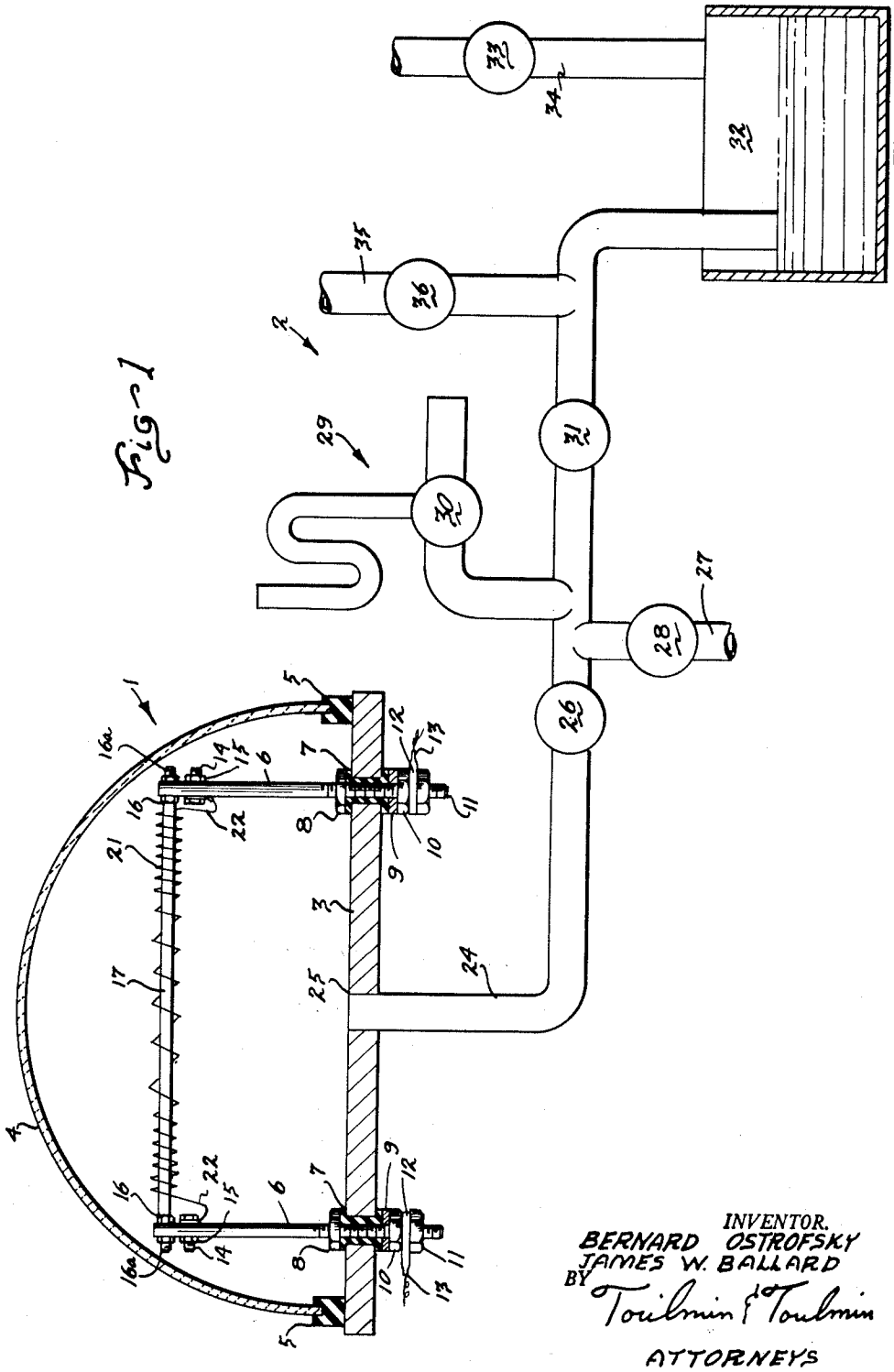
Dec. 29, 1964 B. OSTROFSKY ETAL 3,163,733

SLOW BLOW FUSE

Filed Sept. 23, 1959 2 Sheets-Sheet 1



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Filed Sept. 23, 1959 2 Sheets-Sheet 2

Fig-2

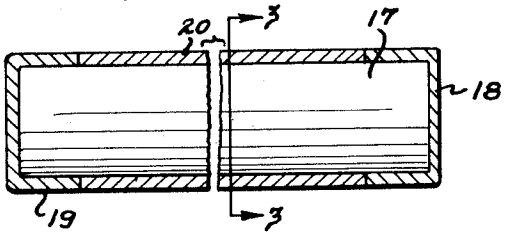


Fig-3

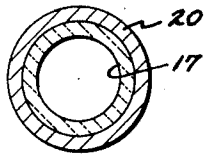


Fig-4

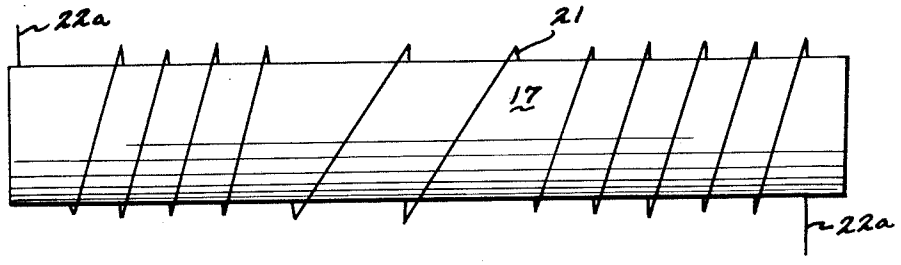
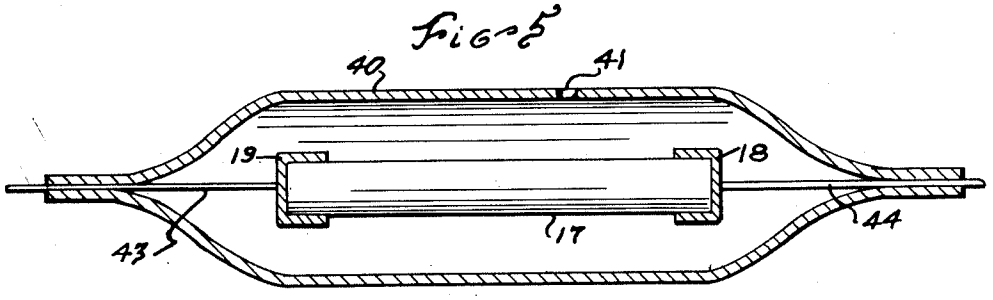


Fig-5



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United States Patent Office 3,163,733 Patented Dec. 29, 1964

3,163,733

SLOW BLOW FUSE

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Filed Sept. 23, 1959, Ser. No. 841,797
3 Claims. (Cl. 200—135)

This invention is directed to electrical fuses and particularly to the production of slow blow fuses, wherein an overload current is carried for a period of time before the fuse opens the electrical circuit.

The slow blow fuses of this invention are produced by the deposition of an electrically conductive, heat sensitive film of an electrically conductive metal on an electrically non-conductive core material. Deposition is effected from the gaseous state of a heat decomposable metal bearing compound.

The fuse itself comprises the electrically non-conductive core material, the heat sensitive metallic film, and electrically conductive terminals in electrical contact with the metal film.

The terminals are selected to have an electrical conductivity which is greater than that of the metal film in order to minimize potential drop through the fuse under usual operating conditions and to provide the primary heating effect within the metal film. Cooper and silver serve the purpose as terminals well, either in the form of caps or as films on the base.

Preferably the metal film is nickel deposited from gaseous nickel carbonyl on the non-conductive core or base material; this metal film engages the terminals and forms an electrically conductive path between the terminals. The film has a low ohmic resistance but an electrical resistivity which is suitably relatively high and greater than that of the material of the terminals. Such a film when heated by an electrical current flow to red heat in an oxidizing atmosphere opens the electrically conductive path without fusion of the material of the film. Nickel with a resistivity of about 7.8 micro-ohm CM. is readily deposited in a film to provide a low resistance in such a fuse device. Iron is readily deposited from iron pentacarbonyl and has a resistivity somewhat greater than the nickel. Corrosion resistance of such films at normal temperatures in air is high.

Films on refractory or temperature resistant core materials such as ceramic cylinders one inch long and 5/16 of an inch in diameter when bounded by end terminals of copper about ¼ of an inch long have exhibited low electrical resistance values of much less than one ohm, and usually may be prepared of nickel or iron to have a resistance of less than ½ ohm.

Such a fuse is operated in an oxidizing atmosphere either in the open or in a confining chamber. The nickel film when subjected to an overload current glows at red heat for a short period of time and opens the electrical circuit. No melting or fusion of the metal film occurs. Further, if the film is subjected to an overload current for a period of time insufficient to effect opening of the circuit the fuse property of the film is not deleteriously affected.

In the practice of the method of the invention the refractory core is suitably heated by a winding which in the case of cores of small cross-section is wound around the outside of the core. In the area where deposition of metal is desired the turns of the coil are suitably spaced well apart to permit permeation of the metallizing gas between turns. At the core ends the winding is suitably more closely spaced to provide for rapid heating of the core. The end terminals may be applied prior to plating in which case the deposited metal contacts the terminals

in the deposition process, or the terminals may be applied to the deposited metal film after plating.

In the preferred method the heating coil and the refractory core are brought to a relatively high temperature in a non-oxidizing and evacuated atmosphere; the heating temperature is well above that of the thermal decomposition point of the metallizing gas employed. Suitably evacuation takes place while heating to provide for exhaustion of all unwanted gases from the plating chamber.

After attainment of the desired relatively high temperature heating power is cut off and the heating coil and refractory core are permitted to cool. The heating coil cools more rapidly than the core due to the nature of the materials. When the refractory core is in a desired temperature range for thermal decomposition of the metallizing gas, such gas is introduced to the chamber. The gas then decomposes depositing metal on the refractory core. In some instances deposition may occur to a slight extent on the heating coil, but such is not detrimental.

The above procedure has been found to provide very uniform films as to thickness. Temperature change during deposition is not deleterious as the operation is of short duration—a matter of seconds.

It is therefore a primary object of this invention to provide a novel slow blow fuse.

It is an important object of this invention to describe a novel method of producing fuses.

The invention will be more fully understood by reference to the following detailed description and accompanying drawings wherein:

FIGURE 1 is a view partially in section of apparatus useful in the practice of the invention;

FIGURE 2 is a view of a fuse produced in accordance with the invention;

FIGURE 3 is a sectional view taken on line 3—3 of FIGURE 2;

FIGURE 4 is a somewhat enlarged view of a ceramic cylinder provided with a heating element and ready for insertion into the apparatus of FIGURE 1; and

FIGURE 5 is a view of the fuse within a cartridge.

Referring to the drawings in detail the numeral **1** in FIGURE 1 generally designates a plating chamber to which there is connected a system indicated at **2** for providing a heat decomposable metal bearing gas to the chamber.

The plating chamber comprises a metal plate **3** suitably of steel over which a dome **4** extends. Dome **4** is suitably transparent and may be of heavy glass or plastic material, such as Lucite, and it rests in a rubber sealing ring **5** and air tightly seals the interior of the chamber from the atmosphere.

Passing through the plate **1** and extending vertically are a pair of brass rods **6**. Bushings **7** of electrical insulating material surround the rods in their passage through the plate **1** and electrically insulate the rods from the plate. Upper retaining nuts **8** engage the bushings **7** to retain the rods **6** from movement in a downward direction.

On the exterior of the dome **4** there is provided about the rods washers **9** and nuts **10, 11**. Between the nuts **10, 11** there is secured an electrically conductive inlet **12** to which an electrical lead **13** is suitably soldered. Heating current passes through one lead **13** and outwardly through the other through the rod **6**. Mounted on the upper end of each of the rods **6** by securing screws **14** are electrically conductive securing members **15**. Above the members **15** on the rods are collars **16** retained by screws **16*a***.

The collars **16** are apertured and receive therein the ends of a ceramic rod **17**. Rod **17**, as most clearly shown in FIGURE 2, may have applied thereto caps **18, 19** of electrically conductive material, such as copper. These

end caps might suitably be conductive films on the ceramic rod or may be removable caps as indicated in FIGURE 2.

The central portion of the ceramic rod **17** is to receive a metal deposit **20** by means of deposition from the gaseous state. For the purpose of heating the ceramic rod **17** an electrical resistance heating wire **21** is provided (FIGURE 1) which is coiled relatively closely together at either end, but which has rather widely spaced turns centrally of the rod, to permit of adequate deposition of metal. Leads **22** at either end of the electrical resistance heating wire connect to the members **15** and accordingly current flow is through a lead **13**, a copper rod **6**, member **15**, heating resistance wire **21** and outwardly through the second end **22**, member **15**, rod **6** and lead **13**. Current may flow in either direction through the assembly as will be apparent.

Referring now to the system for supplying the heat decomposable metal gas to the dome **4**, the numeral **24** designates a main line which extends at **25** through the plate **3** and opens into the dome **4**. The main line **24** has a main line valve **26**. A branch line **27** provided with a valve **28** connects the main line to a vacuum pump (not shown). Also a manometer arrangement designated at **29** and having a stop cock **30** is connected with the main line.

A source valve shown at **31** is provided for the purpose of communicating a source of metal bearing gas in container **32** with the dome **4**. A valve **33** and conduit **34** provide for filling of the container **32**. Another conduit **35** having a valve **36** provides for supplying an inert carrier gas to the system. Such carrier gas may be utilized for flushing the system. Also suitably the container **32** is provided with a liquid form of nickel carbonyl. This carbonyl volatilizes readily and may be utilized without a carrier gas if so desired.

Referring now to the method of operation, initially all valves are closed except valves **26** and **28**, with the apparatus in the condition shown in FIGURE 1. At this time heat is preferably applied to the electrical resistance element **21**. With the vacuum pump operating and heat applied to the ribbon coil to a relatively high temperature of about 800° F., the pressure within the dome is reduced to a very low value.

Suitably with a pressure of about 0.01 mm. of mercury the electric current flow is terminated and the coil and ceramic body allowed to cool. With the gases substantially completely exhausted from beneath the dome and with the ceramic body at a temperature of about 350° F., valve **28** is closed and with valves **26**, **30** and **31** open nickel carbonyl vapors flow into the dome. A pressure of about 8½ mm. of the nickel carbonyl is sufficient for the metallizing operation in a time of about 3 minutes in a chamber having a volume of 1000 cc. Decomposition of the nickel carbonyl is apparent due to cloud formation within the chamber.

Accordingly when the noted pressure has been attained valve **31** is closed and the plating operation is effected. Any deposition which may occur over the end portion of the ceramic rod **17** is not detrimental, for it is only essential that the central area of the ceramic rod between the terminals **18**, **19** be completely coated with a continuous uniform film.

The wide spacing of the heating element in this central area permits appropriate penetration of the metallizing gas to the heated body, and the hot gas contacting the body decomposes, depositing the film of nickel. A film prepared as described may suitably have a resistance of 0.40 ohm at room temperature.

A plurality of fuses have been prepared in the manner described. It has been found that at a resistance of about 0.40 ohm and with nickel as the metal a ceramic rod having a diameter of 5/16 of an inch and 1 inch in length will withstand a current of about 10 amps. D.C. for 10 seconds and will then interrupt the circuit.

As already noted hereinbefore there is no melting of the fused material, the fuse simply glows at red heat for a few seconds and then interrupts the circuit.

The fuses of this invention have been found to withstand a current surge at which they would normally blow for a number of seconds and to be still reusable if the time of glow is relatively short, that is, less than about 5 seconds.

Fuses prepared with nickel as the metal and initially showing a resistance of about 0.4 ohm have exhibited the following properties:

Fuse	Current in amperes	Time to blow in seconds
1	5	10
2	10	10
3	14	12
4	10	10

Very low resistance films may also be prepared with iron, employing iron pentacarbonyl as the metal bearing compound.

Also in the method of invention the ceramic body may be supported somewhat differently, as indicated in FIGURE 4, for example. In FIGURE 4 the ceramic body is designated at **17** and the relatively stiff coil of ribbon is designated at **21**. However, in this instance the ribbon coil has its end turns only in contact with the ceramic body **17**; the remaining coils being spaced slightly from the surface of the ceramic body. Thus the ceramic body is resiliently supported by its own leads **22*a***, and this provides for easy removal of the coated body from the coil. As illustrated in FIGURE 4 the relatively stiff coil of ribbon may be very closely wound adjacent the ends and widely spaced at the center.

In the utilization of iron a system such as that previously described in connection with FIGURE 1 is employed. In this instance, however, the temperature of plating is suitably about 395° F. and the pressure of the iron pentacarbonyl within the chamber is about 2–3 centimeters of mercury.

Preferably also the system is heated to high temperatures at a substantially red heat of the ribbon coil before the introduction of the iron pentacarbonyl.

Experiments in connection with iron deposition have provided fuses in which the resistance is well less than .02 of an ohm. Due to the purity of the iron deposited from the gaseous state the iron itself does not oxidize readily at normal temperatures.

Nickel iron deposits have been achieved utilizing a flow of nickel and iron pentacarbonyls together and co-depositing the metals.

Referring now to FIGURE 5, the fuse is shown as provided within a cartridge **40** which may be provided with an opening **41** to the exterior atmosphere. Alternately the cartridge may be sealed and contain an oxidizing atmosphere.

As shown leads **43**, **44** extend from the terminal caps **18**, **19** in sealed relation through the material of the cartridge. The cartridge is itself formed of glass or plastic. The leads may, of course, extend to electrical connectors for convenient incorporation into the circuit which is to be fused.

While not necessary with either the nickel carbonyl or the iron pentacarbonyl a carrier gas may be employed. Dilution of atmosphere within the chamber and limitation of the plating rate must thus be achieved. Also a carrier gas may be used for purging the system when so desired.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. A slow blow fuse comprising a base of a refractory, substantially electrically non-conductive material, electrical terminals spaced apart on the base, and a film of metal deposited from the vapor phase on the base engaging the terminals and forming an electrically conductive path between the terminals, said film of metal deposited by thermal decomposition of a heat-decomposable metal bearing compound, said metal film having a low ohmic resistance and the metal of said film having a resistivity greater than that of the material of said terminals and having the property of opening said electrically conductive path without fusion of the film when glowed at red heat in an oxidizing atmosphere.

2. A slow blow fuse comprising a base of a refractory, substantially electrically non-conductive material, electrical terminals spaced apart on the base, and a film of nickel deposited from the vapor phase on the base engaging the terminals and forming an electrically conductive path between the terminals, said film of nickel being deposited by thermal decomposition of nickel carbonyl and having an electrical resistance of about 0.40 ohm and the nickel having a resistivity greater than that of said terminals.

3. A slow blow fuse comprising a base of a refractory, substantially electrically non-conductive material, electrical terminals spaced apart on the base, and a film of iron deposited from the vapor phase on the base engaging the terminals and forming an electrically conductive path between the terminals, said film of iron being deposited by thermal decomposition of iron carbonyl and having an electrical resistance of a fraction of one ohm and the iron having a resistivity greater than that of said terminals.

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