

Aug. 25, 1936.

H. PENDER

2,052,533

RESISTANCE UNIT

Filed Dec. 8, 1933

4 Sheets-Sheet 1

Fig. 1-B.

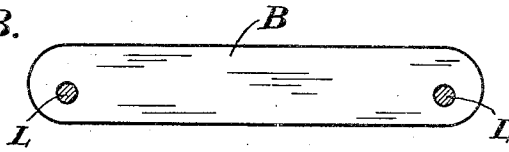


Fig. 1.

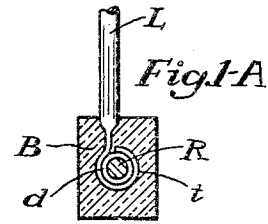
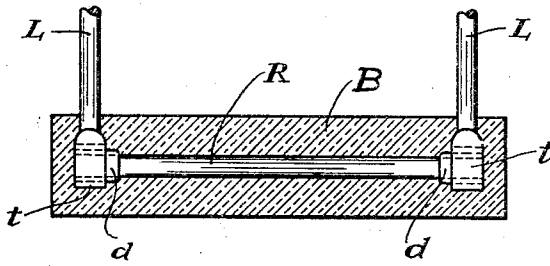


Fig. 1-C.

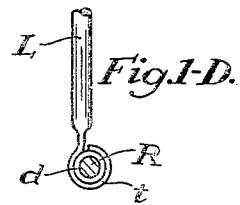
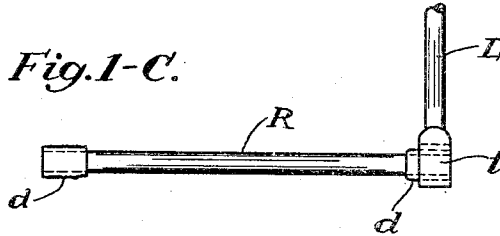


Fig. 2.

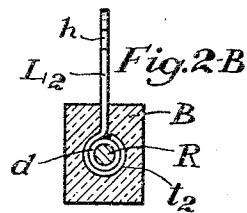
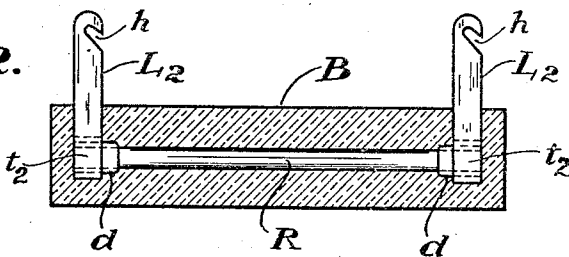


Fig. 3.

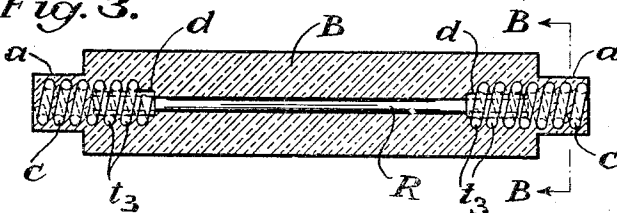


Fig. 3-B.

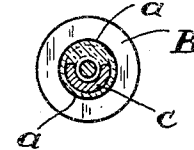
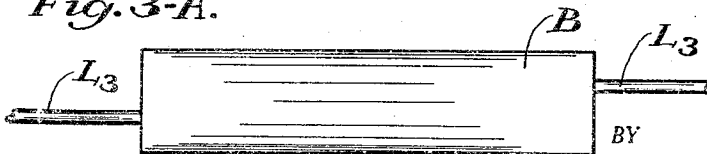


Fig. 3-A.



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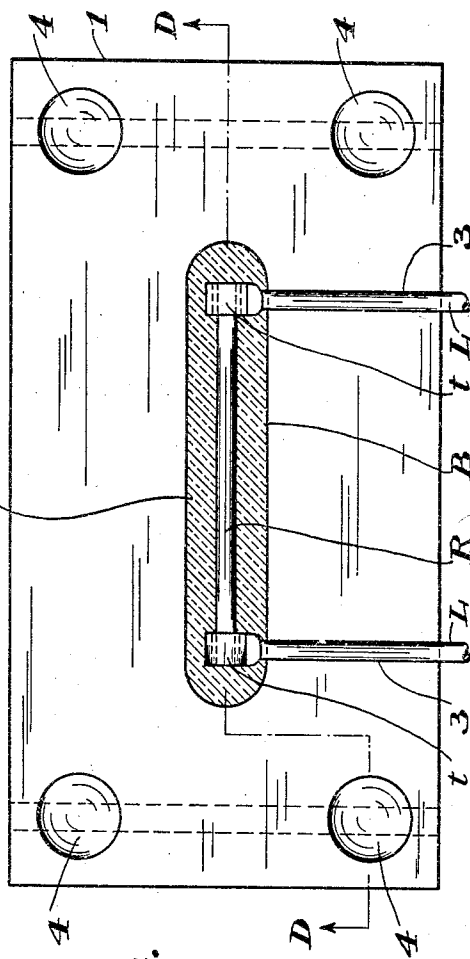
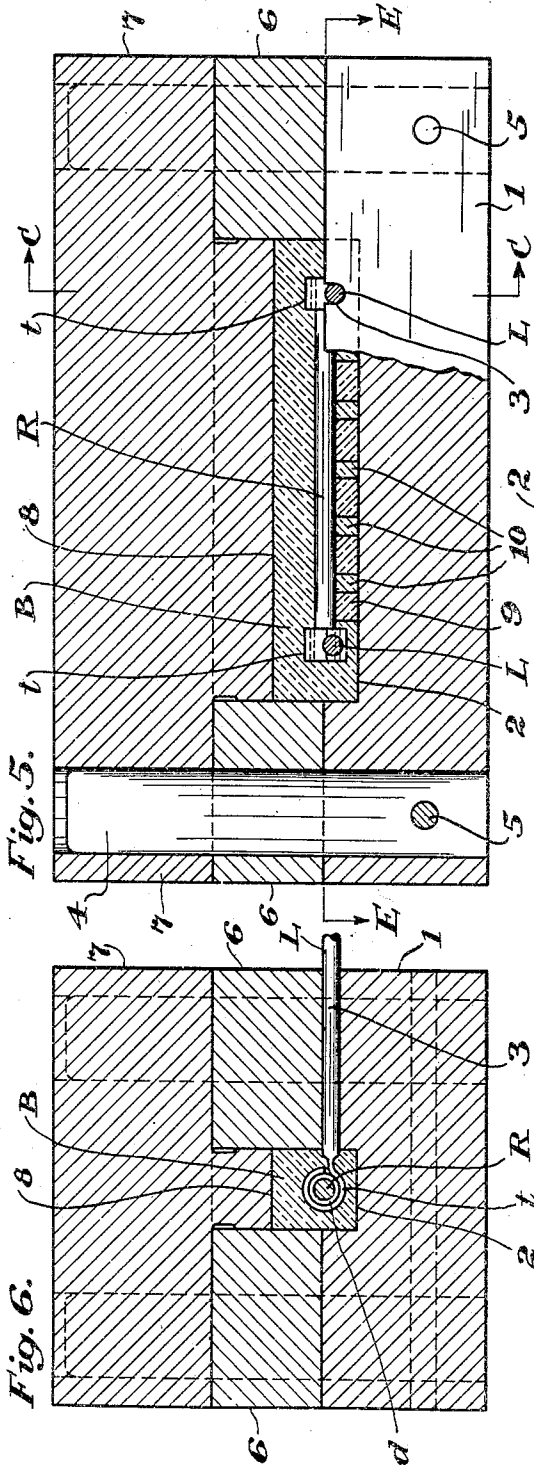
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2,052,533

RESISTANCE UNIT

Filed Dec. 8, 1933

4 Sheets-Sheet 2



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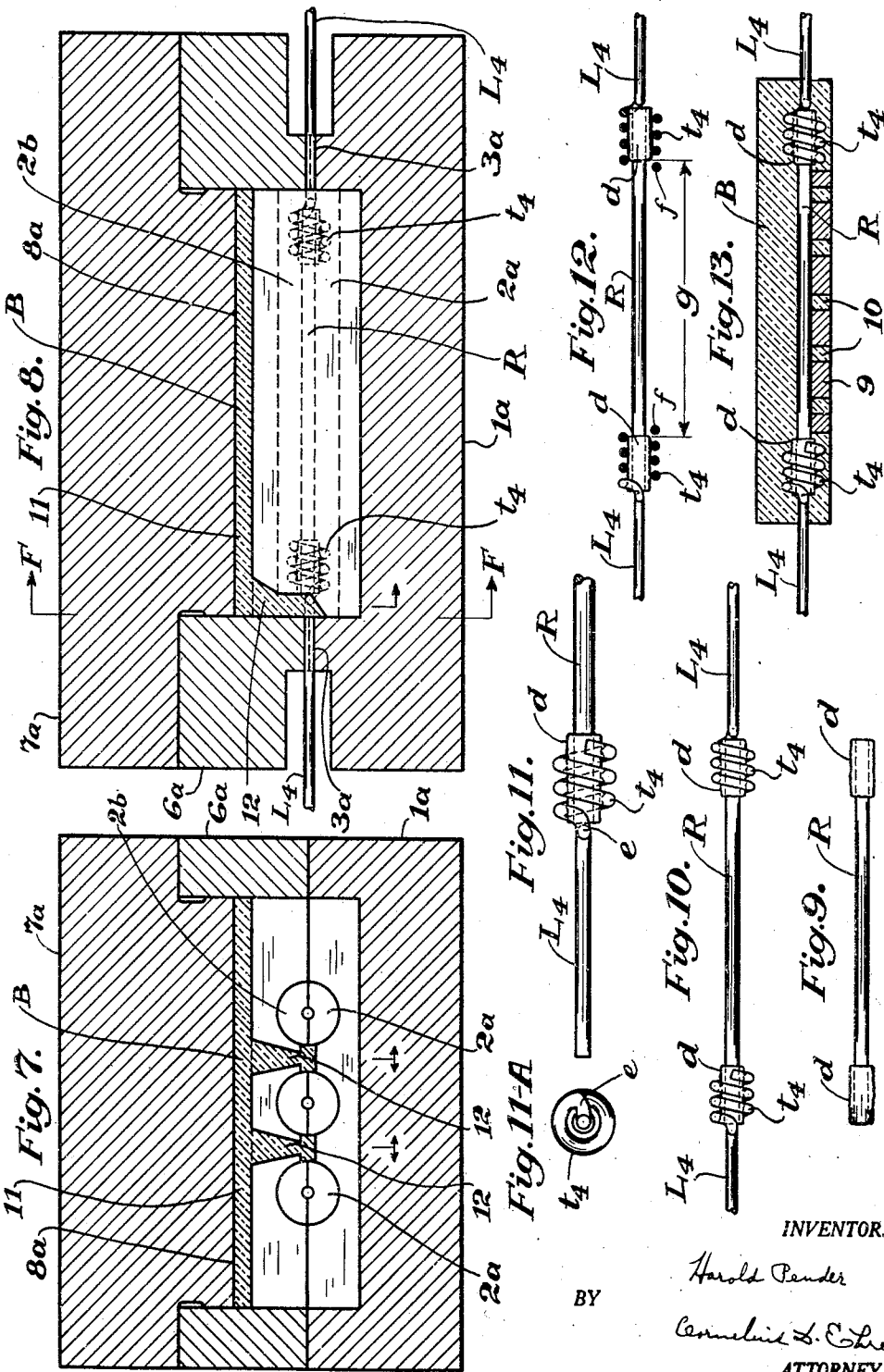
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2,052,533

RESISTANCE UNIT

Filed Dec. 8, 1933

4 Sheets-Sheet 3



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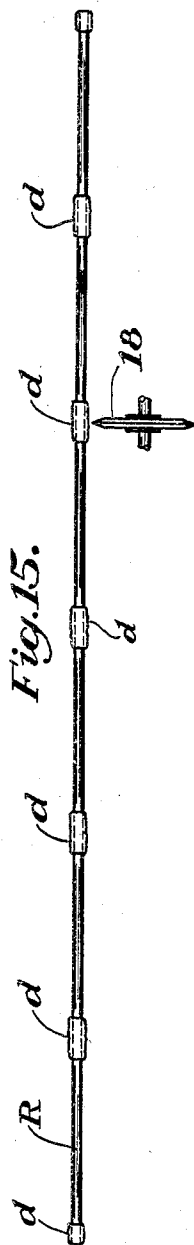
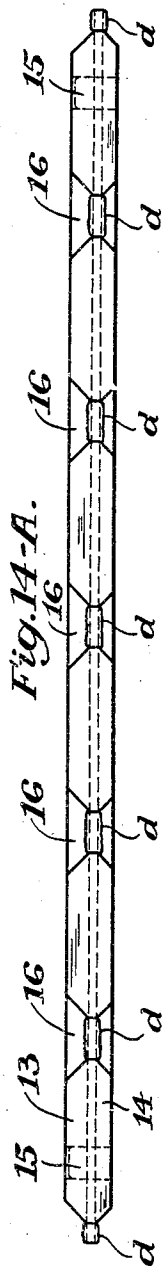
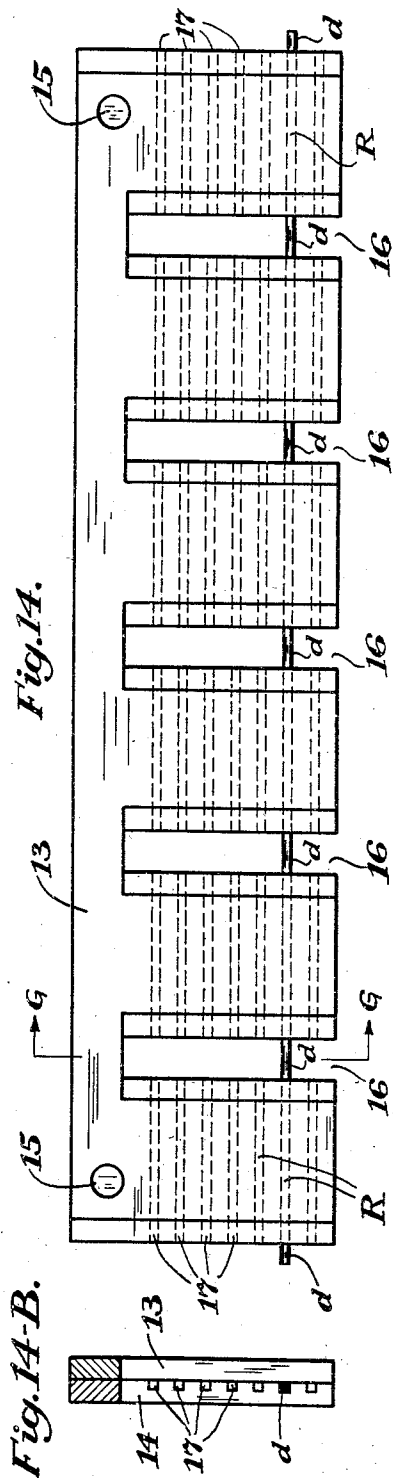
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RESISTANCE UNIT

Filed Dec. 8, 1933

4 Sheets-Sheet 4



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2,052,533

RESISTANCE UNIT

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Application December 8, 1933, Serial No. 701,471

9 Claims. (Cl. 201—76)

My invention relates to resistance units, of general application, and more particularly to those finding their application in radio receiving systems and sets, radio transmitters, telephonic, telegraphic and other communication and signalling systems, and more particularly of application in those relations in which the currents, alternating or direct, traversing the resistance elements are weak or of low orders of magnitude, as less than one ampere.

In certain of the resistance units of the above type, the resistance element may comprise a filamentary or rod-like element of insulating material such as glass, porcelain or other vitreous product coated with a resistance material, the specific resistance of which may vary within wide limits in accordance with the uses to which the unit is to be adapted, or the resistance element may comprise a molded body of any of several well-known mixtures of conductive and insulating materials. Such resistance elements in general have a relatively high specific resistance which gives rise also to a relatively high contact resistance between the element and its associated terminal structures. This contact resistance may be not only relatively high, but may tend to fluctuate substantially and rapidly, particularly when the resistance element has a hard and rough surface, giving rise to noises or disturbances in the apparatus of which the resistance unit forms a part. My invention is directed primarily to resistance units of the above type in which provision is made for reducing to a minimum and maintaining substantially constant the contact resistance between the terminal structure of the unit and the resistance element.

My invention resides also in new and improved methods of forming resistance units of the type described above and to new and improved methods for ensuring a satisfactory contact between a resistance element and its terminal structure and to new and improved methods for pressure molding an insulating compound about a frangible resistance element.

My invention resides also in new and improved methods of forming resistance units of the type described above and to new and improved methods for ensuring a satisfactory contact between a resistance element and its terminal structure and to new and improved methods for pressure molding an insulating compound about a frangible resistance element.

It is an object of my invention, therefore, to provide a new and improved resistance unit which is simple, rugged and economical to manufacture.

It is another object of my invention to provide a new and improved resistance unit in which a frangible resistance element is completely molded in and supported by a mass of insulating material.

It is another object of my invention to provide a new and improved resistance unit comprising a resistance element molded in a mass of insulating material in which the parts projecting from the molded insulation are reduced to a minimum.

It is a further object of my invention to provide a new and improved resistance unit which will maintain the value of its resistance substantially constant over a long period of use.

It is a further object of my invention to provide a new and improved resistance unit in which the contact resistance between the resistance element and its terminal structure is maintained at a constant and fixed minimum.

It is a further object of my invention to provide a new and improved resistance unit including a relatively high resistance frangible resistance element in which the contact resistance between the frangible resistance element and its terminal structure is maintained at a constant and fixed minimum.

It is a still further object of my invention to provide a new and improved resistance unit which may be applied in communication or signalling circuits without the production of noises or other electrical or audio disturbances.

It is a still further object of my invention to provide a new and improved resistance element suitable for use in my improved resistance units which may be readily manufactured in large quantities with a small and uniform tolerance as to resistance value.

It is another object of my invention to provide a new and improved method of forming a resistance unit including a frangible resistance element.

It is another object of my invention to provide a new and improved method of forming a resistance unit by means of which the contact resistance between the resistance element and its terminal structure is maintained at a constant and fixed minimum.

It is a still further object of my invention to provide a new and improved method of forming a resistance unit including a frangible resistance element which will minimize the breakage of the resistance elements during the molding operation.

It is a further object of my invention to pro-

vide a new and improved method of forming resistance elements suitable for use in my improved resistance unit.

This application is in part a continuation of my application Serial No. 655,890, filed February 9, 1933.

For a better understanding of my invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

Figs. 1, 1A and 1B are, respectively, a longitudinal section, a cross section and top plan view of a resistance unit embodying my invention;

Figs. 1C and 1D are, respectively, side and end elevational views of a resistor or resistance element with a lead applied thereto;

Figs. 2 and 2B are, respectively, a longitudinal section and a cross-section of a modification in which the conducting leads are in the form of metal lugs;

Figs. 3, 3A and 3B are, respectively, a longitudinal section of a unit of modified structure, a plan view when completed, and a cross-sectional view on the line B—B; Fig. 3, on enlarged scale, of a modification in which an external helical connecting lead is temporarily held in the molded mass and thereafter more or less completely uncoiled;

Fig. 4 is a top plan view of the lower member of a mold by means of which my improved method of forming resistance units may be practiced, while Fig. 5 is a longitudinal cross-sectional view along the lines D—D of Fig. 4. Fig. 4, on the other hand, is a view along the lines E—E of Fig. 5.

Fig. 6 is a cross-sectional view along the line C—C of Fig. 5;

Figs. 7 and 8, are, respectively, a cross-sectional view and a longitudinal sectional view of a modified form of a mold particularly suitable for forming resistance units including frangible resistance elements;

Figs. 9, 10, 11, 11a, 12 and 13 illustrate the several steps in the development of a complete resistance unit as produced in the mold of Figs. 7 and 8;

Figs. 14, 14a and 14b are, respectively, a top plan view, an elevation and a cross-sectional view along the lines G—G of Fig. 14 of a jig particularly suitable for forming resistance elements for use in my improved resistance unit, while Fig. 15 shows a detail of an assembly of my improved resistance elements.

Referring to Figs. 1, 1A and 1B, the resistor or resistance element proper, indicated at R, and its connector structure, such as the terminals *t* of its conducting leads L, are disposed within the block or relatively massive envelope B of insulating material molded around and upon the resistor and its terminals, completely enclosing them and the inner portions of the leads L adjacent the terminals *t*. With the exception of the external leads L, the entire conductive structure is completely housed in insulating material, yielding a unit which is characterized by strength and ruggedness, fully mechanically to protect the contained resistance element and associated parts.

The insulating material constituting the casing or envelope B may be anything suitable for the purposes in view. There may be employed moldable condensation products, such as phenol-formaldehyde resins, common among which is bakelite; phenol-furfural resinoids; or plastic compounds of rubber or equivalent, all moldable

under pressure at elevated temperatures. Or, for cold molding, such material as asphaltic base compounds or equivalents may be utilized.

The resistor R of the several figures of the drawings may comprise a core of insulating material of cross-section of any suitable shape, commonly circular, of any suitable diameter and material. It may be in the form of a filament, rod or tube, coated, either exteriorly or, when in the form of a tube, interiorly with any suitable conductive material, including finely divided metal, carbon and the like, to constitute conductively coated filament or core of glass, ceramic and the like. The resistance element R may, for example, be of the character described in my prior Letters Patent No. 1,832,419, dated November 17, 1931. When the element R comprises a tube interiorly conductively coated, the terminals *t* will be of a form to enter the end of the tube and contact with its interior conductive coating; or the element R may comprise a molded body of any material having suitable resistance characteristics.

The resistance elements of the types mentioned above may vary in resistance from values as low as a few ohms to as high as hundreds of megohms. As stated above, the contact resistance of such a resistance unit is affected by the specific resistance of the resistance element. Furthermore, this contact resistance is subject to substantial and troublesome variations. In accordance with my invention, this difficulty is overcome by disposing a plastic coating of conductive or relatively low resistance material upon the portions of the resistance element to which the terminal structures are attached. This coating is illustrated in detail in Figs. 1, 1A, 1C and 1D of the drawings in which the coating material is indicated by the reference *d*. The coatings *d* formed on the resistance R may be of any suitable material having a relatively low resistance such as a composition comprising a finely divided metal or other conductor and a suitable plastic binder, although I prefer to use as this coating material a composition of varnish or similar binder and graphitic or amorphous carbon. The preferred coating material has a specific resistance of the order of 0.03 ohms per centimeter cube. The coatings *d* may be applied in any suitable way, as by spraying, dipping, painting, etc., although I prefer to spray the coating on the resistance element R, as described more fully hereinafter.

The leads L are provided with a terminal portion *t* which may be, for example, of flexible or readily malleable metal wire or ribbon. For example, the terminal portion may be formed by flattening one end of the lead L and applying it under suitable pressure, by the fingers or a tool, into at least sufficiently firm engagement with the end of element R to hold it in relative position suitable for placing in a mold such as hereinafter referred to. The pressure applied in molding the insulating material upon the element R exerts, upon each terminal *t*, pressure which is effective to compress the terminal portion *t* about the coated section of the resistor R so that the coating material *d* fills the interstices of the resistance element R and the terminal portion *t*, establishing a good electrical contact between these two elements. This pressure is more or less completely maintained upon the solidification of the molding material, thereby permanently establishing an electrical contact between the resistance element and its terminal structure having a constant and fixed minimum value. The pressure of the molding operation is also effective to bring the mold-

ing material into direct and intimate contact with all portions of the resistance unit establishing a rugged, protective and supporting envelope. It is preferable that the molding insulating material B should be of such material as will "wet" during the molding operation, the leads or conductor elements L thereby effecting a close moisture-proof connection or attachment consisting of or comparable with a hermetic seal.

While the resistance element R has been described as comprising an insulating filament or rod covered with a conductive coating, this element may, if desired, be additionally coated with a suitable film-like insulating coating of any conventional type.

In Figs. 2, 2A and 2B the structure is generically the same as hereinbefore described, differing only as to the modification and the structure of the leads. In this instance the external leads L₂ of any suitable conducting material, such, for example, as the leads L of Fig. 1, have any suitable terminal structure t₂ embracing and contacting with the resistor R. The leads L₂ are in the form of lugs or more or less rigid plates projecting beyond the exterior of the envelope B, and having any suitable structure such as end hooks h, h by which they may be hooked on to or otherwise attached to other conductors in the form of posts, wires or the like.

In Figs. 3, 3A and 3B, the terminals t₃, contacting with the resistor R, are in the form of a conductor or wire wrapped around or coiled upon the ends of the element R in electrical contact therewith. The wire may extend beyond the exterior of the block B proper in the form of a straight lead. Or, as illustrated, the wire continues to the exterior of the block B proper in the form of a coil or helix c, or otherwise substantially compactly arranged, and molded in a temporary lug a integral with the envelope B proper. The material of the lug a fills the interior of the coil or compactly arranged conductor c, and preferably extends between neighboring turns or convolutions thereof, and in some instances, as indicated in Figs. 3 and 3B, may extend somewhat outwardly beyond the conductor c. After molding the structure into the form shown in Fig. 3, the material of the lug a being of relatively small dimensions and more or less readily frangible, is broken off from the conductor c and envelope B, whereupon the wire c may then be drawn out substantially axially yielding a more or less straight or undulating final lead L₃, Fig. 3A.

My invention also comprises improved methods of forming resistance units of the type described above. In the conventional methods of molding inserts, such as the resistance elements R in an insulating medium, the insert to be molded is rigidly mounted in a chamber or cavity of the mold, together with a quantity of the molding compound. These elements are then subjected to heat and pressure. In the molding process there are ordinarily developed substantial unbalanced pressures due to the fact that the change in volume of the molding material is ordinarily of the order of 3 or 4 to 1, and due to the impossibility of exactly distributing the mass of molding material uniformly with respect to the insert. Also, the heating is progressive from the parts of the molding material directly in contact with the hot mold to those portions in intimate contact with the insert, causing wide variations in the viscosity of the molding material. These unbalanced pressures tend to cause a breakage of the

inserts which may become a serious problem particularly in case the inserts are of a frangible nature, as in the preferred form of my resistance element. This tendency to breakage is further aggravated by the fact that the molding pressure is generally applied at right angles to the length of the insert. If the ratio of length to diameter of the insert is great, as is often the case, particularly with the type of resistance element described above, a relatively small unbalanced pressure is sufficient to cause a breakage of the insert. As an example, my invention has been utilized to mold a resistance element comprising a glass fibre 0.04 inches in diameter and 2 inches long.

My present invention embraces an improved method of molding resistance units which overcome the above-described difficulties and makes the molding operation of very frangible elements a simple, economical and practical procedure.

In Figs. 4, 5 and 6 is illustrated one of various mold structures by means of which my improved method of forming resistance units may be practiced. In the lower mold member 1 is formed a pocket or cavity 2 of the length and breadth of the unit to be formed, and of a depth which is a fraction, practically one-half, of the depth of the unit to be molded. Extending from one side of the cavity 2 are channels or grooves 3 to receive the terminals or leads L of the resistance element. Adjacent the corners of the member 1 are upstanding posts or pins 4, held by screws, rods or equivalent elements 5; the middle mold element 6 is provided with holes, receiving the posts 4, and whose inner wall forms part of the end and side wall structure registering with the like walls of the cavity 2. The plunger or upper mold member 7, also provided with holes to receive posts 4, has a projecting lower portion entering into the opening into the middle member 6, and whose bottom face 8 forms the top wall of the upper half of the mold cavity, forming with the cavity 2 in the member 1 a mold of the form and dimensions of the unit.

With the mold members 6 and 7 removed, a resistor R, having its leads L attached thereto by terminal elements t which engage the resistor R about the coatings d, is placed in the position indicated, with the leads L in the channels or grooves 3. Due to the thinness of the terminal portions t of the leads L, they are flexible or easily bendable, so that the resistor R is accordingly flexibly held in place, within or adjacent the top surface of the bakelite or other molding powder in the cavity 2. In certain instances, it may be desirable also to support the resistance element R upon an auxiliary strip or block 9 of molding material which has been previously molded under heat and pressure. This block 9 is preferably provided with slots or perforations 10 which are effective to key it to the main mass of molding material and also to give it a certain resiliency. This auxiliary block 9 is preferably of a material similar to that of the main mass of molding material.

In carrying out the molding process, molding powder B of a predetermined total amount by volume or weight is placed in the mold cavity, with the mold member 6 in position, the latter holding leads L in their grooves 3. Thereafter the plunger member 7 is forced downwardly, eventually coming to the position illustrated in Fig. 5, thereby forcing, under suitable conditions of pressure and temperature, the molded material to fill the mold cavity, corresponding with

the dimensions or volume of the finished casing B. The pressure developed in the molding operation causes the flexible terminals *t* of the resistor R to firmly grip or engage the resistor about the coated portions compressing the plastic coating *d* into the interstices of the resistance element and the terminals forming a good electrical contact of a substantially fixed resistance. As the molding material B sets, upon treatment with heat and pressure, this relatively low resistance contact is maintained at a substantially fixed value.

The resistance elements illustrated as subject to the molding operation of Figs. 4, 5 and 6 are similar to those illustrated in Figs. 1 and 2 of the drawings. As stated above, the thinness of the terminal portions *t* of the leads L gives the resistance element R a certain flexibility of support which permits the element a limited freedom of motion so that it may adjust its position in response to unbalanced pressures developed in the molding operation, as described above, thus reducing breakage to a negligible factor. In Fig. 3, described above, is illustrated another terminal structure for resistance elements effective to give the resistance element a similar flexible support for the molding operation.

In certain cases where the resistance element to be molded is particularly frangible or where the nature of the molding operation demands it, an auxiliary perforated block 9, as described, may be used to support the resistance element intermediate the terminal supports, as illustrated in detail in Fig. 5 of the drawings. This auxiliary supporting block is preferably of the same material as the main mass of molding material, thus forming a substantially integral envelope of molded insulated material about the resistance element R.

A modified molding apparatus by means of which my improved method of molding resistance units may be practiced is illustrated in Figs. 7 and 8 as applied to the molding of a resistance element of the type illustrated in Figs. 9 and 10 of the drawings and described more fully hereinafter. By the use of this method, the amount of breakage of the resistance units is still further reduced by forcing the molding material axially into the mold cavities containing resistance elements. The molding apparatus of Figs. 7 and 8 is somewhat similar to that of Figs. 4, 5 and 6 and comprises a lower mold member 1a having a plurality of mold cavities 2a, an intermediate mold section 3a provided with mold cavities 2b registering with and complementary to the cavities 2a. The mold is also provided with an upper mold element or plunger 7a having a pressure surface 8a for forcing the molding material B into the mold cavities. In this arrangement, however, the molding material B is not placed in the mold cavities with the resistance elements to be molded, but the intermediate mold section 3a is provided with an auxiliary chamber 11 immediately above the mold cavities and communicating therewith at one end of the mold through ports 12. In these figures there is illustrated the molding of resistance elements R provided with flexible terminal structures L4 coaxial with the resistance elements and extending through grooves 3a in the end of the mold element 1a. In the operation of this molding apparatus, when heat and pressure are applied to the upper mold element or plunger 7a, the molding compound in the auxiliary chamber 11 is reduced to a semi-fluid state and is forced in thin

streams through the ports 12 into the mold cavities 2a—2b in a direction parallel to the length of the frangible resistance element R. The direction of the flow of the molding material is as indicated in the small arrows in Figs. 7 and 8. The molding material may be introduced into each of the mold cavities through a separate port, or two or more ports may supply the molding compound in parallel, as shown in Fig. 7 of the drawings. In this method of molding, the unbalanced pressures transverse to the length of the frangible resistance elements are substantially eliminated.

In Figs. 9 and 10 are illustrated the development of the preferred form of the resistance element for embodiment in my improved resistance unit. In Fig. 9 is shown the resistance element R with the coatings *d* disposed upon its end portion. As stated above, these coatings are preferably of a mixture of varnish or other plastic binder and finely divided carbon. After the coating, the elements are preferably treated at elevated temperatures for a period to partially harden the coating material. However, this heat treatment is stopped at such a point that it is still quite soft compared to ordinary metallic conductors. The leads L4 are then formed with terminal portions *t4* comprising substantially helical coils, and these coils are threaded on the relatively soft coatings of the element R. The helical coil cuts its own thread on the coated end of the resistor and embeds itself in this cutting, making an intimate contact of very low resistance, irrespective of the resistance of the element itself. This contact resistance is still further reduced in the molding operation which is effective to still further embed the turns of the helical coil into the coating material, and this low resistance contact is permanently maintained by the setting of the molding insulating material.

In the preferred form of the terminals *t4*, the turns immediately adjacent the leads L4 are deformed so that the helical coils begin at approximately the axis of the resistor element and the leads L4 are coaxial with the resistor element. These deformed turns act as automatic stops to limit the travel of the terminals *t4* as they are threaded on the resistor element R. This is illustrated more clearly in Figs. 11 and 11a in which the portion *e* of the terminal structure *t4* represents the deformed turn which acts as a stop against the end of the resistor R.

In the forming of resistance units of the type covered by my invention, the value of the resistance of the unit is dependent upon the distance between the terminal structures, and it is important that this distance should not be varied by variations encountered in the assembly procedure. This problem is also solved by the improved resistor element of Figs. 9 and 10, provided only that the terminal coatings are accurately spaced on the resistor element. As shown in more detail in Fig. 12, if the terminals *t4*, due to inaccuracies of manufacture or assembly, extend beyond the coated portions of the resistor element, the projecting portions *f* of these terminals are separated from the element R by the thickness of the terminal coatings *d* so that the effective length of the resistor element is maintained at the value *g*, as indicated in Fig. 12. In Fig. 13 is shown, in longitudinal section, the completed resistance unit embodying the preferred form of my invention. It will be noted that this unit embodies the auxiliary perforated supporting block 9 described above.

While the coatings *d* may be applied to my improved resistor elements in any desired manner, there is shown in Figs. 14, 14a and 14b a simple apparatus by means of which this coating may be applied with great accuracy and facility. This apparatus or jig comprises the complementary supporting members or racks 13 and 14 maintained in alignment by means of pins or bolts 15. The supporting members 13 and 14 are formed regularly and accurately spaced openings 16, the distance between the openings corresponding to the desired length of the resistor elements and the width of the openings being approximately twice the width of a terminal. One of the supporting elements, for example, the member 14, is provided with a plurality of longitudinal slots 17 of the proper dimensions to snugly hold a length of resistance element. One such element R is shown as placed in one of the slots of the apparatus. By filling the several slots 17 of this apparatus with resistance elements, the coatings *d* may be applied by means of a spray gun with great rapidity and ease. If desired, there may be provided severing apparatus comprising a plurality of cutters, one of which is designated by the reference numeral 18 of Fig. 15. Such an apparatus is effective to accurately sever the several resistance elements at a single operation either by cutting, nicking or chipping, according to the physical properties of the particular resistance element which is being utilized.

What I claim is:

1. In a resistor construction, in combination, an elongated resistance element, electrical conductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being concentric with said element and in intimate contact with said element, thereby providing an excellent electrical connection between said element and said coatings, said coatings being of much greater electrical conductivity than said element, wire terminals having portions encircling said coatings and proportioned to fit firmly against said coatings when pressure is exerted thereagainst, and a mass of solid electrical insulating material completely encasing said element and the encircling portions of said terminals and exerting pressure thereagainst so that said terminals are held firmly against said coatings to provide an excellent electrical connection between said terminals and said coatings.

2. In a resistor construction, in combination, an elongated resistance element, electrical conductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being concentric with said element and in intimate contact with said element, thereby to provide an excellent electrical connection between said element and said coatings, said coatings having much greater electrical conductivity than said element, wire terminals having helical shaped portions encircling said coatings and proportioned to fit firmly thereagainst when pressure is exerted thereon, said terminals having substantially straight portions extending away from said encircling portions, and a solid mass of electrical insulating material completely encasing said element and the helical portions of said terminals to exert pressure against said encircling portions thereby causing said terminals to fit firmly against said coatings thereby providing an excellent electrical connection between said terminals and said coatings.

3. In a resistor construction, in combination, an elongated resistance element electrical con-

ductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being concentric with said element and in intimate contact with said element, thereby to provide an excellent electrical connection between said element and said coatings, wire terminals including portions encircling said coatings and proportioned to fit firmly thereagainst, portions of each of said terminals extending inwardly to engage the ends of said element to act as stops, and a solid mass of electrical insulating material completely encasing said element and the encircling portions of said terminals to exert a pressure on said terminals and hold them in firm engagement with said coatings.

4. In a resistor construction, in combination, an elongated resistance element, electrical conductive coatings superimposed on the end portions of said element immediately adjacent the ends thereof, said coatings being concentric with said element and in intimate contact with said element, thereby to provide an excellent electrical connection between said element and said coatings, said coatings having much greater conductivity than said element, wire terminals comprising helical shaped portions and substantially straight portions, the helical shaped portions encircling said coatings, said terminals being deformed at the junctions of said straight portions and said helical portions to form stops in engagement with the ends of said element, and a mass of electrical insulating material completely encasing said element and the helical portions of said terminals to maintain said terminals in firm engagement with said coatings thereby providing an excellent electrical connection between said terminals and said coatings.

5. In a resistor construction, in combination, an elongated resistance element having an irregular surface electrical conductive coatings concentrically superimposed on the end portions of said element and immediately adjacent the ends thereof, said coatings comprising a binder filling the irregularities in the surface of said element and having particles of conducting material suspended therein thereby to provide a connection between said coatings and said element having a constant resistance value, wire terminals encircling said coatings and proportioned to fit firmly against said coatings, and a solid mass of electrical insulating material completely encasing said element and the encircling portions of said terminals to hold said terminals permanently and fixedly against said coatings whereby a connection having a constant resistance value is provided between said terminals and said coatings.

6. In a resistor construction, in combination, an elongated element formed from electrical insulating material, an electrical resistance coating on said element comprising a binder having particles of conducting material suspended therein, the surface of said coating being irregular, electrical conductive layers on the end portions of said element immediately adjacent the ends thereof and concentric with said element and superimposed on said coating, said layers comprising a binder filling the irregularities in the surface of said element and having conducting particles suspended therein, thereby forming an excellent electrical connection between said coating and said layers, said layers having much greater conductivity than said coating, wire terminals having portions encircling said layers and proportioned to rest firmly thereagainst, and a solid mass of

electrical insulating material encasing said element and the encircling portions of said terminals to hold said terminals firmly and immovably against said layers thereby providing an excellent electrical connection between said terminals and said layers.

7. In a resistor construction, in combination, an elongated resistance element having irregularities in the surface thereof, electrical conductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being concentric with said element and filling said irregularities in said element, thereby providing an electrical connection between said element and said coatings having a stable resistance value, terminals having portions encircling said coatings and proportioned to fit firmly against said coatings, and a mass of solid electrical insulating material completely encasing said element and the encircling portions of said terminals to hold said terminals permanently and fixedly against said coatings whereby a stable electrical connection is provided between said terminals and said coatings.

8. In a resistor construction, in combination, an elongated resistance element, electrical conductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being in intimate contact with said element thereby providing excellent electrical connections between said element and said coatings, said

coatings being of much greater electrical conductivity than said element, wire terminals having portions in interfitting and engaging relation to said coatings to form connections with said element and proportioned to fit firmly against said coatings when pressure is exerted against said connections, and a mass of solid electrical insulating material completely enclosing said element and the relatively interfitting portions of said terminals and said element.

9. In a resistor construction, in combination, an elongated resistance element, electrical conductive coatings on the end portions of said element immediately adjacent the ends thereof, said coatings being in intimate contact with said element thereby providing excellent electrical connections between said element and said coatings, said coatings being of much greater electrical conductivity than said element, wire terminals having portions in interfitting and engaging relation to said coatings to form connections with said element and proportioned to fit firmly against said coatings when pressure is exerted against said connections, and a mass of solid electrical insulating material completely enclosing said element and the relatively interfitting portions of said terminals and said element, said terminals having bendable portions extending endwise from the opposite ends of the unit for attachment purposes.

HAROLD PENDER.