July 6, 1937. T. R. WILSON 2,086,107

CONDENSER MICROPHONE

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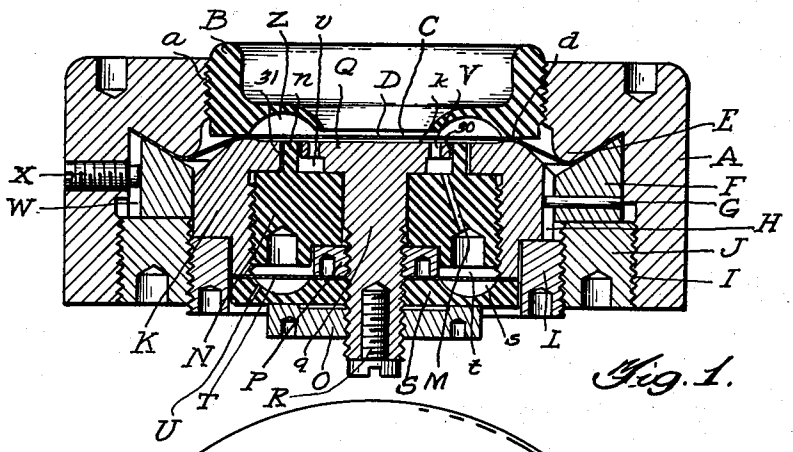


Fig. 1.

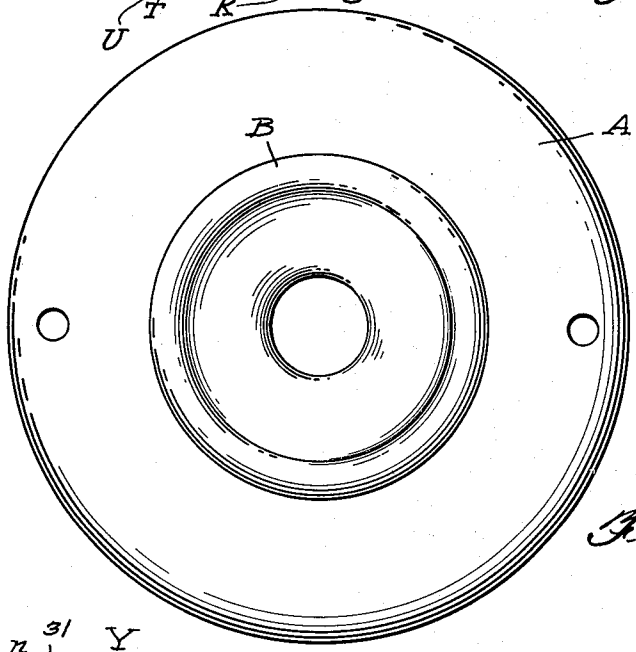


Fig. 2.

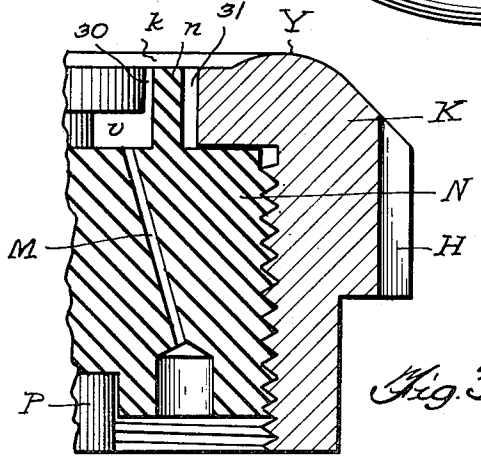


Fig. 3

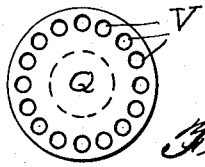


Fig. 4

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CONDENSER MICROPHONE

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2 Claims. (Cl. 179—111)

This invention involves the production of a condenser-microphone and has for its object to provide a device of this character having important functional advantages over known devices of this nature. It is the function of a condenser-microphone to convert variations in sound-waves into corresponding variations in capacity. With the proper amplifier circuit, these minute variations in capacity produce similar modulation of the amplifier output, which is usually reduced to an impedance suitable for transmission over a line to other amplifiers. It is the sole function of the condenser-microphone of this invention to vary its electrical capacity in exact accordance with whatever audible sounds are impinged upon the diaphragm. More specifically, I aim to provide a microphone having a uniform response throughout the entire range from 20 to 15,000 cycles-per-second. The further object of the invention is to avoid discrimination against response to high frequencies which ordinarily results with conventional types of microphones whenever the sound-waves impinge at an oblique angle to the plane of the diaphragm.

I further aim to provide an improved system of pneumatic damping of the diaphragm and to design the mechanical features with the optimum of simplicity, ruggedness, and compactness; in order that the design shall yield readily to quantity production with precision.

A further object of the invention is to provide a design which will function equally well either as a straight microphone used in the conventional manner; or in conjunction with a concave mirror as a "beam microphone."

The features in which my invention differs from known devices, together with the important functional results flowing therefrom, will be more fully set forth in the detailed description which follows.

In the accompanying drawing: Fig. 1 is a central transverse vertical section through the condenser-microphone head of my invention.

Fig. 2 is a front or face view thereof.

Fig. 3 is a detailed view illustrating one of the elements of the back-plate hereinafter described, and Fig. 4 is a magnified fragmentary sectional view through certain of the elements of the back-plate.

Like numerals designate corresponding parts in all of the figures of the drawing.

In the drawing, A designates the main body of my improved condenser-microphone head, which is preferably made of bronze. This body is provided with a central opening, internally threaded at *a* for the reception of the externally threaded bezel B, which shields all but the central portion of a diaphragm D, of thin duralumin or Berrilium. The annular clamp ring F clamps the outer-edge portion of the diaphragm into tight engagement with the body A, said body being provided with a rounded annular rib E which permits the placing of the diaphragm under the desired tension without danger of injury to said diaphragm. The clamp ring F is thrust forcibly against the diaphragm and the body A by an annular nut J, said nut being externally threaded at I for engagement with corresponding threads of the body A. The nut J is also internally threaded for engagement with ring nut L, which holds in place a back-plate assembly comprising a metallic member K of inverted cup shape. The upper or outer face of the member K is recessed as indicated at *k*, said recessed portion being surrounded by the annular raised rib Y, which engages the diaphragm, as the back-plate is thrust inwardly under the action of the ring nut L; the bezel being at this time removed. In order to prevent the back-plate from turning (with possible injury to the diaphragm) I provide a pin G which projects inwardly from clamp ring F and engages a vertical slot H in the periphery of the member K. In like manner, ring F is held against rotation and prevented from injuring the diaphragm by a screw X which engages a slot W in the periphery of said ring.

The member K is internally threaded for engagement by an externally threaded block of highly dielectric or insulating material, N. This block is provided with an annular neck extension, *n*, which projects into the central opening of the member K, but lies in spaced relation to the walls thereof, the space between being best illustrated at 31 in Fig. 4. A metallic plate Q is disposed in the chamber formed within the annular extension *n*, and is carried by a shank *q* which passes through the insulating block *n* and is engaged below said block by a nut P. The plate Q is pierced by a plurality of openings V and the space *v* immediately beneath said plate is in communication with the space *t* beneath the block N through the medium of a port or ports, M. The periphery of the plate Q is spaced from the neck extension *n* of the insulating block to provide a concentric air space indicated at 30. The two concentric air spaces 30 and 31 form a part of the pneumatic damping mechanism hereinafter described. By referring to Fig. 1, it will be seen

that the rear surface of the nut P is exactly in line with the rear face of the member K. It will also be seen that the rear surface of the insulating block N lies inwardly of the rear face of the member K. A thin flexible rubber diaphragm T spans the rear face of the body K, and is clamped tightly between nut P and the rear surface of member K, upon the one hand, and an insulating disk S, upon the other hand. The insulating disk S is thrust forcibly inward to clamp the diaphragm in place by a nut O. The various annular nuts and clamping rings are provided with openings for engagement by a spanner wrench in a manner common in mechanical devices, and no specific description of these openings is deemed to be necessary. The insulating disk S has a concentric internal recess *s* which permits the rubber diaphragm T to expand and contract with changes in barometric pressure; yet excludes moisture from the delicate interior mechanism of the microphone. A small hole U is provided in the insulating disk S in order to permit atmospheric pressure to be applied to the rubber equalization diaphragm T at all times.

As previously explained, a port M is provided in insulation N, and this permits constant equalization of the gas-pressure existing in space *v* and between the diaphragm D and head Q with outside atmospheric pressure as applied through rubber equalization diaphragm T. It should also be noted that the nut O makes concentric contact with insulation disk S at a point mid-way between its inner and outer contacts with the rubber equalization diaphragm T. This prevents warping of the insulation disk S, and insures that the rubber diaphragm T will afford a permanent seal excluding moisture, etc., from the inside of the microphone.

Screw R is the terminal screw used in coupling the microphone to its pre-amplifier, and is the only screw used in this microphone.

It should be noted that the bezel makes contact with the diaphragm at the point *d*, at which point said diaphragm is rigidly supported by the back-plate assembly. Bezel B is screwed into place after all other members have been assembled and the tuning operation, accomplished by the placing of the diaphragm under tension by manipulation of nut L, has been completed. The bezel is formed with a few thousandths of an inch clearance at C. That is to say, the lip about its central opening does not contact with the diaphragm, but is spaced therefrom a sufficient distance to permit the diaphragm to vibrate in response to impinging sound-waves. However, this bezel acts as a shield over all but the center of the diaphragm, as hereinbefore stated. Attention is directed to the fact that the plate or head Q is somewhat larger in diameter than the central opening of bezel B.

In using this microphone, it is assumed that the mechanism described herein is coupled to a pre-amplifier of conventional design; the only special requirement being that care is taken to use an input circuit of the correct impedance for the microphone. This is purely a matter of amplifier design, and need not be discussed further.

As before stated, it is the function of a condenser-microphone to convert sound-waves into corresponding variations in capacity existing between the insulated back-plate Q and the metal stretched diaphragm D. With the proper amplifier circuit, these minute variations in capacity will produce a similar modulation of the amplifier output.

The new type condenser-microphone which I have invented is a radical departure from conventional types. Its advantages may be best appreciated by considering the several factors which exert a marked influence upon the functioning of conventional types of microphones.

Through extensive study and experimentation with models tuned to cover all audible frequencies from 30 to 10,000 per second, I discovered that the quality suffered severely from attenuation of the high-frequencies whenever the impinging sound-waves made contact with the diaphragm at an oblique angle to its face. This effect was found to be most exaggerated when the direction of the impinging wave was parallel to the plane of the diaphragm, and appeared to vary with each selected angle.

As a result of these experiments and discoveries, I concluded that it would be well to study the wave-lengths of sound-frequencies lying between 1,000 and 20,000 cycles-per-second; with the hope of locating the reasons for the peculiar results which had been observed.

These studies and experiments enabled me to discover the reason for the loss of high frequencies, as the direction of the wave approached parallelism with the microphone diaphragm. For instance, conventional microphones, such as are now manufactured by leading companies, have an exposed free-diaphragm diameter of from 3.5 c. m. to 4.5 c. m. It is obvious, therefore, that if the direction of wave propagation is parallel to the diaphragm, in a given instant there will be more than an entire wave-length acting upon the diaphragm for frequencies of 8,000 cycles or more. The algebraic sum of all pressure displacements in a sound wave is zero, and therefore the net response of the diaphragm will be zero whenever it is acted upon by an entire wave-length in a given instant. Assuming that we are considering this effect upon a conventional microphone having a diaphragm diameter of 3.4 c. m., we find that this is exactly the wave-length of a frequency of 8,000 cycles per second. Therefore, with the wave direction parallel to the face of the diaphragm, this microphone will have no response whatever to a frequency of 8,000 cycles; and from mathematical calculations, will give only a 50% response to a 4,000 cycle frequency. Another astonishing result of this condition is that if a frequency higher than 8,000 cycles strikes this size diaphragm parallel to its face, a parasitic sub-harmonic will be generated.

It is now quite obvious that in order to have a perfect response, regardless of wave-length or direction, it is necessary to reduce the diaphragm to a mere needle-point in diameter. Again, it is equally as obvious that it would be impossible to construct a diaphragm with a diameter of one, over infinity, and have it be free to vibrate with the sound-waves.

I must, therefore, be willing to effect a compromise with the theoretically ideal diameter, and select one which will give an excellent response under the most unfavorable angles-of-incidence, and still be capable of actuating its pre-amplifier.

In designing my latest microphone, therefore, I first selected a percentage-of-attenuation which should be permissible, and then calculated the size diaphragm required. I assumed that an attenuation of slightly less than 25% would be

permissible at a frequency of 10,000 cycles-per-second, and by mathematical deductions found that the free, exposed diaphragm diameter should be approximately 1 centimeter. Further reduction would lessen the attenuation of high frequencies, but would also reduce the energy output. This attenuation will reach 25% only when the plane-of-incidence of the impinging wave is parallel with the face of the diaphragm, and the exact degree of attenuation will depend upon the angle-of-incidence, and the frequency of the sound-wave.

A diaphragm of only one centimeter in diameter is relatively very small, and if constructed in the conventional manner would be practically unable to respond to the minute energy of a sound-wave.

It was with the foregoing facts in mind that the construction of the present application was evolved. Chief of the new principles involved is the plan of shielding a diaphragm by means of a special bezel, in such a manner that the exposed active area is reduced to approximately 1 centimeter; while the diaphragm is free to vibrate on a diameter of about one inch, or 2.54 c. m.

Again referring to Figure 1 of the attached drawing, note that the diaphragm D is rigidly clamped around its periphery by means of clamp-ring F, and ring-nut J, which latter member has been tightly screwed into threads provided in main body A. Also note that the diaphragm D has been stretched by forcing the entire back-plate assembly against it by means of ring-nut L, which screws into threads provided inside ring-nut J, and applies pressure to the main back-plate body K by bearing against the shoulder shown in the drawing. Also note that the diaphragm is free to vibrate throughout its entire central portion, i. e. in a circle described by the point-of-tangency of radius Y with the radial axis of the back-plate assembly. Note that the clearance between the diaphragm D, and the back-plate Q remains constant, regardless of how tightly the diaphragm may be stressed during the tuning operation.

Bezel B acts as a shield covering all but the central portion of diaphragm D. The sound-waves apply their energy through the central opening in the bezel, which has only a few thousandths of an inch clearance at C. Space Z in the bezel is primarily designed to absorb any leakage which might occur at C, but also contributes a great deal to the pneumatic damping of the diaphragm. Every movement of the diaphragm results in an increase and decrease of the pressure within concentric space Z, and there is therefore a tendency for a small amount of air to slide in and out through the small clearance at C.

Additional damping of the diaphragm D is obtained from the vibrating air between the diaphragm and back-plate being permitted to rush in and out of space *v* (see Fig. 4) through small clearance 30, and through the small holes in the head of back-plate Q (shown in Fig. 3). Space 31 also contributes somewhat to the damping.

Observe also that the diameter of the head of back-plate Q is somewhat larger than the opening in bezel B. This is so arranged because of the fact that the diaphragm D is vibrating practically as a piston throughout its central portion; and this slightly larger back-plate results in better than twice the energy output than was obtained when the back-plate was made the same size as the opening in the bezel.

It will be apparent that many ways will readily suggest themselves to the skilled engineer of varying the suggested construction while retaining the highly desirable principles herein disclosed. Therefore, it is to be understood that the invention is not limited to the particular construction illustrated, but that it includes within its purview whatever changes fairly come within either the terms or the spirit of the appended claims.

Having described my invention, what I claim is:

1. A device of the character described comprising a main body portion having a central opening formed therein, a thin metallic diaphragm spanning said opening, a ring, shaped to engage said diaphragm and to clamp it against said body, an externally and internally threaded annular nut screwed into the rear of said body and thrusting said clamping ring inwardly, means for preventing said ring from turning, a back-plate construction comprising a metallic member of inverted cup shape, shaped to engage the outer portion of said diaphragm while lying out of contact with the remainder of said diaphragm, an insulating block mounted in said member, a metallic plate supported from said block and lying in closely spaced relation to the inner face of the diaphragm, a second diaphragm spanning the outer face of the cup shaped member, a second annular nut engaged with the internal threads of the first named annular nut and acting to thrust the cup shaped member forcibly inward to place the first diaphragm under tension, the under side of said plate being spaced from said insulating block and the second named diaphragm being spaced from the rear side of the insulating block, means for permitting air flow between the said two spaces and means for admitting atmospheric air to the exterior surface of the second named diaphragm.

2. A condenser microphone comprising a body portion, a diaphragm, means for clamping the peripheral portion of the diaphragm to the body portion, a back plate assembly comprising a metallic member, means for thrusting said metallic member forcibly into the body and against the diaphragm, said body being provided with a depressed center portion surrounded by an annular edge over which the diaphragm is stretched by the act of forcing said metallic member into the main body, said main body being provided with a central opening, a bezel threaded in said central opening and comprising portions which rest upon said diaphragm opposite its point of engagement with said metallic member, said bezel being provided with a central opening surrounded by an inwardly curved lip which lies relatively close to but does not contact the said diaphragm, the inner face of the bezel between said lip and the point of engagement of the bezel with the diaphragm comprising an annular recess, the depth of which is much greater than the distance between the inner edge of the lip and the diaphragm and the opening through the bezel defined by said lip being of such size that the central area of impingement will be considerably less than the total area of vibration.

THEODORE R. WILSON.