Jan. 17, 1956 P. W. PATTON 2,730,986

COATING

Filed March 18, 1953

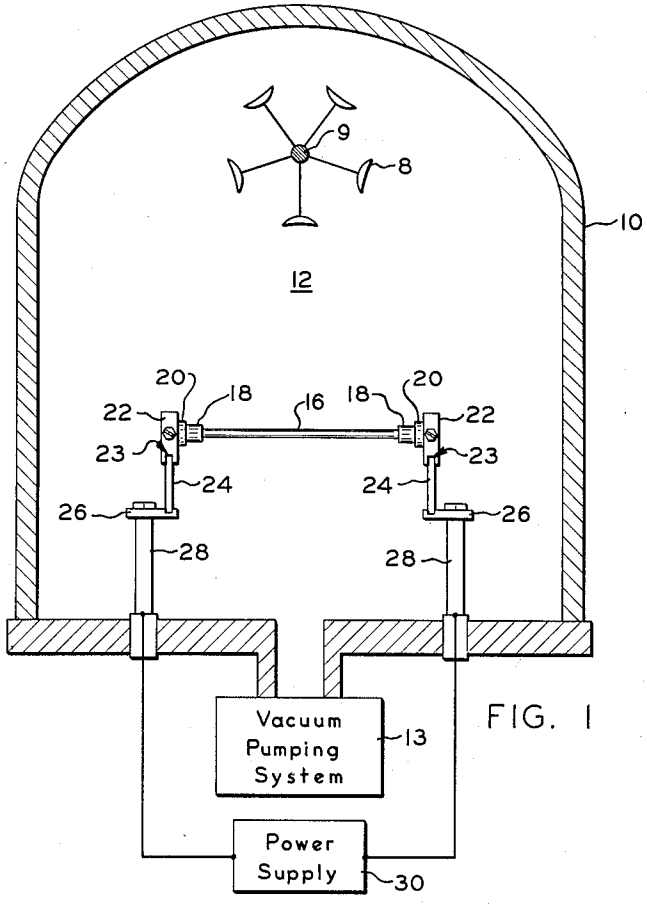


FIG. 1

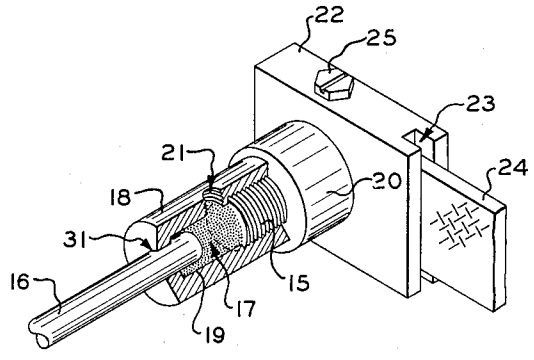


FIG. 2

INVENTOR.
PAUL W. PATTON

BY
Oliver W. Hayes

ATTORNEY

United States Patent Office

2,730,986

Patented Jan. 17, 1956

2,730,986

COATING

Paul W. Patton, Bedford, Mass., assignor to National Research Corporation, Cambridge, Mass., a corporation of Massachusetts

Application March 18, 1953, Serial No. 343,175

4 Claims. (Cl. 118—49)

This invention relates to coating and more particularly to the coating of articles by vacuum evaporation of aluminum with condensation of the aluminum vapors on the articles. This invention is particularly directed to a novel arrangement of elements serving as the support for molten aluminum during the evaporation thereof.

A principal object of the present invention is to provide an improved aluminum-evaporation source which is cheap and which has a relatively long operative life.

Another object of the invention is to provide an improved arrangement of elements which permits the use of a cheap carbon rod in lieu of a tungsten filament as the support for the molten aluminum during evaporation thereof.

Still another object of the invention is to provide an improved holder for a carbon rod of the above type which is particularly arranged to prevent injury to the carbon rod despite vibration or misalignment thereof.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing wherein:

Fig. 1 is a diagrammatic, schematic, sectional view of one preferred embodiment of the invention; and

Fig. 2 is an enlarged, perspective, partially cutaway view of a portion of Fig. 1.

The aluminum vapor deposition coating of articles such as flashlight reflectors, pieces of jewelry, and ornamental plastic objects has become increasingly important in the last few years. Numerous large industrial installations have been put into operation for coating thousands of such articles in a single batch coating operation. Almost universally the art has employed, as a support for the molten aluminum during evaporation, a relatively expensive tungsten filament which has a short operating life. In large batch installations a number of such tungsten filaments are usually mounted along the axis of a large coating tank and rotary jigs mounted around this axis to support pieces to be coated. Tungsten, while serving as an excellent support for molten aluminum, is very expensive and has a short operating life due to the high solubility of tungsten in molten aluminum. Accordingly, tungsten filaments must be replaced after only a few operating cycles.

In the Clough et al. application, Serial No. 231,916, filed June 16, 1952, there is described a new type of filament which is designed to replace the tungsten filaments previously employed in the art. This filament is preferably an elongated carbon rod, this rod having a surface which is readily wet by molten aluminum, but which is relatively inert to molten aluminum. This rod surface

preferably comprises a carbide of one of the metals tungsten or molybdenum.

Since carbon has a relatively high conductivity it is preferred that the carbon rod be so designed that its overall resistance is relatively high. This high resistance permits the use of relatively high voltage heating current for heating the rods to the necessary high evaporation temperature. To achieve this high resistance the rods are preferably made quite long and thin, on the order of 0.25" in diameter by 6.0" long, and, accordingly, they are relatively fragile. As a consequence, it is necessary to protect these rods from external vibration and thermal stresses resulting from expansion of the rods due to the high temperature to which they are heated in order to get rapid evaporation of the aluminum.

In a preferred embodiment of the invention the elongated carbon rod of the type described in the Clough et al. application is supported at each end by a hollow refractory member which is also preferably made of a conducting material such as graphite. Since the rod will move somewhat with respect to this hollow refractory member, the contact between this member and the rod cannot be made rigid. This requirement, of necessity, provides a relatively poor electrical contact between the carbon rod and the hollow refractory conducting member. For completing the electrical circuit, the hollow conducting member is preferably filled with a high-melting-point powdered conducting material. This powdered conducting material is preferably a metal powder and, in a preferred embodiment, is iron powder. The hollow conducting member is, in turn, supported by a resilient conducting support which permits movement of the hollow conducting member with respect to the other elements of the vacuum system, so as to provide for thermal expansion of the carbon rod during operation and also to permit ready alignment of the hollow conducting members with each end of the carbon rod. This arrangement also permits relatively great freedom of orientation of the axis of each rod to provide for predetermined vapor distribution patterns and the like.

Referring now to Figs. 1 and 2 there is shown one preferred embodiment of the invention as applied to a batch coating apparatus wherein it is desired to coat a plurality of articles **8** mounted on suitable rotary jigs **9**. The apparatus includes a vacuum-tight housing **10** defining therein a vacuum coating chamber **12** which is arranged to be evacuated by a vacuum pumping system **13**. This chamber is arranged to hold the jigs **9** so that they support the articles **8** in position to be coated by aluminum vapors. The source of aluminum vapors is preferably a carbide-coated carbon rod **16** which, during operation, is covered by a film of molten aluminum, this molten aluminum being heated to a high temperature so that its vapor pressure is above the residual air pressure in the vacuum chamber. For simplicity, only one of these carbon rods is shown, although it should be understood that the invention is well adapted to large-scale industrial vacuum coating devices wherein a number of such carbon rods will be employed. As mentioned previously, this carbon rod is preferably provided with a tungsten or molybdenum carbide surface of the type more fully described and claimed in the above mentioned copending application of Clough et al.

The supports for the carbon rod are illustrated in considerable detail in Fig. 2 and are shown as comprising hollow supporting end members **18**, these hollow members being preferably in the shape of an end bell and being preferably formed of graphite. Each end bell is supported by a screw-threaded copper conductor **20** which is inserted in a clamp **22**, this clamp **22** also being preferably of copper. The graphite end bell **18** includes a center cavity **19**, a filler hole **21**, and an opening **31**

through which the carbon rod **16** may be inserted. After the carbon rod has been inserted into the end bell, the center cavity **19** is filled with conducting powder, preferably iron powder (illustrated at **17**) and the filler hole **21** is then plugged with an appropriate graphite screw. This iron powder **17** serves as a relatively good conductor between the rod **16** and both the graphite end bell **18** and the copper conductor **20**, thus furnishing a relatively low resistance path for current passing into the end of rod **16**.

The resilient conducting support for the carbon rod holder preferably comprises a flat, braided copper wire cable **24** which is connected to the clamp **22** by means of a suitable groove **23**. The other end of the braided cable **24** is connected to a similar clamp **26** which, in turn, may be supported on a copper bus bar **28**. As illustrated the two bus bars **28** are shown in the vertical position. In a large coating device these bus bars **28** would probably be horizontal and positioned near the axis of the coating chamber. A suitable power supply **30** is connected to each of the bus bars **28**.

In the operation of the device illustrated in Figs. 1 and 2, the two ends of the carbon rod **16** are supported in the two graphite end bells **18**, the iron powder is poured into the inner cavity **19**, and the holes **21** are suitably plugged. With large-scale equipment this operation is usually carried out in a jig which can be moved into the vacuum coating chamber. Aluminum clips are then hung on the carbon rod **16** so as to provide a sufficient quantity of aluminum to serve for several batch coating operations. When the carbon rods are in coating position with respect to the articles to be coated, the vacuum coating tank **10** is evacuated to a suitable low free air pressure, preferably on the order of a tenth of a micron Hg abs. Current is then passed through the rod **16** to heat it to an appropriate high temperature to melt the aluminum clips carried by the rod **16**. This aluminum wets the rod and flows out over the surface of the rod as it melts and is evaporated by the high temperature of the rod.

When the voltage is applied across the carbon rod, a partial sintering of the iron powder may take place inside the graphite bell **18**. This sintering action provides a high-conductivity electrical path so that the electrical energy is dissipated in the rod rather than in the rod support. The sintering action is not complete, however, so that the carbon rod still has limited freedom of movement with respect to the graphite bell **18**. The flexible support **24** also furnishes additional freedom of movement for the whole assembly.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description, or shown in the accompanying drawing, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An improvement in a source of aluminum vapors for an apparatus wherein an article is coated with aluminum by evaporation of said aluminum in a vacuum and condensation of the aluminum vapors on the article, the improvement comprising an elongated carbon rod for supporting molten aluminum within an evacuated chamber, a surface stratum of a carbide of one of the metals molybdenum and tungsten on said elongated carbon rod, graphite end bells containing iron powder and forming a relatively low resistance connection between the ends of the rod and the graphite end bells, copper conductors joined to said graphite end bells, and flat braided copper wire cables for supporting said copper conductors to hold said elongated rod in said vacuum chamber and to isolate said rod from external vibrations.

2. An improvement in a source of aluminum vapors for an apparatus wherein an article is coated with aluminum by evaporation of said aluminum in a vacuum and condensation of the aluminum vapors on the article, the improvement comprising an elongated carbon rod for supporting molten aluminum within an evacuated chamber, a surface stratum of a carbide of one of the metals molybdenum and tungsten on said elongated carbon rod, a hollow refractory support for receiving each end of said carbon rod, at least a portion of each said support forming a high conductivity electrical path, a metal powder filling said hollow support to serve as a low resistance path for heating current passing between each end of said carbon rod and the high conductivity portion of each support, and flexible conductors for predeterminedly positioning said supports and rod within said evacuated chamber.

3. An improvement in a source of aluminum vapors for an apparatus wherein an article is coated with aluminum by evaporation of said aluminum in a vacuum and condensation of the aluminum vapors on the article, the improvement comprising an elongated carbon rod for supporting molten aluminum within an evacuated chamber, a surface stratum of a carbide of one of the metals molybdenum and tungsten on said elongated carbon rod, a support for each end of said rod, each said support comprising a hollow graphite member for receiving an end of said carbon rod, one end of said hollow graphite member being closed by a copper plug carried by a resilient flexible conductor, said hollow graphite member being filled with iron powder.

4. An improvement in a source of aluminum vapors for an apparatus wherein an article is coated with aluminum by evaporation of said aluminum in a vacuum and condensation of the aluminum vapors on the article, the improvement comprising an elongated carbon rod for supporting molten aluminum within an evacuated chamber, a surface stratum of a carbide of one of the metals molybdenum and tungsten on said elongated carbon rod, a hollow refractory support for receiving each end of said carbon rod, each said hollow support comprising hollow graphite end bells each having an opening for holding an end of said rod in sliding engagement with the rod, a copper plug screwed into a second opening in each said end bell, iron powder filling the interior of the hollow end bell and serving as a high conductivity electrical path between the end of the rod and the copper plug, and a flat braided copper conductor serving as a resilient holder for each said hollow support.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 18,420	Shaw	Apr. 12, 1932
1,378,189	Northrup	May 17, 1921
2,013,755	Hediger	Sept. 10, 1935
2,282,098	Taylor	May 5, 1942
2,416,211	Osterberg et al.	Feb. 18, 1947
2,430,994	Reynolds	Nov. 18, 1947
2,450,857	Colbert et al.	Oct. 5, 1948
2,479,541	Osterberg	Aug. 16, 1949
2,548,897	Kroll	Apr. 17, 1951