Jan. 18, 1927. 1,614,774

C. E. BONINE

VARIABLE RESISTANCE DEVICE

Filed Jan. 10, 1924

FIG. I.

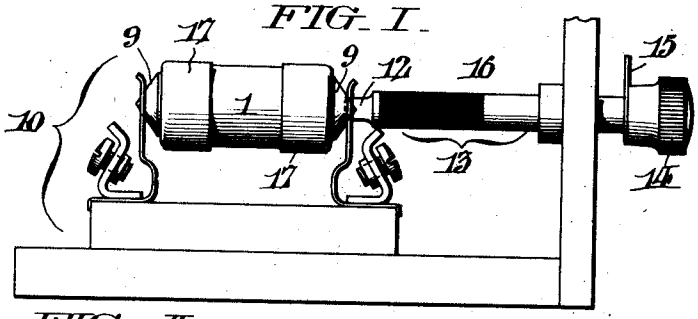


FIG. II.

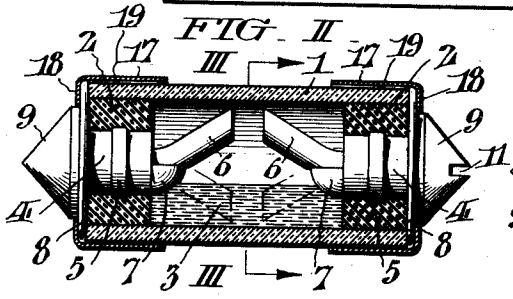


FIG. IV.

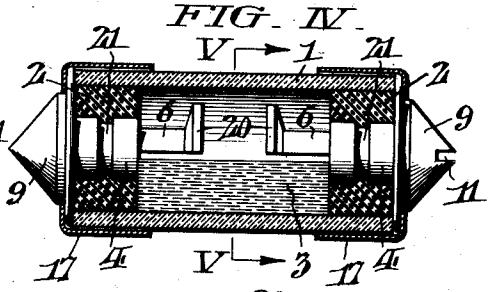


FIG. III.

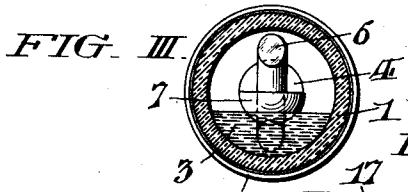


FIG. V.

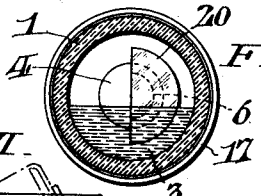


FIG. VI.

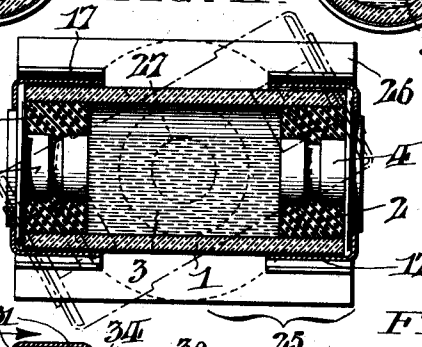


FIG. X.

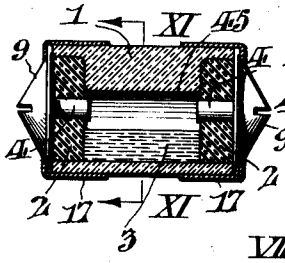


FIG. XI.

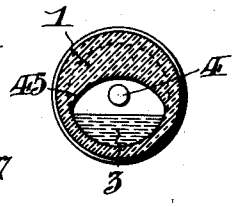


FIG. VII.

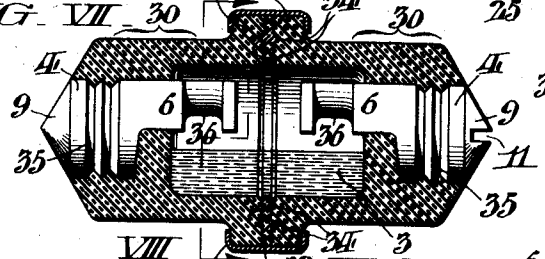


FIG. VIII.

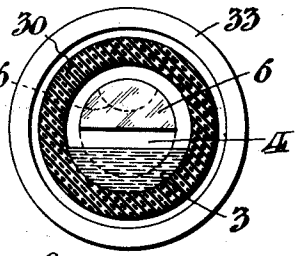


FIG. IX.



WITNESSES:

John C. Bergen

Thomas W. Kerr Jr.

INVENTOR:

Charles E. Bonine,

BY Fraley & Paul

ATTORNEYS.

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UNITED STATES PATENT OFFICE.

CHARLES E. BONINE, OF MELROSE PARK, CHELTENHAM TOWNSHIP, PENNSYLVANIA.

VARIABLE-RESISTANCE DEVICE.

Application filed January 10, 1924. Serial No. 685,317.

My invention relates generally to variable resistance devices for controlling current flow in electric circuits, and more specifically to a type especially adapted for use as a variable grid leak in connection with audion tubes employed in radio communication.

Variable resistance devices at the present available for the purpose mentioned include those comprising a metallic plunger shiftable in a cell containing mixtures of graphite and grease; and others comprising a hard graphite bar with an associated swingable contact arm. Devices constructed upon these principles I have found to be unsatisfactory in that the resistances are inconstant and therefore when used in radio communicating apparatus, are attended by corresponding inconstancies in microphonic operation.

The purpose of my invention is to overcome the objections noted, and to provide a variable resistance unit which is simple in construction, easily adjusted, and absolutely reliable and accurate in controlling the flow of electric current more particularly in extremely delicate circuits.

In the drawings, Fig. I is an illustration—in side elevation—showing one form in which a variable resistance unit or grid leak of my invention may be embodied and one way in which it is conveniently mounted and actuated.

Fig. II is a longitudinal sectional view of the device on an enlarged scale.

Fig. III is a cross sectional view taken as indicated by the arrows III—III in Fig. II.

Figs. IV and V are illustrations similar to Figs. II and III showing a slightly modified form of my invention.

Fig. VI is a longitudinal sectional view of another modification.

Figs. VII and VIII are respectively a longitudinal and cross section of an alternative form of construction of the device.

Fig. IX shows another modification of which my invention is capable.

Fig. X a longitudinal section of still another modification of the device; and

Fig. XI a central cross section of the same.

Referring first more particularly to Figs. I, II and III of the drawings, in the form therein shown, the device comprises a tubular body portion 1 of cylindrical configuration and preferably constructed of glass to secure the advantages of transparency, although other substances such as fibre, bakelite or composition may be employed if desired. The tubular body portion 1 is closed fluid tight at the opposite ends by insert plugs 2, also of insulating material—preferably resilient rubber—to form a cell for accommodation of a quantity of fluid electrolyte which is conventionally indicated at 3, in the illustrations. The plugs 2 are axially pierced to receive electrodes, the axial shanks 4 of which are provided with annular ridges or protuberances 5 insuring their fluid-tightness in the rubber. The inner ends 6 of the electrodes are reduced somewhat in diameter, and extended laterally or eccentrically as shown by being bent angularly relative to the axes of the shanks 4. By such disposal of the electrode ends 6, 6, the meniscus of the electrolyte 3 is prevented from leaping up upon them as they are dipped into the fluid upon axial rotation of the cell or body portion 1 as will be explained later. In order to insure complete isolation of the electrodes relative to the electrolyte 3 when their ends 6 are completely raised—as shown in Fig. II—the portions of said ends directly adjacent the shanks 4, 4 as well as the shouldered faces of said shanks are protected at one side by insulation indicated at 7. The application of the insulation 7 may be conveniently effected by initially completely covering the inner ends of the electrode shanks 4, 4 with fusible or cementitious material such for example as asphaltum, and subsequently scraping the portions of the surfaces intended for exposure to the electrolyte 3. At the exterior, the electrodes are formed immediately adjacent the shanks 4 with circumferential face flanges 8 designed to abut against and to cover the exposed flush ends of the plugs 2, as well as the tubular body portion 1. Beyond the face flanges 8, the electrodes terminate in conical heads 9 which serve in the capacity of trunnions whereby the device may be supported for axial rotation between the spring clips of a holder such as shown in Fig. I and designated comprehensively by the numeral 10. Either one, or both of the trunnion heads 9 of the electrodes may be transversely slotted as shown at 11 so as to be engageable by the flattened end 12 of a turn key 13, rotatable in the front panel of a radio receiving set as shown in Fig. I,

which at its protruding end is equipped with an actuating knob 14 and pointer 15 for convenience of adjustment. A length of insulation 16 interposed in the shaft of the key 13 protects the variable resistance device or grid leak against extraneous influence electrically. The insert plugs 2 as well as the electrodes 4, 6 are maintained against displacement in the assemblage by ferrules 17 which embrace the extremities of the body portion 1 and are formed with circumferential inwardly-turned flanges 18 adapted to overlap marginal portions of the face flanges 8 of the electrodes. Any appropriate cementing compound 19 may be employed to secure the ferrules 17 to the body portion 1.

Assuming the cell to be mounted—as shown in Fig. I—and filled with electrolyte to a level somewhat below the axis of rotation as in Figs. II and III, its operation is as follows:

By axial rotation of the cell in the holder 10 through manipulation of the thumb knob 14 of the key 13, the inner ends 6 of the electrodes may be shifted from a position completely clear of the electrolyte 3 as shown in full lines in Figs. II and III to any extent or degree of immersion in said electrolyte from the time contact is made with the liquid to the maximum when positioned as shown in dotted lines in Fig. II, the resistance being in inverse proportion to the extent of surface submerged. As a consequence of the angular disposal of the electrode ends 6, their introduction into the liquid electrolyte 3 is after the manner of a rolling action which prevents the meniscus of said liquid electrolyte from leaping and completely covering the ends 6, 6, immediately upon contact with the fluid electrolyte 3 as previously stated.

The construction shown in Figs. IV and V is identical with the form just described except as to the construction of the electrodes. In this instance the eccentric inner ends 6 instead of being round in cross section and angularly disposed as before, are semi-circular in cross section and extended laterally through formation of enlargements or heads 20. One other difference may be noted in the substitution of circumferential grooves 21 in the shanks 4 of the electrodes in lieu of the annular ridges 5 of the first form. The modified features pointed out are to be considered merely as structural alternations and do not in any way modify the use of the device or the attending results.

Fig. VI shows a type of construction in which the cell is adapted to be rotated about an axis at right angles to its longitudinal center line, said cell being supported by a clip holder 25 with its base 26 fulcrumed on a fixed stud 27. In this instance, the electrode shanks 4 terminate flush with the inner faces of the plugs 2, the extensions 6 of the previous forms being entirely dispensed with. The conical trunnion heads 9 of the previous types are also omitted in view of the modified mounting of the cell. Rotation of the cell in this instance in either direction about the swivel 27 as suggested by dotted lines in the illustration, will result in variation in the area of the electrode faces exposed to the electrolyte 3 and thus control flow of electric current in the circuit in which the device is interposed.

Figs. VII and VIII of the drawings show a variable resistance unit which differs from that of Figs. I and II in the manner of its construction generally although intended to be used in exactly the same manner. In this embodiment, the body portion comprises two cylindrical sections or halves 30 which are identical both as to configuration and dimensions, and they are constructed of any suitable insulation composition capable of being molded or cast to the desired form. The sections 30 have integral flanges 31 which, after introduction of the electrolyte 3 and the interposition between them of a resilient gasket 32, are secured together by an embracing ferrule 33. Annular grooves or recesses 34 in the opposed faces of the flanges 31 insure fluid tightness of the joints with the contiguous faces of the gasket 32. The cylindrical shanks 4 of the electrodes in the present instance are embedded axially in the ends of the body sections 30 in the course of the moulding of the latter, and said shanks are provided with circumferential ridges and grooves as at 35 so as to engage the composition with fluid-tightness and to prevent axial displacement of the electrodes. The inner ends 6 of the electrodes are reduced to semi-circular cross section thereby providing projections which are eccentric relative to the axes of the shanks 4, and which, by axial rotation of the cell, are caused to dip to different extents into the electrolyte 3 in precisely the same manner as described in connection with the operation of certain of the other embodiments. Leaping of the meniscus of the electrolyte fluid 3 on to the projections 6 is prevented by virtue of the recessed or cut-away construction indicated at 36. As a result of embedding portions of the reduced ends 6 in the material of the body sections 1 as shown, the electrodes are firmly held against rotation in addition to being fixed against axial displacement as previously noted. The outer ends of the body sections 30 are preferably given a conical configuration in conformity with, and in continuation of the trunnion heads or ends 9 of the electrode shanks 4.

In the construction of Fig. IX, a bent tube 40 is employed as the body portion of the cell. The inner ends 6 of the electrodes are bent angularly relative to their shanks

4 in conformity with the shape of the tube 40. Rotation of the cell under support of the trunnion heads 9 of the electrodes results, as will be apparent from the illustration, in variable immersion of the portions 41 of said electrodes exposed to the electrolyte 3.

The alternative form of the device shown in Figs. X and XI is characterized by having a body portion 1 with its bore 45 eccentric, the electrodes being however disposed, as in the previous instances, on the axial center of the tube. From the cross section of Fig. XI, it will at once be apparent that as the device is rotated, the level of the liquid 3 will move gradually toward and away from the electrode shanks 4, 4 by virtue of the eccentricity of the tube bore, the positional changes being attended by corresponding variations in the resistances precisely as hereinbefore explained.

In each of the embodiments described, the fluid electrolyte 3 is protected against deterioration by various modes of hermetical sealing which may be resorted to. Any compound or fluid mixture substantially stable against decomposition and formation of gases under passage of small electric currents and characterized by the desired resistive properties may be employed as the electrolyte 3. A solution having these characteristics will insure the sealed cell against destruction in long continued usage; and one such solution, which has been found to give good results when the variable resistance device is used as an adjustable grid leak in association with electron tubes of radio apparatus, is a solution of cadmium iodide in amyl alcohol. With this solution any decomposition that may take place under abusive conditions will result in precipitation of solids only, no gases being evolved. The amount of the salt in solution is gauged to provide the desired range of resistance in accordance with requirements of any special or particular use to which the device may be put. The longevity of the cell may be increased by plating the portions 6 of the electrodes exposed to the electrolyte 3 with the metal forming the base of the salt employed in the solution such provision entirely obviating the possibility of "poisoning" the electrolyte.

Having thus described my invention, I claim:

1. A variable resistance device of the character described comprising a rotatable tubular cell with a body of conductive liquid and serial electrodes therein, said cell when rotated varying the area of immersion of the electrodes in the liquid, or moving said electrodes clear of the conductive liquid and thus the resistance of the device.

2. A variable resistance device of the character described comprising a rotatable tubular cell with a body of conductive liquid therein, and serial electrodes eccentrically located and arranged in the cell so that their area of immersion and consequent resistance of the cell may be varied by its rotation or the electrodes may be turned clear of the conductive liquid.

3. A variable resistance device of the character described having electrodes and a conductive liquid, and comprising as its means of resistance variation rotatable serial contacts of variable area between said electrodes and said liquid; so that the resistance of the device may be adjusted substantially irrespective of the lengths of the liquid and electrode paths therein, or the electrodes may be shifted completely clear of the conductive liquid.

4. A variable resistance device of the character described comprising a body of conductive liquid, and electrodes rotatable relative thereto in contact therewith over areas varying with their rotation, and in series through the liquid with a substantially constant length of path through the latter, so that the resistance of the device may be adjusted by variation at the contacts, substantially unaffected by the length of path.

5. A resistance device of the character described, comprising, in combination with a hermetically sealed cell having serial electrodes exposed therein, a quantity of liquid electrolyte stable against decomposition and liberation of gases under passage of electric current, for serially connecting said electrodes within the cell.

6. A resistance device of the character described, comprising, in combination with a hermetically sealed cell having serial electrodes, a quantity of liquid electrolyte for serially connecting said electrodes within the cell, comprising a solution of cadmium iodide in amyl alcohol.

7. A variable resistance device of the character described comprising a tubular cell containing a conductive liquid, plugs of insulation forming end walls for said cell, and inset electrodes having shanks embedded in the end walls and exposed outer ends forming trunnion bearings for rotation of the device.

8. A variable resistance device of the character described comprising a tubular cell containing a conductive liquid, plugs of insulation forming end walls for said cell, and inset electrodes for the liquid having shanks embedded in the end walls and enlarged conical heads forming trunnion bearings for rotation of the device.

9. A variable resistance device of the character described comprising a tubular cell containing a conductive liquid, and electrodes for the liquid in the cell ends having projecting trunnion heads to serve as bear-

ings for rotation of the device, at least one of said trunnions being slotted for a turning key.

10. A variable resistance device of the character described comprising a tubular insulative body, insert plugs of insulation in the ends of said body, a conductive liquid partly filling the body, and serial inset electrodes embedded in the plugs and exposed in the body.

11. A variable resistance device of the character described comprising a tubular insulative body, insert plugs of insulation in the ends of said body, a conductive liquid partly filling the body, and inset electrodes with shanks embedded in the plugs and flanges covering the joints between plugs and body.

12. A variable resistance device of the character described comprising a tubular insulative body, insert plugs of insulation in the ends of said body, a conductive liquid partly filling the body, inset electrodes with shanks embedded in the plugs, and ferrules on the ends of the body with internal flanges externally overlapping said electrodes.

13. A variable resistance device of the character described comprising a tubular cell containing a conductive liquid, plugs of insulation forming the cell ends, electrodes for the liquid with shanks embedded in the cell ends and enlarged external heads, and ferrules on the cell ends with internal flanges externally overlapping said heads.

In testimony whereof, I have hereunto signed my name at Philadelphia, Pennsylvania, this 3rd day of January 1924.

CHARLES E. BONINE.