Feb. 27, 1923. 1,446,544

P. W. BRIDGMAN

ELECTRICAL SOUND DETECTING APPARATUS

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Fig. 1.

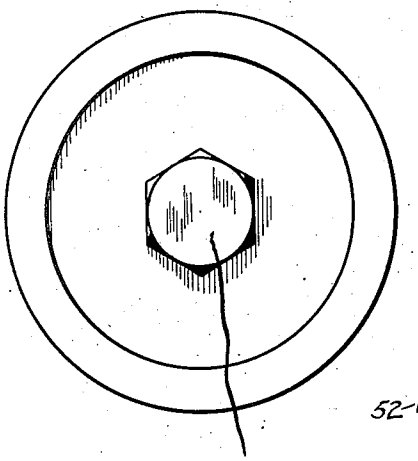


Fig. 2.

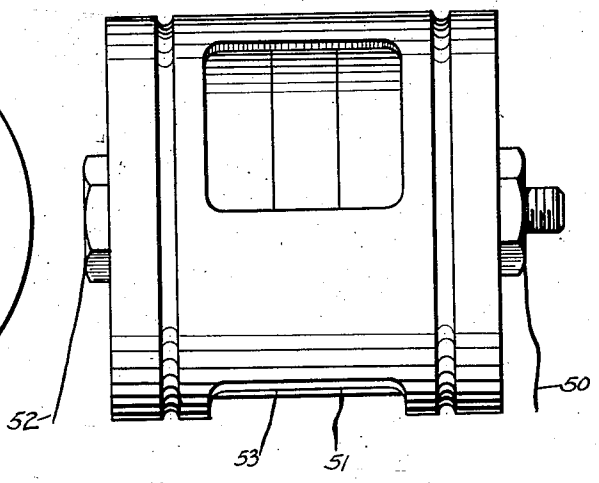


Fig. 3

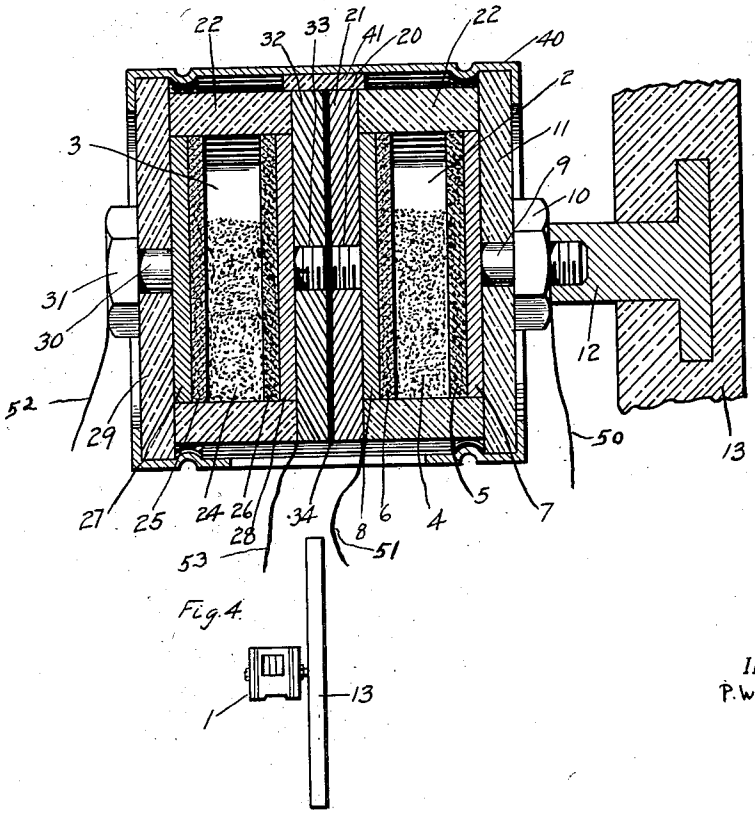


Fig. 4.

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Fig. 5

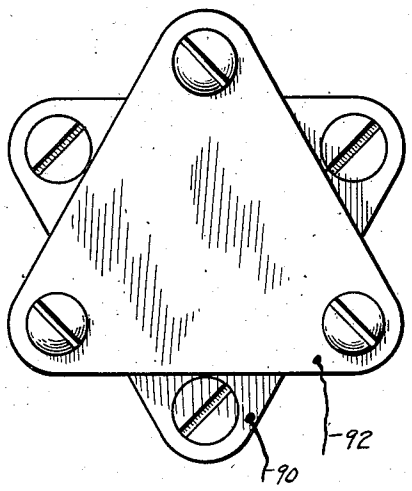


Fig. 6.

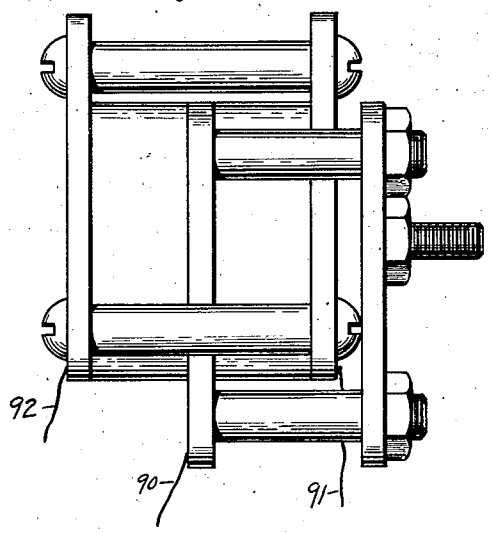
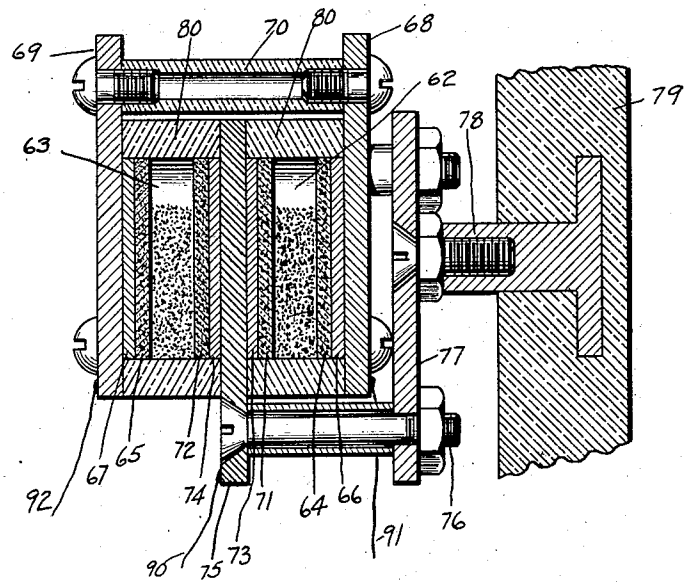


Fig. 7.



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FIG. 8.

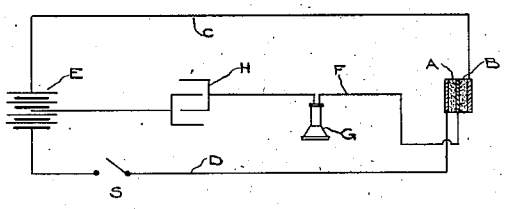


FIG. 9.

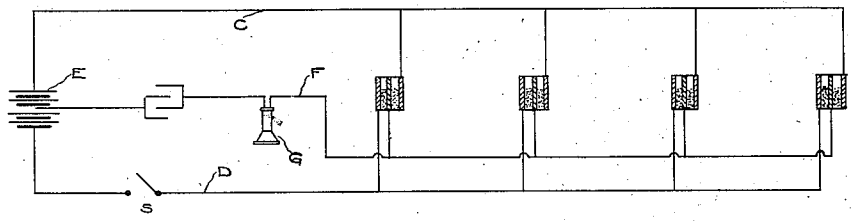
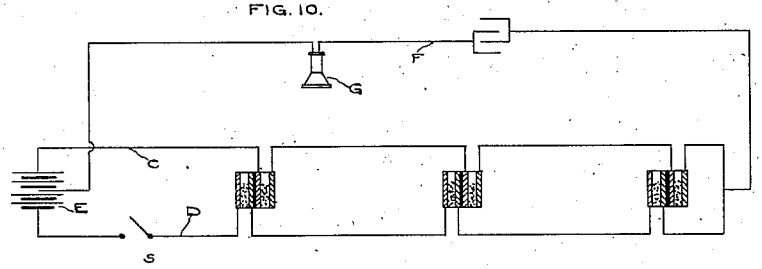


FIG. 10.



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UNITED STATES PATENT OFFICE.

PERCY W. BRIDGMAN, OF CAMBRIDGE, MASSACHUSETTS.

ELECTRICAL SOUND-DETECTING APPARATUS.

Application filed June 25, 1919. Serial No. 306,690½.

To all whom it may concern:

Be it known that I, PERCY W. BRIDGMAN, a citizen of the United States, residing at Cambridge, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in Electrical Sound-Detecting Apparatus, of which the following is a specification.

The present invention relates to electrical sound detecting apparatus and more particularly to a microphone of the double cell type and the connection of a receiver thereto. The object of the invention is to make apparatus of this type more sensitive and reliable, of simpler construction, and less affected by extraneous mechanical vibrations or jars.

Referring to the drawings, Figs. 1, 2 and 3 are an end elevation, a side elevation and a vertical section of a microphone embodying the invention. Fig. 4 is a side elevation showing the microphone mounted on a vibrating diaphragm. Figs. 5, 6 and 7 are an end elevation, a side elevation and a vertical section showing a modification. Fig. 8 is a wiring diagram showing the receiver connection to the microphone. Fig. 9 is a wiring diagram showing a number of microphones connected in parallel. Fig. 10 is a wiring diagram showing microphones connected in series.

The invention is illustrated as embodied in a double cell inertia microphone. Referring particularly to the microphone as illustrated in Figs. 1 to 4, the microphone 1 has two carbon granule containing cells 2 and 3, arranged end to end. The carbon granules 4 in cell 2 are contained between two end contact plates 5 and 6 of the usual hard carbon. The plates 5 and 6 are soldered in the usual way to metal backing plates 7 and 8. Plate 7 is connected by the stud 9 and clamping nut 10 to the end supporting plate 11, which is of material known to the trade as micarta. This is a stiff strong insulating material. The end of the stud 9 is threaded into a post 12 which is embedded in the sound receiving diaphragm 13. The diaphragm 13 is illustrated as a soft flexible rubber diaphragm, which is the material ordinarily employed for submarine sound receivers.

The metal plate 8 at the other end of the cell 2 is connected by means of the threaded stud 20 to a metal supporting plate 21.

The carbon granule containing space and the plates 5, 6, 7 and 8 are surrounded by a casing 22 made of a short piece of soft india rubber tubing.

The second microphone cell 3 is of similar construction. The carbon granules 24 are contained between carbon plates 25 and 26, which are soldered to metal plates 27 and 28. The metal plate 27 is mounted on an end supporting plate 29 by means of the stud 30 and nut 31. The center metal plate 28 is mounted on a metal plate 32 by means of a threaded stud 33. The cell is enclosed in a soft rubber casing 22.

The center plates are cemented to a sheet of paper insulation 34 placed between them. The end plates 11 and 29 are rigidly yoked together by a sheet metal casing 40. Thin soft rubber shims 41 may be interposed between the edges of the plates 21 and 32 and the inside of the metal casing 40 to steady the plates 21 and 32. In the microphone illustrated in Figs. 1 to 4, the end plates act as the agitating plates while the center plates act as the vibration resisting or inertia plates. When the diaphragm 13 is thrown into vibration by incident sound waves, the sound vibrations are transmitted to the end contact plates 5 and 25 of the microphone cells. The central plates 6 and 26 are rigidly connected together through the central plates 21 and 32 and form with these plates an inertia member which tends to remain stationary and by its inertia resists the vibrations impressed on it through the carbon granules and the flexible soft rubber housings 22. As the sound vibrations are comparatively rapid, the inertia of the center plates is sufficient to affect a noticeable compression and release of the carbon granules in the cells. When the diaphragm 13 moves to the left under the influence of a sound wave, the carbon granules 4 in the cell 2 are pressed together and the cell resistance decreased, while the carbon granules 24 in cell 3 are released and the resistance of the cell 3 is increased. As the end plates and center plates are respectively rigidly yoked together, the two cells 2 and 3 are oppositely and equally affected, and as hereinafter explained, by connecting a telephone receiver to a point between the two cells, this differential effect is utilized.

The contact plates 5, 6, 25 and 26 are connected through lead wires 50, 51, 52 and 53 to the external circuits.

In Figs. 5, 6 and 7 is shown a modification

in which the center plates are the agitated plates and the end plates are the inertia plates. The carbon granule containing cells in 62 and 63 are arranged end to end. The end carbon plates 64 and 65 are soldered to small brass plates 66 and 67 which in turn are soldered to end supporting plates 68 and 69. These end plates 68 and 69 are rigidly connected together by struts 70 of insulating material. The end plates with their supporting members form the inertia element of the microphone. The center contact plates 71 and 72 are soldered to brass plates 73 and 74 which are in turn secured to a supporting metal plate 75. The metal plate 75 is connected through the spacer screws 76 to the plate 77 which in turn is rigidly mounted on the post 78 which is carried by the diaphram 79. The microphone cells are enclosed in soft rubber casings 80 which permit the inertia member to float and permit the proper pressure and release of the carbon granules in the cells under the vibrations of the agitating member. Soft gum india rubber tubing has been found particularly successful for this use as it transmits of itself a minimum vibration from the agitating to the inertia members, and it also tends to damp out any free vibrations in the inertia member.

In the form of microphone shown in Figs. 5, 6 and 7, the two center plates 71 and 72 are not insulated from each other, but are in electrical connection with the supporting plate 75 from which the lead wire 90 is tapped off. The lead wires 91 and 92 are connected with the end plates 68 and 69 respectively.

When a single microphone is used, it is connected as shown in Fig. 8. The two microphone cells A and B are connected through lead wires C and D to battery E. A branch circuit F is tapped off between the microphone cells A and B and contains the telephone receiver G. The other end of this branch circuit F is connected to the battery E. For reasons of symmetry it is preferred to connect this branch circuit to the middle of the battery. This, however is not necessary as it may be connected to either end of the battery by a connection to one of the leads C or D. A condenser H is preferably interposed in the branch circuit F to protect the receiver G from the battery current. However, the presence of the condenser H in this circuit is not a necessity.

The to-and-fro vibrations of the diaphragm upon which the microphone is mounted cause the resistances of the microphone cells A and B to be oppositely affected, one being increased while the other is decreased. The resistance variations are in opposite phase to each other and combine to shift with respect to the battery the potential of the point in the battery circuit between the two cells where the branch circuit F is tapped off. These out-of-phase components of the resistance variation of the microphone cells therefore combine to send current through the receiver G in the branch circuit. It is to be particularly noted that it is only the out-of-phase components of the resistance variations of the cells which cause any current flow through the telephone receiver G and therefore the receiver is responsive only to the to-and-fro vibrations of the microphone supporting diaphragm. Any motion or conditions which affect the microphone as a whole do not send a current through receiver G. For example, any motion of the microphone supporting diaphragm which takes place in the plane of such a diaphragm tends to cause an equal increase or decrease of the resistance of the two microphone cells, causing in-phase resistance variations which send current around the battery circuit as a whole but do not cause a flow of current through the branch circuit F. This characteristic of the apparatus renders it of particular value for use on shipboard or in submarine listening devices carried upon ships or floated objects. It is found that when microphones of this type are used on submarine sound detecting devices, they are little, if any, affected by the rise and fall of the ship in the waves. The receiver G is also substantially independent of electrical variations in the battery circuit as a whole. For example, a loose contact or other cause of variable potential impressed on the microphone does not cause a differential effect which sends current through the receiver.

When it is desired, as for example in some types of submarine listening apparatus, a number of the microphones may be connected together. In Fig. 9 is shown a parallel arrangement of microphones in which the microphones are connected in parallel to the battery leads C and D and the telephone receiver circuit F is tapped off from the middle points of the several microphones. When a single microphone is used, as shown in Fig. 8 or the parallel arrangement is used as shown in Fig. 9, the two center contact plates of the microphones may be electrically connected together in the microphone as shown in Fig. 7. When the microphones are put in a series connection, the central contact plates are insulated from each other as shown in Fig. 3. A series connection of microphones is shown in Fig. 10, in which the battery current goes through all the microphone cells in series, and the branch circuit F which contains the telephone receiver, is tapped off at a point midway between the several microphone cells.

From the foregoing description it will be seen that the useful effect in the telephone receiver is that produced by the equal and

opposite resistance variations of the two microphone cells. To have the system operate properly the two cells should be matched so that these resistance variations are as near equal as possible for each of the two cells. To attain this the yielding connections between the plates of the two cells should be the same. It has been found from a long series of experiments that the soft rubber casings such as are shown at 22 and 80 in Figs. 1 to 7 are the most satisfactory material for this purpose. Such soft rubber casings preserve the proper spacing between the plates of the two cells and at the same time form a readily yielding connection between them. They permit substantially the same yielding between the contact plates of the two cells with a consequent matching of the resistance variations of the respective cells. This feature is emphasized because attempts which have heretofore been made to construct a satisfactory double cell microphone of this type have failed because of the failure to employ proper yielding connections between the contact plates of the two cells which would permit an equal and proper yielding such as is afforded by the soft rubber casings.

It will be noted that the electrical circuits required are very simple. No induction coils or transformers are required. The elimination of the inductance of the transformer renders the apparatus more sensitive for a given change in the resistance of the microphone. Also since no inductive devices, such as transformers, are required no condenser is necessary around the switch S to prevent the microphones from packing in opening the circuit. Packing is a permanent decrease of the resistance of the microphone and which may be caused by the inductive kick when a microphone circuit containing inductance is opened. The elimination of inductance also prevents packing if the battery circuit is accidentally opened at any other point. This is of particular importance in submarine sound detection where the microphones are frequently placed in inaccessible positions where they cannot be reached to be mechanically rapped to restore them from a packed condition.

While the preferred embodiment of the invention has been specifically illustrated and described, it is to be understood that the present invention is not limited to its illustrated embodiment but may be embodied in other structures within the scope of the following claim.

I claim:

An inertia microphone having two cells arranged end to end and having the center plates and end plates thereof respectively rigidly connected together, one of said sets of plates being connected to be vibrated by the received sound waves and the other set of plates acting by inertia to resist such vibrations, and soft rubber casings for the two cells permitting the inertia element to float and yielding to permit substantially equal relative movements of the plates of each cell under the received vibrations, substantially as described.

PERCY W. BRIDGMAN.