July 29, 1941. G. W. SUTTON 2,250,781

MICROPHONE

Original Filed Nov. 25, 1935 3 Sheets-Sheet 1

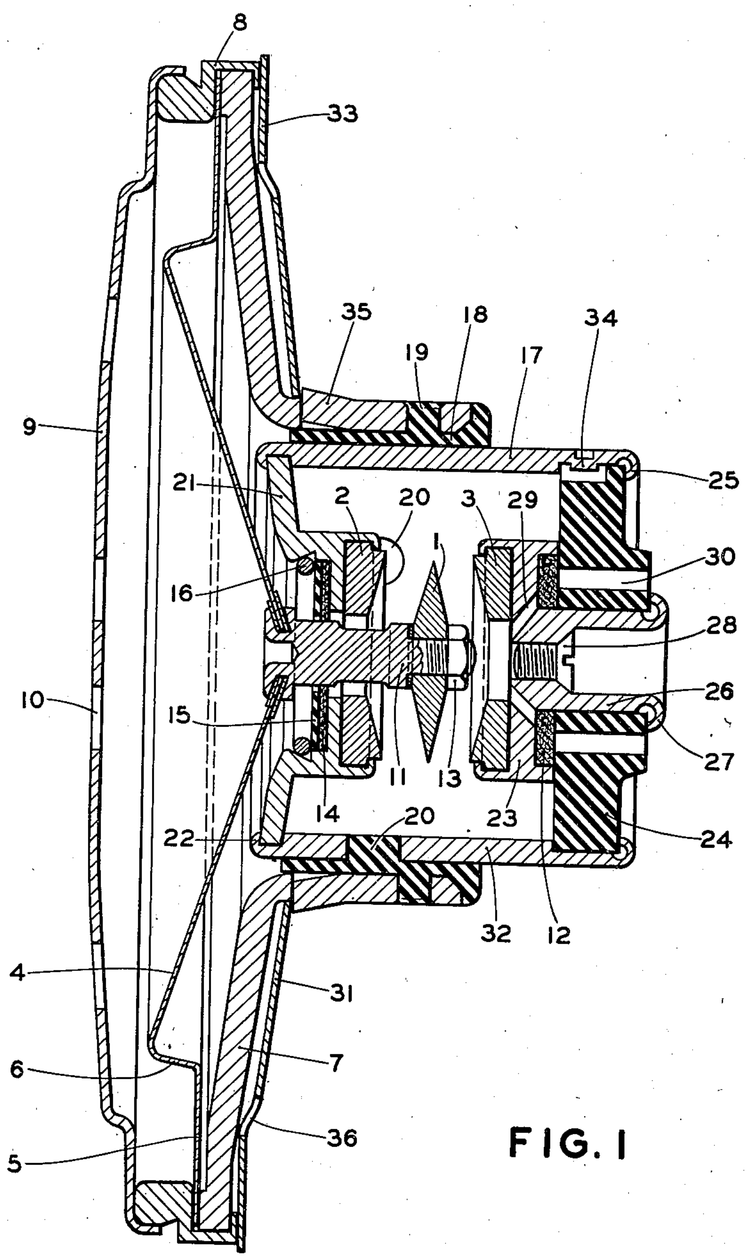

FIG. I

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MICROPHONE

Original Filed Nov. 25, 1935 3 Sheets-Sheet 2

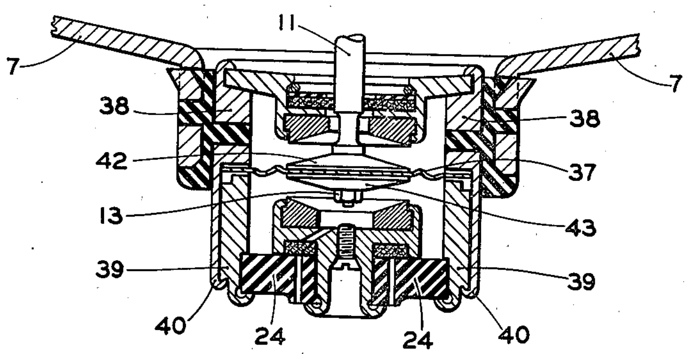

FIG. 2

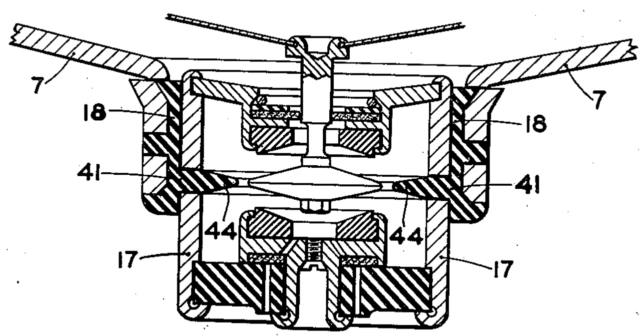

FIG. 3

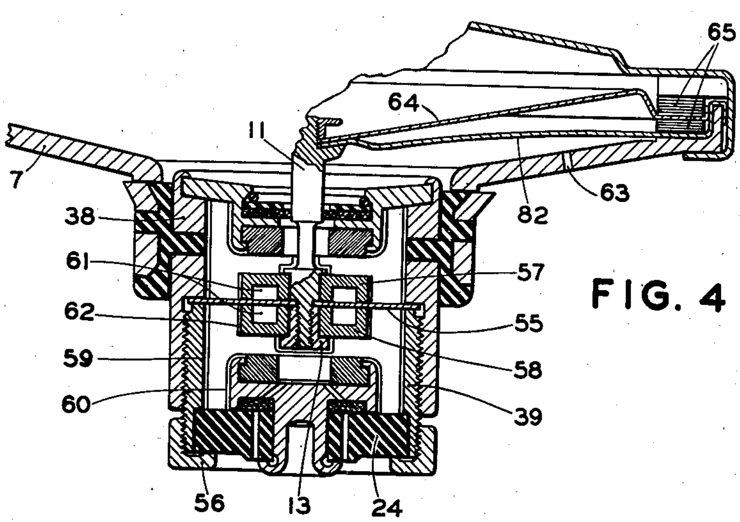

FIG. 4

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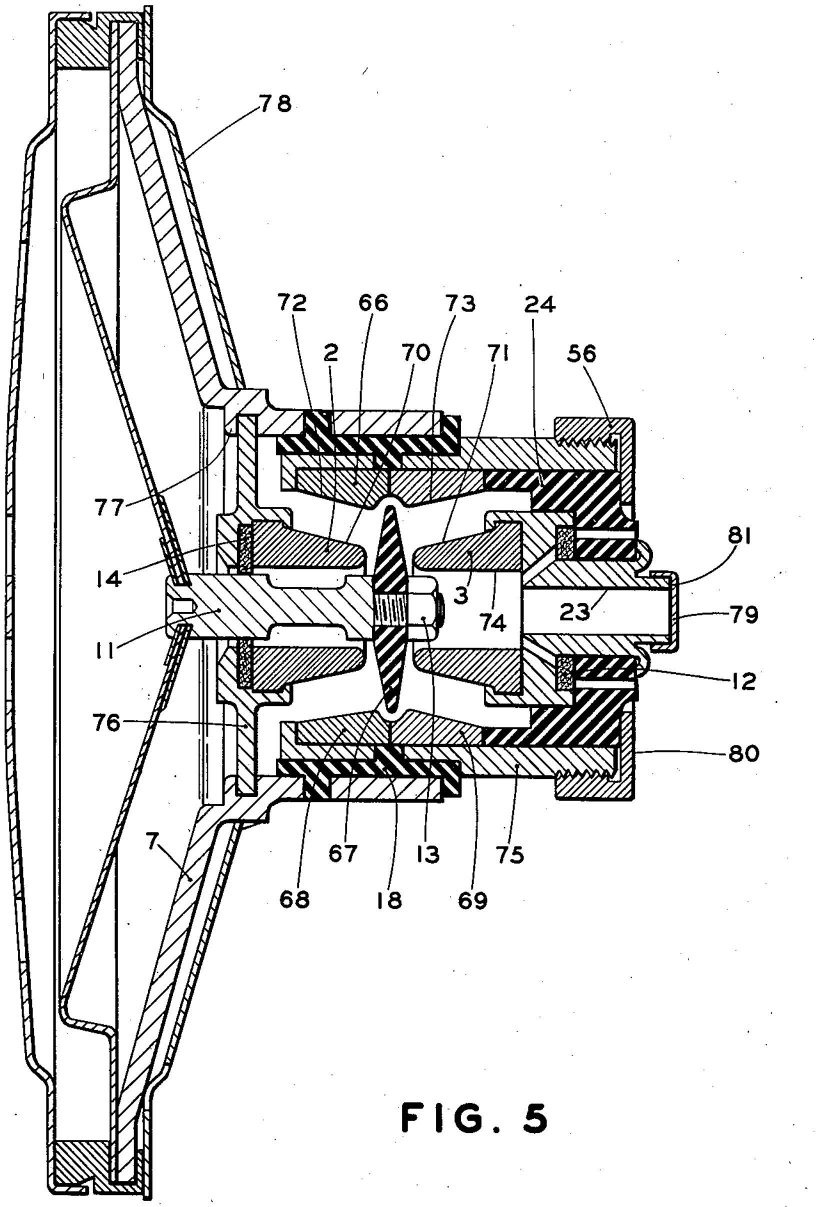

FIG. 5

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UNITED STATES PATENT OFFICE

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MICROPHONE

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Original application November 25, 1935, Serial No. 51,501, now Patent No. 2,179,733, dated November 14, 1939. Divided and this application May 23, 1938, Serial No. 209,507. In Great Britain November 27, 1934

13 Claims. (Cl. 179—135)

The present invention relates to microphones or transmitters such as are used in telephone, public address and sound recording systems and more particularly to improvements in the form and construction of microphones or transmitters of the differential type in which carbon or other conducting granules are used.

This application is a division of my co-pending application Serial No. 51,501, filed November 25, 1935, and the claims herein are directed to the microphone chamber construction and electrode arrangement.

By a microphone or transmitter of the differential type is to be understood one which has two paths for current, a movement of the diaphragm causing the resistance of one of the paths to be increased as the resistance of the other path is decreased. In the usual differential transmitter a moving electrode which is coupled to the diaphragm is situated between two fixed electrodes. It is also feasible to have three fixed electrodes, the pressure of the granules being varied by an element coupled to the diaphragm.

According to one feature of the invention, a differential microphone or transmitter is constructed so that with a proper filling of granules in the granule chamber a substantial "head" of granules acts on the active face or faces of each of the three electrodes at all positions of the transmitter. This construction helps among other things to ensure the two halves of the transmission system corresponding to the two current paths referred to in the preceding paragraph are maintained substantially in balance under all working conditions. With a differential microphone or transmitter it is important that a sufficient degree of balance should be maintained, as a lack of balance results not only in a decreased efficiency of conversion from sound waves to alternating currents but also in a diminution of that freedom from the production of even harmonies and from trouble due to a noisy source of microphone current which should result from push-pull operation. The terms microphone and transmitter are used in a wide sense, and are intended to cover a transmitter element with or without parts not concerned with the invention such as a holding or mouthpiece.

In applying the invention to a differential microphone or transmitter of the kind comprising two fixed electrodes and a moving electrode, it is preferably arranged that the maintenance of a substantial head of granules on the active face of each fixed electrode at all positions of the microphone or transmitter is due to the use of a construction wherein the active face of each fixed electrode stands away from the end of the granule chamber on which the electrode is supported and wherein a space for the accommodation of granules exists around the body of the electrode and/or around a member supporting the electrode and projecting into the granule chamber. A construction may be used wherein a diaphragm to which the moving electrode is coupled has a central portion consisting of a cone of thin material wherein the apex of this cone is attached to the moving electrode by a rod or pin which passes through a hole in a fixed electrode lying between the diaphragm and the moving electrode, and wherein the apex is situated within a depression in a wall of the granule chamber, this depression having its counterpart inside the granule chamber in a protuberance on which the said fixed electrode is mounted. This construction has the advantage that it allows the rod or pin to be short and rigid and yet provides for the immersion in the granules of the fixed electrode concerned.

In certain contemplated embodiments of the invention comprising microphones or transmitters of the kind having two fixed electrodes and a moving electrode, the overall internal dimensions of the granule chamber in directions transverse to its length are considerably greater than would be necessary just to accommodate the fixed and moving electrodes, and according to a subordinate feature of the invention in cases where such a construction is employed an insulating barrier is provided round the moving electrode to prevent or minimize the flow of current through the granules in paths not including this electrode and in paths the resistance of which is not effectively varied by movement of this electrode. The insulating barrier may be a partial one allowing granules to pass freely from one section of the granule chamber to the other, or it may be a complete barrier, in which case care must be taken to ensure that in spite of the presence of the barrier a substantial head of granules acts on the active faces of the moving electrode at all positions of the microphone or transmitter.

The invention is applicable to a differential microphone or transmitter of the kind in which a modulating member attached to a diaphragm and situated between two fixed electrodes is not itself an electrode but acts to vary the resistance of the current paths between the two fixed electrodes mentioned and a third fixed electrode. In a contemplated embodiment of the invention comprising a microphone or transmitter of this kind, two of the fixed electrodes project from opposite ends of the granule chamber, and the active face of the third fixed electrode is in the form of a complete surface of revolution which encompasses the other two electrodes and the modulating member.

A microphone or transmitter according to the invention may be used as an ordinary subscriber's or operator's transmitter in a public or private telephone system, and, owing to the sensitivity resulting from the use of the differential principle, it may also, for example, be used in cases where it is desired to operate a loudspeaking receiver or receivers without the aid of an amplifier or where it is desired to render it unnecessary for the source of sound to be situated close to the transmitter.

A number of specific embodiments of the invention will now be described with reference to the accompanying drawings. The invention is not limited to these embodiments, which are described by way of example only. Fig. 1 of the drawings shows a cross-sectional view of a capsule or "inset" transmitter according to the invention, and Figs. 2, 3, 4 and 5 show cross-sectional views of other capsule or inset transmitters according to the invention. With the exception of Figs. 1 and 5, each figure shows only part of the transmitter concerned. For convenience in laying out the drawings, the transmitters in Figs. 2–4 are shown lying on their backs, although this would, of course, not be the usual position when in use.

Referring firstly to Fig. 1, the capsule transmitter shown has a moving electrode 1 situated between two fixed electrodes 2 and 3. It is, of course, intended that the two microphone elements formed by the variable resistance path between the moving electrode and one fixed electrode, and the variable resistance path between the moving electrode and the other fixed electrode, shall be connected in the usual manner to give a push-pull effect.

The transmitter has a thin aluminum alloy diaphragm consisting mainly of a central portion 4 of conical form, this portion being surrounded by a flat annular portion 5 to which it is connected by a further portion 6 having the form of a frustum of a cone. The periphery of the diaphragm is clamped to the main casing 7 of the transmitter by a spun brass ring 8. The outer face of the diaphragm is stove enameled to minimize the possibility of corrosion. The casing 7 is of brass, and a brass guard plate 9 which fits tightly on the ring 8 and is carried thereby serves to protect the comparatively fragile diaphragm from damage. The guard plate has apertures 10 to allow sound waves to reach the diaphragm.

Attached to the apex of the center conical portion 4 of the diaphragm is one end of a light aluminum alloy rod or pin 11, the other end of this rod being attached to the moving electrode 1 by means of a small aluminum alloy nut 13. Although the rod is shown in cross-section, the usual shading has been omitted in order to avoid confusion of the drawing. The parts of the transmitter are designed in such manner as to enable the rod 11 to be as short and rigid as is possible compatible with a permissible weight. The rod 11, the diaphragm, and the casing 7 serve to provide the necessary electrical connection to the moving electrode 1. The moving electrode is a stiff disc of carbon having a hole drilled in its centre, the requisite rigidity compatible with a permissible weight being obtained by making the disc thick near the centre and thin at the edge. The diameter of the disc is about one fifth that of the free portion of the diaphragm, and the disc vibrates substantially as a whole at the frequencies which are important for the transmission of articulate speech. The shape of the disc tends to minimize the flow of current through the granules in paths the resistance of which is not effectively varied by movement of the disc.

In the quiescent condition, the moving electrode 1 is equidistant from the fixed electrodes 2 and 3, which are carbon electrodes of annular form. It is always totally immersed in the granules, which are of carbon. The granules are not shown in the drawings, but a normal filling of granules occupies a sufficiently large portion of the available volume of the granule chamber to ensure that the active faces of all three electrodes remain totally immersed in granules at all positions of the transmitter. The surfaces of the fixed electrodes which face the moving electrode (i. e. the active faces) are shaped in such a manner that the opposing surfaces of the fixed and moving electrodes are substantially parallel. The rod 11 passes through the hole in the centre of the front fixed electrode 2, a felt washer 14 surrounding the rod to prevent leakage of granules from the granule chamber. The felt washer is held in position by a further washer 15 and a sprung ring 16. The further washer 15 is an insulating washer made of a synthetic resin product. The hole in the center of the back fixed electrode 3 serves to provide the passage through which the granules are inserted into the granule chamber on the completion of the assembly of the transmitter, and also serves to make the mechanical impedance to displacement of the moving electrode more nearly the same for similar displacements in either direction and to maintain the symmetry of the two current paths through the transmitter. Since the portion of the rod 11 lying within the hole in fixed electrode 2 is appreciably smaller in diameter than the hole, both the holes in the fixed electrodes serve to provide room for a small quantity of granules and thus assist to some extent in that "immersion" of the fixed electrodes which is a feature of the transmitter.

The granule chamber is carried by the casing 7, the cylindrical brass wall 17 of the chamber being insulated from the casing 7 by insulating material 18. In manufacturing the transmitter, the material 18 is pressed, moulded, or squirted into the correct form and position. The material is locked in position in the casing 7 by rivet-shaped portions such as 19, and three projecting portions 20 spaced 120° apart with respect to the axis of the capsule lock the granule chamber in position. The material may conveniently be a material such as ebonite or a cellulose acetate compound or a synthetic resin product. The front wall 21 of the granule chamber is of brass and is fixed to the cylindrical wall 17 by the spun over edge 22 of the latter. The front fixed electrode 2 is mounted directly on the front wall so that the cylindrical wall 17 serves as one terminal of the transmitter in the way that the casing 7 serves as another terminal. The back fixed electrode 3 is carried by a brass member 23 which in turn is carried by a member 24 composed of insulating material. The member 24 forms the rear wall of the granule chamber, and is fixed to the cylindrical wall 17 by the spun over edge 25 of the latter. The member is secured against rotation by a punched out portion 34 of the wall 17 which engages a corresponding slot in the member. The brass member 23 has a hollow stub 26, and the spun over edge 27 of this stub serves to fix the member 23 securely to the member 24 and also forms the third terminal of the transmitter. A screw 28 closes the passage through which the granules are inserted into the granule chamber on the completion of the assembly of the capsule. The fixed electrodes 2 and 3 are situated in cup-shaped receptacles formed in the members 21 and 23, the spun over sides of the cups holding the electrodes firmly in position. Air passages 29 and 30 pass through the members 23 and 24, and a felt washer 12 pervious to air serves to prevent leakage of granules via these passages. The function of the passages is to ensure that the air pressure behind the diaphragm and in the granule chamber remains substantially the same as that of the outside air.

It will be seen from the drawings that both the internal diameter and internal length of the granule chamber are greater than would be necessary just to accommodate the fixed and moving electrodes with their active faces at the appropriate distance apart (e. g. the diameter is about one and three-quarters times that of the electrodes) and that the two fixed electrodes are arranged to protrude into the granule chamber, the effect being to "immerse" these electrodes in the granules. The form of the member 21 is such that it allows the rod 11 to be short and rigid and yet provides for the immersion of the front electrode 2 and a sufficient air-space behind the diaphragm. The immersion of the electrodes operates to the end that a substantial "head" of granules acts on the active face or faces of each of the three electrodes at all positions of the transmitter.

The interior walls of the granule chamber (including the surfaces of pin 11 and nut 13) and the exposed surfaces of the fixed electrodes other than the active faces are covered with a layer of insulating varnish or enamel.

The transmitter is of a size suitable for insertion in the transmitter container of a handmicrotelephone or in a holder of similar dimensions. The member 33 is a form of spring ring and its purpose is to force the transmitter against the mouthpiece part of a holder into which it is inserted. The punched out portions or projections 35 of the casing 7 serve to secure the spring ring. The projections are four in number, three (including the one shown at the top in the figure) being spaced 120° apart with respect to the axis of the transmitter and one (shown at the bottom in the figure) being midway between two of the others. The three equally-spaced projections are spaced from the flange of the case while the fourth projection abuts it. The edge of the central hole of the spring ring 33 is cut away in three places corresponding to the three equally spaced projections, but each of the cuts extends for a considerable distance round the periphery of the hole. In assembling the ring in position on the casing 7, it is pressed against the flange of the casing with the cuts coinciding with the four projections (the cuts are sufficiently long to enable the odd projection to enter the same cut as one of the adjacent equally spaced projections) and is then rotated until the end of one of the cuts abuts the odd projection. The spring ring has a series of holes 36 cut in it to decrease its stiffness. In so far as the terminals of the transmitter are concerned the ring where provided is looked upon as forming part of the casing 7.

It will be realized that the three terminals formed by the surfaces 31 and 32 of members 33 and 17 and the spun over edge 27 of stub 26 are of such a form that contact between them and contact springs in a casing adapted to receive the transmitter is unaffected by rotation of the transmitter.

The passage through which the granules are inserted may alternatively be closed by a cap permanently fixed in position by a spinning operation. It should be noticed that where this is done a capsule transmitter is obtained which cannot be tampered with by undoing screws or screwed parts.

In describing the embodiments shown in the remaining figures, only points in which the construction differs from that of a previously described embodiment will be dealt with in detail. For the sake of simplicity, the granular filling of the granule chamber is not shown in any of the figures.

Referring now to Fig. 2, this shows a capsule transmitter the construction of which only differs materially from that of the capsule transmitter shown in Fig. 1 in that an insulating barrier is provided around the moving electrode. The barrier is formed by an annular portion of a disc or membrane 37 of very thin and flexible insulating material such as Swiss silk. The disc or membrane 37 has a small hole at its centre, and is threaded on the screwed portion of the rod or pin 11 which couples the moving electrode to the diaphragm. The moving electrode is composed of two separate carbon discs 42 and 43 between which the central portion of the disc 37 is clamped. The periphery of the disc 37 is clamped between two brass members 38 and 39 which together form the cylindrical wall of the granule chamber and correspond to member 17 in the capsule transmitter of Fig. 1. As shown in the figure, member 39 is held in position by a spun over edge 40 of member 38, but it could equally well be arranged to screw into member 38. Similarly, of course, member 24 could be arranged to screw into member 39 instead of being held by a spun over edge of the latter. The unclamped annular portion of the disc 37 is slack and not taut, and this, in conjunction with the thinness and flexibility of the material of which the disc is composed, enables the pressure due to a "head" of granules on one side to be readily transmitted to granules on the other side. By suitably filling the two halves of the granule chamber with granules it can therefore be arranged that a substantial head of granules acts on both faces of the moving electrode at all positions of the transmitter. The barrier formed by the disc serves to prevent the flow of current through the granules in paths not including the moving electrode to minimize the flow of current in paths the resistance of which is not effectively varied by movement of this electrode.

In assembling the transmitter, the correct quantity of granules for the half of the granule chamber through which rod 11 passes is placed in said half before the parts 42, 37, 43, and 39 are fitted and fixed in position.

In the capsule transmitter Fig. 2 just described, the disc 37 may take the form of a comparatively stiff annular washer which is of insulating material and which is supported only by being clamped at its outer edge between members 38 and 39. The annular washer may conveniently be made of a synthetic resin product. The moving electrode in this case is in one piece as in the capsule transmitter of Fig. 1, and the central hole of the annular washer is appreciably larger than the electrode so that the annular gap around the moving electrode between the electrode and the washer is sufficiently wide to allow the free passage of granules. The annular gap is however not wide enough seriously to impair the effect of the barrier formed by the washer in so far as confining current flow to desired paths is concerned.

Referring now to Fig. 3, this shows a capsule transmitter in which the granule chamber is internally equivalent to that of the capsule transmitter described in the preceding paragraph but in which the partial barrier around the moving electrode is formed by a fin 44 of insulating material which is in one piece with the material 18 which insulates the cylindrical brass wall 17 of the granule chamber from the casing 7. The fin is linked with the main body of insulating material via circular holes 41 in the wall of the granule chamber. In manufacturing the transmitter, the insulating material is pressed, moulded or squirted into the correct form and position.

Referring now to Fig. 4, this shows a capsule transmitter having a granule chamber in which a complete insulating barrier around the moving electrode is formed by an auxiliary diaphragm 55 which is fairly stiff and may for example be of mica or of metal covered with a layer of insulating varnish or enamel. The diaphragm 55 is adapted to play an important part in controlling the movement of the vibrating system of the transmitter, and makes it possible for the main diaphragm to be flexibly mounted at its edge (i. e. to be a "floating" diaphragm). The diaphragm 55 has a small hole at its centre, and is threaded on the screwed portion of the rod or pin 11. The moving electrode is composed of two separate carbon members 57 and 58 between which the central portion of the diaphragm 55 is clamped. Each of the two carbon members consists of a ring of carbon in which a channel 61 has been cut in order to make the vibrating system as light as possible. The periphery of the diaphragm is clamped between the two brass members 38 and 39 which together form the cylindrical wall of the granule chamber. The member 24 of insulating material is clamped to member 39 by a clamping ring 56. In the case of the figure now being referred to, it has been deemed advisable to indicate the various layers of insulating varnish or enamel inside the granule chamber (such as 59, 60, 62). It will be seen that the two annular active faces of the composite moving electrode stand away from the corresponding faces of the diaphragm 55 so that spaces for the accommodation of granules exist around the body of the electrode. This construction ensures that an adequate head of granules acts on the said active faces at all positions of the transmitter. The hole 63 in the casing 7 serves to maintain equal air pressure on both sides of the main diaphragm. The main diaphragm 64 is of an aluminum alloy and is a floating diaphragm having its outer edge lightly damped by packs of paper washers 65. A good electrical connection between the diaphragm 64 and the casing 7 is provided by a flexible metal spider 82. The diaphragm may be constructed in known manner of two concave shells of thin light metallic material placed concentrically with the concave sides facing each other, the construction being such that the edges of the shells clamp between them a thin disc or annulus of metal foil the outer edge of which is clamped to the casing 7.

Referring now to Fig. 5, this shows a capsule transmitter in which all three electrodes are fixed electrodes, the resistance of the current paths between the two similar electrodes 2 and 3 and the other electrode 66 being varied during the operation of the transmitter by a modulating member 67 attached to the diaphragm by an aluminum alloy rod or pin 11. In effect, the modulating member 67 and electrode 66 together perform the functions performed by the moving electrode in the previously described embodiments. The modulating member 67 is of insulating material, and is held in position on rod 11 by a small aluminum alloy nut 13. Both the member and all three electrodes are solids of revolution about the axis of the capsule. Both faces of the aluminum alloy diaphragm are stove enameled to minimize the possibility of corrosion. The enamel also serves to insulate the diaphragm from the brass casing 7 which in this embodiment is electrically connected to electrode 2. It will be seen that electrode 66 is a composite one consisting of two parts 68 and 69. The active faces 70 and 71 of electrodes 2 and 3 are parallel to the corresponding active faces 72 and 73 of electrode 66. The exposed surfaces of the electrodes other than the active faces, and the interior walls of the granule chamber where of metal (including the surfaces of pin 11 and nut 13,) are covered with a layer of insulating varnish or enamel 74. A normal filling of granules occupies a sufficiently large portion of the available volume of the granule chamber to ensure that a substantial head of granules acts on the active face or faces of each of the three electrodes at all positions of the transmitter. The felt washers 12 and 14 correspond to the washers similarly designated in Fig. 1 and serve to prevent leakage of granules from the granule chamber. The cylindrical brass wall 75 of the granule chamber is carried by the casing 7 but is insulated therefrom by insulating material 18. In manufacturing the transmitter, the material 18 is pressed, moulded, or squirted into the correct form and position. The front wall 76 of the granule chamber is of brass and is fixed to the casing 7 by a spun over edge 77 of the latter. The front electrode 2 is mounted directly on the wall 76. The back electrode 3 is carried by a brass member 23 which in turn is carried by a member 24, composed of insulating material. The member 24 and the parts 68 and 69 of electrode 66 are clamped in position in the brass member 75 by a metal clamping ring 56. The passage through which the granules are inserted is closed by a metal cap 81.

The terminals for electrodes 2, 3, and 66 are formed by the surfaces 78, 79, and 80, respectively, and are hence of such a form that contact between them and contact springs in a casing adapted to receive the transmitter is unaffected by rotation of the transmitter.

What is claimed is:

1. In a differential transmitter, a microphone chamber having a cylindrical wall, a cylindrical casing surrounding said microphone wall for supporting the same, insulating means moulded between said microphone wall and said casing, three electrodes supported within said microphone chamber, said microphone wall serving as a conducting element to a terminal for one of the electrodes, said casing serving as a terminal for the second electrode, and an end wall for said microphone chamber serving as a terminal for the third electrode, each of said ter-

minals being circular in form so that, with said transmitter mounted in a holder having contact-making members, rotation of the transmitter will not affect the contact between the terminals and contact members.

2. In a differential transmitter adapted to be mounted in a holder having contact-making members therein, a microphone chamber having three electrodes supported therein, a casing for supporting said microphone chamber, insulating material moulded between said chamber and said casing permanently securing them together, an end wall for said microphone chamber insulated therefrom; said casing, said microphone chamber, and said end wall serving as terminals for the electrodes within said microphone chamber; each of said terminals being circular and making contact with the contact making member of said holder so that contact between the terminals and the contact making member is unaffected by rotation of the transmitter within the holder.

3. In a differential transmitter, a main casing of moulded insulating material, a metallic microphone chamber having a cylindrical wall, a cylindrical metal supporting casing surrounding said microphone wall, said main casing being moulded between said microphone wall and said supporting casing to secure the same together, electrodes supported within said microphone chamber, said supporting casing and said microphone wall serving as terminals for said electrodes.

4. In a transmitter, a microphone chamber having a cylindrical wall, a casing for supporting said microphone chamber having a portion surrounding said chamber wall, an insulating separator moulded between said chamber wall and said casing, and perforations in said casing and said microphone wall cooperating with the moulded insulation to lock said elements together in their proper relationship.

5. In a transmitter, a microphone chamber having a cylindrical wall, a supporting casing for said microphone having a portion surrounding said microphone wall, an insulating member positioned between the casing and the microphone wall, said member having projections engaging openings in said chamber wall and the casing to lock the casing and chamber in proper position and prevent relative rotation therebetween.

6. In a differential transmitter, a microphone chamber having resistance material therein, three fixed electrodes supported within said chamber and insulated from one another, a diaphragm, and a modulating member of insulating material within said chamber positioned between said electrodes, said modulating member coupled to said diaphragm and actuated thereby to vary the resistance of the current path through said resistance material and between said electrodes.

7. In a differential transmitter, a microphone chamber having resistance material therein, three fixed electrodes supported within said chamber, two of said electrodes fixed to opposite end walls of said chamber and one of said electrodes fixed to the side wall of said chamber, a diaphragm, a modulating member of insulating material in said chamber positioned between said first two electrodes, a coupling rod connecting said modulating member with said diaphragm, said modulating member actuated by said diaphragm to vary the resistance of the current path through said resistance material between said side wall electrode and said end wall electrodes, and means for electrically insulating all three of said electrodes from each other.

8. In a differential transmitter as claimed in claim 7, a casing for supporting said microphone chamber electrically insulated from said chamber, said casing serving as a terminal for one of the end wall electrodes, said microphone chamber serving as a terminal for the side wall electrode, and a terminal member secured to the other of said end wall electrodes.

9. In a differential transmitter, a cylindrical microphone chamber, three fixed electrodes supported within said chamber, two of said electrodes supported on opposite end walls of said chamber and the third electrode supported around the inside of the cylindrical chamber wall, said chamber wall serving as a terminal connection for said third electrode, a casing having a portion surrounding said microphone chamber but insulated therefrom serving as a terminal for an end wall electrode, a terminal member for the other end wall electrode secured to the said end wall, a modulating member positioned between said end wall electrodes, a diaphragm positioned outside of said chamber, and a coupling rod connecting said diaphragm and said modulating member extending through one of said end wall electrodes.

10. In a differential transmitter, three concentric metallic elements, insulating means moulded between said elements to form an integral granule chamber, three stationary electrodes, each of said electrodes conductively associated with a different one of said elements, a diaphragm, and means controlled by said diaphragm for varying the pressure of the granules between two of said electrodes and the third electrode.

11. A sound translating granule chamber comprising three concentric metallic elements, insulating means electrically separating said elements, three stationary electrodes mounted within said chamber, and non-conductive means in said chamber for varying the pressure of the granules, each of said electrodes electrically associated with a different element and each element forming a circular contacting surface for connecting its associated electrode in an electrical circuit.

12. In a differential transmitter, a chamber containing granular resistance material, three stationary electrodes mounted within said chamber, a granular contacting surface for each of said electrodes parallel to the surface of another electrode, a granular pressure varying means mounted within said chamber actuated transversely to the direction of current flow between said parallel surfaces of said electrodes.

13. In a translating device, a chamber containing granular resistance material, three fixed electrodes mounted within said chamber spaced apart from each other, means in said chamber for varying the pressure of the granules to thereby vary the resistance in current paths between said electrodes, and means for actuating said pressure varying means in directions transverse to the current paths between said electrodes.

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