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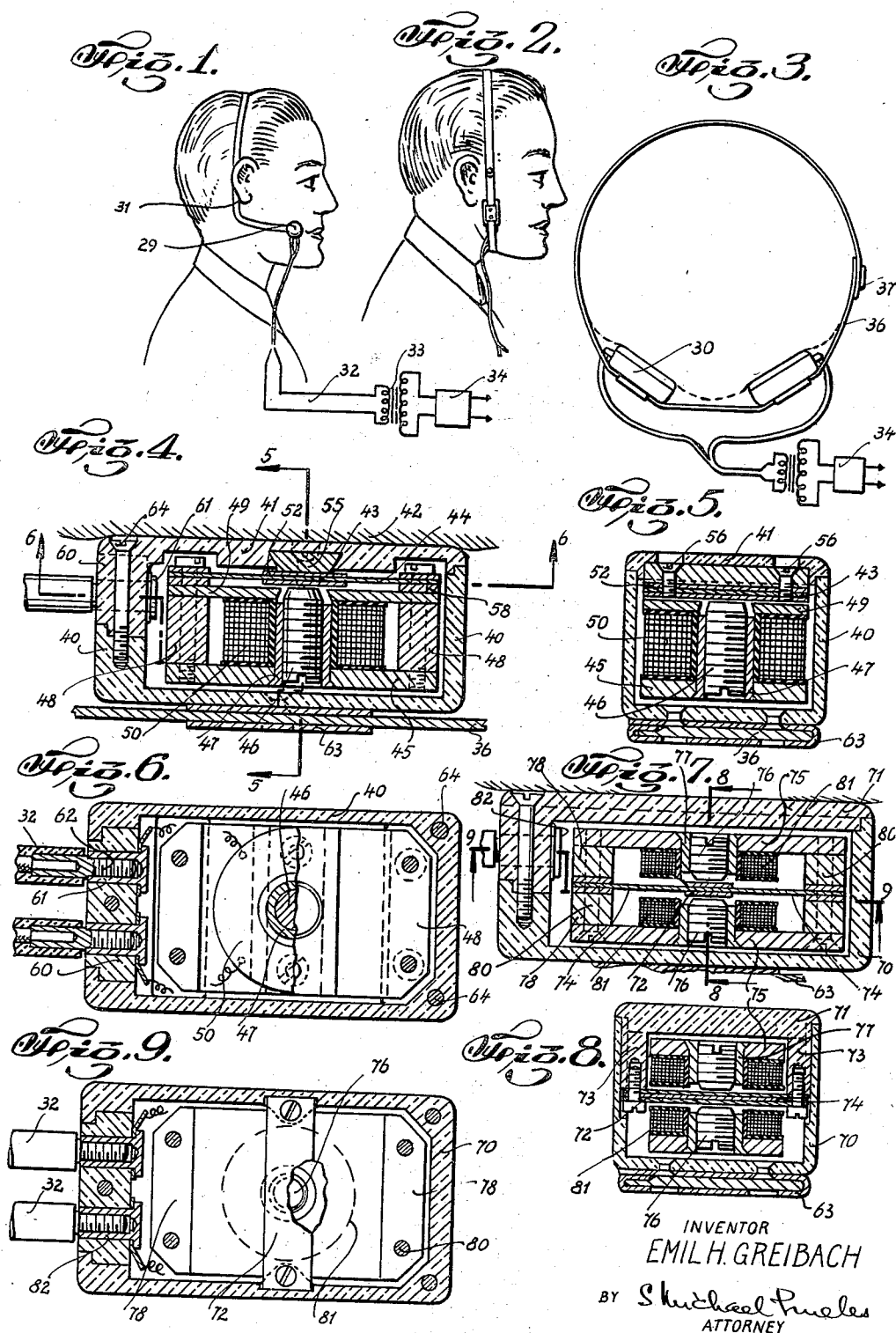
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VOICE TRANSLATING MICROPHONE

Filed Sept. 7, 1939

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

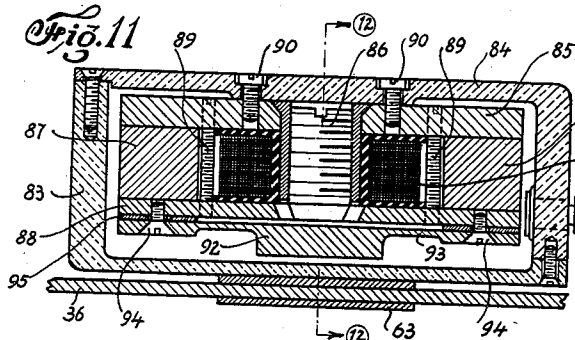
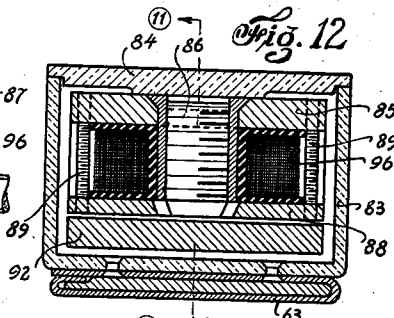
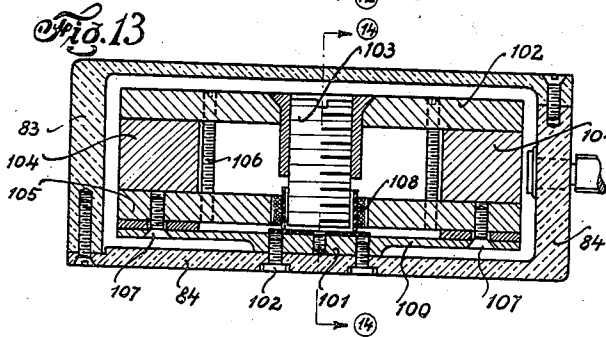
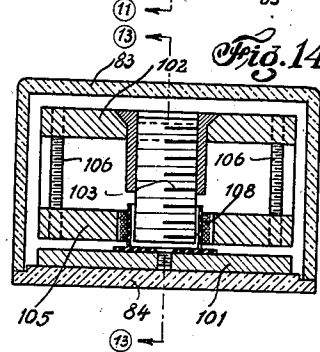
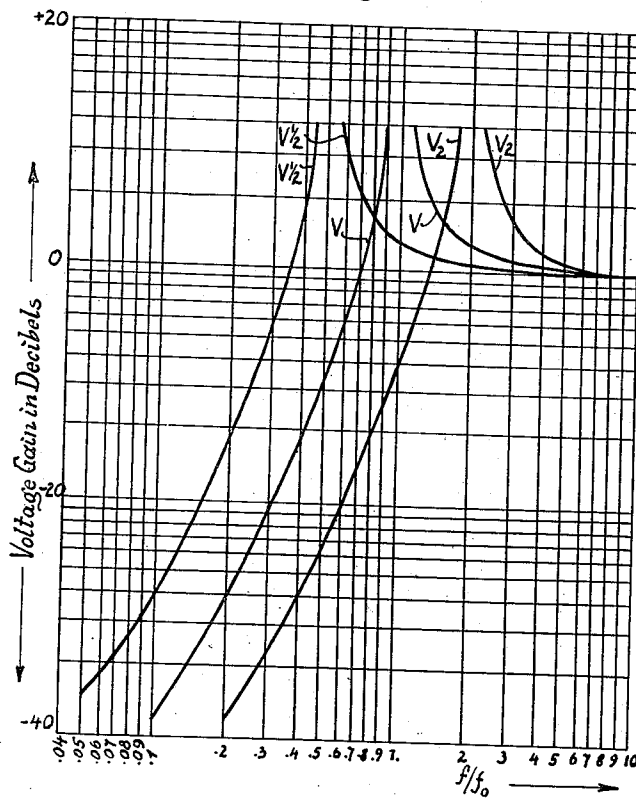


Fig. 10

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2,255,250

VOICE TRANSLATING MICROPHONE

Emil Henry Greibach, Brooklyn, N. Y.

Application September 7, 1939, Serial No. 293,769
In Japan and Canada November 10, 1934

8 Claims. (Cl. 179—121)

This application is a continuation-in-part of my application Serial No. 224,446, filed August 12, 1938, which was a continuation-in-part of my application Serial No. 8,585, filed February 28, 1935, and some of the features of the present invention were disclosed in my application Serial No. 697,673, filed November 11, 1933, on which Patent 2,127,468 was granted August 16, 1938.

This invention relates to voice translating microphones for translating the vibrations of a speech organ, such as the cheek or throat, against which the microphone is held, into electrical oscillations that enable intelligible reproduction of the voice, although the component vibrations of the speech organ, to which the microphone is subjected, differ in character from the component vibrations present in the normal voice waves emanating from the mouth and transmitted through the air.

There are many applications requiring microphones capable of translating the vibrations of a speech organ, such as the cheek or the throat, into electric oscillations which make possible the reproduction of speech with a high degree of intelligibility, while preventing noise or other sounds propagated in the surrounding air from affecting the operation of the microphone. For instance, in the case of an aeroplane pilot communicating with a ground station, it is important to have a microphone which will enable him to transmit a spoken message without interference by the surrounding noise.

Speech is produced by the effect which the vocal cords of the larynx, the tongue, the lips and cavities of the throat, nose and mouth exert on the stream of air discharged by the lungs through the mouth of the speaker. The resultant speech wave with its component frequencies emerging from the mouth reacts on the various speech organs, and as a result the vibrations of the individual speech organs discriminate against the high frequency component vibrations present in the speech wave transmitted through the air and required for intelligible reproduction of the normal speech. These conditions make it difficult to produce with the known microphone devices that are actuated by a speech organ against which it is held electric oscillations that enable intelligible reproduction of the normal speech wave emerging from the mouth of the speaker and transmitted through the air.

In accordance with the invention, this problem is solved by a voice translating arrangement comprising an energy translating vibratory microphone structure having a driving vibratory

portion provided with a contact surface arranged to be held against a vibrating speech organ and resiliently carrying in a vibrating condition a driven vibratory portion of a mass of at least three grams that exerts sufficient inertia reaction so as to generate in response to constant velocity vibrations imparted to the driving contact portion electric voltage oscillations which rise with the frequency at a rate of at least about six decibels over at least one octave of the frequency range up to at least about 1200 cycles per second or higher and enable substantially intelligible reproduction of normal speech transmitted through the air when the contact surface portion is actuated by vibrations of a speech organ that differ from the speech vibrations transmitted through the air.

In accordance with the invention, such microphone device is constructed in the form of a sound-proof casing, the exterior of which is shaped to serve as a contact portion arranged to be held in contact with the speech organ and to be vibrated thereby, and resiliently carrying in its interior, in a free vibratory condition, a driven vibratory portion designed and so arranged relatively to the driving vibratory contact casing portion, as to generate electric oscillations in response to the relative vibratory motion between the driving contact casing portion and the resiliently carried inner driven vibratory portion.

A distinct feature of the invention resides in an inertia reaction microphone device of the foregoing type utilizing an energy translating vibratory structure which, in response to vibrations imparted to its contact portion, generates a voltage proportional to the velocity imparted to the resiliently carried vibratory mass portion relatively to the contact portion that is driven by the speech organ, because such microphone device is able to discriminate in favor of the high frequencies at the rate of about 12 decibels over each octave of the principal parts of the speech frequency range required for intelligible reproduction of speech.

The special frequency discriminating characteristics of such inertia reaction velocity microphones make it possible to translate vibrations of a voice organ against which the contact portion of such microphone is held into electric oscillations which enable highly intelligible reproduction of speech with a standard substantially flat response amplifier. As distinguished therefrom, inertia reaction displacement microphones, utilizing, for instance, piezo-electric vi-

bratory structures, in which the magnitude of the generated voltage is determined by the difference in the displacement between the resiliently carried portion and the contact portion, are less effective because the generated voltage rises with the frequency at a lower rate. This is probably due to the fact that as the high frequency vibrations present in the speech wave emerge from the mouth, they react upon the voice organ, such as the vocal cords, the lips and the body parts which form the cavities of the throat, nose and mouth, which, as a result of the inertia reaction of their masses, discriminate against the high frequencies in a way analogous to the discrimination in favor of the high frequencies resulting from the inertia reaction exerted on the resiliently carried mass portion of the microphone of the invention.

Although various types of energy translating vibratory structures, such as electromagnetic, electrodynamic or piezo-electric vibrating structures, may be utilized for the construction of microphone devices in accordance with the principles of the invention, the preferred exemplifications of the invention described hereinafter are formed of electromagnetic and electrodynamic energy translating vibrating structures.

In the drawings,

Figs. 1 to 3 are views illustrating different ways for holding a microphone of the invention coupled in contact with a vibratory speech organ of the person;

Fig. 4 is an enlarged vertical sectional view of a microphone exemplifying one form in the invention;

Figs. 5 and 6 are vertical and horizontal views, respectively, along lines 5—5 and 6—6 of Fig. 4;

Figs. 7, 8 and 9 are views similar to Figs. 4, 5 and 6 illustrating another exemplification of the invention;

Fig. 10 is a curve diagram illustrating the response characteristics of a microphone of the invention;

Figs. 11 and 12 are views similar to Figs. 4 and 5, respectively, illustrating a still further exemplification of the invention; and

Figs. 13 and 14 are views similar to Figs. 4 and 6, respectively, illustrating a still further exemplification of the invention.

Velocity-type inertia reaction microphones of the invention may be constructed to have an overall size small enough for placing it in the mouth cavity, and may be designed to generate output voltages required for reproducing the speech with a high degree of intelligibility with a standard amplifier. Such microphone is very efficient when it is operated while held by an external support in contact with the vibrating portions of the face, cheeks, lips, jaws or the throat, and it will, under the vibrations imparted by such organ, deliver relatively large output voltages that will enable intelligible reproduction of the normal speech transmitted by the mouth of the speaker to the air.

As shown in Fig. 1, a casing 30 forming the microphone of the invention may be held by a light head band 31 in contact with a vibrating cheek portion of the speaker, the output leads 32 from the microphone, being connected through a step up transformer 33 to the input side of an amplifier 34, the output leads 35 of which are connected either to a receiver or to a modulating stage of a radio transmitter, for transmitting a radio message from an aeroplane, for instance. As shown

in Fig. 2, a rectangular casing microphone 30 of the invention, may be held in contact with a vibrating cheek portion of a speaker by an elastic strap 36 of light flexible material extending over the top of the head and below the chin, the ends of the strap 36 being joined by a snap fastener 37. As shown in Fig. 3, two such casing microphones 30 may be held in contact with the vibrating throat portions overlying the larynx by a strap 36, the ends of which are joined by a snap fastener 37, as in Fig. 2, the two microphones supplying their combined output to the amplifier 34.

Such small microphone unit of an overall mass of only about 20 grams, which is so light that it does not materially suppress or modify the vibrations of the speech organ against which it is held, will reproduce the speech of the speaker with a very high degree of intelligibility if the resiliently carried vibrating structure is designed to have a resonance frequency of about 1250 cycles. However, the rising frequency characteristic, and the protective casing arrangement make it possible to design the encased vibratory microphone structure of the invention to operate with any desired higher resonance frequency suitable for generating under the vibrations imparted by a speech organ an output voltage that will enable intelligible reproduction of speech. By damping the vibratory motion of enclosed vibratory structure, the response in the high frequency region is greatly improved. Since the vibrating structure is entirely encased, a damping medium, such as oil, may be placed in the casing so as to give the desired damping effect, and the enclosing casing may be made liquid tight so as to prevent leakage of the damping liquid.

One distinct advantage of the inertia reaction casing microphone of the invention resides in the elimination of all shielding problems. By constructing such vibratory casing microphone as an electromagnetic vibratory structure, its impedance may be made so low as to leave it unaffected by any stray fields interlinked with the microphone structure. If such self-generating casing microphone is constructed as a vibrating structure having a high internal impedance, it may be easily given complete protection against disturbing stray field, by utilizing the casing itself as a shield, for instance, by providing its surface with a layer of shielding metal.

In Figs. 4 to 6 is shown an electromagnetic casing microphone 30 of the invention constructed along the lines of the device described in connection with Figs. 2 to 4 of my copending United States application Serial No. 697,673, filed November 11, 1933, on which Patent Re. 21,030 was granted.

It comprises a small rigid sound proof casing 40 having a base 41, and arranged to be held in contact with a portion 42 of a vibratory speech organ of a speaker so that the casing 40 vibrates substantially in unison with the speech organ.

The casing 40 is a part of an electromagnetic vibratory structure mounted in the interior of the casing 40. It comprises a magnetic armature core portion 43 which is clamped to the base 41 and carries on resilient diaphragm extensions 44 a magnetic system formed of a magnetic bar 45, having a central pole piece 46 threadedly held within a core sleeve 47 fixed within the core bar 45, and two magnetic blocks 48 and a pole plate 49 clamped to the ends of the diaphragm 44.

An output coil 50 surrounds the pole piece 46

and is interlinked with its magnetic flux. The resiliently carried magnetic core system has a permanently magnetized portion which produces a permanent flux through the pole piece 46 and therefrom over the magnetic gap to the armature 43, and therefrom back by way of the pole plate 49 and the core blocks 48 to the pole piece 46.

The central portion of the armature 43 is made rigid, for instance, by soldering or otherwise uniting strips 52 of magnetic material into a rigid armature member held clamped to an anchor 55 within the base 41 by means of two screws 56. The end portions of the armature diaphragm 44 are likewise stiffened by metal strips soldered or brazed to the diaphragm ends which are clamped to the resiliently carried core structure by means of screws 57 over underlying spacer shims 58.

The base has a terminal block 60 with terminal bushings 61 connected to the ends of the output coil 50. The bushings 61 have threaded holes for receiving terminal tips 62 of the core leads 32 to the amplifier 34. The base is clamped to the casing 40 by bolts 64. To the outer wall of the casing 40 is secured, as by riveting, a U-shaped metal clamp 63 for clamping the supporting strap 36 which holds the casing microphone against a vibrating speech organ.

Under the action of the vibratory motion imparted to the microphone casing 40 by a vibrating speech organ, a relative vibratory motion is produced across the magnetic gap between the armature 43 and the mass of the resiliently carried magnetic system 45-50 and varies the flux through the magnetic gap and the pole piece. The resulting variations in the flux through the pole piece 46 will induce in the output coil 50 corresponding voltages.

A mathematical analysis shows that the approximate general equation of the voltage E generated in the coil 46 of an inertia reaction velocity microphone of the type illustrated in Figs. 4 to 6 is

$$E = KV \frac{1}{\left(\frac{f_0}{f}\right)^2 - 1} \quad (A)$$

wherein

V is the velocity imparted by the vibrating speech organ to the contact casing 40 and the armature 43 which forms part of the casing.

K is a numerical constant determined by the design of the microphone.

f_0 is the resonant frequency of the vibratory system formed by the mass of the vibratory contact portion 40-41-43 that is vibrated by the speech organ, the mass of the resiliently carried driven vibratory portion 45-46-48-49, and the compliance of their resilient junction 49, and

f is the frequency of the vibrations imparted by the speech organ to the contact portion.

For frequencies sufficiently below resonance,

$$\left(\frac{f_0}{f}\right)^2$$

is much greater than unity, and the Equation A reduces to

$$E = KV \left(\frac{f}{f_0}\right)^2 \quad (B)$$

showing that for a given resonant frequency and constant velocity vibrations, the generated voltage rises as the square of the frequency; and that the ratio of the voltages generated, at two fre-

quencies, separated by an octave, expressed in decibels, is

$$\log E_{2f}/E_f = 40 \log \frac{2f}{f} = 12 \text{ db.}$$

In an inertia reaction microphone using a vibratory energy translating structure, for instance, of piezo-electric material, in which the generated voltage is determined by the displacement of the resiliently carried vibratory portion relatively to the vibrated contact portion, the general equation of the generated voltage, corresponding to Equation A, is given by

$$E = K \frac{V}{2\pi f \left(\frac{f_0}{f}\right)^2 - 1} = \frac{K}{2\pi} V \frac{1}{\left(\frac{f_0}{f}\right)^2 - 1} = KV \frac{1}{\left(\frac{f_0}{f}\right)^2 - 1} \quad (A-1)$$

which in the region sufficiently below the resonant frequency reduces to

$$E = KV \frac{f}{f_0^2} \quad (B-1)$$

showing that in an inertia reaction displacement microphone, for a given resonant frequency, the generated voltage rises not as the square of the frequency, but only at the same rate as the frequency; and that the ratio of the voltages generated by the constant velocity vibrations, at two frequencies, of this range, separated by an octave is only

$$E_{2f}/E_f = 20 \log \frac{2f}{f} = 6 \text{ db.}$$

In Fig. 10 the function expressed by Equation A is plotted, for $KV=1$, on a logarithmic scale, for three values of the resonant frequency $f_0=5$; $f_0=1$; and $f_0=2$, as curves $V^{1/2}$, V and V^2 , respectively, to graphically illustrate the variations of the voltage generated by such inertia reaction velocity microphone as a function of the frequency when the microphone is subjected to vibrations of constant velocity.

The foregoing analysis, and the curves of Fig. 10, show that the voltage generated by an inertia reaction velocity microphone rises with the frequency at the rate of about 12 db. per octave in the range up to about 60% of the resonant frequency, the rate of rise being higher in the range near the resonance frequency, and remaining at a high level in the range above the resonant frequency. Obviously, damping resistance makes possible keeping the rate of rise of the generated voltage at about 12 decibels per octave up to near the resonant frequency.

An inertia reaction microphone that is vibrated by a voice organ and in which the generated voltage is determined by the difference in the velocity of the contact portion and the velocity of the resiliently carried vibratory mass portion that is driven by the contact portion, will discriminate in favor of the high frequencies by about 12 db. over one octave, about 24 db. over two octaves, about 36 db. over three octaves, and about 48 db. over four octaves of the speech frequency range.

The foregoing frequency discriminating characteristics of an inertia reaction velocity microphone make it possible to translate vibrations of a voice organ, against which the contact portion of the microphone is held, into electric oscillations which enable highly intelligible reproduction of speech with a standard substantially flat-response amplifier. This is probably due to the fact that, as the high frequency vibrations present in the speech waves emerge from the

mouth, they react upon the voice organs, such as the vocal cords, the lips, and the body parts which form the cavities of the throat, nose and mouth, and impart thereto component high frequency vibrations, which, as a result of the inertia reaction of their masses, discriminate against the high frequencies in a way analogous to the discrimination in favor of the high frequencies resulting from the inertia reaction exerted by the resiliently carried mass portion of the microphone unit.

As distinguished therefrom, the voltage generated by an inertia reaction displacement microphone, rises with the frequency at a much lower rate, and would require a special frequency discriminating arrangement in order to secure the same degree of discrimination in favor of the high frequencies as obtained with an inertia reaction velocity microphone of the type described in connection with Figs. 4 to 6.

It is thus seen, that an inertia reaction velocity microphone of the invention will generate voltages which rise with the frequency at a rate greater than about 12 db. over two octaves, greater than about 18 db. over three octaves, and greater than about 24 db. over four octaves of the speech frequency range, and these operating characteristics make it possible to secure intelligible reproduction of speech when such microphone is actuated by a voice organ.

The actual design dimensions of an electromagnetic contact casing microphone of the type shown in Figs. 4 to 6 having a total mass of only about 20 grams, which proved successful in actual use, are as follows:

A resiliently carried mass of about 12 grams; a resilient diaphragm of about 0.8 gram having a resonance frequency of about 4000 cycles; a casing of about 8 grams; and an assembled vibrating system having a resonance frequency of about 1250 cycles. Such contact casing microphone made possible highly intelligible reproduction of speech when held in contact with the jaws, cheeks or the throat of the speaker. When intended for coupling to the cheeks of the speaker, highly intelligible reproduction will be obtained with such microphone structure having even a lower resonance frequency. However, since the resiliently carried vibrating structure is not exposed to interfering external forces, it may be readily designed to operate with higher resonance frequencies up to about 3000 cycles or even higher frequencies within the speech frequency range, particularly when the vibrations are damped. Damping may be obtained by placing a damping liquid, such as oil, inside the microphone casing which may be designed to have liquid tight joints.

Electromagnetic energy translating vibrating structures are particularly suitable for the construction of vibratory contact casing microphones of the invention. Since the resiliently carried mass of the energy translating microphone structure is maintained in a freely vibrating condition within the enclosing contact casing, its operation is free from interfering effects of external forces, and the effective magnetic gaps of the system may be made of the order of one thousandth of an inch and even less without danger of fringing. The small gap and the large magnetic forces acting in the gap make it possible to utilize very stiff resilient spring supports for the resiliently carried mass. This makes also possible the utilization of a large resiliently carried magnetic system while

keeping the resonance frequency at a value at which a desirable response is obtained. In addition, the small gap makes possible the operation of the electromagnetic energy translating structure with very high flux densities and gives large variations of the flux density for small variations of the gap spacing. As a result, a very small contact casing microphone unit, having a very small total mass as low as 15 grams, or even less, which does not materially affect the vibrations of the speech organ against which it is held, is able to supply a relatively large output required for intelligibly reproducing the spoken message with a standard medium gain amplifier.

In Figs. 7 to 9 is shown a balanced electromagnetic contact casing microphone exemplifying the invention, similar to the device described in connection with Figs. 8 to 10 of my copending application Serial No. 697,673, filed November 11, 1933, now Patent Re. 21,030. It comprises a sound proof rigid contact casing 70 similar to that of Figs. 4 to 6, which is a part of a balanced electromotive vibratory structure formed of a magnetic core armature 72 having its opposite ends clamped to two base extensions 73 and a magnetic system resiliently carried on the magnetic diaphragm extensions 74. The magnetic system is formed of two core bars 75 having central pole pieces 76 threadedly held in core sleeves 77 which are secured to the core bars 76, and core blocks 78 held clamped by screws 80 between the core bars 76.

The magnetic system is so magnetized that a permanent magnetic flux passes serially through one of the pole pieces 77 across the gap to the armature 72, and therefrom through the other gap to the other pole piece 77 on the other side of the armature 72.

Each pole piece 77 is surrounded by an output coil 81 which is interlinked with the magnetic flux passing through the pole pieces and the two magnetic gaps on the opposite sides of the armature 72. Terminal bushings 82 in a terminal block extending from the base 71, provide terminal connections to the coils 81. The two coils 81 are so connected that when, under the action of vibratory forces, the armature 72 is moved from its neutral position, and the flux through one pole piece is decreased, and the flux in the other pole piece is increased, these differential flux variations induce in the two coils 81 additive voltages, and the differential flux returns through the magnetic diaphragm extensions 78.

The microphone of Figs. 7 to 9 operates similarly to that of Figs. 4 to 6. By using a balanced magnetic system even harmonic distortions are eliminated and objectionable saturation of the flux paths is avoided. In addition, such balanced electromagnetic contact casing microphones may be operated with smaller magnetic gaps, and greater efficiency.

In Figs. 11 and 12 is shown another form of electromagnetic contact casing inertia reaction microphone exemplifying the invention. Inside a sound-proof rigid casing 83 having a base 84 and a strap clamp 85 is mounted an electromagnetic vibratory structure similar to that shown in Figs. 4 to 6. It comprises a magnetic bar having a central pole piece 86 held within a core sleeve fixed within the core bar, two core blocks 87 and a magnetic pole plate 88 held clamped to the core bar by screws 89, so as to join the core blocks and the core bars into a unitary rigid structure. The magnetic core system so formed is rigidly clamped

to one of the inner walls of the casing, for instance, to the base 84, by screws 90. A massive magnetic core portion 92 of relatively substantial mass is resiliently carried by the magnetic system 85—86—88 by two resilient diaphragm extensions 93 clamped to the ends of the pole plate 88 by screws 94, spacers 95 serving to maintain a small magnetic gap between the pole piece 86 and the resiliently carried core portion 92. An output coil 96 surrounds the pole piece 86. The core system is permanently magnetized, as in the arrangement of Fig. 4.

Under the action of the vibratory motion imparted to the microphone casing 83 by a vibrating speech organ against which the casing is held, the inertia reaction exerted by the resiliently carried massive core portion 92 produces a vibratory motion between the resiliently carried core portion 92 and the magnetic system 85—86—88 which is a part of the casing 83. The resulting variations in the flux in the pole piece 86 will induce in the output coil 96 interlinked with the flux path voltages proportional to the relative velocity between the resiliently carried vibratory portion and the magnetic system of the casing portion, as in the arrangement of Figs. 4 to 6.

In Figs. 13 and 14 is shown a microphone of the invention using an electrodynamic vibratory structure. In a casing 83—84, similar to that of Figs. 11 and 12, is mounted a resilient diaphragm 100 having a rigid central portion 101 clamped to a wall of the casing by screws 102. A magnetic system comprising a magnetic bar 102 having a pole piece 103 held in a sleeve fixed within the bar 102, two core blocks 104 and a magnetic pole plate 105 clamped to the core bar 102 by two screws 106, is resiliently carried by the diaphragm 104 to which it is secured by screws 107. The pole piece 103 and the pole plate 105 surrounding the pole piece confine an annular magnetic gap in which is mounted a cylindrical output coil 108 mounted on a suitable support clamped to the central diaphragm portion 101. The magnet system 102—103—104 is magnetized to provide a radial magnetic flux through the annular magnetic gap between the pole piece 103 and the pole plate 105, so that when the casing 83 with the diaphragm 101 moves relatively to the magnet system 102—103—104, the flux in the air gap induces in the output coil 108 a voltage proportional to the relative velocity between the casing portion and the resiliently carried mass portion of the vibrating system, in a way analogous to the operation of the microphone of Figs. 4 to 6.

In all of the exemplifications of the invention described above, the contact casing portion of the vibratory energy translating microphone structure is made so small that its mass does not substantially modify the component vibrations of the voice organ against which it is held. Actual tests show that a contact casing microphone of the type shown in the drawings will operate satisfactorily when its casing portion is designed to have a mass of about eight grams. Although contact casing microphones of the type shown in the drawings will operate satisfactorily with vibratory structures having a resonant frequency of about 1250 cycles, they may readily be designed to operate with higher resonant frequencies between about 1100 and 3000 cycles or even up to 6000 cycles, if the vibratory motion of the enclosed resiliently carried vibratory mass is damped. With such arrangements, satisfactory operation may be secured with a microphone unit in which the mass of the resiliently carried vibratory por-

tion is of the order of the mass of the casing portion or even less.

The principles of the invention explained in connection with the various specific exemplifications thereof will suggest to those skilled in the art many other modifications thereof. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

I claim:

1. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a relatively freely vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about seven decibels per octave over at least one octave in a part of the frequency range up to about 3000 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air.

2. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said

driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about seven decibels per octave over at least two octaves in a part of the frequency range up to about 3500 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air.

3. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a relatively freely vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about nine decibels per octave over at least one octave in a part of the frequency range up to about 3000 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air.

4. In an apparatus for translating into electrical oscillations required for intelligible repro-

duction of the normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about nine decibels over at least two octaves in a part of the frequency range up to about 3500 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air.

5. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and

the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about seven decibels per octave over at least one octave in a part of the frequency range up to about 3000 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air, said contact portion forming a part of a casing enclosing the resiliently carried portion and preventing the microphone unit from responding to speech vibrations transmitted through the air.

6. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about seven decibels per octave over at least two octaves in a part of the frequency range up to about 3500 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air, said contact portion forming a part of a casing enclosing the resiliently carried portion and preventing the microphone unit from responding to speech vibrations transmitted through the air.

7. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vi-

brating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about nine decibels per octave over at least one octave in a part of the frequency range up to about 3000 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency characteristics substantially similar to those of speech transmitted through the air, said contact portion forming a part of a casing enclosing the resiliently carried portion and preventing the microphone unit from responding to speech vibrations transmitted through the air.

8. In an apparatus for translating into electrical oscillations required for intelligible reproduction of normal speech the vibrations of a speech organ which differ in character from the component vibrations present in the normal speech transmitted from the mouth through the air, a microphone unit constituting an elastically deformable energy translating vibratory structure designed and arranged to be held against a vibrating speech organ and to have an overall mass sufficiently small to prevent substantial modification of the component vibrations of said organ required for intelligible reproduction of said speech; said microphone unit comprising: a driven vibratory portion having a relatively substantial mass; and a driving vibratory contact portion arranged to be held coupled in contact with said organ so as to be vibrated thereby and having a resilient junction carrying said driven vibratory portion in a vibrating condition; the elements of said vibrating structure forming parts of a magnetic core structure having a gap and windings interlinked with the flux of said core and arranged to generate in said windings oscillations substantially proportional to the relative velocity between said resiliently carried portion and said contact portion when it is subjected to vibrations of a substantial part of the principal speech frequency range extending below the resonance frequency of said vibrating structure; said windings forming a part of said contact portion; the masses of said vibratory portions and the stiffness of their resilient junction being designed and arranged to form a vibratory system having a resonance frequency at which it

generates under constant velocity vibrations imparted to the contact portion a voltage which rises with the frequency at a rate of at least about nine decibels per octave over at least two octaves in a part of the frequency range up to about 3500 cycles per second, so that the oscillations generated in said windings when the contact portion is vibrated by said speech organ has frequency

characteristics substantially similar to those of speech transmitted through the air, said contact portion forming a part of a casing enclosing the resiliently carried portion and preventing the microphone unit from responding to speech vibrations transmitted through the air.

EMIL HENRY GREIBACH.