This invention is concerned generally with condenser microphones, and, more particularly with improved mounting means for the fixed plate of the microphone condenser.

In order to provide adequate sensitivity and suitable damping of the microphone, the fixed condenser plate must be spaced very close to the vibratory diaphragm which forms the movable condenser plate. Such close spacing can be uniformly maintained only if the fixed plate is very rigidly mounted within the microphone housing. On the other hand, the two plates of the condenser must be very well insulated from each other to avoid leakage of the relatively high polarizing voltage across the insulating material, since such leakage causes noise and other defects in the microphone output.

It is difficult, if not impossible to find dielectric materials which combine the properties of very high and uniform insulation and extreme mechanical strength and stability. In previous condenser microphone structures it has been necessary to compromise between maximum mechanical and maximum electrical stability of the supporting means for the fixed condenser plate.

An important object of the present invention is to provide an insulative mounting for the fixed plate which is so shielded electrically as to overcome the difficulties that normally result from the use of materials having only moderate insulative qualities. By the provision of such shielding, it becomes feasible to select the insulating material of the mounting primarily for its mechanical properties. The mechanical rigidity and stability is thereby greatly increased, permitting closer tolerances to be maintained throughout the construction of the microphone, and, in particular, permitting a closer and more stable working spacing between the fixed and vibratory plates of the microphone condenser. That improves the sound response of the microphone, and permits the physical size of the apparatus to be reduced while maintaining an effective electrical signal.

A full understanding of the invention and of its further objects and advantage will be had from the following description of a particular preferred manner of carrying it out. Details of that description and of the appended drawings, which form a part of it, are for purposes of illustration only, and are not limiting of the scope of the invention.

In the drawings:

Fig. 1 is an elevation of a typical preferred condenser microphone and preamplifier structure, embodying the invention:

Fig. 2 is a fragmentary vertical axial section, taken on line 2—2 of Fig. 1, and showing the microphone proper and connections at enlarged scale;

Fig. 3 is a fragmentary section taken on line 3—3 of Fig. 1, at an intermediate scale, showing a preferred manner of supporting the preamplifier tube; and

Fig. 4 is a schematic diagram showing typical electrical circuitry adapted for carrying out the invention.

In the preferred embodiment illustrated, the microphone proper 10 is designated by the numeral 10, and is removably mounted at one end of the tubular support 12, which acts also as housing for the preamplifier tube 14 and its electrical connections.

The microphone proper 10 comprises the generally cylindrical case 20, within which are mounted the vibratory diaphragm 22 and the closely spaced back plate 24, constituting respectively the movable and the fixed plates of the microphone condenser. Diaphragm 22, which is of, or coated with, conductive material, is peripherally mounted between a fixed annular shoulder of the mounting ring 26 and the pressure distributing ring 28, resiliently urged toward the diaphragm by the annular spring 30. Mounting ring 26 is threaded into internal threads in housing 26, being spaced by the spacing ring 31 from the annular shoulder 33 of the housing, which serves also as a seat for spring 30. This mounting also serves to electrically connect the diaphragm to the case.

Back plate 24 is fixedly mounted in coaxial relation to the ring 32, and is insulated therewith from by outer and inner annular insulating rings or bushings 34 and 36. Those two rings of insulating material are separated by the shield ring or sleeve 38, formed of conductive material. Typical electrical connections for shield ring 38 for carrying out the present invention are described below.

The parts just mentioned comprise the back plate assembly, which is preferably assembled by molding the insulating material of rings 34 and 36 directly in position between the metal parts 24, 32 and 36, the surfaces of the latter preferably being roughened, as by knurling, at the areas of contact to improve the effective strength of the bond. That back plate assembly, designated generally by the numeral 40, is mounted securely in mounting ring 26 by thread-
A generally flat end wall 50 on microphone case 20, preferably formed integrally with the cylindrical side walls of the case, forms a sound chamber 52 directly above diaphragm 22. (Such terms as "above," "below" and the like are used here for clarity of description with reference to the drawings, and not as limitations upon the orientation of the elements described.) Sound passages are provided, as at 54, by means of which the pressure within chamber 52 varies in accordance with the periodically varying sound pressures outside the microphone. Passages 54, as illustrated, comprise transverse slots cut just above annular shoulder 33 and opening through the internal face of end wall 50 near its periphery. That passage structure and its relation to other parts of the microphone, as typified in the present embodiment of the present invention, are more fully described and claimed in the copending patent application of George E. Carrington, entitled Microphone Sound Passage Structure, Serial No. 146,015, filed February 24, 1950, now Patent No. 2,567,875, granted September 11, 1951.

The figures illustrate a preferred manner of mounting and providing electrical connections to the microphone proper. The support 12 comprises a lower hollow body portion 60, an intermediate, relatively narrow hollow neck portion 62 and a hollow upper or head portion 64 which includes a microphone receiving socket. The latter, as illustrated, employs internal threads which mate with external threads on the cylindrical wall of microphone case 20, such threads typifying any suitable releasable securing means for the microphone. The external form of the assembled microphone 10 and support 12 is claimed as an ornamental design in the copending design patent application of Vernon K. Albert, Ser. No. D-2,331, filed April 28, 1949, issued as Design Patent No. 197,724, on March 21, 1950.

Body portion 60 of the microphone support forms a generally cylindrical housing in which preamplifier tube 14 is mounted. The lower end of that housing is closed by the male portion of an electrical connector, indicated at 68. The female portion 70 of the connector is mounted on a base 72, from which an electrical cable 74 makes connection to any elements of the electrical system that are not mounted within support 12. Connector portions 68 and 70 are releasably secured together in any conventional manner, forming a mechanical as well as electrical connection between base 72 and support 12, so that, for example, the entire assembly may be suspended from cable 74 when in use.

In the embodiment illustrated, connector portion 68 is mounted, as by the screws 76, in a thin-walled sleeve 78 which extends both above and below the body of the connector, the lower portion forming a protective skirt about the connector pins 80 and providing also a secure mechanical connection with connector portion 70 by slipping over it. A bracket formation, typically comprising two independent arms 82, supports the conventional tube socket 90, adapted to mount preamplifier tube 14. If, as in the present embodiment, that tube is of the type having its grid contact in the base, the socket and tube are mounted on brackets 82 in inverted position, as illustrated. Connections are then made from tabs 79 of connector 68 to corresponding tabs 91 of tube socket 90 by means of sections of insulated wire 92. Those wires, only one of which is shown in full in Fig. 3, are preferably resiliently tied to the body of tube 14, as by a flexible ring 94.

As will be explained, the electrical connections to the microphone proper in accordance with the invention are of three types. As in previous condenser microphones, the microphone condenser is connected across the input of the amplifying system, the microphone diaphragm 22 being preferably connected to ground; and back plate 24, which is insulated from the case, being connected to the control grid of the preamplifier tube. The third connection is to shield ring 38. In the preferred embodiment illustrated, that ring is mounted as a cathode follower, and shield ring 38 is connected directly to the suppressor grid of the tube, and is related to the tube cathode as will be described.

The three types of connection just mentioned are present in the present embodiment in the following preferred manner. Ground connection from microphone case 20 is carried through its mounting connection to metal plane 12, which is a metal plate of unitary structure that fits releasably over sleeve 78. Electrical contact to the grounded pin of connector 68 may be made via sleeve 78 and bracket 82 and by a short soldered lead, indicated at 85.

Connection to shield ring 38 is made via a shield sleeve 100 which is mounted coaxially within support 12 in a space in the connector portion 64 which includes the microphone receiving socket. The latter, as illustrated, the lower end of sleeve 100 rests upon the upturned central tongue 56 of sleeve 50, and is thereby supported and transversely located. Sleeve 100 is electrically connected to the appropriate one of tube socket tabs 91, as by a wire 93, soldered at both ends. The upper end of sleeve 100 is held in coaxially spaced relation within the cylindrical inner face 102 of support 12 by the insulative bushing 104, which is preferably fixed to sleeve 100 and freely slidable within support 12. A telescoping contact sleeve 106 is slidable mounted on the upper end of sleeve 100, and is yieldingly urged upward as by the coil spring 108, which also affords soldered electrical contact between the relatively movable sleeves. The upper spring tip 110 is bent radially inwardly and extends through the relatively large hole 109, thereby forming a limit stop which limits the relative telescopic movement of the tubes 100, 106. The upper end of contact sleeve 106, directly engages the lower face of guard ring 38, which is centered by radial flange 114 to insure good contact.

Connection to back plate 24 of the microphone condenser is made via the conductor 120, which is axially centered within sleeve 100 by the relatively thick layer of flexible insulation 122, conductor and insulation preferably forming a unitary
cable. That cable is bent radially outward through an aperture 124 at the lower end of sleeve 108, making conductor 125 readily available for soldering directly to the appropriate one of tube socket tabs 91. At its upper end cable 120, 122 leads into an insulating bushing 130 within sleeve 100. Bushing 130 is bored and counterbored to receive an axially slidable headed contact pin 135, which is urged upwardly by coil spring 134, permitting the latter to be seared directly to the pin and to the upper end of conductor 126, into firm contact with the lower exposed face of back plate 24.

The preferred structure described has the advantage of easy disassembly. By removal of screws 83, support sleeve 13 is released for axial movement with respect to the internal structure, and may be completely removed, together with microphone 10, by simply sliding it upward. During that process, connector 88 is preferably left attached to connector 70 on base 72. Such removal of housing 12, and microphone 10 breaks the spring-pressed contacts between guard ring 38 and sleeve 106, and between back plate 24 and pin 132, leaving connector 88, bracket 82, tube socket 80 with its tube 14, and the connecting sleeve 100 and cable 120, 122 supported on base 72 and fully accessible for inspection and repair, when necessary, the microphone proper may be removed from its support without disturbing any of the remainder of the apparatus, simply by unscrewing it from support 12. The electrical spring contacts are again opened at the points just referred to. The particular connection structure herein shown and above described is for illustrative purposes only and is not herein claimed in and of itself.

Fig. 4 shows in schematic form typical electrical connections for carrying out the invention. The plate 150 of preamplifier tube 14 is by-passed to ground via condenser 174, and is connected via resistor 152 to the positive terminal of a suitable source of direct current, indicated typically by battery 154. The negative terminal of battery 154 is connected to relative ground at 156 via line 155. The case 28 and support 13 of microphone 10 are connected to ground via line 157, grounding vibratory microphone diaphragm 22.

Tube cathode 158 is connected to ground through the two resistors 162, 164, which comprise the cathode load and form a voltage divider. Suitable voltage for tube screen 168 is provided from the positive side of battery 154, as via voltage dropping resistor 172, with bypass condenser to the cathode as indicated at 176.

The fixed back plate 24 of the microphone is connected via contact pin 132 and line 178 directly to tube control grid 160, the usual grid resistor being preferably omitted, so that the potential of the control grid and back plate system is determined by the balance of positive and negative grid current. In operation, that system comes to a stable voltage that is more negative than the cathode by a suitable bias voltage. The ratio of cathode load resistors 162, 164 is so chosen that the drop across 162 equals that bias voltage. The junction of 162 and 164 is thus at the same average potential as the control grid and back plate system, and the voltage standing across 162, 24 of the microphone condenser is substantially the voltage drop in cathode resistor 164.

In accordance with the present invention, shield ring 38 of the microphone is so connected that its potential follows that of the microphone back plate closely, both as to the fixed equilibrium component and as to the variable component that results from vibratory movement of microphone diaphragm 22, while at the same time the shield ring has an impedance to ground that is relatively very small in comparison to that of the microphone back plate, the latter impedance being substantially the tube grid resistance in the present preferred embodiment, and being typically many megohms even in circuits employing a grid resistor. That type of connection is preferably accomplished, as illustrated, by connecting the shield ring directly via line 180 to the junction between voltage dividing cathode resistors 162 and 164, selected as described, with a large bypass condenser to the cathode itself, as at 182. Tube screen grid 164 is preferably tied directly to the shield ring and its described connections, but may alternatively be connected in any conventional manner, as directly to the tube cathode. Connection 163 establishes the equilibrium potential of the shield ring substantially equal to that of back plate 24 and tube control grid 160; and condenser 182 provides a low impedance connection to the tube cathode, by which the tube, acting as a cathode follower, drives the shield ring potential in direct accordance with the variable component of the grid voltage.

A result of such connection is that the voltage across insulating bushing 36 of the back plate assembly is substantially zero, both as regards fixed and variable voltage components. Hence there is negligible leakage across that insulation, even if the material used is not selected specifically for its electrical properties. The full polarization voltage is applied across insulating bushing 34, but leakage across that bushing does not result in microphone noise, since shield ring 38 is isolated from the tube control grid, and is related to ground by a relatively low impedance.

Therefore the material for both insulating bushings 34 and 36 can be selected with primary attention to its mechanical properties without appreciably affecting the electrical performance of the microphone. It is therefore feasible to use insulating bushings that have maximum rigidity and maximum stability against deformation with time, with changing atmospheric conditions and the like. That relative freedom of selection of insulating material has been a vital factor in the development of a practical condenser microphone of very small size and having remarkably high fidelity and signal strength.

Furthermore, the introduction of shield ring 38 does not increase the effective stray capacitance of back plate 24, but rather the opposite. The effect of stray capacitance between back plate and shield ring is substantially eliminated by the connection via condenser 182 to the tube cathode, the action of the cathode follower in that respect being functionally the same as its well-known action in reducing the effect of grid to cathode capacitance in the tube. The stray capacitance between the guard ring and ground is relatively ineffective because it shunts the relatively low output impedance of the preamplifier tube.

An alternative manner of connection, which operates on the same general principle but with less complete effectiveness, involves a direct connection of shield ring 38 to tube cathode 160. That connection results, for example, if line 180 is disconnected from the junction of resistors 162 and 164 and is connected instead to the tube cathode, short circuiting condenser 182. There is then a slight difference in potential between...
the microphone back plate and shield ring, that difference being equal to the control grid bias of tube \(14\). Such connection leads to substantially equivalent capacity relationships as the preferred connection, but involves the possibility of leakage currents across insulating bushing \(38\).

It will be understood that the embodiment described and illustrated herein is broadly illustrative of the invention, and that many changes of structure and arrangement may be made without departing from the scope of the invention. In particular, and as an example only, the insulating support structure for back plate \(24\), shown as a system of concentric rings or bushings, is not necessarily limited to that type of geometrical form. One of the advantages of the invention is that the insulative requirements of that mounting are so much reduced that many mechanical arrangements not previously feasible for electrical reasons, are now available.

I claim:

1. A condenser microphone system comprising a conductive housing at effective ground potential, a conductive microphone diaphragm electrically connected to the housing and supported therewithin for vibratory movement in response to sound waves entering the housing, a conductive microphone plate fixedly mounted within the housing in closely spaced parallelism to the diaphragm and separated from ground by a relatively high impedance, an insulating support interposed between the plate and the housing and comprising two mutually spaced elements of dielectric material separated from each other by a conductive shield, an electrical element separated from ground by a relatively low impedance, circuit means for developing across the relatively high impedance between the microphone plate and ground a first voltage that comprises a relatively large fixed component and a relatively small variable component that varies in response to vibrations of the diaphragm, and for developing across the said relatively low impedance between the electrical element and ground a second voltage comprising a fixed component substantially equal to that of the first voltage and a variable component which varies under control of, and in direct proportion to, the variable component of the first voltage, and a relatively low impedance connection between the said electrical element and the conductive shield.

2. A condenser microphone system comprising a conductive housing at effective ground potential, a conductive microphone diaphragm electrically connected to the housing and supported therewithin for vibratory movement in response to sound waves entering the housing, a conductive microphone plate fixedly mounted within the housing in closely spaced parallelism to the diaphragm and separated from ground by a relatively high impedance, an insulating support interposed between the plate and the housing and comprising two mutually spaced elements of dielectric material separated from each other by a conductive shield, a vacuum tube including a plate, a control grid and a cathode, a load resistance connected between the tube cathode and ground, a source of voltage connected between the tube plate and ground, an electrical connection between the microphone plate and the tube control grid, and an alternating current connection between the shield and the tube cathode.

3. A microphone system as defined in claim 2, and in which the last said connection comprises a relatively large capacitance, and there is also a direct current connection between the shield and a point of the electrical system that is at an average voltage from ground approximately equal to the average voltage from ground of the tube grid.

4. A microphone system as defined in claim 3, and in which the said point of the electrical system is an intermediate point of the load resistance.

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