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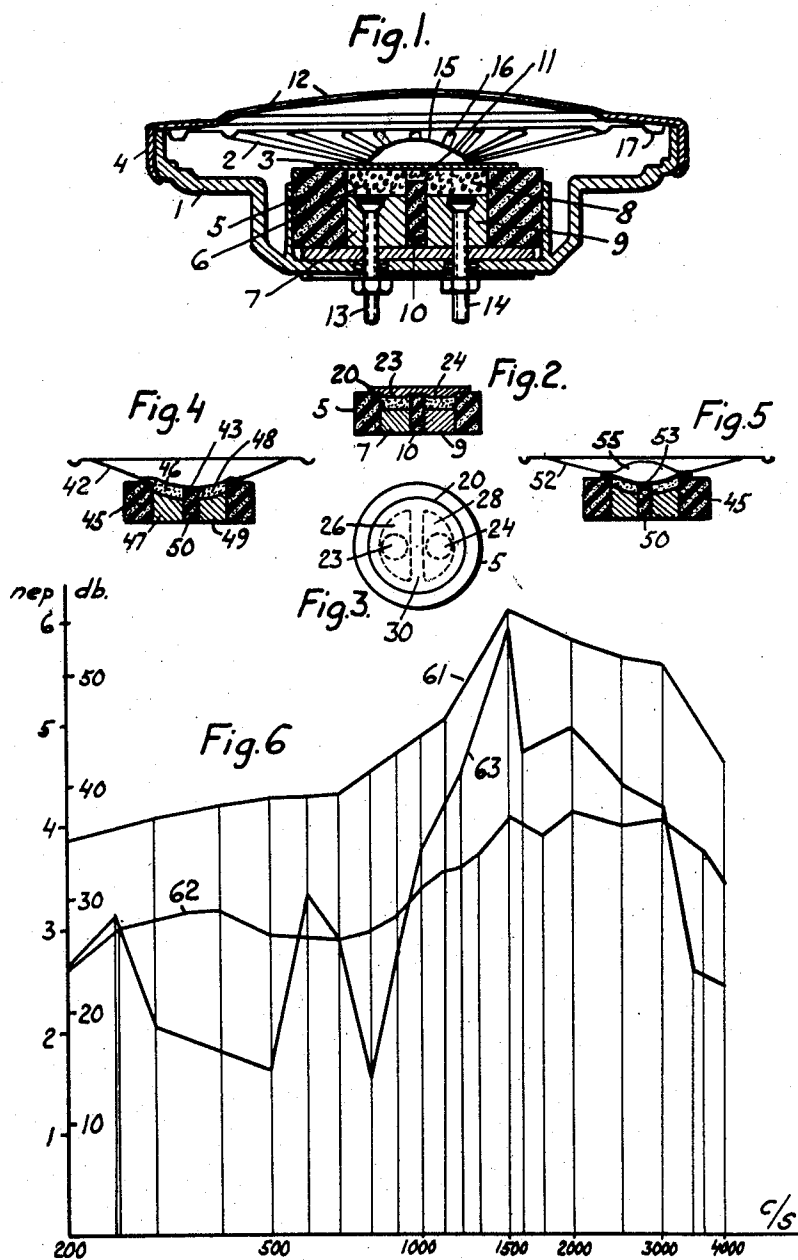
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2,609,458

TELEPHONE APPARATUS

Filed May 17, 1950

2 SHEETS—SHEET 1



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2 SHEETS—SHEET 2

Fig. 7.

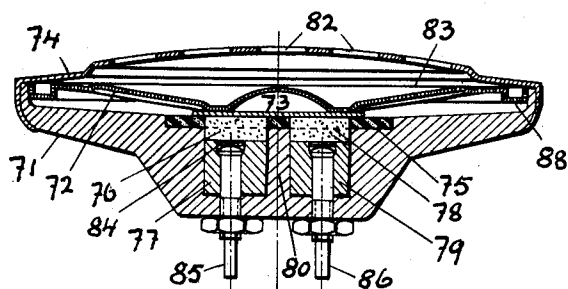
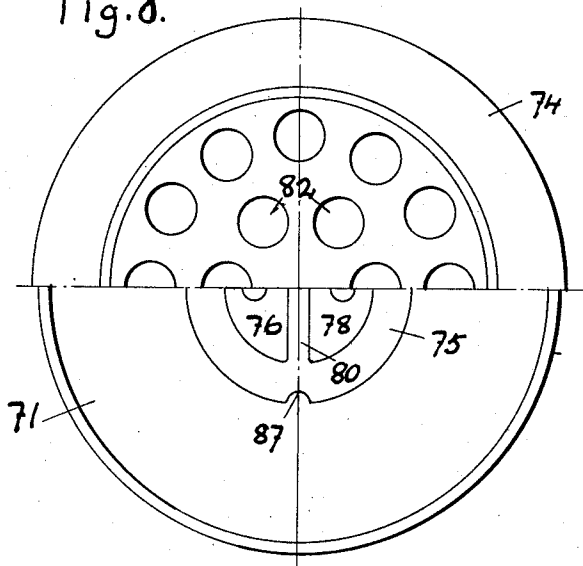


Fig. 8.



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## UNITED STATES PATENT OFFICE

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## TELEPHONE APPARATUS

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9 Claims. (Cl. 179—127)

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This invention relates to a telephone apparatus and particularly to a telephone transmitter having a new arrangement of suspension of its diaphragm with respect to the granular carbon.

Known telephone transmitters can be classified as transmitters with fixed diaphragms and such with loose diaphragms.

A fixed diaphragm is clamped at the periphery to the container and is allowed to vibrate only due to its elasticity. Such a clamped diaphragm has a very bad frequency curve rich in resonance peaks.

A loose diaphragm is clamped at its periphery between paper washers or the like to the container. Such a diaphragm has a frequency curve, which is low in the bass and in the intermediate register, but which otherwise is relatively good and free from resonance peaks.

This invention offers a new type of transmitter, which is provided with a diaphragm dissimilarly movable in one and in the other direction, and which offers a substantially better result than that offered by known transmitters, due to the fact that the new type of transmitter has a substantially straight frequency curve at output levels very much higher than those of known transmitters.

The inventors have found that in order to obtain the best possible result the construction and arrangement of the electrodes should be taken into consideration.

When a diaphragm is actuated by a sound wave, it will alternately be exposed to pressure and pull in step with the frequency of the sound wave. The diaphragm vibrates with the sound wave, and its energy of motion shall be converted into variation of the resistance of the granular carbon by increase and decrease of its compression.

As the granular carbon has a certain mass the most effective variation of the resistance will take place between the diaphragm and the adjacent layer of granular carbon.

The energy of motion shall accordingly be transmitted to an effective surface layer adjacent the diaphragm and not to the surfaces of comminuted carbon particles within the mass of the granular carbon or to a surface layer adjacent an insulating surface.

It is this surface layer, which in known transmitters is exposed to overloads at great amplitudes of the diaphragm, and which overload by and by causes a heavily increasing distortion and reduced sensitivity. This result is obviously related to a change of the resistance variation curve of the granular carbon.

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The inventors have found that an increased depth of granular carbon does not lessen the risk of overload.

According to a feature of this invention the surface area of the granular carbon adjacent the diaphragm is of a size relatively large compared to that of known transmitters. The depth of the granular carbon mass should only be sufficient to give the necessary initial pressure between the granular carbon particles. The pressure between the granular carbon and the diaphragm in non-actuated position should not be allowed to be less than zero, when the diaphragm is pulled outwards at a maximum amplitude. As the range to be used for variation of resistance between the granular carbon particles and the diaphragm is limited, the initial pressure should according to a feature of the invention be so chosen, that the operating value of the resistance would be located in the middle of said range, when the diaphragm is in normal non-operated position.

The surface of the diaphragm adjacent the granular carbon should preferably consist of carbon, for example a carbon disc, of such a diameter only, that the granular carbon chambers are well closed, because the carbon surface gives a certain variation of resistance, when exposed to increased pressure. This feature increases the sensitivity of this transmitter. A carbon surface is further more favourable than a metal surface, because its surface is not deteriorated as, for example, the gilt of a metal diaphragm.

The force needed for compression of the granular carbon is not linear. It increases heavily with the amplitude of the movement of the diaphragm. The variation of resistance is, however substantially linear within the range to be used.

The movement of the diaphragm in the direction from the granular carbon, upon lowering of the air pressure, should according to a feature of this invention be heavily dampened to prevent too much lowering of the pressure of the granular carbon. If the said pressure were lowered too much, distortion would result, due to the fact that for a certain air pressure the pressure phase would cause less variation of resistance in the granular carbon mass than that of the pulling phase.

The best result is obtained, if the entire pressure phase is transmitted to the granular carbon mass, in which case the diaphragm at the periphery should be completely free to move towards the granular carbon mass. No pressure or power robbing details should be allowed at

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the periphery on the side facing the granular carbon mass, for example paper washers or the like.

At the other side of the diaphragm, however, the diaphragm at the periphery should rest against the transmitter case or its protective lid, so that a heavy dampening action is obtained, when the diaphragm moves in the direction from the granular carbon mass.

This dampening action can be increased by making the diaphragm partly conical, and if desired to stiffen it by radial corrugations.

The diaphragm will thus according to this invention be clamped between a fixed peripheral surface at the side of the diaphragm turned from the granular carbon mass and a limited central part of the diaphragm in contact with the said granular carbon mass and with an elastic insulating material surrounding part of said granular carbon mass.

The present telephone transmitter offers several favourable features over those of known transmitters, such as a substantially increased sensitivity, an improved and substantially straight frequency curve, and low distortion.

Its transmission efficiency is 1 to 2 nepers or about 8 to 17 db higher than that of known transmitters.

Due to these favourable features a perceptibility or degree of articulation of  $1\frac{1}{2}$  nepers or about 13 db is obtained over that of known transmitters.

Thanks to all these favourable factors a cheap outside telephone plant can be used, in which the line conductors in cables and aerial lines can be made of small diameters. An economical profit can thus be made, when planning a new plant or an extension of an old one.

In an old telephone plant good transmission can be obtained over greater distances than heretofore.

The invention will be better understood by the following description of different non-limiting embodiments of the invention in connection with the accompanying drawings, in which:

Fig. 1 is a vertical section of an embodiment of a transmitter according to the invention.

Fig. 2 and Fig. 3 are sectional and top views respectively of another embodiment of details of the invention.

Fig. 4 and Fig. 5 are sectional views of other embodiments of diaphragms and granular carbon chambers according to the invention.

Fig. 6 shows frequency curves of a transmitter according to the invention and those of two known transmitters.

Fig. 7 is a vertical sectional view of still another embodiment of the invention, and

Fig. 8 is a top view partly in section of the transmitter shown in Fig. 7.

In Fig. 1 a casing 1 serves to inclose the working parts of the transmitter and to support a face plate 4 provided with openings 12 to admit sound waves to diaphragm 2, which in this embodiment is conical and in the center provided with a dome-shaped part 15. The diaphragm is preferably made of an aluminium or magnesium alloy, for example Duralumin. It can be provided with radial corrugations 16. A channel 17 is provided at the periphery of the diaphragm for stiffening it. The diaphragm at the periphery is pressing against the face plate 4 or against an intermediate moisture proof non-compressible membrane (not shown).

In this embodiment a plane carbon diaphragm

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3, the surface of which only slightly exceeds the opening surfaces of the carbon chambers 6 and 8, is glued to or in any other manner is attached to the center of the metal diaphragm 2.

There are two chambers 6 and 8, each filled with a layer of granular carbon. These layers are at one side limited by carbon electrodes 7 and 9 and at the other side by the carbon diaphragm 3, whereby the initial pressure between the carbon diaphragm and the granular carbon is so chosen, that the working point of the transmitter in non-operated condition is located at about the middle of the resistance variation curve of the transmitter.

The surface area of the layers of the granular carbon masses should be large compared to the depth of said layers in order to obtain a suitable pressure between the granular carbon masses and the carbon diaphragm.

The granular carbon chambers are laterally inclosed by an elastic insulating material 5, for example an elastic felt, sponge rubber or an elastic sponge-like material of a synthetic resin, for example polyethylene, polytetrafluorethylene or the like.

Between the granular carbon chambers there is a wall of separation 10 of the same material as the outside insulation 5, which wall of separation can entirely separate the granular carbon in the chamber 6 from the granular carbon in the chamber 8 by giving the said wall the same height as the outside insulation 5. In Fig. 1, however, the wall of separation 10 is somewhat lower, so that an opening 11 is provided between the chambers and the carbon diaphragm, which opening is filled with granular carbon.

By this conducting connection between the chambers interruption of the electrical circuit through the transmitter is prevented, in case the transmitter should be held in such a horizontal position, that the pressure of the carbon diaphragm should be a minimum, for example zero.

Normally, electric current passes from the granular carbon of one chamber through the carbon diaphragm to the granular carbon of the other chamber.

In Fig. 2 and Fig. 3 a modification is shown, in which the diaphragm 20 has been provided with two protuberances 23 and 24 dipping into the chambers 7 and 9 respectively. The protuberances are intended to secure electrical connection between the granular carbon of the respective chambers and the carbon diaphragm 20, if the granular carbon should be partly lacking and not completely fill the chambers, when in horizontal position. In this embodiment the insulating wall of separation 10 is of the same height as the outside wall 5 of the resilient and elastic insulating material, both kind of walls having been stamped out from a sheet of the desired insulating material of suitable thickness, so that the granular carbon of one chamber is entirely separate from the granular carbon of the other chamber.

In Fig. 3 is shown a top view showing the form of the granular carbon chambers 26 and 28, the opening surfaces of which, adjacent the carbon diaphragm, are large compared to the surface of the carbon diaphragm. The contact surfaces of the granular carbon layers are large compared to the depth of the said layers as noticed from Fig. 2 and Fig. 3.

Fig. 4 shows an embodiment, in which the diaphragm 42 is made in one piece, for example of metal, and provided with a spherical dome 43 towards the granular carbon chambers 46 and 48.

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The surfaces of the carbon electrodes 47 and 49 are spherical and parallel with the surfaces of the said dome. The diaphragm is provided with a horizontal ring-shaped surface between the dome and the periphery, which serves as seat for resting the diaphragm on the elastic resilient insulation 45, 50. On account of the spherical shape of the dome and of the carbon electrodes, the granular carbon will be in contact with the diaphragm in all positions of the transmitter so that interruption of the circuit is prevented.

In Fig. 5 there is shown another embodiment of a composite diaphragm similar to that of Fig. 1, but instead of a flat carbon diaphragm 3 there is in this embodiment a small curved carbon or metal diaphragm or disc 53 attached to the conical metal diaphragm 52 and its outward dome 55. Otherwise the transmitter is constructed as shown in Fig. 4.

In Fig. 6 there are shown actual frequency curves for transmitters of different constructions. In the figure cycles per second (c/s) are shown along the  $x$ -axis according to a logarithmic scale, while along the  $y$ -axis there are shown the output voltages in nepers and decibels (db) at an air pressure of 10  $\mu$  bar for all frequencies.

The curve 61 is the frequency curve for a transmitter according to the present invention, while the curves 62 and 63 show frequency curves for two different transmitters known in the market.

Curve 61 shows according to measurements of a sample transmitter its superior qualities over the known transmitters, to wit, a particularly straight frequency curve, a high overall transmitting efficiency and low distortion.

In Fig. 7 and Fig. 8 the casing 71 is pressed in one piece from an insulating material, for example a synthetic resin, such as a condensation product of a phenol formaldehyde resin, urea-formaldehyde, polyethylene, polystyrol, polytetrafluorethylene, or the like.

The casing is provided with cutouts for the carbon electrodes 77 and 79, for the granular carbon chambers 76 and 78 and for the elastic and resilient insulating material 75, for example felt, sponge rubber, sponge polyethylene, or the like.

The carbon diaphragm 73 and the conical metal diaphragm 72 attached thereto rest upon the said elastic and resilient insulating material and press against the granular carbon in the same manner as in Fig. 1. The carbon electrodes 77 and 79 are fastened to the casing by means of bolts and nuts 85 and 86 respectively. An insulation 84 covers the bolt heads, so that the granular carbon masses 76 and 78 do not directly contact the bolts.

A face plate 74 provided with holes 82 is attached to the casing and a moisture-proof substantially non-compressible membrane 83 is located between the face plate and the diaphragm 72. At the periphery the diaphragm is provided with a reinforcement and rests directly on the said membrane 72 and the face plate 74 at a peripheral surface at the other side of the granular carbon chambers, while the opposite peripheral surface is freely movable in the direction of the said granular carbon chambers.

The granular carbon chambers 76 and 78 are separated by a partition 80. The chambers have the form shown in Fig. 8 similar to that of the chambers 26 and 28 shown in Fig. 3.

As noticed from Figs. 7 and 8 the granular carbon chambers have large surfaces and low

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depth, by which great sensitivity and a great loading capacity are obtained.

The casing is provided with two studs 87 to center the elastic insulation layer 75, so that its position with respect to its partition, which separates the granular carbon masses in the chambers, will be located exactly over the fixed partition 80.

The transmitter operates in a manner similar to that shown in Fig. 1 and Fig. 3.

We claim:

1. A telephone transmitter comprising, in combination, a granular carbon containing chamber, a stiff diaphragm, the central part of one side of said diaphragm being electrically conductive and reciprocatingly movable in operative relation to the granular carbon mass in said chamber, a fixed support for supporting only the other side of the diaphragm at its periphery for heavily damping the movement of the diaphragm, when moving away from the granular carbon mass upon being exposed to the rarefaction phase of a sound wave, said other side of the diaphragm at the periphery being entirely free to move towards the granular carbon containing chamber, when the diaphragm is exposed to the compression phase of a sound wave.

2. The telephone transmitter, as set forth in claim 1, in which the said diaphragm between its peripheral and central parts is conical in shape, and in which the central part of the said diaphragm is pressing against the granular carbon in said chamber.

3. The telephone transmitter, as set forth in claim 1, in which the central part of the diaphragm consists of a carbon disk fixedly attached to the diaphragm and normally subjected to resilient pressure against the mass of granular carbon in said chamber.

4. A telephone transmitter comprising, in combination, two granular carbon containing chambers, a stiff diaphragm, the central part of one side of said diaphragm being electrically conductive and reciprocatingly movable in operative relation to the granular carbon in said chambers, whereby the granular masses in the two chambers are connected in series over the electrically conducting central part of said diaphragm, a fixed support for supporting only the other side of the diaphragm at its periphery for heavily damping the movement of the diaphragm, when moving away from the granular carbon upon being exposed to the rarefaction phase of a sound wave, said other side of the diaphragm at the periphery being entirely free to move towards the granular carbon containing chamber, when the diaphragm is exposed to the compression phase of a sound wave.

5. The telephone transmitter, as set forth in claim 4, in which the granular carbon in each chamber is arranged in the form of a thin layer of large surface area in contact with the central part of said diaphragm.

6. The telephone transmitter, as set forth in claim 4, in which the normal pressure between the diaphragm in non-actuated position and the granular carbon mass is substantially about the middle of the range of the pressure variation of the transmitter, when exposed to sound waves.

7. The telephone transmitter, as set forth in claim 4, which includes a layer of a porous, elastic and substantially resilient substance, on which layer part of the central part of the diaphragm rests while another conducting part of the said central part of the diaphragm rests on

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the granular carbon masses of said chambers.

8. The telephone transmitter, as set forth in claim 4, which includes a layer of a porous, elastic and substantially resilient synthetic resin in sponge form, on which layer part of the central part of the diaphragm rests, while another conducting part of said central part of the diaphragm rests on the granular carbon masses of said chambers.

9. A telephone transmitter, as set forth in claim 1, in which the transmitter comprises a casing of a moulded electrical insulating material containing cavities for the granular carbon and for the diaphragm, and a layer of a porous, elastic and substantially resilient substance, on which layer part of the central part of the diaphragm rests, while another conducting part of

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said central part of the diaphragm rests on the granular carbon mass of said chamber.

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