Oct. 15, 1963 W. M. KOHRING 3,107,179

PROCESS FOR MAKING CARBON-METAL RESISTORS

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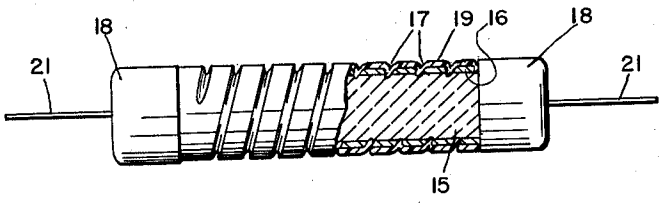


Fig. 1

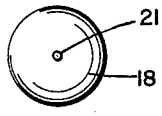


Fig. 2

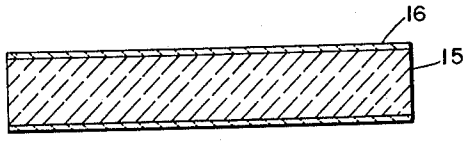


Fig. 3

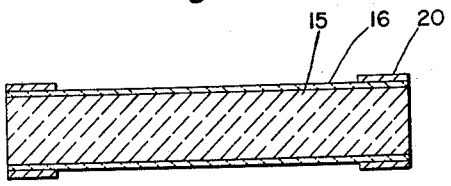


Fig. 4

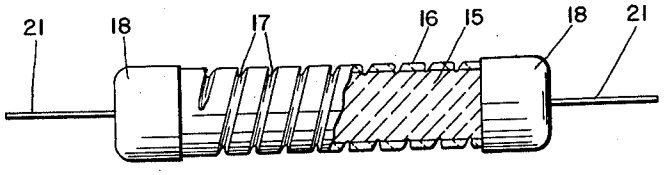


Fig. 5

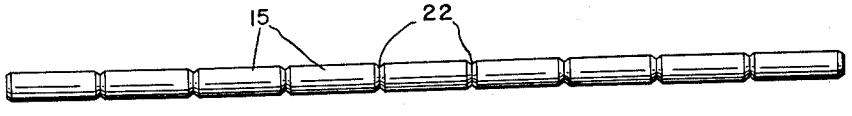


Fig. 6

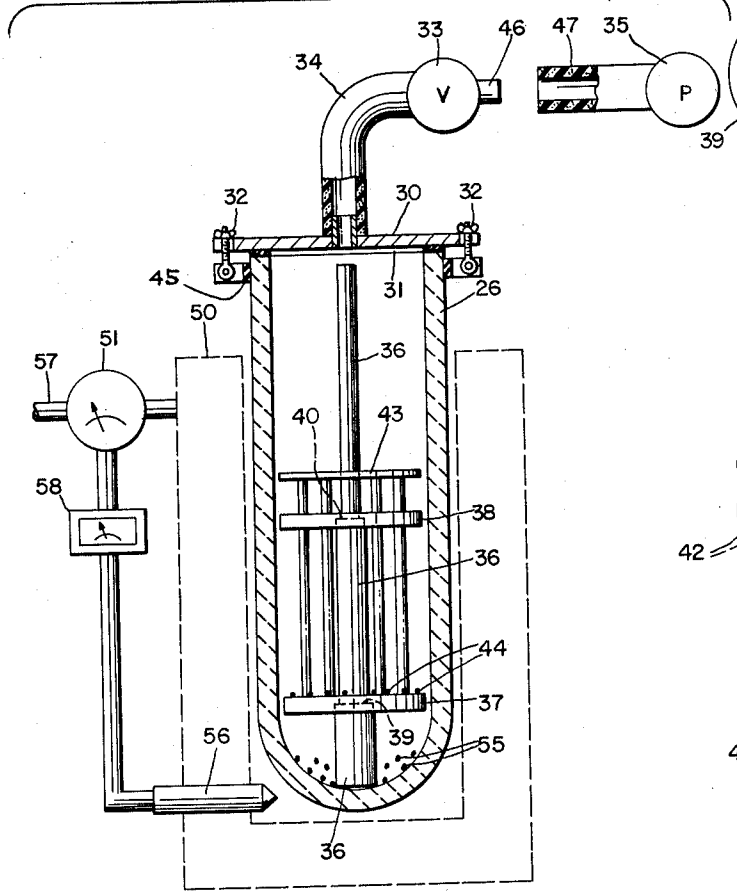
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Fig. 7



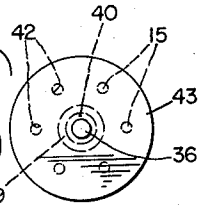


Fig. 9

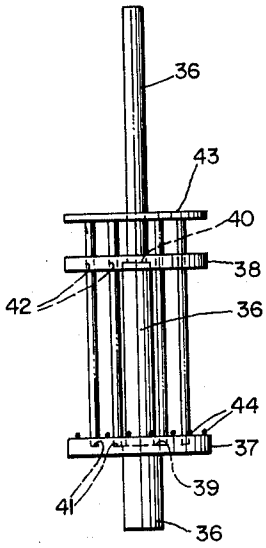


Fig. 8

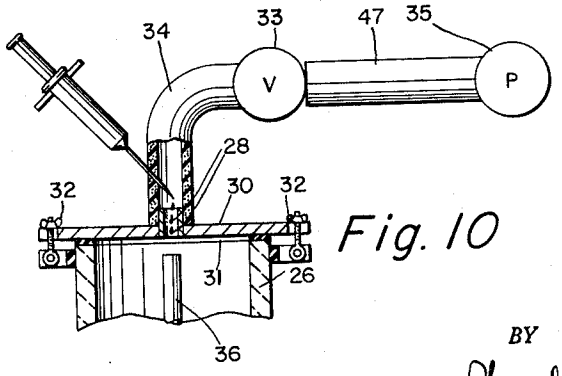


Fig. 10

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PROCESS FOR MAKING CARBON-METAL RESISTORS

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3 Claims. (Cl. 117—226)

The invention relates in general to resistors and more particularly to film resistors and to the process for making same.

An object of my invention is a process of coating a surface of a non-conducting rod with a carbon film.

Another object of my invention is a process of coating a surface of a non-conducting rod with a carbon and sulphur film formed by disassociating the carbon and sulphur from straight mineral oil (no additives) having a natural sulphur content ranging from substantially one to three percent.

Another object of my invention is a process of coating a surface of a non-conducting rod with a carbon film by using a liquid hydrocarbon as a source for the carbon film.

Another object of my invention is to disassociate the carbon from the hydrogen in a liquid hydrocarbon and depositing the disassociated carbon as a film on a non-conducting rod.

Another object of my invention is a process of coating a surface of a non-conducting rod with a carbon-metallic film.

Another object of my invention is a process of coating a surface of a non-conducting rod with a carbon-metallic film by using a liquid hydrocarbon and an organo-metallic substance as a source for the carbon-metallic film.

Another object of my invention is to disassociate the carbon from the liquid hydrocarbon and disassociate the metal from the organo-metallic substance to deposit the disassociated carbon and metal as a carbon-metallic film on the non-conducting rod.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings in which:

FIGURE 1 shows a longitudinal view of a resistance unit embodying the features of my invention, partly in section;

FIGURE 2 is an end view of the resistor shown in FIGURE 1;

FIGURES 3 to 5, inclusive, show the steps by which my invention is constructed, the FIGURE 5 being partly shown in sections;

FIGURE 6 shows a longitudinal view of an elongated non-conducting rod having spaced grooves whereby it may be broken up into a plurality of short resistor component rods;

FIGURE 7 illustrates a bottle shown in section whereby a plurality of non-conducting rods may each be coated with a thin resistance film, under a vacuum by means of an electric furnace;

FIGURE 8 illustrates a carrier upon which the elongated rods may be mounted in the bottle of FIGURE 7;

FIGURE 9 shows the top view of the carrier in FIGURE 8; and

FIGURE 10 shows a modified way of introducing the source material from which the films are made into the bottle.

With reference to FIGURE 1, my invention comprises a non-conducting rod 15, preferably porcelain or steatite, a thin current conducting film 16, and end-caps 18 having terminal wires 21 electrically connected to the thin current conducting film 16. The rod 15 is preferably provided with an unglazed surface and may be made of any

suitable material of a ceramic nature upon which the thin film 16 may adhere. The porcelain rod 15 with a film 16 thereon is shown in FIGURE 3. The film 16 is very thin and is exaggerated in thickness in the figures. The thin current conducting film 16 is preferably carbon, and may be a mixture of carbon and metal. The film may also include sulphur and is applied to the elongated porcelain rod as shown in FIGURE 6, before it is broken into individual resistor components.

The next general series of steps in my process is to connect the end-caps 18 to the end portions of the thin film 16. To do this, I first deposit a band of a solution of colloidal silver as indicated by the reference character 20, see FIGURE 3. The silver band is preferably applied to the elongated non-conducting rod and heated to disassociate the silver from the colloidal solution, and thereby leaving the silver on the surface. The end-caps 18 which comprise cup-members are pressed over the silver bands 20 to make an electrical connection between the terminals 21 and the thin film 16.

To complete the resistance unit, it may or may not be spiralled at 17 depending upon the resistance value desired. The resistor may then be provided with a protective coating 19 which may comprise any suitable material.

The process for applying the thin current conducting film 16 to the porcelain rod 15 may be as follows: With reference to FIGURE 6, a long porcelain rod 15 is employed for making a plurality of resistor components. The long rod 15 has a plurality of longitudinally spaced circumferential grooves 22 to facilitate the easy breaking of the porcelain rod 15 into individual resistor components. A plurality of the long rods 15 are each coated with the thin current conducting film 16 in a vacuum heat chamber 26, see FGURE 7. The vacuum heat chamber 26 is preferably an elongated cast-quartz bottle having a closure plate 30 fastened down by wing nuts 32 which are anchored to a band 45 surrounding the bottle, or by an other suitable means. The closure plate 30 is made vacuum tight by means of a gasket 31. The bottle 26 may be evacuated by means of a vacuum pump 35 which may be located at any suitable place with reference to the electric furnace 50 in which the bottle is heated. A valve 33 is connected to the closure plate 30 by means of a conduit 34. The vacuum pump 35 is connected to the valve 33, by means of a conduit 47 which may be removably inserted over a valve nozzle 46. When a high vacuum is obtained the valve 33 is closed and the conduit 47 is removed from the valve nozzle 46 so that the evacuated bottle 26 may be carried to the furnace for the heating process without the vacuum pump attached.

A supply of the long rods 15 of FIGURE 6 are placed in the bottle 26 by means of a suitable carrier shown in FIGURE 8. The carrier in FIGURE 8 may comprise a center post 36, a bottom carrier plate 37, and a top carrier plate 38. The center post 36 has a shoulder 39 upon which the bottom plate rests. The center post 36 also has a shoulder 40 upon which the top plate 38 rests. The bottom plate 37 is provided with a plurality of depressed portions 41 and the top plate 38 is provided with plurality of openings 42. The elongated porcelain rods 15 extend through the openings 42 with their lower ends resting in the depressed portions 41. The upper end portion of the porcelain rods project above the top plate 42 upon which is mounted a cover plate 43. In actual practice, the carrier may hold a large number of porcelain rods 15 depending upon the size of the porcelain rods and the carrier. Any suitable material may be used in making the carrier but I preferably use a ceramic type material which will withstand high temperatures.

The steps for depositing a thin carbon film on the

porcelain rods 15 may be as follows: After the rods 15 are placed in the carrier as shown in FIGURE 8, I preferably use a hypodermic needle for depositing a few drops of liquid hydrocarbon on the bottom plate 37 or on any other suitable place. The drops in FIGURE 8 are indicated by the reference character 44. The carrier with the drops thereon is now placed in the bottle 26 through the top opening thereof. The bottom of the center post 36 rests on the bottom of the inside of the bottle 26. The closure plate 30 is now secured to the top of the bottle 26 by means of the wing nuts 32. The valve 33 is opened and the vacuum pump 35 is started and continues to run until a high vacuum is obtained preferably in the range of about 30 inches of mercury. The valve 33 is now closed and the pump 35 is stopped. The conduit 47 which is preferably rubber is pulled off of the nozzle 46. The bottle 26 is now placed in the electric furnace 50 where it is heated to disassociate the carbon from the hydrogen in the hydrocarbon. A pyrometer 56 located in the bottom of the furnace is employed to measure the temperature of the furnace 50. A meter 58 connected to the pyrometer 56 shows the temperature of the furnace 50. The power supply for the furnace is indicated by the cable 57.

The temperature in the furnace is constantly maintained about 1900 degrees F. and when the bottle 26 is placed therein the temperature drops because the bottle 26 and its contents take heat away from the furnace and as a result the bottle 26 and its contents take about 20 minutes to heat up to a temperature of approximately 1900 degrees F. At this point the timer 51 is set into operation and holds the temperature in the furnace at approximately 1900 degrees F. for about five minutes, after which the bottle 26 is removed from the furnace and allowed to air cool to room temperature. It takes approximately 30 minutes for the bottle to cool to room temperature. During the cooling period the vacuum is still maintained in the bottle 26. The heating temperature may range from 1200 degrees F. to 2400 degrees F. by varying the heating duration. A longer time is required to deposit a film at lower temperatures than at higher temperatures.

After the bottle 26 is cooled to room temperature the porcelain rods 15 are removed from the bottle 26 and the plurality of resistor components are each made into the final resistor as shown by the FIGURES 1 to 5. After the bottle 26 has been used several times, the carbon that was not deposited on the porcelain rods 15 tends to form on the bottom of the bottle 26 as free carbon particles. These free carbon particles are indicated by the reference character 55. I find from practice that these free carbon particles enables the process to deposit a thicker film on the porcelain rods 15 than is possible when the bottle 26 is first put in operation when the free particles have not as yet had time to collect. In practice I preferably used a liquid hydrocarbon comprising a lubricating oil produced by the MacMillan Petroleum Company of Long Beach, California. The oil has an S.A.E. designation of 10W–10 and is characterized as a ring free oil for service "ML."

The oil is straight mineral (no additives) and has a natural sulphur content of one to three percent. The base crude comes from the Smackover fields in southern Arkansas and is refined at Norphlet, Arkansas. The sulphur contained in this crude is a fixed, non-corrosive type and will vary in amount very slightly, based on viscosity. A typical test for this oil is as follows.

	10W–10
Gravity, API @ 60° F.	21.5
Gravity, specific	.9208
Pounds/U.S. gallon	7.701
Flash, C.O.C. ° F.	365
Fire, C.O.C. ° F.	405
Color, U.C.	—2
Pour point ° F.	—60
Neutralization number	0.02
Carbon residue, percent	0.033

Corrosion:	Neg.
Vis. @ 100° F., S.U.	121.8
Vis. @ 130° F., S.U.	70
Vis. @ 210° F., S.U.	39.5
Vis. @ 0° F., S.U. extrap.	8,200
K/viscosity @ 100° F. cs.	25.55
K/viscosity @ 210° F. cs.	4.03
Viscosity index	26
Sulphur, percent	1.913

It appears that the sulphur in the oil aids in making a carbon film resistor which will withstand high operating temperatures without damage to the film. The carbon film produced by my process adheres with great affinity to the porcelain rod which preferably has no glazed surface. The adherence of the carbon film to the substantially unglazed porcelain rod is better obtained by the natural sulphur in the oil. It appears that the sulphur acts as a bonding agent to aid in holding the carbon film on the unglazed porcelain rods.

The same procedure is followed in making carbon-metallic film, except that I use an organo-metallic substance which is added to the hydrocarbon. The organo-metallic substance may preferably comprise a mixture or solutions of noble metals as disclosed in Patent Numbers 2,689,294;2,440,691;1,954,353; and 2,281,843. The combination of the organo-metallic substance and the hydrocarbon may be applied as previously explained. The rest of the procedure for making the carbon-metallic film is the same as that described for making the carbon film. The metallic-carbon film has great affinity to the substantially unglazed porcelain rods and will withstand exceedingly high operating temperatures without damage to the film. The carbon-metallic film has good power dissipation and provides a stable resistance over a long period of time.

Instead of applying the drops from the hypodermic needle directly on the carrier, the drops may be introduced as shown in FIGURE 10, by piercing the rubber conduit 34 by the needle and allowing the drops to be sucked down into the bottle by the vacuum. The vacuum reduces the oxygen content in the bottle 26 with the result that there is no oxidation of the hydrocarbon. An inert gas may be introduced to aid in the process.

The ratio between the amount of carbon to metal in the film may vary according to the low and high resistance values required in the finished resistor. For a low resistance unit, the metal is large in ratio to carbon and for high resistance unit the metal is low in ratio to the carbon. For a low resistance unit the metal may be as high as 90 percent and the carbon 10 percent. For a high resistance unit, the carbon may be as high as 90 percent and the metal 10 percent. The amount of sulphur in the film may range from .10 percent to 5 percent.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. Method of coating at least a portion of a non-conductive element with a carbon and metal film comprising the steps of supplying a hydrocarbon and an organo-metallic substance in a non-gaseous state at a position spaced from said portion of said non-conductive element, heating said hydrocarbon and said organo-metallic substance at an elevated temperature under vacuum to change said hydrocarbon and said organo-metallic substance from a non-gaseous state to a gaseous state, contacting said portion of said non-conductive element with said hydrocarbon and said organo-metallic substance in said gaseous state while at said elevated temperature and under said vacuum to deposit carbon and metal as a film

upon said portion of said non-conductive element, cooling said portion of said coated non-conductive element under vacuum, and removing said portion of said coated non-conductive element from said vacuum.

2. Method of coating at least a portion of a non-conductive element in an enclosure with a carbon and metal film comprising the steps of supplying a hydrocarbon and an organo-metallic substance in a non-gaseous state in said enclosure at a position spaced from said portion of said non-conductive element, heating said hydrocarbon and said organo-metallic substance in said enclosure at an elevated temperature under vacuum to change said hydrocarbon and said organo-metallic substance from a non-gaseous state to a gaseous state, contacting said portion of said non-conductive element with said hydrocarbon and said organo-metallic substance in said gaseous state in said enclosure while at said elevated temperature and under said vacuum to deposit carbon and metal as a film upon said portion of said non-conductive element, cooling said portion of said coated non-conductive element in said enclosure while under vacuum and removing said portion of said coated non-conductive element from said enclosure.

3. Method of coating at least a portion of a non-conductive element in an enclosure with a carbon and sulfur film comprising the steps of supplying a hydrocarbon and sulfur substance with said substance being in an amount in the range of .01 to 5.0% in a non-gaseous state in said enclosure at a position spaced from said portion of said non-conductive element, heating said hydrocarbon and sulfur substance in said enclosure at an elevated temperature under vacuum to change said hydrocarbon and said sulfur substance from a non-gaseous state to a gaseous state, contacting said portion of said non-conductive element with said hydrocarbon and sulfur substance in said gaseous state in said enclosure while at said elevated temperature and under said vacuum to deposit carbon and sulfur substance as a film upon said portion of said non-conductive element, cooling said at least a portion of said coated non-conductive element in said enclosure while under vacuum, and removing said at least a portion of said coated non-conductive element from said enclosure.

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