

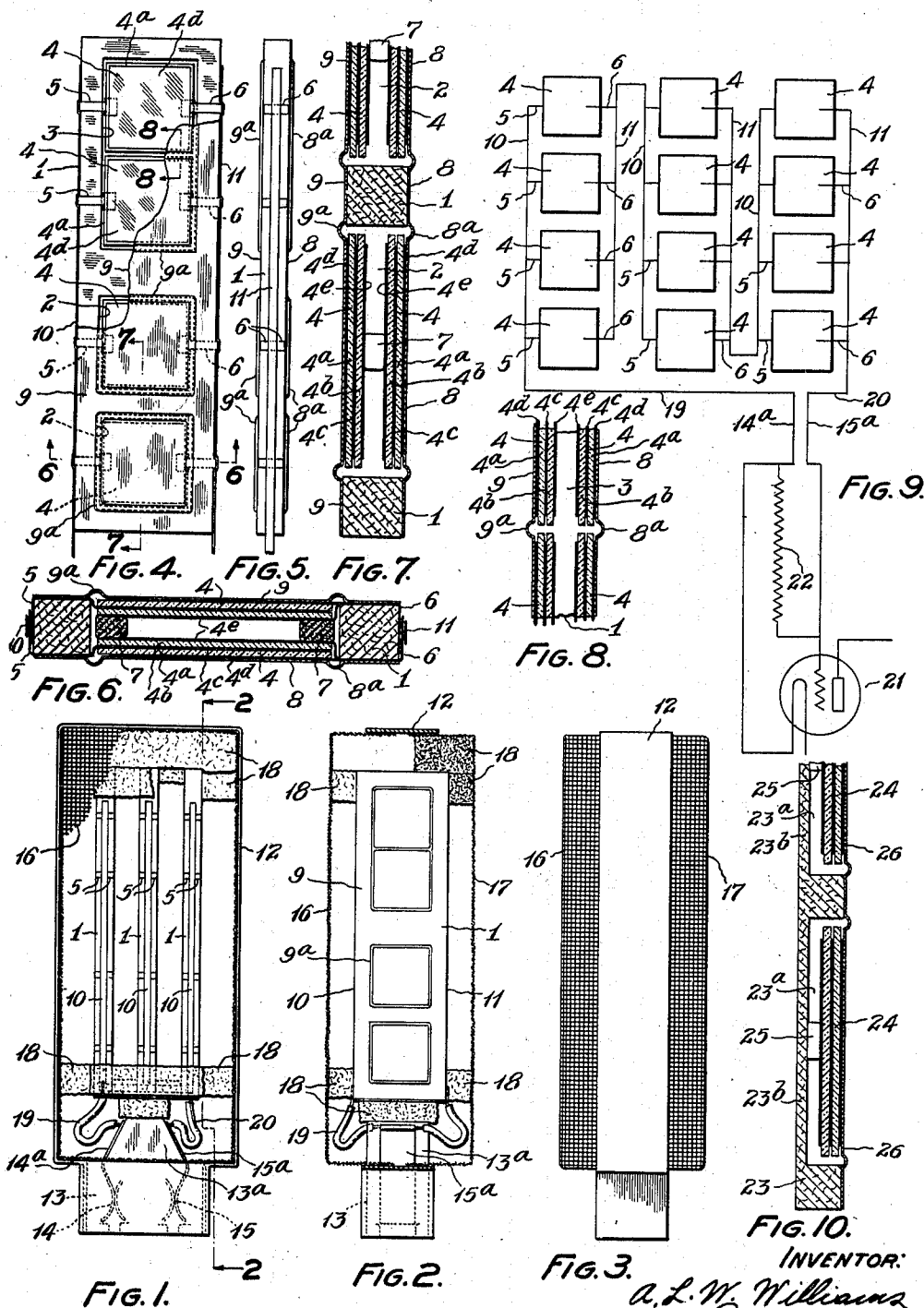
Aug. 9, 1938.

A. L. W. WILLIAMS

2,126,436

ACOUSTICAL APPARATUS

Filed Jan. 7, 1935



INVENTOR:
A. L. W. Williams
BY
Ray J. Gehr
ATTORNEY

UNITED STATES PATENT OFFICE

2,126,436

ACOUSTICAL APPARATUS

Alfred L. W. Williams, Cleveland, Ohio, assignor
to The Brush Development Company, Cleve-
land, Ohio, a corporation of Ohio

Application January 7, 1935, Serial No. 628

2 Claims. (Cl. 179-110)

This invention relates to acoustical apparatus such as microphones and loud speakers and particularly to devices of the multiple unit type such as is disclosed in United States Letters Patent No. 2,105,010 granted Jan. 11, 1938.

An object of the invention is to provide improved means for supporting the individual units of such an acoustical device with a view to rendering the entire structure more rugged, simpler and susceptible of production at lower cost.

A further object of the invention is to provide great freedom of action of the acoustical diaphragms of the apparatus so as to secure high fidelity of sound reproduction.

Other objects of the invention more or less ancillary to the foregoing will appear from the following detailed description.

In the accompanying drawing,

Fig. 1 is a front elevation on an enlarged scale of the microphone with a portion of the foraminous casing broken away to disclose the interior construction.

Fig. 2 is a vertical section on the line 2-2 of Fig. 1.

Fig. 3 is an enlarged side elevation of the microphone.

Figs. 4 and 5 are, respectively, front and side elevations on a still larger scale of one of the multiple unit frames or strips of the instrument, a portion of the flexible cover sheet of the frame or strip being broken away in the upper part of Fig. 4 to better illustrate the details of construction.

Fig. 6 is an enlarged section on the line 6-6 of Fig. 4.

Fig. 7 is a similarly enlarged fragmentary section on the line 7-7 of Fig. 4.

Fig. 8 is an enlarged fragmentary section on the line 8-8 of Fig. 4.

Fig. 9 is a diagram of one form of electrical connections of the microphone.

Fig. 10 is a fragmentary sectional view similar to that of Fig. 7 but showing a modified form of construction.

In the specific construction illustrated, a plurality of acoustical units are arranged in three groups, each with four units. Each of the groups has a supporting frame 1 and each of these three frames and the parts carried thereby are similar in construction so that a detailed description of one of them will suffice for all.

The rectangular frames 1 are preferably formed from strips of Bakelite or the like which may be punched out to form a plurality of rectangular openings 2, 2 and 3 to receive the acoustical units.

For the purpose of illustrating two different methods of mounting the individual acoustical units I have shown the apertures 2, 2 of the supporting frame 1 of a size large enough for one unit only while the opening 3 is made of a size to receive two of the units. It will be understood that the entire strip may, if desired, be formed with an individual opening for each unit or with a single opening to receive all of the units or with two openings of the size of the opening 3 each adapted to receive two of the four units of the group. To insure the desired rigidity of the frame I prefer, ordinarily, not to make the frame openings longer than will accommodate three of the units.

Each of the individual acoustical units comprises two self-actuated diaphragms in the form of piezo-electric bimorph elements of the character shown in Figs. 10 and 11 of the aforesaid Patent 2,105,010, each of these elements being designated as an entirety in the accompanying drawing by the numeral 4. The term "bimorph element" as here used indicates a structure comprising two or more juxtaposed piezo-electric plates of crystal material such as Rochelle salt or the like with suitable electrodes of metal foil or the like and so oriented electrostatically and so constrained that upon flexing of the element a difference of potential is established between the electrodes or vice versa. As is explained in the said Patent 2,105,010 the crystal plates of Rochelle salt have their faces cut at right angles to the *a* axis of the crystal and the edges of the plate are cut at an angle of 45° to the *b* and *c* axes. Thus, with square plates, the *b* and *c* axes join diagonally opposite corners of the plates and the lines along which expansion and contraction of the crystalline material occur are at right angles to the edges of the plates. As illustrated, each of the bimorph elements 4 comprises the two crystal plates 4a, 4b cemented together with an interposed electrode 4c of metal foil or the like in intimate contact with the adjacent crystal faces and similar exterior electrodes 4d and 4e closely cemented to the outer faces of the plates 4a and 4b, respectively. For convenience of manufacture a separate sheet of metal foil may be cemented to the inner face of each of the plates 4a and 4b and the plates thus foiled cemented together so that their two inner foils will constitute the electrode 4c. As is well known (United States Patent No. 1,802,782) such bimorph elements can be made without internal electrodes if the crystal plates of the element are arranged with the *b* and *c* axes of one plate at right angles to the *b* and *c* axes of the other plate. A lead 5, also of metal foil, is

brought out from the inner electrode 4c at the bottom of one side of the element and a similar lead 6 is connected to the outer electrodes 4d and 4e, and carried out from the opposite edge of the element.

The two elements 4 of each pair of oppositely disposed elements are mounted in parallel spaced relation and with opposite crystalline orientation in one of the openings 2 or 3 of the strip or frame 1, the two elements 4 being spaced apart and supported in relation to each other by blocks 7, 7 preferably of soft material, such as soft rubber or partially set or vulcanized rubber cement. These blocks are disposed adjacent the electrical leads 5 and 6 as indicated in Figs. 4 and 6. To secure each pair of piezo-electric elements in suitable position in the frame 1 and to shield the inner side of each element from the surrounding medium, sheets 8 and 9 of thin flexible material, such as paper of a suitable quality, are cemented to the opposite sides of the frame 1 and to the adjacent faces of the crystal elements 4; and in order to provide desirable freedom for the flexing movements of the crystal elements the paper sheets 8 and 9 are embossed to form ridges 8a and 9a extending around the peripheries of the crystal elements so that the connection between said elements and the Bakelite frame 1 is more flexible and permits the sheets 8 and 9 better to accommodate the flexing movements of the crystal elements, as well as prevent passage of air past the edges of the elements. Where a plurality of the units are disposed in a single opening of the frame 1, as in the opening 3, somewhat greater freedom of movement is afforded for the crystal elements because along their adjacent edges they are flexibly attached to each other by the sheets 8 and 9 rather than to the rigid frame 1 and since in the operation of the device the said adjacent edges move simultaneously in the same direction the restraint to such movement offered by sheets 8 and 9 is slight. As is shown in Figs. 4 and 5, the crystal elements have their adjacent edges slightly spaced apart to obviate mutual interference between them. In this connection it will be observed that the leads 5 and 6 are brought out from the crystal elements adjacent the spacing blocks 7, 7 so that at all other points around the peripheries of the crystal elements the only constraint to which they are subjected is that incident to the flexible sheets 8 and 9.

When the series of pairs of crystal elements are mounted in the frame 1 the leads 5 and 6 are preferably brought out over the edges of the frame and joined to ribbon conductors 10 and 11 running longitudinally along the edges of the frames. As shown in the construction illustrated, the inside leads 5 of the crystal elements are all brought out on one side of the frame and the outside leads 6 on the other side of the frame so as to connect the two elements of each unit in parallel and the several units in parallel with each other.

When the parts of the several sound cells have been assembled in the common frame or strip 1 the entire structure is preferably sealed, as by dipping in a bath of paraffin or the like, so as to make it practically both air and moisture tight.

A number of groups or frames of sound cells of the character illustrated in Figs. 4 to 7 are assembled in a suitable case as illustrated in Figs. 1 and 2. The case comprises a strip 12 of sheet metal bent to the form indicated in Fig. 1, the two ends of the strip being secured at the bottom of the

case to a block 13 of insulating material which is fitted with yielding terminal sockets 14, 15 by which the instrument can be connected in circuit by simply pressing it on a suitable receptacle. The metal strip 12 should be sufficiently thick to provide rigidity and freedom from distortion. The open sides of the case are covered by the foraminous casing elements or screens 16, 17 which are secured in position in the case element 12 by any suitable means. These screens protect the microphone from mechanical injury and at the same time permit free passage of air and sound waves through the case. The several frames 1 and their associate parts are disposed in parallel spaced relation within the case as indicated in Figs. 1 and 2, being held therein by blocks of felt 18, 18 which are wedged between the end portions of the frames 1 and the adjacent parts of the case and thus form a rugged yet cushioned support for the crystal structures.

As shown in Figs 1 and 2, the plates 14a and 15a of sockets 14 and 15 of the instrument are carried upward along the upward extension 13a of the insulating block 13 and joined to conductors 19 and 20 which are respectively connected with the conductors 10 and 11 of the groups or frames 1. The diagram in Fig. 9 illustrates one way in which the acoustical units may be connected. Here the crystal elements of each group of four sound cells are connected in parallel, as previously described, and the three groups are connected in series. The parts of the microphone are designated in the diagram by the same numerals as in the other figures of the drawing. The terminals 14a and 15a of the instrument are connected to a thermionic amplifier 21, the customary grid leak for the amplifier tube being provided by the resistance 22.

It will be understood that the multiple unit type of construction which has been described makes possible various forms of electrical connection and so adapts the instrument to widely varying conditions. A sufficient number of the cells may be connected in parallel relation to match the input impedance of the connecting cables and amplifying device with which the microphone is to be used, while a sufficient number of groups of the cells joined in parallel may be connected up in series to give the desired voltage characteristics. Obviously, as an alternative, the individual cells may be grouped together in series and such groups connected in parallel.

In the operation of the microphone, sound waves passing through the foraminous walls of the case enter freely between the frames or groups of acoustical units and simultaneously act upon said units to flex the piezo-electric elements of each unit alternately toward and away from each other. The flexible sheets 8 and 9 prevent the sound waves from acting on the inner faces of the elements. Because of the opposite crystalline orientation of the two elements of each unit, such flexing of the elements generates potentials of similar polarity upon their corresponding electrodes and, through the electrical connections of said electrodes, their current outputs are additively combined and the outputs of all of the units are combined in the manner previously described. As is pointed out in the United States patent previously referred to, crystal elements such as herein described can be made exceedingly thin and small so that distortion of the sound field by the instrument is minimized and the conversion of the mechanical energy of the sound

waves into electrical energy is effected with a high degree of fidelity.

In Fig. 10 I have shown a modification of the frame structure and assembly. Here the plate-like frame 23, instead of being perforated to form chambers for the acoustic diaphragms, is formed with depressions 23a for that purpose and the crystal bimorph elements 24 are mounted singly and not in pairs. The single bimorph element of each unit is supported by blocks 25, preferably of soft material such as rubber or the like, which are attached by flexible cement to the bimorph and to the bottom wall 23b of the depression 23a. The crystal diaphragm is further supported by the flexible sheet 26 of paper or the like which is cemented thereto and to the frame 23. The construction of the crystal diaphragm is the same as the construction of the diaphragms of the first described construction and the leads may be carried out from the electrodes of the diaphragms as in the first construction. It will be observed that the wall sections 23b of the frame 23 serve, in the operation of the device, to shield the backs of the diaphragms 24, whereas in the first form of construction each diaphragm of a pair thereof shields the other.

A plurality of frame assemblies of the modified form can be mounted in a case and electrically connected in the manner described in connection with the first construction and the two forms of construction operate in substantially the same manner. However, while the modified form of construction has some of the advantages of the first form of construction it obviously has the disadvantage that two of the single diaphragm units are required to equal the capacity of one of the double diaphragm units.

From an inspection of the multiple unit frame of the acoustical units it will be seen that the structure of the assembly of units is itself exceedingly rugged, the frame structure proper being quite strong and the crystal elements of the units being, in the preferred construction, flexibly supported from the frame in manner to minimize the transmission of shocks to said elements. Furthermore, the individual frames or assemblies, while strongly secured in the case by the blocks of felt, are at the same time well cushioned so that the vital crystal elements of the structure are given in effect a double protection against shock.

The assembly of a plurality of the acoustical units in a single supporting frame obviously simplifies the construction, as compared with the grid structure shown in the patent above referred to, and facilitates production with resultant decrease in cost.

By embossing the sheets 8 and 9 to form the flexible ridges 8a, 9a, increased freedom of movement is afforded for the flexing crystal elements; and such freedom of movement is still further increased where a plurality of the pairs of crystal elements are mounted in a single opening of the frame.

While the first form of construction herein illustrated is such as I prefer, it will be understood from what has been said that such construction can be varied widely in various respects without departing from the invention as defined in the appended claims.

What I claim is:

1. In acoustical apparatus, a frame formed with an opening, a plurality of vibratory diaphragms mounted in said opening in substantially the same plane and with an edge of each diaphragm spaced slightly away from an edge of another diaphragm, each diaphragm comprising a piezo-electric element adapted by flexing to co-act with an adjacent fluid medium, and a flexible sheet attached to said diaphragms and to said frame to flexibly connect the frame and adjacent edges of the said diaphragms together and the adjacent edges of separate diaphragms together and prevent passage of the surrounding medium past the edges of the diaphragms.

2. In acoustical apparatus, a frame formed with an opening extending therethrough from one face to the other face thereof, a plurality of pairs of oppositely disposed parallel diaphragms mounted in said opening with an edge of each diaphragm of each pair closely adjacent an edge of a diaphragm of another pair, each diaphragm comprising a piezo-electric element adapted by flexing to co-act with an adjacent fluid medium, and flexible sheets attached to said diaphragms and to said frame to flexibly connect the frame and adjacent edges of the said diaphragms together and the edges of adjacent diaphragms of separate pairs together and prevent passage of the surrounding medium past the edges of the diaphragms.

ALFRED L. W. WILLIAMS.