

Aug. 22, 1950

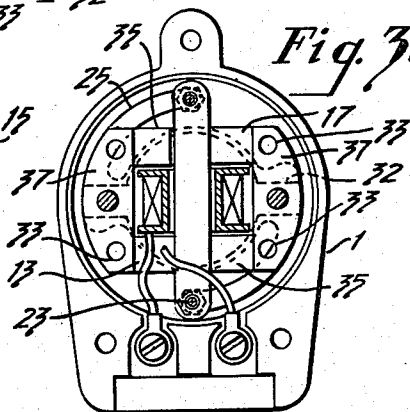
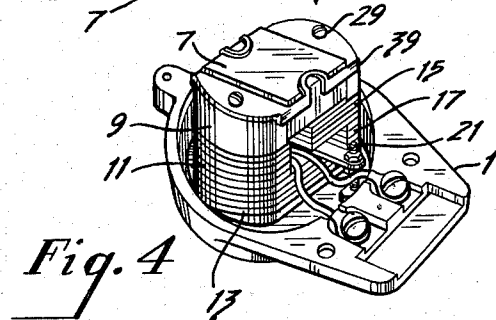
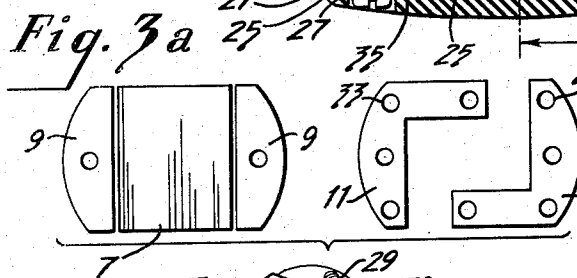
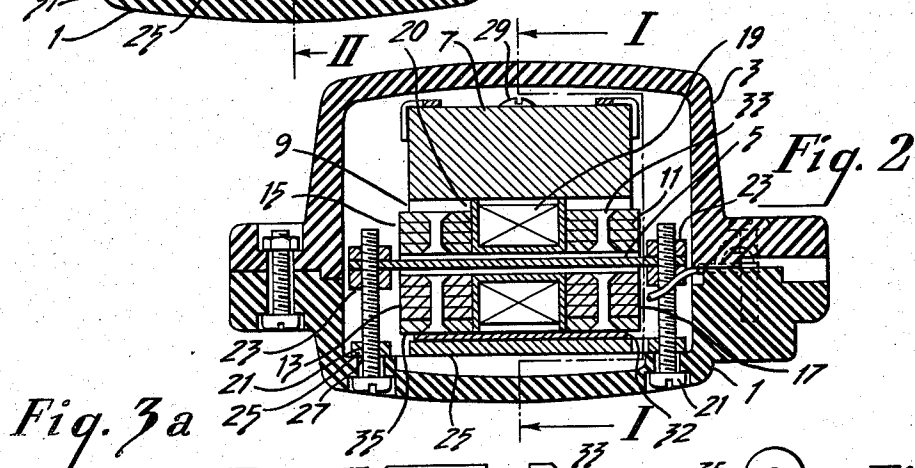
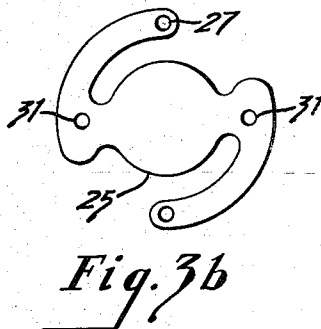
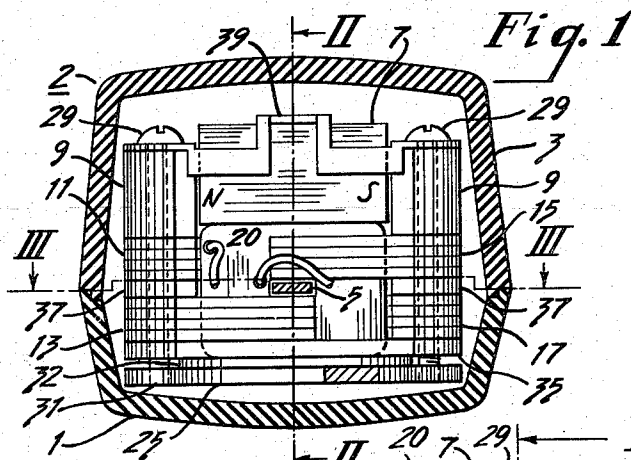
D. W. MARTIN

2,519,916

INERTIAL ELECTROMAGNETIC THROAT MICROPHONE

Filed April 30, 1945

2 Sheets-Sheet 1



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INERTIAL ELECTROMAGNETIC THROAT MICROPHONE

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2 Sheets-Sheet 2

Fig. 6

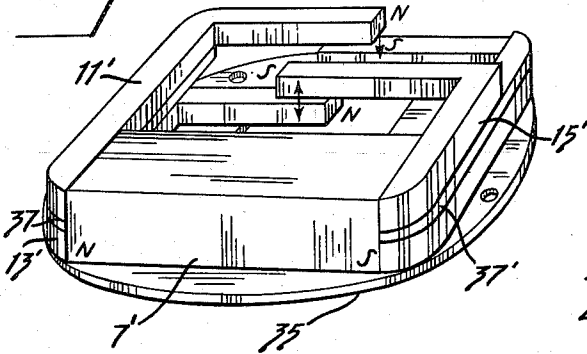


Fig. 5

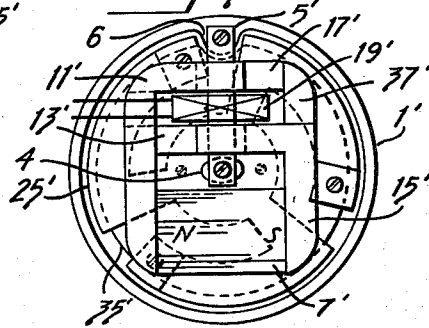


Fig. 7

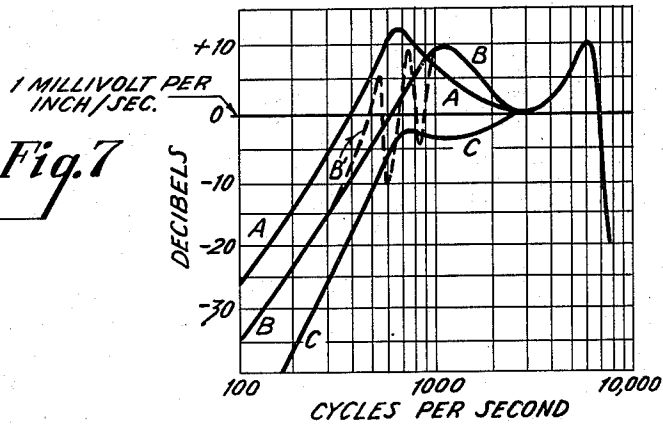


Fig. 9

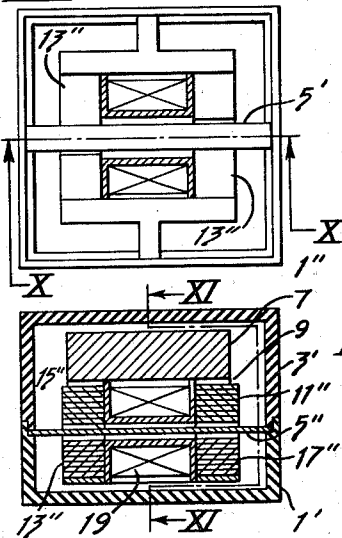
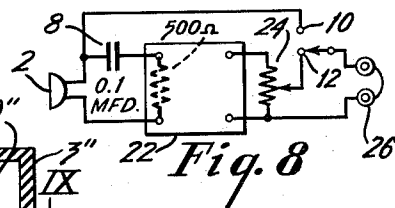
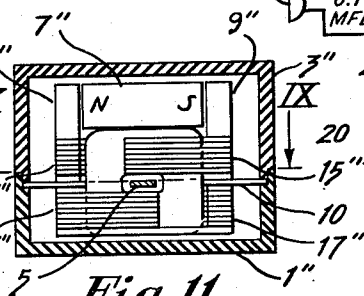


Fig. 10

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Fig. 11



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UNITED STATES PATENT OFFICE

2,519,916

INERTIAL ELECTROMAGNETIC THROAT
MICROPHONEDaniel William Martin, Indianapolis, Ind., as-
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poration of Delaware

Application April 30, 1945, Serial No. 591,070

8 Claims. (Cl. 179—121)

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This invention relates to vibration translating devices and more particularly to a sound powered throat microphone of the inertia type adapted to be supported externally in contact with the throat adjacent the larynx of the user for translating voice sound waves or vibrations into corresponding signal currents.

An object of the invention is to provide a small low mass microphone of the inertia type capable of generating sufficient signal voltage in response to speech vibrations, transmitted through the neck of a user to the casing of the microphone adapted to be worn in contact with the throat, to operate satisfactorily one or more telephone receivers without the use of external power such as amplifiers and batteries in circuit, as well as to operate properly with amplifiers.

Another object of the invention is to substantially improve the efficiency and linearity of response, and thereby the intelligibility of devices of this type, without increasing size and weight. Certain devices in the prior art use push-pull magnetic structures which eliminate even harmonic distortion components, but in the invention the odd harmonics are also eliminated due to the use of a balanced armature.

Another object of the invention is to improve the construction of such devices in the way of ruggedness, simplification, adaptability to quantity production, serviceability, and low cost considering the performance obtained.

Still another object of the invention is to provide a sound powered throat microphone of the inertia type having improved performance as a result of a novel magnetic unit in which magnetic and dynamic symmetry in a double air gap arrangement are combined with a rectilinearly moving magnetically balanced armature. According to the invention, this combination is free from electrical response to spurious non-rectilinear vibratory movements. For example when rocking occurs, the displacements of the ends of the armature in the two gaps are equal in magnitude and opposite in direction. Because the magnetic fields in the two gaps are also opposite in direction and equal in magnitude, there is no flux variation in the armature due to the rocking motion, and therefore no contribution to the electrical output. In conventional single gap arrangements and unsymmetrical double gap arrangements, rocking motion introduces double frequency distortion components into the electrical output.

Further, in accordance with the invention the vibratory device is adapted to operate in contact

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with selected portions of the body of the user, such as the neck through which sound vibrations are transmitted from the throat. It comprises a casing containing a magnetic armature and an associated field magnet system including a permanent magnet, pole pieces and signal translating coil. The armature is secured to the casing by stiffness means for cophasal vibratory movement therewith and the magnet system is suspended from the casing by compliance means, the relations of the mass of the casing and armature to that of the magnet system, together with the characteristics of the stiffness and compliance means, being such that there is relative vibratory movement between the armature and pole pieces in accordance with sound vibrations transmitted through contact to the casing. The mass of the magnet system, the inertia member, exceeds that of the casing and armature, the driven member.

In a preferred modification, using a magnetically balanced armature, in combination with magnetic and dynamic symmetry, substantially only true rectilinear vibratory movement of the armature, i. e. in a direction normal to its plane or length, generates signal voltage and current, spurious response due to rocking vibratory movements being balanced out.

In the drawings:

Fig. 1 is an enlarged end elevation view partly in section of the device embodying the invention, the increased scale size being of the ratio of about one to three,

Fig. 2 is an enlarged side elevation view in section of the device embodying the invention, the section being taken on the lines II—II of Fig. 1,

Fig. 3 is an enlarged plan view of the device with top cover removed showing the interior, partly in section, as viewed on line III—III of Fig. 1, this view being drawn on a smaller scale than are Figs. 1 and 2, the dimensions being twice those of an actual working model from which the drawings were made,

Fig. 3a is a top plan view of certain of the elements of Fig. 3 removed by sectioning, shown in elevation in Fig. 1, while Fig. 3b is a plan view of a flexible element partly visible in Fig. 3,

Fig. 4 is an enlarged view in perspective of the device embodying the invention, the top cover being removed, and the scale being slightly smaller than in the case of Fig. 3,

Fig. 5 is an enlarged plan view of a modification embodying the invention, with portions of the casing removed to show the interior,

Fig. 6 is a further enlarged view, in perspective, of the magnet system shown in Fig. 5.

Fig. 7 shows characteristic curves of performance of the devices shown in different figures.

Fig. 8 is a block diagram showing a system in which a device embodying the invention has been successfully employed.

Fig. 9 is a diagrammatic plan view, partly in section, showing a form of the invention that is preferred, from the standpoint of performance, with parts removed to show the interior.

Fig. 10 is a side elevation view partly in section taken on lines X—X of Fig. 9 prior to removal of parts.

Fig. 11 is an end elevation view of the device, partly in section, taken on lines XI—XI of Fig. 10.

Referring now to the drawings, Figs. 1 to 4, an inertia type contact microphone comprises a molded casing 2 of insulating material including a base portion 1 and a cover 3. In the casing is mounted a bar type armature 5 of highly permeable magnetic material, and a field magnet system consisting of a block magnet 7 of material having a high magnetic energy density, pole members 9, pole pieces 11, 13, 15, 17, and a signal translating coil 19 surrounding the armature 5. The casing is of relatively low mass, rigid in construction, and is substantially air tight for the purpose of excluding dirt and magnetic particles as well as reducing undesired air vibrations or external noise. However, the construction of the inner mechanism is such that entrance of air vibrations would have little or no effect. The casing 2 can easily be made water-tight by sealing the joints with suitable material. The magnet material of high magnetic density is an alloy of about 8% aluminum, 14% nickel, 24% cobalt, 3% copper and rest iron and is described in Proc. IRE, October 1942, pages 437 to 440 by Ruder, also in G. E. Review, volume 45, Number 4, April 1942 by B. M. Smith. It carries about twice the magnetic flux of ordinary magnet material comprising aluminum, nickel, cobalt and steel, heretofore widely used, and has approximately three times as much available magnetic energy. It cannot be made and magnetized in horseshoe shapes because a D. C. or unidirectional field must be applied during heat treating period. It is available only in bars or blocks with a linear magnetic axis. It displays its unusual magnetic properties only along the axis where the field was applied. Applicant has taken advantages of its shape and unusual characteristics and has adapted it in novel arrangement of magnetic parts to a small efficient or highly sensitive transducer.

The armature 5 is rigidly secured within the casing by means of support elements such as bolts 21 and nuts 23. These support elements have a high degree of stiffness so that the armature moves in cophasal vibratory relation with the casing. The bolts are locked in place in the casing by a clamping action resulting from a threaded engagement with a compliant support element 25 of brass, the bolt threads engaging corresponding internal threads in holes 27 (Fig. 3b) in the ends of the flexible arms, respectively, of the compliant element 25. These ends of the arms acting as nuts for the bolts, are clamped tightly against integrally molded seats in the lower casing. Likewise, the compliant element 25 is held in place in the casing and the magnet field system is bolted securely in place on the body portion of this compliant member by means of bolts 29 the ends of which engage threaded holes 31 in

the compliant member, a spacing element 32 being interposed between the magnet system and member 25 to provide clearance for the flexible arms of member 25.

The compliance of these arms of element 25 together with the mass of the magnet system is such relative to the lesser mass of the casing and armature that there is relative vibratory movement between the armature and the pole pieces, later described. The resonant period of the device can be made different for various applications by using compliant support members of different resilient material or thickness or by other changes in design. For example, in one case the microphone is used in announce systems employing loudspeakers. The compliant member was made of different material and design to give a substantially higher resonant period, thereby attenuating lower audio frequencies, a desirable feature for actuating speakers.

The block magnet 7 is provided with a pair of mild steel highly permeable interconnecting members 8 for completing the magnetic circuit through pole pieces 11, 13, 15 and 17, thereby effecting a saving in space and magnet material and obtaining better magnetic effects than might be expected from a horseshoe shaped magnet of other material and comparable size. Flat plane faces on element 9 engage corresponding flat polar north and south faces, respectively, of magnet 7, thereby establishing equipotential magnetic surfaces at the ends of the magnet system members. By having the flux turn the corner within the members 8 instead of within the magnet member 7, greater efficiency and a saving of magnet material is effected. Members 9 are provided with bottom flat faces at right angles to the first-mentioned faces disposed in a plane spaced below and parallel to the bottom face of said magnet and to its magnetic axis for engaging the top face of a lamination element of pole piece 11. Each pole piece is made up of a group, say four, laminations riveted together by rivets 33. Laminar pole piece groups 11 and 15 are separable from the remaining structure as shown in Figs. 3 and 3a, whereas the laminae composing pole pieces 13 and 17 are riveted to a common plate 35, as of brass, for ease of assembly, along with a spacing laminae 37. The different groups of laminae constituting the four pole pieces are spaced by laminae 37 a distance such that the vertical spacing, or air gaps, between their inwardly extending end portions is greater than the thickness of the armature 5. Whereas in the prior art the air gaps were formed by bending the inwardly extending pole piece portions, in this arrangement the pole pieces, and component laminations, are all flat and of like shape for production and are easily assembled, with the resultant air gap formed as above mentioned. The lower edges of the spool ends 20 of the translating coil extend through an opening in the base plate 35 and bears against spacer 32 and the body of flexible element 25. The upper edges of the spool support the magnet in spaced relation from the top pole pieces 11 and 15. While the magnet is prevented from sliding downward by means of the coil form it is limited in any upward tendency to movement by means of a non-magnetic flexible clamp 39 of Phosphor bronze held in place by the heads of the screws 29 in the complete assembly.

True rectilinear balanced magnetic armature action is obtained by reason of the fact that the inwardly extending portions of the pole pieces

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overlap in such manner that pole pieces of like polarity are at diagonally opposite ends of the armature, and the steady flux traverses the two gaps in relatively opposite directions. Referring to Fig. 1, the pole piece 15 and its inward extending portion is, say a south pole, while the pole piece 13 and its inwardly extending portion is a north pole. At the other end of the armature, not shown, the inwardly extending portion of pole piece 17 beneath the armature is of south polarity while the inwardly extending portion of pole piece 11, overlapping the top of the armature, is of north polarity. This arrangement is more clearly shown in Fig. 5 and it is partially illustrated in Figs. 2 to 4.

It will be understood that when the armature is in a neutral position in the two gaps, centered midway between the overlapping pole piece ends, there is negligible flow of magnetic flux in the armature which is, therefore, free of steady flux saturation. As the armature moves relatively to the pole pieces in an upward direction from the mid position there is a flow of magnetic flux longitudinally through the armature from north pole piece 11 to south pole piece 15 in one direction through the armature by reason of the air gap to those pole pieces being shortened. As the armature moves downwardly from mid position to shorten the air gaps to pole pieces 13 and 17 the flux flows in the opposite direction longitudinally through the armature. As the flux flows through the armature, signal current flows in one direction in the translating coil as a result of induced potential, the current flowing in the opposite direction as the flux flows in the opposite direction through the armature. This action will be readily understood by those skilled in the art and need not be further elaborated upon, attention being called to a broadly similar magnetic circuit arrangement in a loud-speaker disclosed in Brigham Patent 1,533,372, April 14, 1925.

One novel advantage of this arrangement as applied to inertia type microphones is that only rectilinear vibratory movement induces useful signal currents whereas undesired rocking movement, which would ordinarily produce spurious response, is substantially balanced out and induces no current. This is illustrated in Fig. 7 where curve A represents the response characteristic in decibels versus audio frequency in cycles per second, of the device shown in Figs. 1 to 4. The stiffness of the compliant support and the mass of the magnet system determines the resonant points. Curve B' illustrates the characteristic produced by rocking movements in other arrangements, for example that shown in Figs. 5 and 6 hereinafter described. Curve A illustrates the performance characteristic to the sound powered device of Figs. 1 to 4. Curve B shows the performance of a similar device but with a stiffer compliant support for causing the first resonant peak to occur at a higher frequency, thereby attenuating the lower frequencies. Curve C represents the same device as does curve A but in combination with the capacitor and resistor circuit elements of Fig. 8.

Figs. 5 and 6 show an earlier form of the present invention. Fig. 5 shows a permanent magnet block 7' of Alnico V with the pole pieces 11', 13', 15' and 17' attached directly to the polar ends of the block magnet 7' without the use of intermediate separate connecting members as in Fig. 1. Spacing elements 37' are disposed between pairs of pole pieces of like polarity for spacing

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same in different planes, the ends of adjacent unlike ones constituting active air gaps in which the armature 5' shown in Fig. 5 is disposed. The pole pieces extend laterally and inwardly relative to the magnet and casing, instead of beneath the magnet as in Figs. 1 to 4. The magnet system, including the block of magnetic material, the pole pieces and the translating coil 19', are mounted upon an assembly plate 35' and mounted upon a flexible spider member 25'. The center portion of the spider member is apertured and anchored to the casing around a central raised seat or boss 4 molded in the casing for rigidly supporting one end of the armature 5'. The outer ends of the flexible arms of the spider member 25' are attached to the plate 35' supporting the magnet system. The other end of the armature is attached to an inwardly extending seat 6 on the wall of the lower portion 1' of the casing. While this arrangement results in a shallower construction and has certain of the advantages of the preferred modification, it lacks the dynamic symmetry of the arrangement of Figs. 1 to 4. The stiffness of the compliant element 25' was so chosen as to produce a main resonance above 800 cycles, as in the case of curve B, but the lack of symmetry produced a characteristic B' (Fig. 7).

In one actual use, the preferred form, of Figs. 1 to 4, is used as a sound powered throat microphone in combination with a sound powered type of telephone headset. Reference is made to patent Anderson et al. 2,345,966, April 4, 1944, over which this invention is an improvement. The equipment carried by one user will consist of a throat microphone and a headset adapted to be connected in circuit with similar equipment worn by other users, resulting in ready communication, particularly in wartime on land or on the water, without the necessity for amplifiers and batteries. In other arrangements, however, amplifiers for obtaining still better results are employed, arrangements being made for ready switching to sound powered operation in case of failure of amplifiers and/or power supply sources. Equipment known as "MI-2466" (later superseded by "MI-2478") consisted of a sound powered throat microphone and headset and included a volume control 24 with the headset together with plug-in connections for an amplifier. See Fig. 8. Sound powered communication is provided for emergency (power off) conditions as shown by the position 10 for the switch in Fig. 8. In order to realize higher signal to noise ratio in extremely high noise levels an amplifier 22 is used between the microphone 2 and earphones 26 for better operation. The amplifier 22 with a 500 ohm shunt resistor in its input has a capacitor 8, of 0.1 mfd. in series with its input to reduce the low frequency transmission from the throat microphone. The capacitor is not included in the circuit used for sound powered operation for the reason that the lower levels involved the additional low frequency response obtainable without the capacitor, is found to be advantageous. In some cases, the capacitor plus the higher resonance point, previously described, were used with amplification for best results as to intelligibility in systems employing loud-speakers.

Still better results from dynamic symmetry can be obtained if the magnet system is compliantly supported in a plane with the air gaps. Such an arrangement is illustrated in Figs. 9 to 11 which may also serve to illustrate some of the features

inherent in the device of Fig. 1. It would have been preferable in Fig. 1 to have supported the magnet system in the manner of Fig. 9 but overall size limit requirements did not permit of this arrangement and somewhat of a compromise had to be made. The advantage of this suspension is that it achieves a cancellation of the effects of rocking vibratory motion from the output signal to an even higher degree than in the species of Fig. 1. In this arrangement one of the spacing laminae 10 between the pole pieces is provided with an integral flexible extension which engages in locking relation the side walls of the casing. The armature and this special separation member are locked in the same plane, an advantageous relation in that the axis of rotation is actually in the plane of the gap while it was only parallel to it and passing through the center line of the unit in the arrangement of Fig. 1.

Output energy due to rocking motion or vibration parallel to the plane of the gap was balanced out to a first approximation in the structure of species in Fig. 1 because of the fact that there existed a substantial amount of symmetry (gaps equally spaced from center, armature supports equally spaced from center, spring supports equally spaced from center, equal gaps, centered armature, mass of structure balanced about an axis in the armature), and as a result of having the magnetic field opposite in direction in the two gaps. With the spring supports, however, moved to the plane of the armature, the output voltage caused by rocking motion is balanced out to a still greater degree than in the case of Fig. 1. The arrangement shown in Fig. 9 has been simplified by omission of certain details illustrated in the other figures. The structures of Figs. 1 and 9 have other uses than throat microphones. They are adapted to be connected to various vibratory devices under test. They can also be used as a telephone receiver, for example, of the bone conduction type. They also have utility as electrical pickups for musical instruments.

While the invention has been described for the purposes of illustration with respect to particular structures, it will be understood that other modifications and uses will become apparent to those skilled in the art, and it is intended to be limited only by the scope of the following claims.

I claim as my invention:

1. In a microphone of the inertia type responsive to voice frequency sound waves for translation thereof into corresponding electric currents, a housing adapted for operative direct contact with a selected speech transmitting portion of the human body, an armature carried by said housing and secured thereto for cophasal vibratory movement therewith, a high inertia member comprising a translating coil surrounding said armature, a magnet and pole pieces disposed in operative balanced magnetic relation to said armature, compliant means attached to said housing at points substantially in a plane with said armature and supporting said coil, magnet and pole pieces for relative vibratory movement with respect to said armature, said pole pieces comprising two pairs of oppositely polarized pole pieces forming air gaps with said armature and being disposed at each extremity of said armature in such manner that rectilinear vibration of said armature relative to said pole pieces induces a substantial voltage in said coil, the arrangement and design of the microphone parts being characterized by substantial dynamic symmetry rela-

tive to said armature, whereas rocking movement balances out and induces substantially no voltage in said coil.

2. In a microphone of the inertia type responsive to voice frequency sound waves for translation thereof into corresponding electrical currents, a housing having relatively low mass and arranged to be held in direct contact with a selected speech transmitting portion of the human body, an armature carried by said housing and secured thereto for cophasal vibratory movement therewith, an inertia member comprising a translating coil surrounding said armature, a magnet and pole pieces disposed in operative balanced magnetic relation to said armature, compliant means attached to said housing at points substantially in a plane with said armature and supporting said coil, magnet and pole pieces for relative vibratory movement with respect to said armature, said pole pieces comprising two pairs of oppositely polarized pole pieces forming air gaps with said armature and being disposed at each extremity of said armature in such manner that pole pieces of like polarity are disposed on opposite sides of said armature adjacent opposite extremities thereof, the mass of said housing and armature being low relative to that of said inertia member and such that, together with the characteristics of the compliant means, there results relative vibratory movement between said armature and said pole pieces in accordance with voice waves transmitted through contact between said body portion and said housing.

3. In a vibration translating device of the inertia type for generating signal currents, a vibratory casing, a field magnet system mounted within said casing comprising a block magnet of high retentivity material, pole pieces forming a pair of air gaps and a translating coil coupled to said system, a bar type armature disposed centrally within said coil and said gaps in balanced magnetic relation to and mounted independently of said system, means for mounting said armature transversely of said casing and rigidly thereto at spaced points for cophasal vibratory movement therewith, resilient means attached to said casing at spaced other points in substantially the same plane as said first-named points and said gaps for compliantly supporting said magnet system whereby to cancel the effects of rocking vibratory motion.

4. In a contact microphone of the inertia type, an enclosed housing for excluding air vibrations, a bar type armature carried within said housing and secured thereto for cophasal vibratory movement therewith, a translating coil disposed in magnetic relation to said armature, a short rectangular block magnet having first and second pole faces in planes normal to its magnetic axis at opposite ends of the block, a pole member of magnetically permeable material engaging each of said faces, a plurality of plane laminations of magnetically permeable material engaging said members and stacked upon each of said members in spaced parallel relation to a neutral face of said magnet, certain of said laminations of opposed polarity having portions extending inwardly from said pole members in overlapping relation toward each other and relative to one end of said armature for forming an active air gap in which said one end of said armature is centered, others of said laminations of opposed polarity having portions extending inwardly toward each other in overlapping relation at the other end of said armature for forming a second active

air gap in which said other end of said armature is centered.

5. In a contact microphone of the inertia type, an enclosed housing for excluding air vibrations, a bar type armature carried within said housing and secured thereto for cophasal vibratory movement therewith, a translating coil disposed in magnetic relation to said armature, a short block magnet of high retentivity material having a linear axis with first and second pole faces on opposite ends of the block, a metallic pole member of magnetically permeable material engaging each of said faces, a plurality of plane laminations of magnetically permeable material engaging said members and stacked upon each of said members in spaced parallel relation to a neutral face of said magnet, certain of said laminations of opposed polarity having portions extending inwardly from said pole members parallel to the magnetic axis of said magnet and in overlapping relation toward each other relative to one end of said armature for forming an active air gap in which said one end of said armature is centered, others of said laminations of opposed polarity having portions extending inwardly toward each other in overlapping relation at the other end of said armature for forming a second active air gap in which said other end of said armature is centered, the portions of like polarity being disposed at diagonally opposite ends of said armature whereby only rectilinear vibratory movements of said armature induce signal currents in said coil.

6. In a transducer, an armature, a translating coil, a short block magnet having a linear magnetic axis with first and second pole faces at opposite ends of the block, a metallic pole member of magnetically permeable material for engaging each of said faces, a plurality of plane laminations of magnetically permeable material engaging said members and stacked upon each of said members in spaced parallel relation to a bottom face of said magnet parallel to its magnetic axis, certain of said laminations of opposed polarity having portions extending inwardly from said pole members in overlapping relation toward each other and relative to one end of said armature for forming an active air gap in which said one end of said armature is centered, others of said laminations of opposed polarity having portions extending inwardly toward each other in overlapping relation at the other end of said armature for forming a second active air gap in which said other end of said armature is centered, the portions of like polarity being disposed at diagonally opposite ends of said armature whereby only rectilinear vibratory movements of said armature induce signal currents in said coil, said armature extending in transverse relation to said magnetic axis.

7. In a transducer, an armature, a translating

coil, a short block magnet having a linear magnetic axis with opposed pole faces at opposite ends of the block, a metallic pole member of magnetically permeable material for engaging each of said faces, said members having flat faces engaging said pole faces and having second faces in a plane at right angles to said flat faces said second faces being spaced below a neutral face of said block magnet, a plurality of flat pole pieces of magnetically permeable material engaging said second faces and stacked upon each other in parallel relation to said neutral face of said magnet, certain of said pole pieces of opposed polarity having portions extending inwardly from said pole members in overlapping relation toward each other for forming an active air gap in which one end of said armature is supported centrally, others of said pole pieces of opposed polarity having portions extending inwardly toward each other in overlapping relation at the other end of said armature for forming a second active air gap in which said other end of said armature is supported centrally thereto, and resilient means for flexibly supporting said magnet block and said pole pieces with said air gaps centered around opposite ends of said armature for relative vibration thereto.

8. In a microphone of the inertia type, a housing, an armature carried by said housing and secured thereto for cophasal vibratory movement therewith, a translating coil surrounding said armature, a magnet and pole pieces disposed in operative balanced magnetic relation to said armature, compliant means attached to said housing and supporting said coil, magnet and pole pieces for relative vibratory movement with respect to said armature, said pole pieces comprising a pair of opposed pole pieces forming an air gap disposed at each extremity of said armature in such manner that rectilinear vibration of said armature relative to said pole pieces induces a substantial voltage in said coil whereas rocking movement balances out and induces substantially no voltage in said coil, said compliant means being substantially in the same plane with said air gaps.

DANIEL WILLIAM MARTIN.

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