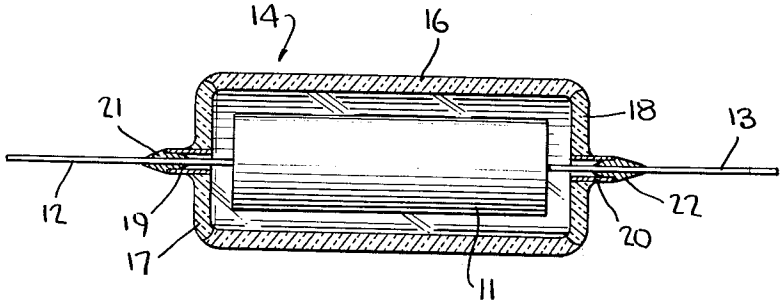
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ELECTRICAL RESISTOR UNIT

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ELECTRICAL RESISTOR UNIT

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This invention relates to the encapsulation of electrical devices and to an improved capsule.

The device to be encapsulated is of the type having one or more terminals, or leads, which must extend through the wall of the enclosure to make connection with other devices on the outside. A typical example of such a device is a resistor having a cylindrical body and a pair of wire leads extending axially outward from opposite ends of the body. Only the resistor body must be enclosed so as to be protected for operation under certain conditions, but in order to enclose the body hermetically, the wire leads must be hermetically sealed to the capsule. While these leads could be made of metal suitable for sealing directly to glass, such metals are not normally used as resistor leads and would require resistors for encapsulation to be made up specially. This would increase the cost of encapsulated resistors, both because of the extra cost of special materials and because of the fact that standard resistors could not be used.

According to the invention a glass capsule is formed having a separate hollow metal tube inserted through and fused to the glass for each terminal, or lead, of the encapsulated device. The metal tube has a co-efficient of expansion suitable for hermetically sealing to the glass without separating therefrom when the capsule or the metal tube is later heated in the process of encapsulation. The cross-section of the passageway through the metal tube is sufficiently large to permit the terminal of the encapsulated device to pass through it. Thereafter the terminal is hermetically sealed to the tube by solder or low vapor pressure cement. Silver solder has proved to be very satisfactory for hermetically sealing resistor leads to Kovar tubes in capsules made of 7052 glass.

In the process of making the capsule and enclosing the device within it, according to the invention, the capsule is formed with an opening large enough to insert the device. A glass cap having the metal tube sealed into it is then threaded over the terminal so that the latter extends through the metal tube and the periphery of the cap is thereafter sealed to the remainder of the capsule to enclose the device. As a final step the terminal is soldered or otherwise hermetically sealed to the metal tube.

The invention will be described in greater detail in connection with the drawing in which the only figure is a partial cross-sectional view of a hermetically sealed electrical device.

In the drawing an electrical device **11**, such as a resistor, having wire leads **12** and **13** of tinned copper extending axially from the ends thereof is enclosed within a glass capsule **14**. The capsule comprises a tubular glass section **16** surrounding the body of the resistor **11** and extending slightly beyond each end of the resistor. The ends of the tubular section **16** are closed by relatively flat, glass end caps **17** and **18** hermetically fused thereto.

Each of the end caps has a hollow metal tube **19** and **20**, respectively, hermetically sealed therein and extending a short distance outward from the capsule. The leads **12** and **13** extend through the tubes **19** and **20**, respectively. It will be noticed that the cylindrical leads fit loosely in the cylindrical tubes. This permits the interior of the capsule **14** to be evacuated easily, or as easily to be filled with inert gas, such as helium. While an evacuated structure has an advantage in withstanding

high voltage, a filling of inert gas is advantageous in transferring heat from the device **11** to the wall of the capsule **14**. The tubes **19** and **20** are hermetically sealed by plugs **21** and **22** of solder or a suitable, low vapor pressure cement.

In forming the capsule **14** the end caps **17** and **18** are formed separately of glass discs, or buttons, having central apertures into which the short metal tubes **19** and **20** are inserted. The metal tubes and glass discs are then heated to fuse them into unified end caps. The glass of the discs and the metal of the tubes are selected to have relatively closely similar coefficients of thermal expansion so as to be suitable for hermetically sealing to each other. Furthermore, the seal between the metal and glass must be strong enough to withstand later heating when the discs are sealed to the tubular portion of the capsule and when the leads are soldered to the tubes. A very suitable combination is Kovar metal for the tubes **19** and **20** and 7052 glass for the discs.

The order in which the end caps **17** and **18** are assembled with the tubular section **16** of the capsule and the device **11** may vary. The end caps **17** and **18** may be placed on the leads **12** and **13** and a length of glass tubing **16** slid over them and sealed to them, or one of the end caps **17** may be separately sealed to the glass tubular section **16** and then the lead **12** slipped into place in the metal tube **19**, after which the other end cap is threaded onto the other lead **13** and sealed to the glass section **16**.

Furthermore, one of the leads, for example lead **12**, may be soldered to its metal tubing after the associated glass disc of the end cap had been fused to one end of the glass section **16** but before the other end cap has been slipped onto the lead **13**. Of course, at least one of the leads **12** or **13** must be left unsoldered to its respective tube **19** or **20** until the capsule **14** has been properly evacuated or gas-filled, or even liquid-filled.

The glass section **16** must be of a proper type to seal to the end caps **17** and **18** without breaking. The simplest solution is to use the same type of glass for all of the glass members. In addition it is desirable that the total thermal expansion (not the coefficient of thermal expansion) of the glass section **16** be approximately equal to the total expansion of the device **11** plus the short sections of the leads **12** and **13** within the capsule **14**. The reason for this is that it will reduce strain on the end caps **17** and **18** and on the solder seals **21** and **22** if these expansions are about equal. Since the device **11** will, if it is a resistor, usually consist of a low-expansion ceramic member with resistive material formed or wound thereon, the low-expansion, borosilicate, 7052 glass provides a good match. This glass does not melt until heated to quite a high temperature, so that the capsule **14** can be used at an ambient temperature of 300° C. or more, and if the device **11** is a carbon film resistor, the completed unit may be operated at temperatures of 200° C. or higher. Of course, other types of glass may be used instead.

After the capsule **14** has been completed but before the solder seals **21** and **22** are applied, the unit may be baked out for a suitable period of time to drive out occluded gas and may be evacuated and the solder seals applied while the unit is in a vacuum chamber. A bake-out temperature of about 400° C. applied for one hour has been found to be sufficient, and the unit can be evacuated to a pressure of 10^{-6} mm. of mercury.

As an alternative or as a supplemental procedure, the capsule may be baked out in flowing inert gas, such as helium, and then sealed off by the solder seals **21** and **22** while still in the inert gas atmosphere. This has the advantage of providing an easy means of detecting imperfect hermetic seals at any of the joints by placing the completed unit in a mass spectrometer leak detector and

noting whether any helium is present outside of the capsule 14.

While the invention has been described in terms of a specific embodiment, modifications may be made therein without departing from the true scope as defined by the following claims.

What is claimed is:

1. In combination, an electrical device having a pair of terminals extending from opposite ends thereof; and a hermetic enclosure surrounding said device and comprising a tubular glass member with integral glass end portions and a pair of hollow metal tubes hermetically fused into said end portions to provide passageways therethrough, one of said tubes being fused into each of said end portions, respectively, with the glass of said end portions hermetically sealed to and encircling the outer surface of said tubes, one of said terminals extending through each of said tubes, respectively, and hermetically sealed outside of said hermetic enclosure.

2. The combination comprising: a cylindrical resistor having a pair of wire terminals extending generally parallel to the axis of said resistor from opposite ends thereof; a tubular glass member surrounding said resistor; a pair of glass end caps having their outer peripheries directly fused to the ends of said tubular member to form a hermetic enclosure for said resistor; a pair of metal tubes, the outer surface of each of said metal tubes being directly fused to one of said end caps, respectively, the internal diameters of said tubes being slightly larger than said wire terminals, said wire terminals extending through said metal tubes and being sealed thereto; and an inert gas atmosphere within said enclosure.

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