizing only the winding 30 at high frequencies and for energizing either the entire coil i. e., both the winding 28 and the winding 30, at low frequencies or else energizing only the winding 28 at low frequencies. The compliant coupling 32 is quasi-flexible, the degree of flexibility being relatively high at high frequencies and relatively low at low frequencies. Thus, at high frequencies the winding 28 does not move to an appreciable extent due to the aforesaid connection between winding 28 and winding 30 and at low frequencies when the winding 26 is energized and the compliant coupling is comparatively rigid, both windings move together as a unit. As a result of this arrangement the effective mass of the driving coil is materially reduced at high frequencies due to the fact that there is substantially no vibration of the winding 28 and the section of the voice coil form on which it is wound.

In double voice coil loudspeakers of the type hereinbefore described, it is desirable to have the leads for supplying energy to the different windings extend to the external circuit from some point between the diaphragm 12 and the outer pole piece 22. In some instances it is desirable to have the leads secured to the diaphragm 12 or to the coil form 24, in the neighborhood of the junction between the diaphragm and the coil form.

Some difficulty has been experienced due to breakage of the leads extending to the winding 28. This is due to the fact that there is relative movement between the winding 28 and the winding 30 or the part of the diaphragm where the leads are usually secured. This relative movement produces repeated bending of the wires forming the leads and eventually causes them to break. This difficulty is overcome according to the present invention, by making the compliant coupling member from conducting material, dividing the coupling member into longitudinal sections separated and electrically insulated from each other, and by connecting the terminals of the winding 28 to these sections. The ends of the sections adjacent the diaphragm are then connected in the circuit which supplies energy to the winding.

Figs. 2 and 3 illustrate an approved form of the invention. The diaphragm 12 has a coil form secured thereto in the usual manner but in this instance the coil form is formed of conducting material and is divided by two longitudinal cuts or slots 34 into two semi-cylindrical sections 36 and 38. The coil form has windings 28 and 30 arranged thereon just as in the apparatus of Fig. 1 and it is provided with annular corrugations forming a compliant coupling 32 just as in the apparatus of Fig. 1. One terminal of winding 28 is connected to the semi-cylindrical section 36 and the other terminal of the winding 28 is connected to the semi-cylindrical section 38. Suitable connections are made to the sections 36 and 38 at the ends thereof adjacent their connection with the diaphragm 12, for supplying energy to the winding 28.

When the entire coil form is composed of conducting material it is usually desirable to provide some sort of means for retaining the two semi-cylindrical portions in their relative positions. This may be accomplished by providing small cylinders of non-conducting material adapted to fit either inside or outside of the coil form. The semi-cylindrical sections may also be retained in place by placing the two sections on a suitable form, winding the windings 28 and 30 about the sections and then applying lacquer or any other suitable substance to the windings and voice coil sections so as to unite winding 28 and its associated parts of sections 36 and 38, and winding 30 and its associated parts of sections 36 and 38 into two substantially rigid sections with the compliant coupling 32 interposed therebetween. The lacquer or other cementing substance will have the additional property of electrically insulating the sections 36 and 38 from each other and from other parts of the system. It is especially desirable, for example, to have sections 36 and 38 sufficiently coated with insulating material so that they will not rub against either the inner or outer pole pieces 20 and 22 and thereby short circuit the winding 28.

Figure 3*a* is a cross sectional view illustrating how the insulating material may be applied to the inner and outer surfaces of members 36 and 38, and also in the spaces between the sections.

It is not necessary to form the entire coil form of conducting material as the compliant coupling 32 may be made of a different material from that of the cylindrical coil form sections supporting windings 28 and 30. For example, windings 28 and 30 may each be supported by a cylindrical member of paper or other suitable material and the members may be joined by a metallic compliant coupling member 32. The compliant coupling member may then be cut by longitudinal slots into two semi-cylindrical portions in the same manner as illustrated in Figs. 2 and 3. In still another arrangement the entire coil form may be made of some insulating material and provided with a conductive coating or a layer of conducting material divided into sections by longitudinal cuts or slots or separations of any kind. The conductors may also be formed by imbedding longitudinal strips of conducting material 36*a* and 38*a* in a coil form of insulating material, as shown in Fig. 6.

While I have shown the compliant coupling member 32 as being divided into two semi-cylindrical sections 36 and 38, it is to be understood that the sections need not be semi-cylindrical but may be of any form or shape as long as two longitudinally extending conductors are formed thereby. For example, the slots 34 might extend helically or diagonally along the coil form. Moreover, in some instances such as where the voice coil is divided into three sections i. e., a high frequency section, an intermediate section and a low frequency section, the coil form or compliant coupling is divided into sufficient sections to provide a conducting member for each of the voice coil windings which is spaced from the diaphragm by a compliant coupling. Even if the voice coil is only separated into two sections i. e., a high frequency section and a low frequency section, it might be desirable to provide a second compliant coupling between the high frequency section and the diaphragm and it might also be desirable

to secure the voice coil leads to the diaphragm. With this arrangement the voice coil form and the compliant coupling members are divided into a number of sections depending on the number of external leads that are required by the specific circuit arrangements used to supply energy to the windings.

Fig. 4 illustrates one of the circuit arrangements for energizing the windings 28 and 30. According to this circuit arrangement windings 28 and 30 are connected in series and winding 28 is shunted by a suitable high frequency by-pass condenser 40. In this arrangement high frequencies are by-passed around winding 28 thus causing winding 30 to be the only winding to respond to high frequencies. On the other hand low frequencies pass through both windings and cause both windings to respond thereto. It will be seen that a point 42 is connected to one terminal on winding 28 and one terminal on winding 30. The windings are supplied with energy from any source such as the output of a radio receiver. The energy is supplied at the two terminals marked Input in Fig. 4.

Fig. 5 shows how the terminals of windings 28 and 30 are connected to the sections 36 and 38 when the windings are connected in a circuit corresponding to that of Fig. 4. The leads for supplying energy from an external source are indicated at 44. The leads are secured by any suitable means such as staples 46 to the diaphragm 12.

One of the leads 44 is connected at 48 to one terminal of the high frequency winding 30 and the other lead is connected as at 50 to section 36 of the coil form. The other terminal of winding 30 is connected as at 52 to section 38 of the coil form. The terminals of coil 28 are connected respectively to sections 36 and 38 of the coil form, one terminal being connected to 36 as indicated at 54 and the other section being connected to section 38 as indicated at 56.

The flow of current through the two windings 28 and 30 is as follows: from the source of audio-frequency through one of the leads 44 to point 50; through the conductive coil form section 36 to point 54; through the low frequency winding 28 to point 56 on the conductive coil form 38; through the conductive coil form section 38 to point 52; through the low frequency winding 30 to point 48; and back through the other lead 44. The conductive section 38 and the two terminals 52 and 56 correspond to point 42 in the circuit of Fig. 4.

It is to be understood that the windings 28 and 30 need not be connected in the exact manner shown in Fig. 4 but that they may be connected in any other suitable circuit arrangement such, for example, as any of those shown in the aforementioned Ringel and Olson applications.

Although no connections are shown in Fig. 5 for connecting the condenser 40 across the low frequency winding 28, it is obvious that the condenser may be connected in the circuit merely by connecting its terminals to the conductive coil form sections 36 and 38. Moreover, in some instances it is not necessary to connect a condenser across these two sections as the cuts 34 may be made of such a size that the two sections 36 and 38 constitute the two plates of the condenser having the desired capacity. In general, however, it is more desirable to connect a condenser across the coil form sections 36 and 38 and to make the cuts 34 sufficiently wide so that the capacitive effect between the two sections is negligible. It is also possible to use the capacitive effect between sections 36 and 38 and the pole pieces 20 and 22.

It is to be understood that the apparatus specifically described and illustrated herein is only one modification of apparatus embodying the invention and that various other modifications and arrangements may be made without departing from the spirit of the invention which is to be limited only by the scope of the appended claims.

What I claim is:

1. A vibratile system for electrodynamic acoustic apparatus comprising a voice coil consisting of a pair of windings, a coil form on which the windings are disposed, a compliant coupling in said coil form separating the portions thereof on which said windings are disposed, said compliant couplings being formed of conducting material and divided into sections, and electrical connections between said sections and the terminals of one of said windings whereby said sections constitute leads for supplying energy to the winding.

2. Electro-dynamic acoustic apparatus comprising a diaphragm, a voice coil for actuating said diaphragm, a coil form on which said voice coil is disposed, said voice coil being divided into a plurality of windings, compliant coupling means dividing said coil form into sections corresponding in number to the number of said windings, said compliant coupling means being of conducting material and divided into sections electrically insulated from each other, and connections from the terminals of certain of said windings to sections of said compliant coupling means whereby the sections constitute conductors for supplying energy to said windings.

3. Electrodynamic acoustic apparatus comprising a diaphragm, a coil form connected to said diaphragm, compliant coupling means dividing said coil form into portions, said compliant coupling means being separated into sections, a voice coil winding disposed on each of the coil form portions, conductive connections for supplying energy to each of the windings, and means for completing the conductive connections to certain of said windings through sections of said compliant coupling means.

4. Electrodynamic acoustic apparatus comprising a diaphragm, a voice coil form secured thereto, a compliant coupling dividing said voice coil form into a pair of cylindrical sections, said coupling being of conducting material and separated into a pair of sections electrically insulated from each other, a high frequency voice coil winding on the section of said voice coil form adjacent the diaphragm, a low frequency winding on the section of said voice coil form spaced from said diaphragm by the high frequency section and the compliant coupling, and connections between the terminals of said low frequency voice coil and the sections of said compliant coupling, whereby said compliant coupling constitutes conducting means for supplying energy to said low frequency winding.

5. An electrodynamic loudspeaker comprising a diaphragm, a voice coil form secured to said diaphragm, said voice coil form comprising two semi-cylindrical members of conducting material electrically separated from each other, a voice coil on said coil form, connections between terminals of said voice coil and said semi-cylindrical members, and other connections to said semi-cylindrical members for supplying energy thereto to energize said voice coil.

6. Electrodynamic acoustic apparatus compris-

ing a diaphragm, a voice coil form secured thereto, said voice coil form comprising a cylindrical metallic member divided longitudinally into two parts electrically isolated from each other, compliant means extending circumferentially about said voice coil form to divide said form into two cylindrical sections one adjacent said diaphragm and the other spaced therefrom, a voice coil winding on each of said cylindrical sections, connections between the terminals of the voice coil winding on the section spaced from the diaphragm and the sections of said voice coil form electrically isolated from each other whereby said sections comprise conductors for supplying energy to said winding, a second connection to one of said sections from an external circuit, a second connection to the other section from one of the terminals of the winding on the cylindrical section of the voice coil form adjacent the diaphragm, and a connection from the other terminal of the winding on the cylindrical section of the coil form adjacent the diaphragm to said external circuit.

7. Electrodynamic acoustic apparatus comprising a diaphragm, a coil form secured to said diaphragm, a compliant coupling dividing said form into two parts, a winding on each part, and layers of conducting material extending from one side of said coupling to the other, said layers of conducting material being insulated from each other and connected respectively to the terminals of said winding.

8. Electrodynamic acoustic apparatus comprising a diaphragm, a coil form secured to said diaphragm, a compliant coupling dividing said form into two parts, a winding on each part, and conductors imbedded in said coil form and extending from one side of said coupling to the other, and electrical connections between said conductors and the terminals of one of said windings.

9. A vibratile system for electrodynamic acoustic apparatus comprising a voice coil consisting of a plurality of windings, a coil form on which the windings are disposed, compliant coupling means in said coil form separating the portions thereof on which said windings are disposed, said compliant coupling means including electrical conducting material and being divided into sections connected to the terminals of certain of said windings to function as leads for supplying energy thereto.

10. Electrodynamic acoustic apparatus comprising a diaphragm, a voice coil for actuating said diaphragm, a coil form on which said voice coil is disposed, said voice coil being divided into a plurality of windings, compliant coupling means dividing said coil form into sections corresponding in number to the number of said windings, said compliant coupling means including a layer of conducting material divided into sections electrically insulated from each other, and connections from the terminals of certain of said windings to the sections of said layer of conducting material whereby said sections constitute conductors for supplying energy to said windings.

11. Electrodynamic acoustic apparatus comprising a diaphragm, a coil form connected to said diaphragm, compliant coupling means dividing said coil form into sections, a voice coil winding disposed on each of said sections, means forming a plurality of electrical conductive paths through said compliant coupling means, conductive connections for supplying energy to each of said sections, the conductive connections to certain of said windings being completed through the conductive paths through said compliant coupling means.

12. Electrodynamic apparatus comprising a diaphragm, a voice coil form secured thereto, a compliant coupling dividing said voice coil form into a pair of sections one adjacent the diaphragm and the other spaced therefrom by the coupling, said coil form and coupling including a layer of conducting material divided into a pair of longitudinal sections electrically insulated from each other, a high frequency voice coil winding on the section of said voice coil form adjacent the diaphragm, a low frequency winding on the section of said voice coil form spaced from the diaphragm, and connections between the terminals of said low frequency voice coil and the conducting layer of the sections of said compliant coupling for supplying energy to said low frequency winding.

13. Acoustic apparatus comprising a diaphragm, a voice coil winding for actuating said diaphragm, a voice coil form secured to said diaphragm and having said winding arranged thereon, said voice coil form including two conductive members insulated from each other and extending longitudinally of the coil form, a compliant coupling in said coil form between said winding and said diaphragm, connections from the terminals of said winding to said conductive members, and connections for supplying energy from an external circuit to said conductive members.

14. Electrodynamic acoustic apparatus comprising a diaphragm, a coil form secured to said diaphragm, said coil form consisting of a pair of longitudnial extending conductive members, a pair of windings on said coil form, connections between the terminals of one of said windings and said conductive members, means for preventing short circuiting of said conductive members, and a lead from at least one of said conductive members to an external circuit.

15. An electrodynamic loudspeaker comprising a diaphragm, a voice coil form secured to said diaphragm, said voice coil form comprising two semi-cylindrical members of conducting material electrically separated from each other, a compliant coupling circumferentially dividing said coil form into two sections, a voice coil winding on each section, connections between terminals of one of said voice coil windings and said semi-cylindrical members, and other connections to said semi-cylindrical members for supplying energy thereto to energize said voice coil.

16. Electrodynamic acoustic apparatus comprising a diaphragm, a voice coil form secured thereto, said voice coil form comprising a cylindrical metallic member divided longitudinally into parts electrically isolated from each other, compliant means extending circumferentially about said voice coil form to divide said form into cylindrical sections, a voice coil winding on each of said cylindrical sections, connections between the terminals of at least one of the voice coil windings and sections of said voice coil form electrically isolated from each other whereby said sections comprise conductors for supplying energy to said winding, a second connection to one of said sections from an external circuit, and other connections between said windings and said sections for completing the circuits for supplying energy to said windings.

LESLIE J. ANDERSON