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VAPORIZED METAL COATING APPARATUS

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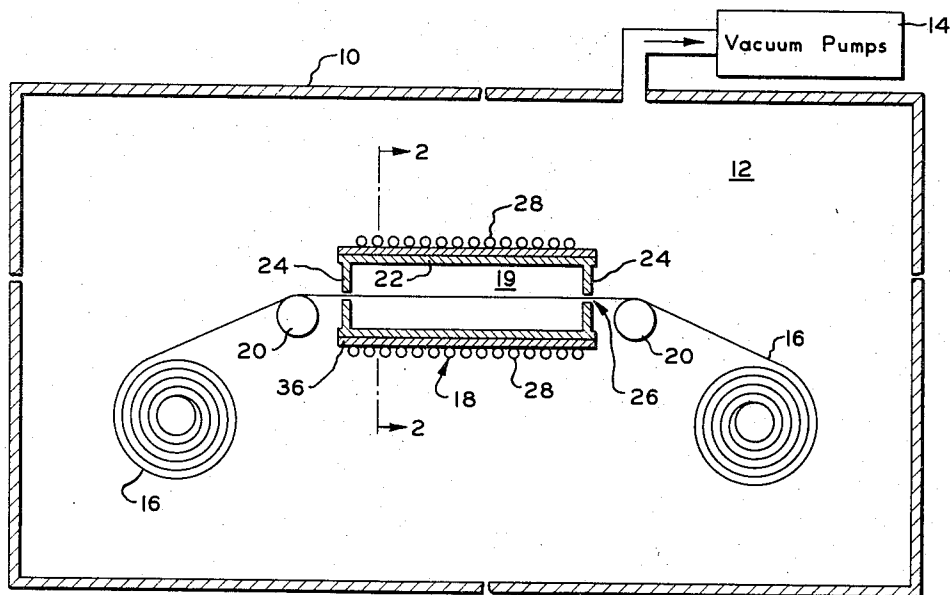


FIG. 1

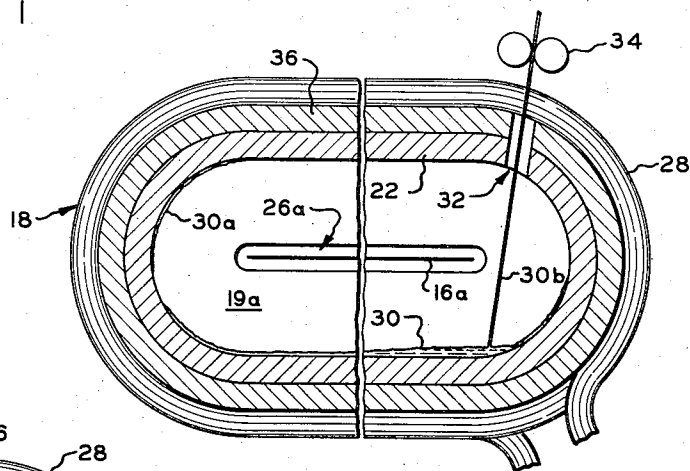


FIG. 2a

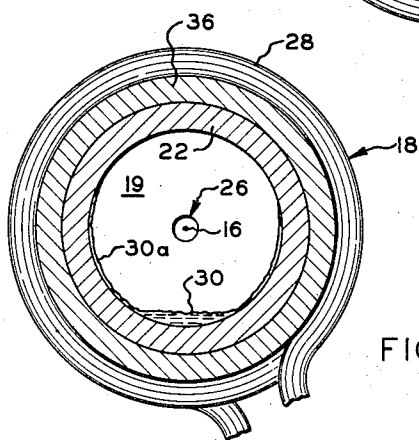


FIG. 2

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VAPORIZED METAL COATING APPARATUS

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3 Claims. (Cl. 118—49)

The present invention relates to coating and more particularly to the continuous coating of flexible substrates such as fibers, threads, strips of sheet material and the like by the vapor deposition of a coating material on the substrate as it is advanced through a vacuum chamber.

A principal object of the present invention is to provide for maximum utilization of a given quantity of coating vapors so as to provide increased speed of operation of the coating equipment.

Another object of the invention is to provide improved coating apparatus particularly arranged for coating a thin filament at a high rate of speed with maximum utilization of the coating material.

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 present invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

Fig. 1 is a diagrammatic, schematic, sectional view of one continuous coating apparatus embodying the present invention;

Fig. 2 is an enlarged fragmentary view of a portion of Fig. 1; and

Fig. 2a is an enlarged fragmentary view of a portion of Fig. 1 showing a variation in shape from that shown in Fig. 2.

The vacuum coating of thin filamentary materials such as fibers, textile threads and the like by vapor deposition techniques has long been an object of workers in the art. Numerous techniques have been suggested but, so far as is known, none has obtained any great commercial success. The present invention is particularly directed to the coating of such filamentary materials in a rapid, expeditious and economical fashion. This is achieved by providing a smaller chamber within a vacuum chamber capable of evacuation, the smaller chamber being for the purpose of confining a high-density mass of coating vapors.

The invention will initially be described in connection with the coating of a wire with aluminum vapors, this description being for illustrative purposes only without intent to limit the invention. In such an arrangement, the smaller inner chamber preferably comprises a hollow member in the form of a tube of carbonaceous material such as graphite and the like, this tube being arranged to confine aluminum vapors within its interior by means of end members which are preferably carbon discs. The carbon discs are supplied with openings for permitting passage of the wire to and from the inner chamber so formed. The graphite tube is preferably horizontally positioned in the vacuum chamber and is provided with a heating means arranged to heat the graphite to a tempera-

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ture which is high enough to give the desired partial pressure of aluminum vapors within the inner chamber. This heating is most conveniently accomplished by means of an induction coil which heats the graphite by induced high-frequency currents. Contact between the graphite and the induction coil is preferably prevented through the use of an interposed dielectric refractory member.

Referring now to the drawings, there are shown several preferred embodiments of the invention. In these figures, 10 represents a vacuum-tight housing defining therewithin a vacuum coating chamber 12 which is arranged to be evacuated to a low-free-air pressure on the order of less than 1 micron Hg abs. by means of a vacuum pumping system 14. Within this chamber, the substrate to be coated, illustrated as a wire 16, is guided through a coating vapor source 18 by means of a pair of guide rolls 20. The coating vapor source 18 comprises a horizontally positioned cylindrical tube 22, the ends of the tube 22 being preferably closed by means of discs 24 which define, with tube 22, a coating vapor space 19. The discs 24 are provided with aligned openings 26 through which the substrate 16 passes into vapor space 19. The tube 22 is preferably made of a high-temperature-resistant, conductive material. For this purpose, dense forms of carbonaceous material such as graphite or carbon or mixtures thereof have been found particularly suitable. This carbonaceous tube 22 is heated to a high temperature on the order of 1250° C. by means of a water-cooled coil 28. A dielectric refractory member 36, preferably of a material such as alundum or zirconia, separates the induction coil 28 from tube 22 to insure against burning out of these members.

A charge of aluminum, for example, is provided inside of the carbonaceous tube 22, this being shown particularly in Fig. 2 as a pool 30 which wets the surface of the tube 22 at 30a as it travels up the surface to provide a greatly increased evaporation area. This wetting of the carbonaceous tube surface is preferably achieved by lining tube 22 with a group IVa, Va or VIa metal carbide, this carbide preferably being formed by adding one of said metals to the aluminum to be evaporated. Of these carbides, those of titanium, zirconium, hafnium, vanadium or columbium are preferred, since these carbides additionally aid in preventing attack of the carbonaceous tube by the high-temperature molten aluminum or its vapors.

In the operation of the device in Fig. 2, a charge of aluminum is positioned inside of the tube 22 and wire 16 is threaded through the holes 26 in the end discs 24. The vacuum chamber 12 is then evacuated by means of pump 14 to a low-free-air pressure of less than 1 micron Hg abs. The inductor heating coil 28 is energized to bring the graphite sleeve 22 up to an elevated temperature on the order of 1250° C. or thereabouts. This high temperature will cause the aluminum to become molten and to vaporize sufficiently so as to fill the small chamber 19 with aluminum vapors. Since substantially all of the walls of the chamber 19 are at an elevated temperature, which is substantially equal to the temperature of the aluminum vapors, a uniform high vapor pressure of aluminum will be maintained in this space 19. As a result of the uniform high concentration of aluminum vapors in the space 19, essentially all surfaces of the wire 16 traveling therethrough will be coated with a uniform layer of aluminum by condensation of aluminum vapors on the relatively cold wire. Since the holes 26 in the tube 22 and discs 24 are relatively small, there is slight escape of aluminum vapors from the inner chamber 19 to the outer chamber 12. Accordingly, there is achieved considerable economy of utilization of the coating vapors, since these vapors con-

dense substantially only on the wire 16 passing there-through.

Referring now to Fig. 2a, there is illustrated another embodiment of the invention which is particularly adapted to the coating of both sides of a strip of sheet material which is passed through the inner coating chamber 19a. In this case, the chamber 19a can be oval in cross section to accommodate the increased width of the substrate passing therethrough. Similarly, the holes 26a in the end pieces are formed as slits to permit passage of the relatively wide strip 16a. In this embodiment, the tube is preferably provided with a hole 32 through which aluminum wire 30b may be fed by a suitable mechanism indicated as a pair of rolls 34. This is desirable since the relatively larger areas of the strip 16a, as compared to the filament 16 of the Fig. 1 embodiment, will remove a considerably greater quantity of aluminum as a result of its passage through the inner coating chamber 19a. In other respects, the operation of Fig. 2a is similar to that described in connection with the discussions of Figs. 1 and 2.

While the coating of a metal wire or strip with aluminum has been described as a preferred embodiment of the invention, numerous other modifications may be practiced. For example, the invention may be employed for coating textile fibers or fabrics, particularly relatively heat-resistant fibers such as glass fibers and the like. When the heat capacity of the fiber is relatively low with respect to the amount of coating to be applied thereto, it is desirable that the coating be done in stages by passing the fiber through the coating chamber at a high rate of speed so that only a small fraction of the requisite coating material is deposited thereon. The fiber is then cooled, such as by being passed over a cooling roll, and again fed through the inner coating chamber where it receives a second coating. This procedure is particularly helpful for the coating of heat-sensitive material or for providing a relatively thick coating of metal or the like on even such a relatively heat-insensitive material as a glass fiber.

Coating materials that can be utilized include metals such as aluminum, copper, zinc, gold, platinum and other metals having vapor pressures at least as great as that of platinum. Equally, other materials such as metal compounds, normally applied by vacuum coating techniques, can be employed in the present invention.

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 accom-

panying drawings, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A coating apparatus for the continuous coating of a substrate with metal, said coating apparatus comprising a vacuum chamber, an evacuation means for evacuating said chamber, a hollow member located within said vacuum chamber and adapted to form an inner chamber capable of confining vapors of a metal, means for feeding a supply of metal into the inner chamber in position to be heated to vaporization temperature, said hollow member being provided with openings which communicate with the vacuum chamber to permit travel of a substrate to and from said inner chamber, means for guiding said substrate through said openings, and means for electrically heating the interior surfaces of said hollow member and the supply of metal therewithin to a temperature sufficiently high to provide a partial pressure of the metal vapors which is higher than the pressure existing in the vacuum chamber outside of the inner chamber, the surface temperature of the hollow member being at substantially the same temperature as the temperature of the supply of metal to provide equal coating on all surfaces of the substrate while maintaining the substrate at a substantially lower temperature than the temperature of the hollow member.

2. The apparatus of claim 1 wherein the hollow member is formed of a carbonaceous material which is heated to the requisite high temperature by electrical currents flowing therewithin.

3. The apparatus of claim 2 wherein the coating metal is aluminum and the carbonaceous material has an inner surface comprising a carbide which is relatively inert to aluminum at temperatures on the order of 1250° C. and is wetted by molten aluminum.

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