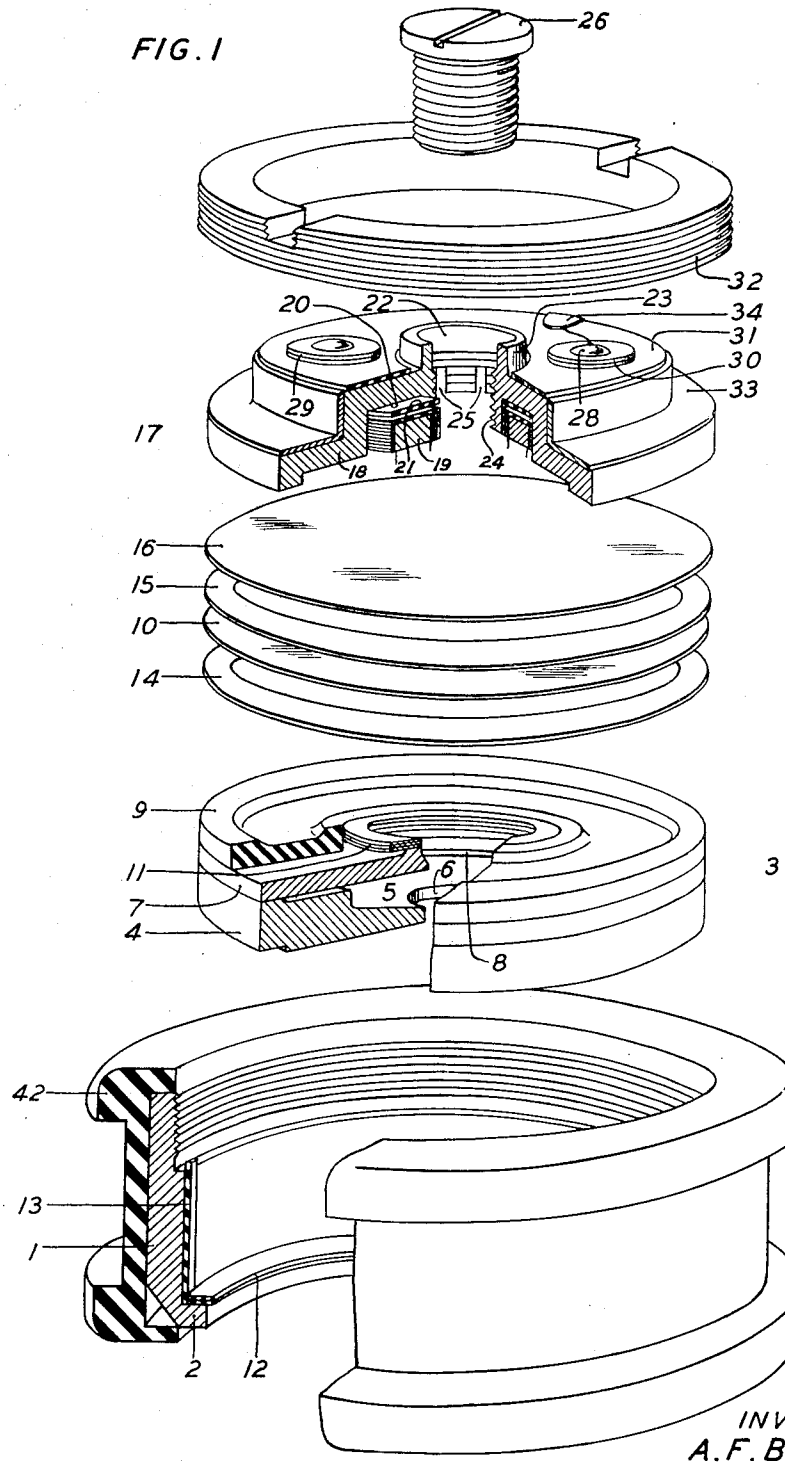
March 27, 1934. A. F. BENNETT 1,952,577

MECHANICAL AMPLIFIER

Filed Feb. 27, 1931 2 Sheets-Sheet 1

FIG. 1



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Filed Feb. 27, 1931 2 Sheets-Sheet 2

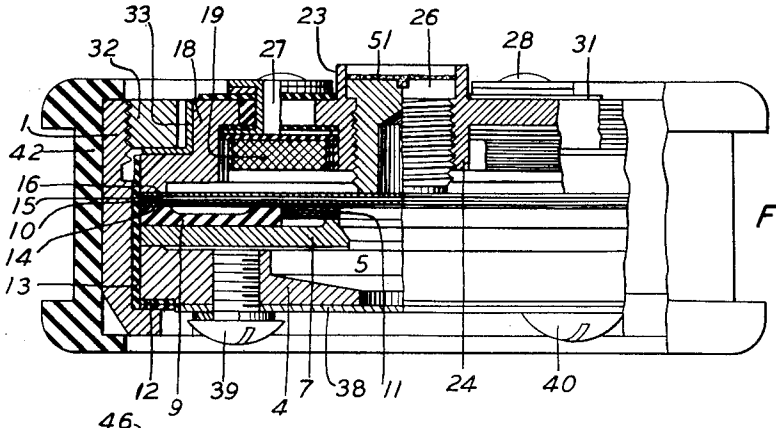

FIG. 2

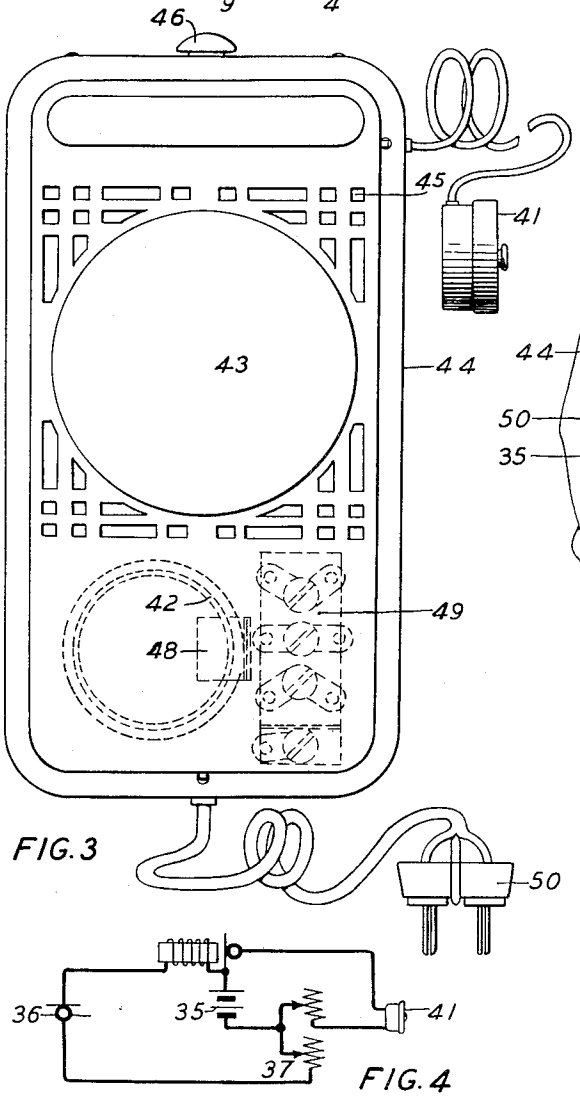

FIG. 3

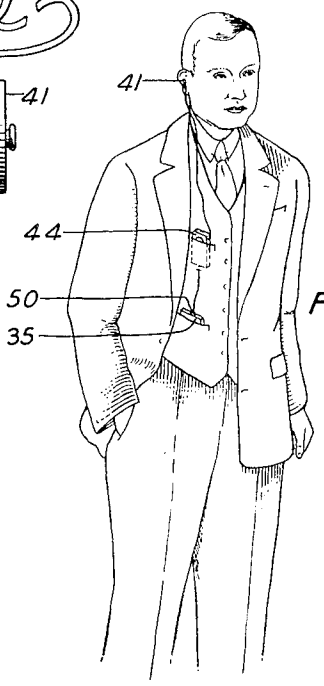

FIG. 5

FIG. 4

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UNITED STATES PATENT OFFICE

1,952,577

MECHANICAL AMPLIFIER

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Application February 27, 1931, Serial No. 518,693

3 Claims. (Cl. 179—171)

This invention relates to mechanical amplifiers comprising a microphone operated by an electromagnet and more particularly to amplifiers of this type which are suitable for use in portable apparatus such as audiphones.

It is the object of the invention to improve the construction and operation of these devices.

An amplifier of this kind for use in an audiphone which is to be worn on the person of the user should, of course, be very small and light in weight to avoid being burdensome. It should be capable of responding fairly uniformly at high efficiency to all important speech frequencies and it should function properly under all conditions of use without requiring frequent attention. Various difficulties are encountered, however, when it is attempted to devise a structure which meets all of these requirements. The smaller the device is made the more difficult it becomes to obtain the desired output for, if such small instruments are worked at too high an energy level, they tend to become unstable and unreliable. In many previous structures it has been found that the direct current through the receiver winding displaces the diaphragm to such an extent that when the circuit is broken and the diaphragm is suddenly released, its movement in returning to normal position packs the carbon in the chamber of the microphone and materially reduces the efficiency of the instrument. Other difficulties in the nature of noisy operation have been experienced, due in some cases, to the actuation of the microphone amplifier by vibrations transferred directly to it from the air and in others to noise originating in the microphone amplifier itself, such as carbon noise.

In the present invention these various difficulties have been overcome by a novel arrangement of parts and by the use of features of construction heretofore not found in devices of this kind. According to the preferred embodiment of the invention, packing of the carbon when the circuit is broken is prevented by the use of closely spaced but separate diaphragms for the receiver and transmitter units of the amplifier, the transmitter being driven entirely by the acoustic coupling between the diaphragms. A carbon chamber of special configuration reduces the load on the diaphragm by confining the contact of the carbon with the diaphragm to a small area near its center and improves the contact in this area by providing a head of inactive particles for maintaining a pressure on the active particles. The opening in the chamber opposite the diaphragm is tapered to prevent packing when the amplifier is subjected to an abnormally high input. An adjustable pole piece in the receiver permits the receiver air gap to be fixed at the optimum value after assembly and a ring of resilient material, such as rubber, renders the microphone insensitive to extraneous disturbances.

These and other features of the invention will be more clearly understood from a study of the following detailed description of the invention in connection with the accompanying drawings in which:—

Fig. 1 is a disassembled view of the amplifier;

Fig. 2 is an assembly view partly in section;

Fig. 3 shows one form of an audiphone incorporating the amplifier of this invention;

Fig. 4 is a circuit showing one way in which the amplifier may be connected with the other parts of an audiphone; and

Fig. 5 shows how such an audiphone may be conveniently carried on the person.

Referring now particularly to Figs. 1 and 2 the various component parts of the amplifier to be described below are contained within a brass housing member 1, which has a projecting shoulder 2 for supporting the transmitter assembly 3. The brass member 4 has a recess 5, which constitutes the carbon chamber of the transmitter, and a central hole 6 for receiving the nozzle of the filling machine. The annular brass member 7 having a central opening 8 of a diameter somewhat less than half the diameter of the carbon chamber forms a partial closure for the chamber and confines the contact of the carbon to the central portion of the diaphragm as already explained. Above this member there is an annular piece of ceramic material 9 which insulates the transmitter diaphragm 10 from the structure of the chamber and also holds in position the book damping 11 which suitably dampens the vibrations of the diaphragm and also prevents the carbon from lodging between the diaphragm and the insulating member 9. This form of damping is fully disclosed in Patent 1,583,416 to C. R. Moore, May 4, 1926. The transmitter unit 3 is suitably insulated from the housing member 1 by fibre washers 12 and a strip of fibre 13. A metallic washer 14 of the order of one mil in thickness separates the non-magnetic diaphragm 10 from the ceramic member 9 and a similar washer 15 holds the magnetic diaphragm 16 in the proper spaced relation with respect to the diaphragm 10 for the desired acoustic coupling between the receiver unit 17 and the transmitter unit 3.

In the receiver unit, the magnetic member 18 and the diaphragm 16 are both preferably of permalloy so that the maximum flux may be obtained with the low magnetizing forces available. The receiver winding 19 is preferably in the form of a flat coil of about 300 turns of number 38 wire and occupies a recess 20 in the magnetic member 18 from which it is insulated by phenol fibre strips 21. This member has a central hole 22, an upwardly extending flange 23 and a downwardly extending threaded flange 24 containing a number of slots 25. The magnetic plug 26 which is also preferably of permalloy is hollowed out in the center as indicated to improve the distribution of the flux and prevent saturation in the central portion of the diaphragm. The plug threads into the opening 22 and is suitably held in any desired position by the pressure of the several parts of the slotted flange 24 which have been previously bent slightly inwardly. The adjustment of the air gap between the plug and the diaphragm for maximum efficiency within the practical limits of operation is rather critical, hence, it is desirable, after the correct position has been finally determined, that the plug be sealed in place by a little cement 51.

The ends of the coil 19 are brought up through the member 18 in holes 27 and 28 containing brass eyelets 29 and 30 which also hold in place the insulating washer 31. A brass member 33 of angular cross-section fits over the outer portion of the magnetic member 18 to form a seat for the clamping ring 32 which holds the whole assembly in the casing 1. The washer 33 has a tongue 34 projecting above the washer 31 to receive a wire connecting it with the coil lead brought out through the hole 28. In this manner a metallic connection is made between one side of the receiver winding and the magnetic diaphragm 16 as indicated in Fig. 5 and from this point a connection is made to the common battery 35 (Fig. 4) which supplies current to the pick-up transmitter 36, the earphone 41 and the amplifier unit just described.

The operation of this amplifier is in many respects similar to that of other previous devices of this general nature, that is to say, current variations of any kind such as those originating in the sound pick-up transmitter 36 may be conducted to the coil 19 of the receiver unit which is associated with the battery 35 as already explained and with a controlling rheostat 37. These current variations in the coil 19 will set up a flux in the magnetic path made up of the member 18, the central pole piece 26 and the magnetic diaphragm 16 and the diaphragm will be vibrated in accordance with the original sound in the usual manner. Since the current circulating in the winding 19 is of the nature of a direct current modulated by alternating the variations, the diaphragm 16 will tend to take a slightly bowed position depending upon the value of the steady component of the current. In devices of the prior art in which this diaphragm served also as the diaphragm of the transmitter unit, it will be evident that this bowing effect varies the resistance of the carbon in the transmitter by an amount depending upon the magnitude of the steady current and that whenever the current is interrupted packing of the carbon will occur due to the return of the diaphragm to a plane position as explained above. The movement of the diaphragm in returning to normal is undoubtedly of the nature of a mechanical transient oscillation but the exact nature of such an oscillation is not fully understood. Experience indicates, however, that when only a single diaphragm is used in an amplifier of this kind packing occurs to such an extent as to render the device impractical but that two diaphragms acoustically coupled as shown give very satisfactory results. With a very small spacing of the diaphragms such as one or two thousandths of an inch the coupling is probably due, at least in part, to the viscous resistance of the air to lateral displacement. Larger spacings such as up to 20 mils have also been found quite satisfactory but in this case the coupling is undoubtedly due principally to the elastic reactance of the confined air. While no air leakage for the confined air has been intentionally provided in the device shown, slow leakage occurs due to the use of a porous carbon diaphragm in the transmitter. Hence, when the receiver diaphragm is bowed by the polarizing current some movement of the carbon diaphragm will also occur but it is of much smaller magnitude and less sudden than the bowing of the receiver diaphragm. Moreover, the slow air leakage permits it to return slowly to its normal position so that variations in the polarizing current of the receiver have much less disturbing effect on the transmitter than when only a single diaphragm is used.

The carbon chamber 5 of the transmitter 3 is preferably filled in the manner outlined in Patent 1,910,980 granted to me May 23, 1933, that is to say, the granular carbon is flowed into the chamber under a considerable head and the button is agitated for a predetermined time during the filling so that the carbon in the chamber completely fills it except for a small predetermined air space. This method of filling has been found to reduce the abrasion of the carbon particles and thereby to prolong the useful life of the carbon. When the filling operation is complete the filling opening 6 is covered by the plate 38 which is held in position by screws 39, 40. The vibrations of the carbon diaphragm 10 act upon this granular carbon in the usual way to produce current variations in the right-hand portion of the circuit shown in Fig. 4 which contains the earphone 41, one side of the regulating rheostat 37 and the common battery 35 which as already pointed out is connected to the amplifying transmitter diaphragm. The amplifier is normally held in an edgewise position when in use so that due to the configuration of the carbon chamber there will normally be a head of inactive carbon pressing downwardly on the granules of carbon which are in actual contact with the diaphragm so that the tendency of the carbon to recede from the diaphragm is materially decreased. It will also be noted that the opening 8 in the barrier member 7 is tapered toward the diaphragm 10 in such a manner that as the carbon is compressed by the diaphragm it moves inwardly toward the center and does not tend to pack in the neighborhood of the diaphragm as in many previous devices.

Since any extraneous vibrations reaching the diaphragm 10 will cause distortion in the output of the device, it is preferably shielded as much as possible from such disturbing vibrations. For this purpose it has been found very effective to enclose the housing member 1 with a grooved ring of long life rubber 42. This ring is grooved on the inside to hold the amplifier in place and also on the outside to receive a suitable resiliently mounted clamping ring for holding the amplifier

in the proper position with respect to the other parts of the system with which it is used. By suitably adjusting the pole piece 26 after assembly to obtain best results it is found that this amplifier may be operated at a gain of from 18 to 20 decibels or approximately the equivalent of a single stage of vacuum tube amplification.

While the amplifier is adapted for use in any kind of system requiring amplification of voice frequencies, it is probably most suitable for use in an audiphone in which the desired output is greater than can be obtained with the usual single transmitter arrangement. One form of an audiphone embodying an amplifier according to this invention is shown in Fig. 3. The sound pick-up transmitter corresponding to 36 in the circuit diaphragm of Fig. 4 is located behind the circular pressed-out portion 43 of the casing 44. The sound waves enter the casing through the grille openings 45 surrounding the portion 43 and impinge upon the diaphragm of the transmitter which is exposed within the casing. Above the transmitter a rheostat corresponding to 37 of Fig. 4 is located and may be adjusted by a projecting button 46. A spring clip 47 carried by the bracket 48 surrounds a rubber ring 42 and holds the amplifier securely in position. For convenience in making connections and in removing the various parts of the set for purposes of inspection and repair, a terminal block 49 is provided and to this block the leads from the earphone 41 and the plug 50 which attaches to the battery are terminated. Such a set is adapted to be worn on the person and may conveniently be placed in an upper pocket of the clothing as indicated in Fig. 5, the battery being contained in a lower pocket and connected to the set by the plug 51.

For purposes of illustration the Figs. 1 and 2 have been shown much larger than actual size. It has been found practical to make this amplifier of substantially the dimensions indicated in the assembly view of Fig. 3 so that a very appreciable gain in output from an audiphone is thereby obtained with only a very slight addition to the necessary weight of such a device.

What is claimed is:

1. In a microphone amplifier a receiver unit and a microphone unit, a magnetic and a non-magnetic diaphragm directly opposed between the units and a spacing washer of the order of 1 mil thick between the diaphragms so that the units are acoustically coupled by the viscous resistance of the air to lateral movement between the diaphragms.

2. In a microphone amplifier, a microphone unit comprising a carbon chamber having an opening tapering toward the inside of the chamber, a non-magnetic diaphragm disposed in front of the opening and book damping forming a closure between the chamber and the diaphragm and a receiver unit comprising an annular winding, a magnetic diaphragm in such close spaced relation to the non-magnetic diaphragm of the microphone unit that the units are acoustically coupled by the viscous resistance of the air to lateral movement between the diaphragms, an annular magnetic member contacting the magnetic diaphragm and a central pole in close spaced relation to said diaphragm and adjustably mounted in the annular member.

3. In a microphone amplifier, a receiver unit having a magnetic diaphragm and a central pole adjustably mounted with respect thereto and a microphone unit comprising a chamber substantially filled with carbon but with a small predetermined air space, a member with a central hole tapering toward the chamber and forming one wall of the chamber, a non-magnetic diaphragm in close acoustically coupled relationship to the diaphragm of the receiver unit and disposed in parallel relation to the member and vibration absorbing material for damping the movements of the diaphragm and sealing the carbon in the chamber.

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