July 12, 1927. L. L. JONES 1,635,184

MANUFACTURE OF ELECTRICAL RESISTANCE UNITS

Filed Oct. 27, 1924

Fig. 1.

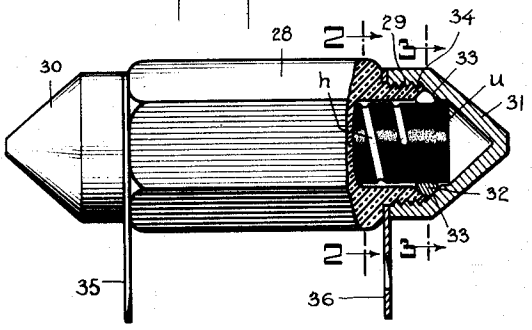


Fig. 2.

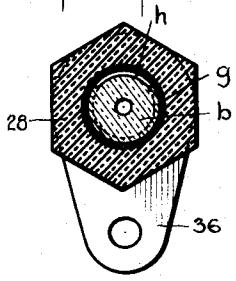


Fig. 3.

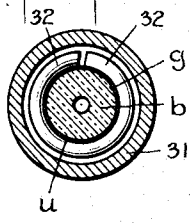


Fig. 4.

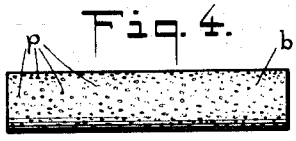


Fig. 5.

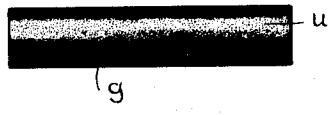


Fig. 6.

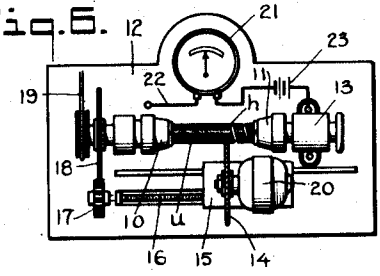


Fig. 7.

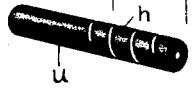
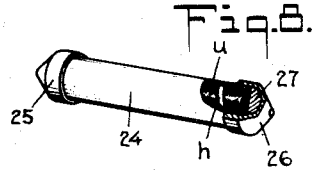


Fig. 8.



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UNITED STATES PATENT OFFICE.

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MANUFACTURE OF ELECTRICAL RESISTANCE UNITS.

Application filed October 27, 1924. Serial No. 746,026.

This invention relates to electrical resistance units and to the method of making the same; and has special reference to the manufacture of capacity and inductance-free high resistances.

As is well known, capacity and inductance-free high resistance elements are made in the art by any of a number of methods, such as by impregnating paper strips or other similar material with various kinds of carbon inks, by surfacing paper or the like with graphite streaks or lines, or by depositing thin films of metal on insulating bases such as glass tubes or the like. These resistances, although compact, inexpensive, inductance and capacity-free, have a number of disadvantages, the inked and graphited paper resistances being for instance quite microphonic, generally destructible in use, and incapable of carrying any considerable current and the metallic film resistances being unstable by reason of the change in the resistance value thereof which takes place due to the crystallization or oxidation of the thin metal film. These resistance units are also open to the common and serious objection that the resistance values thereof for a given type and make vary within wide limits, it being difficult to manufacture the resistances of uniform value, especially where the same are produced by quantity production methods.

The manufacture of resistance units which do not possess the above-stated objections and disadvantages and which are characterized by being non-microphonic, stable in value or magnitude, of large current carrying capacity, durable, and capable of being manufactured uniformly in desired values within wide ranges, is a prime desideratum of my present invention.

A further prime object of my present invention comprehends the provision of a resistance unit of the character referred to provided with a new and improved mounting for connecting the same in circuit, the mounting protectively encasing the resistance element and being constructed to provide uniform water-tight electrical and mechanical joints, the structure being such as to be capable of dissipating the heat generated when the resistance is used for carrying high loads, the said mounting being further characterized by its simplicity of construction and by the ease with which the parts may be assembled while securing efficient electrical contact or engagement of the resistance element with the circuit connecting parts.

To the accomplishment of the foregoing and such other objects as may hereinafter appear, my invention consists in the elements and their relation one to the other, as hereinafter particularly described and sought to be defined in the claims; reference being had to the accompanying drawings which show the preferred embodiment of my invention, and in which:

Fig. 1 is a view with parts shown in cross-section of a resistance unit made in accordance with the principles of my invention and the mounting therefor, with parts broken away,

Fig. 2 is a view taken in cross-section on the line 2—2, Fig. 1,

Fig. 3 is a view taken in cross-section on the line 3—3, Fig. 1, and

Figs. 4–8 are views showing in sequence steps of the method of making the resistance units or elements.

Before describing my invention in detail, I will briefly premise that the resistance unit of my present invention generically comprises a base made of an insulating material having a surface layer of graphite which is so applied and subjected to such treatment as to produce a homogeneous and set graphite layer firmly adhering to and embedded in the body of the base, the resulting unit having the properties of stability in magnitude or value, of large current-carrying capacity, durability and absence of any microphonic tendencies. These resistance units are made so that after the graphited layer base or blank is produced, it may be subjected to a further simple operation to produce any given or desired magnitude with accuracy and within a wide range of values. The resistance unit of predetermined value is then mounted in a protective casing which is constructed with moisture-proof electrical and mechanical joints and designed so as to be capable of quickly extracting from within and dissipating the heat generated by the resistance element when the same carries heavy loads.

Referring now more in detail to the drawings, and having reference first to Figs. 4–7 thereof, showing certain steps in the method of making the resistance unit, the resistance element comprises a base or blank *b* (Fig. 4) of an insulating material, the said base

having a hard and semi-permeable or porous surface, to which base is applied a layer of graphite *g* (Fig. 5) in such manner as to become firmly and intimately united with the body of the base and to form a homogeneous, compacted and stable layer thereover.

The blank *b* is preferably cylindrical in contour for a purpose which will become clearer hereinafter, and consists of unglazed porcelain or clay known in the trade as "lavite", the base having a relatively smooth external surface free from oil or grease and provided with surface pores *p* shown in exaggerated form for purposes of illustration in Fig. 4 of the drawings. In producing the applied layer of graphite, this blank or base *b* is first dipped into a solution preferably of colloidal graphite known in the trade as "Kollag". Where resistance units of less than one megohm are desired, a water soluble solution is used and where the resistance units are to be compact and of values larger than one megohm, an oil soluble solution is preferably used. In either case, the blank after being dipped in the graphite solution is allowed to soak to permit the colloidal graphite to be carried by the liquid into the pores of the lavite surface, causing the graphite to become embedded in and firmly adhered to the body of the base. Where a water soluble solution is used, the dipped blank is left to stand for about one half a minute without being permitted to dry, and in the case of the oil soluble solution, the blank may be left to soak for a longer period of time to allow a more or less deep penetration of the graphite into the pores of the blank.

After the dipping and soaking steps, the adhering graphite layer is then compacted to effect intimate cohesion between the graphite particles, and this step is carried out by rapidly burnishing the graphite layer by a preferably axial action of a smooth metallic surface pressed with a fairly high degree of pressure against the graphite covered blank. The burnishing motion is preferably rapid and the pressure adjusted to the highest point short of that which will abrade the lavite. Under the influence of this burnishing process, the colloidal graphite is compacted into a hard shiny mass on the surface and in the top layer of the lavite blank. In the use of the water soluble solution, the burnishing step is carried out while the dipped blank is still in a moist state, so as to prevent the compacted graphite from flaking off.

To effect a substantial amalgamation or solidification of the graphite layer and to set the same, the compacted graphite unit is subjected to the action of an electric current at preferably high voltage. This is accomplished by mounting the blank at its ends in an electric circuit of approximately 110 volts with a series ballast resistance. Under the influence of the electrical current, either from a thermal or electrolytic action, the graphite becomes densely compacted, forming practically a solid layer, and the layer permanently decreases in resistance and becomes set in value. The resistance drop due to this step in the process is usually of the order of 50 to 75%, and after this operation further successive passages of current result merely in the normal temperature resistance changes due to the negative resistance coefficient of the graphite, the resistance coming back to its normal value after cooling.

In the resistance unit so obtained, as shown in Fig. 5 of the drawings and generally designated as *u* therein, the layer of graphite *g* is permanently united with the base, and becomes substantially unitary or integral therewith, the unit being entirely free from microphonic noises; and the said unit may be heated to at least 500° Fahrenheit without alteration. The layer so formed is furthermore substantially indestructible, and may be buffed against a cloth wheel without appreciably changing the resistance value obtained.

To produce resistances of any given or desired value, the resistance unit *u* is then subjected to an operation in which parts of the layer are removed to produce a resistance path of any given value. This is accomplished by mounting the resistance unit in a suitable lathe, as diagrammatically shown in Fig. 6 of the drawings, operating to produce a helical groove in the grapite layer for obtaining a helical resistance path. As shown in Fig. 6, the unit *u* is received by the end chucks 10 and 11, the chucks being preferably provided with fingers which firmly grip the ends of the unit to make efficient electrical contact therewith, the chuck 10 being grounded on the base 12 and the chuck 11 being insulated therefrom, as by insulatably mounting the tail stock 13 on the base, as clearly shown in Fig. 6 of the drawings. For producing the helical groove in the graphited layer of the unit, a rotary grinder 14, which may be a fine emery wheel grinder, is used, which rotary grinder is mounted in suitable bearings supported in a carriage 15, which carriage is moved longitudinally of the machine by means of screw mechanism 16 operated by the meshing pinion and gear 17 and 18, the latter being fixed to the lathe shaft and operated from any suitable source of energy by connecting means 19. The rotary grinder 14 may be independently driven by means of a motor 20 mounted on the movable carriage 15. For measuring or indicating the resistance value of the unit operated upon, I provide an ohmmeter 21 in circuit with the unit, one end of the ohmmeter being grounded to the machine base 12 by means

of the conductor 22, and the other end being connected to a source of energy 23 which in turn is connected to the tail stock 13.

In operation, it will be understood that the rotary grinder cuts a shallow helical groove h in the resistance unit until the ohmmeter shows the desired resistance value. By changing the pitch of the screw feed and/or the widths of the cut, the resistance of the unit may be varied within wide limits. For example, it has been found practical to change blanks having an initial terminal resistance of 200 ohms into anything up to approximately 200,000 ohms. The unit with the helical groove cut therein is shown in Fig. 7 of the drawings. An important advantage of this type of unit resides in the ability to use the same stock with the same machinery for making units of any predetermined value.

To produce a finished unit, the helical resistance element may be provided with a protective covering 24, as shown in Fig. 8 of the drawings, and to the ends of the unit may be secured the terminal caps 25 and 26 suitably attached by any means such as a Woods metal filling 27.

As heretofore stated, it is a further object of the invention to provide a new and improved mounting for the resistance unit constructed to produce uniform water-tight electrical and mechanical joints, with the structure such that the heat generated by the resistance unit is quickly dissipated, the mounting being further characterized by its simplicity of construction and the ease with which the parts may be assembled while obtaining efficient electrical engagement between the parts. To these ends, and as shown in Figs. 1–3 of the drawings, the resistance unit u is mounted in a tubular casing 28 made of a strong insulating material, such for example as a phenol condensation product, the said casing being exteriorly threaded as at 29 at its opposite ends (only one threaded end being shown in the drawings), the said threaded ends receiving end terminal caps 30 and 31, these caps being interiorly threaded for reception by the threaded casing, as clearly shown in Fig. 1 of the drawings. The resistance element u is slightly longer than the insulating casing 28, the ends thereof projecting into the terminal caps, as is clearly apparent from Fig. 1 of the drawings. For obtaining efficient electrical connection between the end caps and the ends of the resistance elements, I employ contact members made of relatively soft metal which are wedged into circumferential engagement with the ends of the resistance element and the end caps when the latter are threadedly secured to the casing, such members comprising at each end a lead ring 32 received by an end of the resistance unit and wedged into contact therewith by means of the bevelled surfaces 33 and 34 provided respectively in the end caps and casing ends. The construction is such that when the end caps are screwed fast onto the casing, the lead rings are forced into the triangular space between the bevelled surfaces and into intimate contact with the end graphoidal surface of the blank and with the metal end caps. This forms a perfectly uniform and water-tight electrical and mechanical joint.

To permit the resistance unit to be mounted either in spring clips or wired directly into circuit, the preferred construction includes the punched metal tabs 35 and 36 secured at each end between the casing and the metal end caps. These punched tabs, together with the heavy terminal caps, assist in withdrawing and dissipating the heat generated in the interior under the high loads which this type of resistance unit may carry.

The method of making and using resistance units embodying my invention and the numerous advantages thereof will in the main be fully apparent from the above detailed description thereof. It will be further apparent that numerous changes and modifications may be made in the structure disclosed without departing from the spirit of the invention, defined in the following claims.

I claim:

1. The method of making a resistance unit which consists in applying a solution of graphite to a cylindrical base having a hard and semi-permeable surface, the graphite solution penetrating into the pores of the base and forming a layer thereover, in then operating upon said layer to effect an intimate cohesion between the graphite particles for producing a homogeneous layer, and in then producing a helical groove in said layer to lengthen the resistance path and to provide a resistance of a given value.

2. The method of making a resistance unit which consists in applying a solution of graphite to a cylindrical base having a hard and semi-permeable surface, the graphite solution penetrating into the pores of the base and forming a layer thereover, in then compacting and solidifying the layer, and in then cutting a helical groove in said layer to lengthen the resistance path and to produce a resistance of a given value.

3. A resistance unit comprising a cylindrical base, a layer of resistance material on said base, the said resistance layer being provided with a helical groove for producing a resistance of a given value.

4. A resistance unit comprising a cylindrical base, a homogeneous layer of graphite intimately united with the surface of said base, the said layer being provided with a helical groove for producing a resistance of a given value.

5. A resistance unit comprising a cylindrical base having a hard and semi-permeable surface, a homogeneous layer of graphite intimately united with the surface of the base, the said layer having a helical groove cut thereinto to produce a helical resistance path of predetermined value.

6. A resistance unit comprising a cylindrical base having a hard and semi-permeable surface, a layer of graphite penetrating the pores of and burnished onto the surface of said base, the said layer being provided with a helical groove cut thereinto to produce a helical resistance path of predetermined value.

7. A resistance unit comprising a tubular-shaped casing, a cylindrical resistance element therein, terminal end caps secured to the ends of the casing, and contact rings encircling opposite ends of the resistance element wedged between the resistance element and the end caps by the securing of the end caps to the casing.

8. A resistance unit comprising a tubular casing made of an insulated material, a cylindrical resistance element within the casing, terminal end caps threadedly attached to the ends of the casing, and contact rings made of a relatively soft metal wedged into circumferential engagement with the ends of the resistance element and the end caps when the latter are threadedly attached to the casing.

9. A resistance unit comprising a tubular casing having ends exteriorly threaded and interiorly bevelled, terminal end caps interiorly threaded and bevelled received by the threaded ends of the casing, a cylindrical resistance element within said casing, and contact rings made of a relatively soft metal at opposite ends of the resistance element, said contact rings being wedged between the resistance element and the bevelled ends of the casing and end caps to make efficient electrical contact with the end caps and resistance element when the end caps are threadedly secured to the casing.

10. A resistance unit comprising a tubular casing having ends exteriorly threaded and interiorly bevelled, terminal end caps interiorly threaded and bevelled received by the threaded ends of the casing, a cylindrical resistance element within said casing comprising a base having a helical layer of graphite intimately united with the surface thereof, and contact rings made of a relatively soft metal at opposite ends of the resistance element, said contact rings being wedged between the resistance element and the bevelled ends of the casing and end caps to make efficient electrical contact with the end caps and resistance element when the end caps are threadedly secured to the casing.

11. A resistance unit comprising an elongated base made of an insulating material, a layer of resistance material applied to said base, the said resistance layer being provided with a helical groove cut along the base for producing a resistance of a given value.

12. A resistance unit comprising an elongated base of an insulating material, a thin coating of resistance material applied to said base, the said resistance coating being cut with a helical groove for producing a helical resistance layer of a given value.

Signed at New York city, in the county of New York and State of New York, this 21st day of October, A. D. 1924.

LESTER L. JONES.