F. K. RICHTMYER.

HIGH RESISTANCE UNIT.

APPLICATION FILED FEB. 6, 1919. RENEWED JUNE 3, 1921.

1,388,373. Patented Aug. 23, 1921.

Fig. 1.

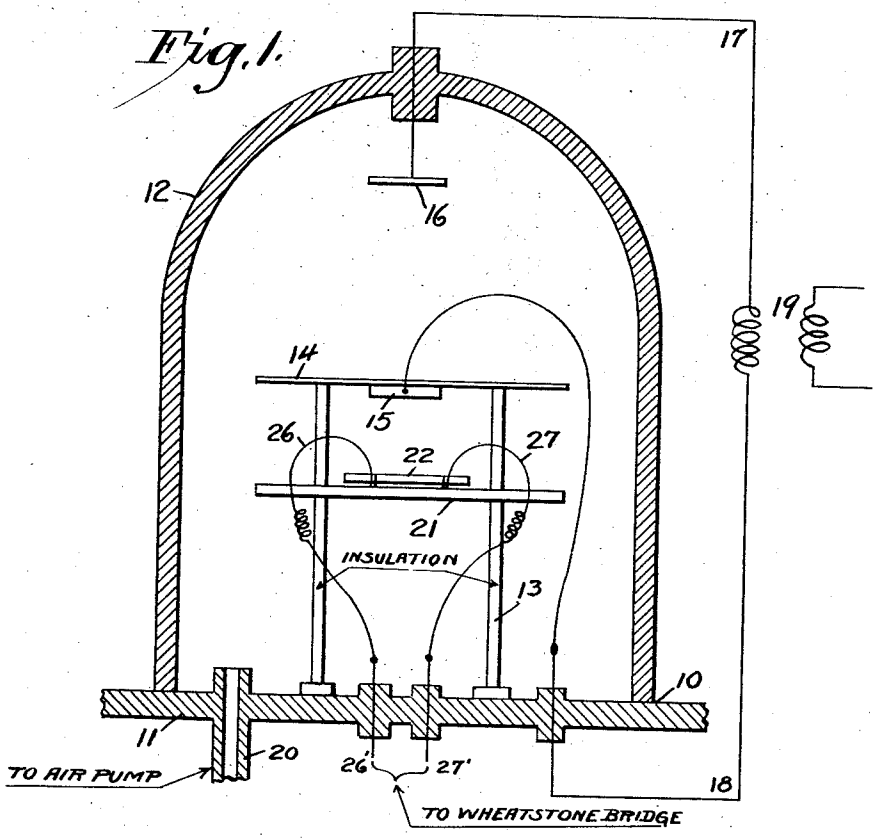


Fig. 2.

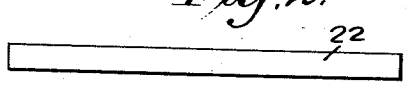


Fig. 6.



Fig. 3.

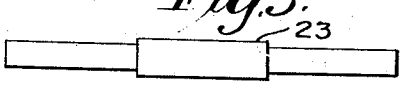


Fig. 7.

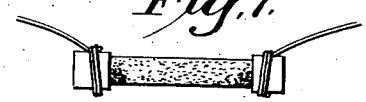


Fig. 4.

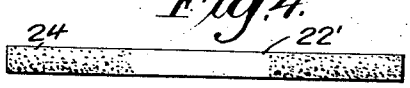
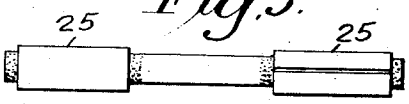


Fig. 8.



Fig. 5.



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HIGH-RESISTANCE UNIT.

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To all whom it may concern:

Be it known that I, FLOYD K. RICHTMYER, a citizen of the United States, residing at Ithaca, in the State of New York, have invented a new and useful Improvement in a High-Resistance Unit, of which the following is a specification.

The principal objects of my invention have relation to an improved high resistance unit. Another object relates to aging such a unit or making it of comparatively fixed permanent value. Still another object has to do with the preparation of such a unit by the deposit of a thin film of metal on a non-conductive base. Other objects relate to various aspects and features of the invention, all of which will become apparent on consideration of specific illustrative examples.

In the drawings and in the following discussion relating thereto, I have disclosed one specific embodiment of the invention. It will be understood that modifications may be made within the scope of the invention. In these drawings, Figure 1 is a diagram illustrating one way of preparing my improved resistance units, and Figs. 2 to 8 are views of a unit at successive steps of its preparation.

Apparatus that may be employed in the practice of my invention is shown diagrammatically in Fig. 1, where the bell jar 12 stands on the base 11 with a tight fitting ground joint at 10. Insulating supports 13 carry a mica plate 14 with a platinum cathode 15 fastened on its under side. The corresponding anode is shown at 16 and these two electrodes 15 and 16 are supplied with high potential current from the source 19 through conductors 18 and 17.

The base 11 has a conduit 20 opening into the space under the bell jar 12 through which air may be evacuated to an air pump as indicated by the legend in the drawing.

Beneath the cathode 15 the supports 13 carry a platform 21 on which may rest a glass rod 22, to be treated as described hereinafter. The two conductors 26′ and 27′ extend through base 11 and they may be connected up within the bell jar 12 as will be explained later. Externally they go to a Wheatstone bridge, as indicated by the legend in the drawing.

I cut off lengths of glass rod, each 7 cm. long by 0.3 cm. diameter, make them chemically clean, and bake them at a temperature of 150° C. for a half hour.

Then I slip a little close fitting cylindrical sheath 23 of sheet aluminum, about 1.3 cm. long, over the middle portion of a rod, as indicated in Fig. 3, and lay the rod on the table 21. No connections are made at this stage to the conductors 26′ and 27′. The air is evacuated through the conduit 20 from under the bell jar 12 and the electric discharge started between the anode 16 and cathode 15. Platinum in a finely subdivided condition is detached and projected from the cathode 15, depositing on the rod 22, sheath 23 and neighboring objects. I continue the deposit about 20 minutes until a comparatively thick coating of platinum is deposited on the portions of the rod 22 not shielded by the sheath 23.

The rod 22 with its coating is then removed from under the bell jar and the sheath 23 removed therefrom. Its condition at this time is indicated by Fig. 4, which shows the end portions 24 heavily stippled to indicate a thick deposit of platinum thereon, while the intermediate portion 22′ remains clean. The rods in this condition are then baked at a temperature of about 200° C. for an hour. This baking "sets" the platinum film.

Provision is next made for terminal contacts by slipping over the terminal films cylinders 25 of thin sheet aluminum. These cylinders are formed on rods of the same size but are not quite complete,—that is, each cylinder has a narrow longitudinal slot so that it does not quite surround the rod. They are placed so as to expose the inner end portions of the films 24, as shown in Fig. 5. Two turns of bare #26 copper wire are wound around the end of each aluminum cylinder near to its inner end. The turns of the wire are then soldered to each other, the wire being kept under tension meanwhile so that it makes a firm contact between the aluminum shell and the film, due to the contraction by cooling after soldering.

Thus equipped with the terminal conductors 26 and 27, the rod is replaced on the support 21 under the bell jar 12 and the terminal conductors 26 and 27 are connected respectively with the lead wires 26′ and 27′ which go to the Wheatstone bridge.

The electric discharge between the anode

16 and the cathode 15 is started as before. At first the Wheatstone bridge indicates entire absence of any conductive connection between the terminals 26 and 27. After about 20 to 25 seconds a feeble current begins to flow, giving an indication at the Wheatstone bridge of a resistance between the terminals 26 and 27 of say about 50 megohms. Continuing the sputtering of the platinum from the cathode 15, the film 28 on the space 22′ continues to build up and the resistance falls very rapidly,—so that in a very few seconds it will be a minor fraction of a megohm. If it is desired to get a resistance of about 1 megohm, the sputtering should be continued intermittently for only a fraction of a second at a time so that it shall not be overdone. The film 28 laps on the end films 24 making a good conductive connection.

After the film has been sputtered upon the rod to give what is deemed the proper resistance, the operation is stopped and the unit removed and placed in an electric oven where its temperature is slowly raised to about 125° C., where it is kept constant for from 30 minutes to an hour. Then the rod is allowed to cool slowly to normal temperature, followed by a second heating in which the temperature is raised only to 110° C. After cooling again, the films are given a coating of bakelite, which is given time to set, and then they are heated again to not above 90° C. The resistance is measured at all stages of this aging process which follows the deposit of the film.

Whatever the reading given by the Wheatstone bridge after sputtering is stopped, this changes at once upon admission of the air under the bell jar 12, indicating a resistance rise of the order of 50%. During the aging process the resistance (usually) drops to some definite final value. Unless so aged the resistance continues to change (usually decreasing) for a long time.

The unit having been aged as described, its resistance may be increased to give a desired definite value. This is done by marking it with a knife edge, all the time watching the indication on the Wheatstone bridge. The knife edge interrupts the continuity of the film to some extent and thus increases the resistance. When the proper adjustment is made, the film is given another coating of bakelite and the ends of the rod are cut off close to the point of attachment of the terminal conductors 26 and 27 as indicated in Fig. 7, the extra length having been provided to facilitate handling. The ends of the unit are covered with sealing wax and it is then slipped loosely into a glass tube 29 of sufficient size to receive it and protect it against scratching and it is ready for use as a high resistance unit.

I have made these units successfully employing a vacuum of about 0.0083 mm. of mercury, the residual gas being air. I find that good results are obtained if the distance of the glass rod 22 from the platinum cathode 15 is such as to bring it at the edge of the Crookes dark space, and I find that it gives good results to adjust the voltage and other conditions so as to make this dark space extend a centimeter or a little more from the cathode. I have used platinum for the cathode metal. Its non-oxidizing property makes it a good material for the conductive film, and it sets well by baking.

The resistance units made in this way can easily be constructed to have a resistance of two megohms with a variation of less than 10%; they are practically constant in value and will stand a potential difference across their terminals of 400 volts. They are conveniently small in size and rugged in service. They find useful application as grid leaks in connection with audion detectors for radio receiving equipments, and for all other purposes requiring a compact high resistance unit capable of initial adjustment.

I claim:

1. A high resistance unit consisting of a convexly formed non-conductive member carrying on its outer face a thin film of metal annealed *in situ*.

2. A high resistance unit consisting of a convexly formed non-conductive rod carrying on an exterior face a thin film of metal at its intermediate part connected with thicker films at its end parts to serve for the attachment of terminal conductors.

3. A high resistance unit consisting of a convexly formed non-conductive rod carrying on its exterior face a thin film of metal and adjusted to a desired resistance value by being marked with a knife edge.

4. A high resistance unit consisting of a convexly formed solid non-conductive rod carrying on its outer face a thin external film of metal.

5. A high resistance unit consisting of a non-conductive rod carrying a thin film of metal and incased in a protecting tube.

6. A high resistance unit consisting of a non-conductive rod carrying a thin film of metal covered by a protective non-conducting coating.

F. K. RICHTMYER.