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Improvements to the Carbon Microphone

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PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

Improvements of the Carbon Microphone.

We, SIEMENS BROTHERS & CO. LIMITED, of Caxton House, Tothill Street, Westminster, London, S.W.1, a Company registered under British Law, and EDMUND RAMSAY WIGAN, of 18, Cambridge Road Lee, London, S.E.12, a British Subject, do hereby declare the nature of this invention to be as follows:—

This invention relates to microphones in which conducting granules are used, such as those of the carbon granule type which are used in telephone systems for instance.

Such microphones usually comprise two electrodes insulated from each other and forming the two ends of a case, the intervening space being more or less filled, according to the type, with carbon granules. A common type of such microphone is the so called solid back microphone. In this type of microphone the electrodes project slightly into the granule chamber.

In another common type of microphone the diaphragm itself forms one of the electrodes. In both these types of microphones the resistance to the passage of an electric current may vary very considerably for different positions, and particularly if the microphone is held with its electrodes in a horizontal position. This is due to a relaxation of the pressure of the granules upon each other and upon the electrodes.

A modification of the solid back type of microphone is described in Specification No. 308,630. In this modified microphone the electrodes project some considerable distance into the granule chamber in order that the mean pressure of the granules on the electrodes may be substantially constant in whatever position the microphone may be held.

One of the electrodes, namely the one directly responsible for "modulation of the resistance of the granules", may be referred to as the "moving" electrode.

In the types of microphones referred to above only one face of the moving electrode is exposed to the granules so that its movement in one direction is restricted by the granules but its movement in the other direction is, so far as the granules are concerned, un-restricted. A type of microphone has been suggested in which the movement of the movable electrode shall be restricted in both directions by granules.

In all these types of microphones the surfaces of the two electrodes are more or less vertical when the instrument is in use. Consequently the current flowing between them may be considered as flowing in substantially horizontal paths. Moreover, in those microphones in which the movement of the moving electrode is restricted in both directions by the carbon granules two fixed electrodes are used whereby two separate current paths are provided, the two substantially separate microphones thus formed being used differentially.

In the microphone according to the present invention the electrode, which for convenience is referred to as the moving electrode, is wholly immersed in the granules and presents opposing surfaces thereto, so that motion in either direction is opposed by the granules. The opposition to the movement may preferably be the same for movement in either direction. One fixed electrode is provided and the chamber is sufficiently filled with granules to ensure that the mean pressure of the granules on the electrodes is substantially constant for any position of the microphone. The fixed electrode constitutes a mechanical re-action against the movement of the granules between the moving electrode and itself to produce a proper resistance modulation, and in order to provide a mechanical reaction against the movement of the granules between the moving electrode and the other end of the granule chamber and to assist in producing a proper resistance modulation this end may be closed by a relatively rigid closing member. This closing member may be pierced to admit the support upon which the moving electrode is carried and to transmit the modulating vibrations to the electrode. The support should pass through the closing member in such a way that, whilst escape of the granules is prevented, lateral movement of the support is

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not restricted or is restricted to a negligible degree compared with the restriction due to the granules acting on the opposing faces of the moving electrode.

The moving electrode may have only one conducting face or both faces may be conducting. In this latter case, by a proper relative positioning of the two electrodes, the resistance between one face of the moving electrode and the fixed electrode can be made from two to three times the resistance in the path between the other face of the moving electrode and the fixed electrode. The resistance changes in such an arrangement are about 180° out of phase in the two paths.

In existing types of microphones, protection against excessive rise of resistance due to mechanical shock or the like is to some extent provided by the stiffness of the diaphragm. In the proposed microphone, due to the total immersion of the moving electrode, this stiffness can be reduced so that the characteristics of the microphone are improved.

The pressure on the lower portion of the mass of granules is relatively higher than that on the upper portion and, moreover, the pressure downwards through the lower portion is greater than that across the granules. We take advantage of these facts by shaping and positioning the electrodes in such a manner that the greater portion of the current is concentrated in the lower portion of the mass of granules and so that a radial flow of current, rather than axial flow, is produced. We have found that by such an arrangement the performance of the microphone is improved. A 60° cone for the moving electrode and a 60° re-entrant fixed electrode, mounted substantially concentrically, constitutes a satisfactory practical arrangement. The conical moving electrode may be solid or hollow or it may be otherwise suitably formed, and the fixed electrode may be provided with a cylindrical surface extending to or beyond the edge of the moving electrode. The radial surface of this cylindrical extension may be conducting.

The electrode system may be arranged and supported so that the restraint controlling the movement of the moving electrode along one line (normally its axis) is substantially due to the forces exerted by the mass of granules alone. Such a construction may be combined with a diaphragm system exercising a certain degree of restraint without departing from the spirit of the invention.

The moving electrode may be made of any light metal or other material to which a good non-oxidizable conducting surface can be applied, as, for instance, the alloy known under the registered trade mark "Duralumin" with gold plating or sputtering, and the fixed electrode may be similarly made or it may be made of carbon.

Dated this 12th day of September, 1931.

SIEMENS BROTHERS & CO. LIMITED,
By their Attorney,
F. A. LAWSON,
For Selves and Co-Applicant.

COMPLETE SPECIFICATION.

Improvements of the Carbon Microphone.

We, SIEMENS BROTHERS & Co. LIMITED, of Caxton House, Tothill Street, Westminster, London, S.W.1, a Company registered under British Law, and EDMUND RAMSAY WIGAN, of 18, Cambridge Road, Lee, London, S.E.12, a British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to microphones in which conducting granules are used, such as those of the carbon granule type which are used in telephone systems for instance.

Such microphones usually comprise two electrodes insulated from each other and forming the two ends of a case, the intervening space being more or less filled, according to the type, with carbon granules. A common type of such microphone is the so called solid back microphone. In this type of microphone the electrodes project slightly into the granule chamber.

The solid back, as well as other types of microphone to which reference will be made herein, is illustrated schematically in Fig. 1 of the accompanying drawings. Fig. 2 illustrates an embodiment of the invention. In Fig. 1 known types of microphone are illustrated at (I), (II) whilst in this Fig. constructions according to the invention are illustrated at (III) to (VIII).

In another common type of microphone, not illustrated, the diaphragm itself forms

one of the electrodes. In both these types of microphone the resistance to the passage of an electric current may vary very considerably for different positions, and particularly if the microphone is held with its electrodes in a horizontal position. This is due to a relaxation of the pressure of the granules upon each other and upon the electrodes.

A modification of the solid back type of microphone is described in Specification No. 308,630. In this modified microphone Fig. 1 (II) the electrodes project some considerable distance into the granule chamber in order that the mean pressure of the granules *g* on the electrodes may be substantially constant in whatever position the microphone may be held.

One of the electrodes, namely the one directly responsible for modulation of the resistance of the granules, may be referred to as the "modulating element" or "moving" electrode, and is represented at *me*.

In the types of microphones referred to above only one face *f* of the moving electrode is exposed to the granules so that its movement in one direction is restricted by the granules but its movement in the other direction is, so far as the granules are concerned, un-restricted. A type of microphone has been suggested in which the movement of the movable electrode shall be restricted in both directions by granules.

In all these types of microphones the surfaces of the two electrodes *me* and *fe* are more or less vertical when the instrument is in use. Consequently the current flowing between them may be considered as flowing in substantially horizontal paths indicated by the thick lines in Fig. 1 (II). Moreover, in those microphones in which the movement of the moving electrode is restricted in both directions by the carbon granules two fixed electrodes are used whereby two separate current paths are provided, the two substantially separate microphones thus formed being used differentially.

According to our invention we provide a two electrode microphone having a modulating element or moving electrode coupled to a diaphragm by means of a driving support in which the modulating element or moving electrode is of such size and/or shape as to vibrate substantially as a whole and in phase with that end of the driving support to which it is fixed, and is totally immersed in the granules in such manner that its motion in either direction is opposed by the granules.

As a feature of our invention we arrange that the movement of the modulating element or electrode is controlled by the inertia and/or "stiffness" of the mass of the granules in which it is immersed. As a further feature we so shape or dispose the modulating element or moving electrode and/or the fixed electrode as to cause a radial, or partially radial flow of current in a direction which is more or less coincident with the lines of gravitational force and in that part of the chamber in which the pressure on the granules induced by that force is greatest.

As the aim of our invention is to improve the clarity of speech and to reduce the distortion due to non-linear relationship between the originating sound pressure and the resulting resistance change, we do not consider as within our claim a telegraph relay of the magneto-microphonic type in which the changes are required to be between a maximum and minimum and intermediate modulations are unrequired.

A two-electrode microphone has been suggested in which the moving electrode is in the form of a thin carbon strip supported horizontally and backed by a tubular felt washer, the electrode being surrounded by granules. The reason stated for this particular formation and the disposition of the electrode in the upper layer of the granules was that the electrode is in a layer that is sensitive not being subject to packing as is a lower layer. However a strip electrode of this character being of a cantilever form is readily distorted and introduces a complex factor into the resistance variations in the microphone. An essential feature of our invention as will have been gathered is that the moving element or electrode is of a size and/or shape adapted to move as a whole i.e. without change of shape.

Other features will appear from the specification.

In the microphone of our invention the clarity of speech is improved and distortion due to a non-linear relationship between the originating sound pressure and the resulting resistance changes is reduced.

In an embodiment of the microphone according to the present invention the electrode *me*, Fig. 1 (III to VIII) and Fig. 2 which for convenience is referred to as the modulating element or moving electrode, is wholly immersed in the granules *g* and presents opposing surfaces *f* and *b* thereto, so that motion in either direction is opposed by the granules. The opposition to the movement may preferably though not necessarily or entirely, be the same for movement in either direction. One fixed electrode *fe* is provided

and the chamber is so shaped and sufficiently filled with granules as to ensure that the speaking efficiency is independent of the position of the microphone. The fixed electrode constitutes a mechanical reaction against the movement of the granules between the modulating element or moving electrode and itself to produce a proper resistance modulation, and in order to provide a mechanical reaction against the movement of the granules between the modulating element or moving electrode and the other end of the granule chamber and to assist in producing a proper resistance modulation this end may be closed by a relatively rigid closing member *cm* or, as in Fig. 2, the inertia of the mass of granules may be relied on. The closing member if such is provided may be pierced to admit the support *s* by which the modulating element or moving electrode is connected to the diaphragm and which transmits the modulating vibrations to the element or electrode. The support should pass through the closing member in such a way that, whilst escape of the granules is prevented, lateral movement of the support is not restricted or is restricted to a negligible degree compared with the restriction due to the granules acting on the opposing faces of the modulating element or moving electrode.

The modulating element or moving electrode may have only one conducting face *f* or both faces *f* and *b* may be conducting. In this latter case, by a proper relative positioning of the two electrodes, the resistance between one face *b* of the moving electrode and the fixed electrode can be made from two to three times the resistance in the path between the other face *f* of the moving electrode and the fixed electrode.

In existing types of microphones, protection against excessive rise of resistance due to mechanical shock or the like is to some extent provided by the stiffness of the diaphragm. In the proposed microphone, due to the total immersion of the modulating element or moving electrode, this stiffness can be reduced so that the characteristics of the microphone are improved.

The pressure on the lower portion of the mass of granules is relatively higher than that on the upper portion and, moreover, the pressure downwards through the lower portion is greater than that across the granules. We take advantage of these facts by shaping and positioning the electrodes in such a manner that the greater portion of the current is concentrated in the lower portion of the mass of granules and so that a radial flow of current, illustrated by the heavy lines in Fig. 1 (V—VIII), rather than axial flow, is produced axial flow being regarded as along the direction of movement of the moving electrode. We have found that by such an arrangement the performance of the microphone is improved. A cone *me* Fig. 1 (VI—VIII) and Fig. 2 for the modulating element or moving electrode and a fixed electrode *fe*, Fig. 1 (VII and VIII) and Fig. 2, mounted substantially concentrically, constitutes a satisfactory practical arrangement. The conical modulating element or moving electrode may be solid as in Fig. 1 (VI and VIII) or hollow as in Fig. 1 (VII) and Fig. 2 or it may be otherwise suitably formed, and the fixed electrode may be provided with a cylindrical surface Fig. 1 (V and VI) extending to or beyond the edge of the moving electrode. The annular surface *as* of this cylindrical extension may be conducting.

The electrode system may as shown in Fig. 2 be arranged and supported so that the restraint controlling the movement of the modulating element or moving electrode along one line (normally its axis) is substantially due to the forces exerted by the mass of granules alone. Such a construction may be combined with a diaphragm system exercising a certain degree of restraint without departing from the spirit of the invention.

In Figure 2 is illustrated, by way of example, a preferred embodiment of the invention in which the mass of the granules is relied on as the restricting influence for controlling the movement of the moving electrode *me*.

Bouncing of the diaphragm appears, from experimental evidence, to be controlled not only by what may be termed the " stiffness " of the granules induced by the relatively rigid closing member *cm* Fig. 1, but also to a large extent by the inertia of the granules so that this becomes an important feature conducive to good characteristics.

The diaphragm *d*, seating and clamping surfaces therefor, moisture proof membrane *mm*, and cover plate *cp* are all those of a known type of microphone though, of course, they need not be those shown. The diaphragm, for instance, might be the well known double cone type in which the edge of the diaphragm is supported by a thin annulus of flexible material and the electrode stem is fixed to the two cones by a spindle running through the centre of the assembly.

The moving electrode *me* has an apical angle of 120° though satisfactory results are obtainable with other angles as 45°, 60° and 90°. It is mechanically and

acoustically coupled to the diaphragm by means of a steam *s* which may be referred to as a spider, shaped as shown in plan at *ps* and as in section at *s*, this section being taken along a line running medially along two oppositely disposed arms of the spider as seen at *ps*. The spider is fixed to this diaphragm by means of a screw *sc* and resilient member *rm*. The moving electrode, spider, screw and resilient member are all made of light metal, as for instance, the alloy known under the trade mark " Duralumin ".

A silk cup *cu*, consisting of two one-piece cups one within the other, is clamped between the spider and diaphragm and the skirt of this cup is fitted into the barrel in the manner shown. It thus forms a lining to the inside surface of the barrel *ba* and a container for the granules.

The granules which fill the container are insulated from the barrel and diaphragm by the silk cup, and from the spider by enamel, for instance, with which the surface thereof is coated. The barrel and fixed electrode are insulated from each other by mica washers *mw*. Granules are introduced into the chamber through the filling hole *fo* until under the influence of gentle vibration of the case the chamber is full. The closing screw is inserted into this hole and the screw head sealed against moisture.

The front and back surfaces *f* and *b* of the moving electrode and that surface *su* of the fixed electrode with which the granules come into contact are gold plated.

There may be provided a cavity where the filling hole is situated, granules in which would help to maintain the granule pressure on the moving electrode when the microphone is in an inverted position.

The diameter of the fixed electrode may be somewhat reduced at that end which is within the granule chamber in such a way as to form with the inner surface of the barrel a circumambient annular chamber which is occupied by granules. The granules in this chamber which may or may not be in electrical contact with the outer surface of the fixed electrode tend to improve the performance of the microphone when held with the diaphragm downwards, though this may be at the expense of a slight reduction in efficiency when used in other positions. Whether this chamber shall or shall not be provided will be determined by the conditions under which the microphone is to operate.

It is to be understood, that, although we have referred to a moving and fixed electrode, two fixed electrodes may be provided and a totally immersed modulating element not forming part of the electric circuit may be provided for modulation of the resistance of the granules.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A two-electrode granular microphone having a modulating element or moving electrode coupled to a diaphragm by means of a driving support in which the modulating element or moving electrode is so dimensioned and/or shaped as to vibrate substantially as a whole and in phase with that end of the driving support to which it is fixed and is totally immersed in the granules in such manner that its motion in either direction is opposed by granules.

2. A two-electrode granular microphone according to claim 1 in which the modulating element moves in one direction towards a fixed electrode and in the other direction towards a non-rigid closing part of the granule chamber, the inertia of the mass of granules lying between said closing part and the element exerting a control on the electrode.

3. A two-electrode granular microphone according to either of the preceding claims in which the modulating element and fixed electrode are so shaped and/or disposed relatively to each other as to conduce to a radial flow of current through the granules.

4. A two-electrode granular microphone according to any of the preceding claims in which the modulating element and fixed electrode are so shaped and/or disposed relatively to each other as to conduce to a radial flow of current through the granules and to cause the intensity of the current to be greatest in that part of the granule mass to which the greatest reaction against movement is presented.

5. A two electrode granular microphone having a fixed electrode provided with a concave surface for presentation to the granules and a modulating element having a front convex surface of substantially the same shape as the concave surface of the fixed electrode, the modulating element being mounted within or partly within the concavity of the fixed electrode with the shaped surfaces of each adjacent that of the other, the modulating element being totally immersed in the granules and mechanically connected to the diaphragm.

6. A two electrode granular microphone according to Claim 5 in which the modulating element is conical and is mounted partly within a conical cavity in the fixed electrode substantially in the relative positions shown in Fig. 2.

7. A two electrode granular microphone

according to Claim 1 in which the modulating element presents a convex face to the granules on one side and a flat face on the other side substantially in the manner shown in Fig. 1 (VI) or Fig. 1 (VIII).

8. A two electrode granular microphone according to Claim 7 in which the modulating element is solid.

9. A two electrode granular microphone according to any of the preceding claims in which the front and back faces of the modulating element are in electrical connection with the granules.

10. A two electrode granular microphone according to any of the preceding claims in which the fixed electrode is provided with a cavity which acts as a reservoir for granules whereby a "hydrostatic" head of granules is provided.

11. A two electrode granular microphone according to claim 1 having a fixed electrode and a modulating element totally immersed in granules contained in a chamber in which reaction against movement of the granules in response to movement of the modulating element in one direction is provided by the fixed electrode and reaction against movement of the granules in response to movement of the modulating element in the other direction is provided by a stiff closing member.

12. A two electrode granular microphone substantially as described.

Dated this 12th day of July, 1932.
SIEMENS BROTHERS & CO. LIMITED,
By their Attorney,
F. A. LAWSON,
For Selves and Co-Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1932.

Fig. 1.

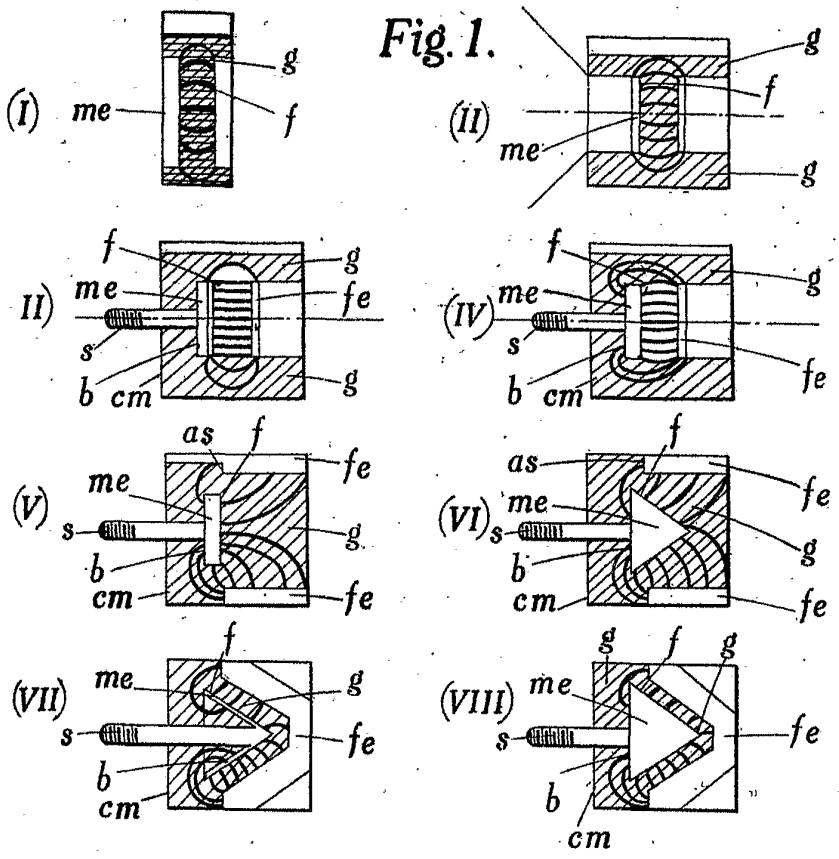
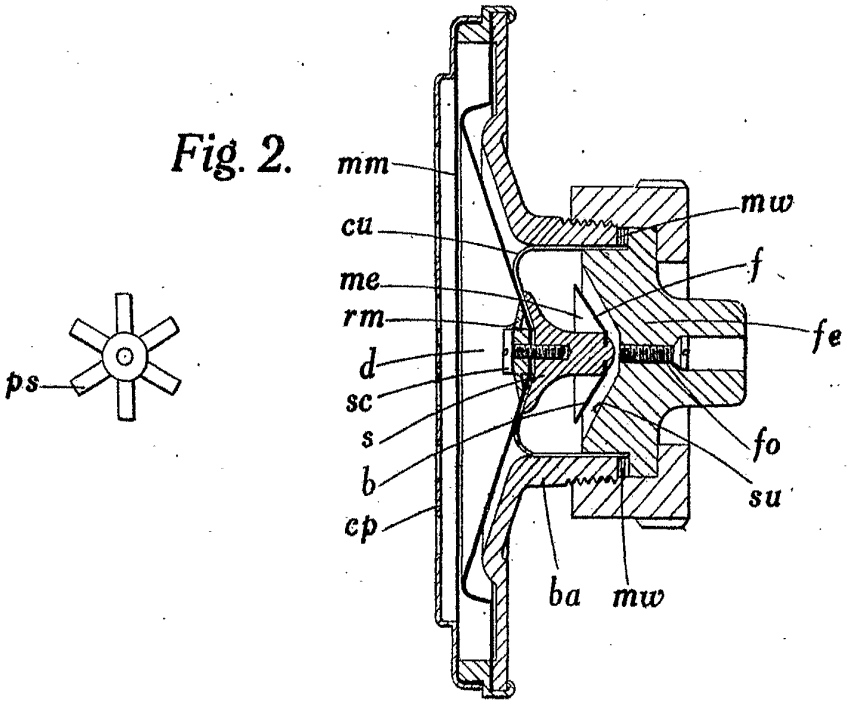


Fig. 2.



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