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METHOD AND APPARATUS FOR COATING METAL STRIP AND WIRE

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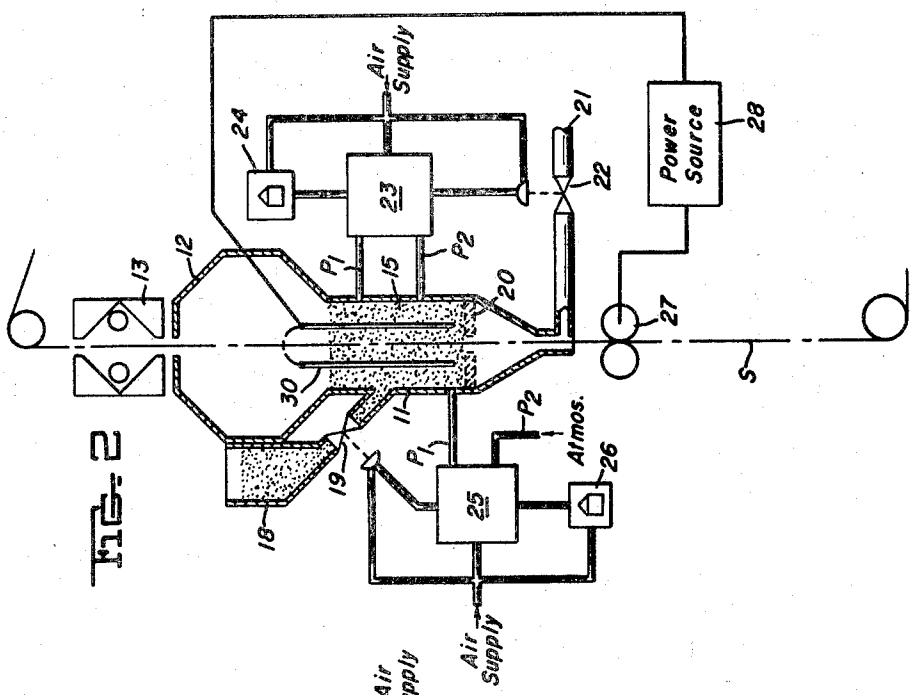


FIG. 2

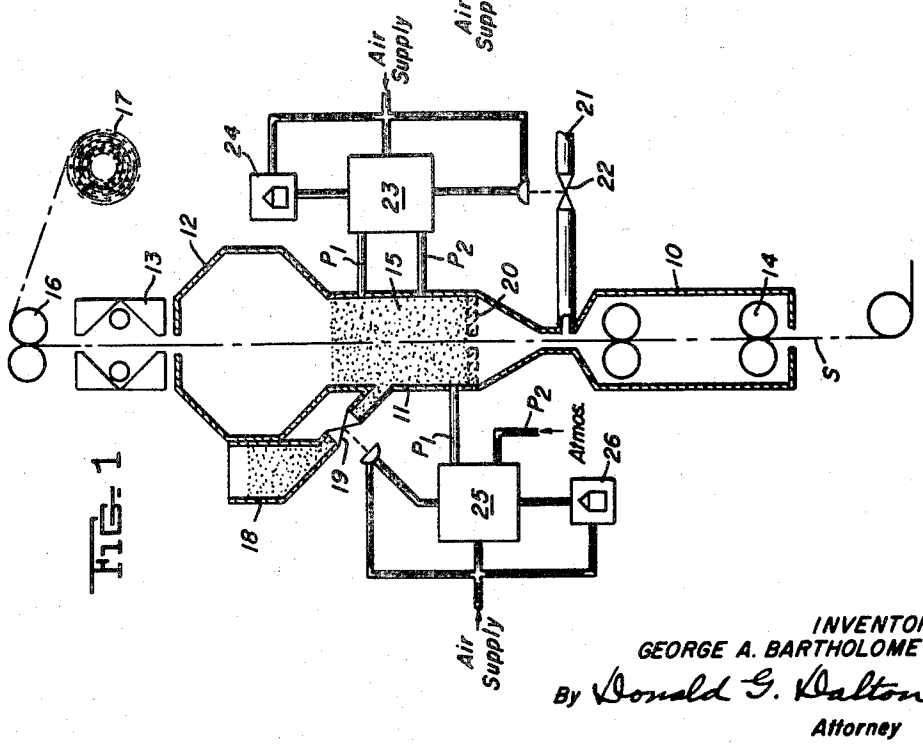


FIG. 1

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METHOD AND APPARATUS FOR COATING METAL STRIP AND WIRE

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This invention relates to the coating of metal with a protective film and, in particular, to the continuous coating of a product of indefinite length such as strip or wire.

The object of the invention is to provide a simple and effective method and apparatus for applying to a traveling product a coating of material in finely divided form.

A further object is to provide control means adapted to insure the formation of a coating of uniform thickness.

In general terms, my improved method comprises progressively heating the product to be coated and drawing it in strand form through a fluidized bed of finely divided coating material. This material may be a thermoplastic synthetic resin such as polyethylene, a refractory material such as magnesium oxide or a metal, e.g., aluminum. I employ means to heat the product to be coated immediately before it enters the fluidized bed, and after it emerges therefrom if desirable. Alternatively, I may heat the coating particles directly by the combustion of fuel in the fluidized bed. I also provide automatic means for maintaining the proper depth of the fluidized bed and the degree of fluidization thereof. I may also utilize electrostatic force to aid the attraction of coating particles to the traveling wire or strip.

A complete understanding of the invention may be obtained from the following detailed description and explanation which refer to the accompanying drawings illustrating the present preferred embodiment. In the drawings:

FIGURE 1 is a flow diagram showing one form of apparatus schematically in vertical section; and

FIGURE 2 is a similar view showing a modification.

Referring now in detail to the drawings and, for the present, to FIGURE 1, I provide apparatus for coating strip or wire comprising a preheating chamber **10** and a coating chamber **11**, vertically disposed. The coating chamber includes an enlarged upper portion **12** above which are mounted radiant or induction heating units **13**. Metal strip S is unwound from a coil entering chamber **10**, passes between contact rolls **14** then through a fluidized bed **15** of coating particles and, after passing between units **13**, passes between heated embossing rollers **16** and is then recoiled at **17**. The portion of the strip between upper and lower pairs of rolls **14** is heated by any convenient means such as radiant heaters, induction or by electric current, to a temperature of from 120° F. to 660° F. Preferable deposition temperatures are specific to individual coating compounds. Deposition temperature ranges for several classes of coating materials have been found to be:

Cellulosics	About 300° F.
Epoxys	About 150° F.
Nylons	About 630° F.
Polyethylenes	About 325° F.

For example, the coating particles may include compounds of the following general classifications: acetates, butyrates, vinyls, cellulose esters, epoxys, nylons, acrylics, polyethylenes and lucites. They should be pulverized to particle sizes less than 100 mesh. The coating material is introduced into chamber **11** from a hopper **18** under the control of a valve **19**. The material in the coating chamber is supported on a porous plate **20** and is fluidized by air introduced therebelow by an inlet pipe **21** including a control valve **22**. As the preheated strip ascends through the fluidized bed, the particles of coating material, being heated by contact with the strip, adhere thereto and fuse together, forming a continuous coating of uniform thickness. The enlarged upper portion **12** of the coating chamber provides a settling space for any coating material which tends to follow the strip without adhering to it. Heating elements **13** effect a final curing or smoothing of the coating by maintaining it above its flow temperature. The coated strip passes between embossing rolls **16** while the coating is still plastic and capable of being impressed with the pattern of the rolls. Thereafter the strip cools in the atmosphere to a non-tacky condition before being recoiled.

I provide means for automatically controlling the flow of fluidizing air to maintain a predetermined bulk density in bed **15**. For this purpose, I employ a controller **23** such as Hagan Corporation's "Ring Balance Meter" responsive to the pressure differential between points P_1 and P_2 in chamber **11** and to an adjustable set-point control **24**. Controller **23** operates valve **22** which is a motorized valve such as the "Flex Valve" of Farris Flexible Valve Corporation. A similar controller **25**, responsive to the pressure of the column of coating material in chamber **11**, operates valve **19** of the same type as valve **22**, in accordance with the adjustment of a set-point control **26**.

The final coating thickness may be accurately controlled by regulation of five controllable factors: (*a*) strip-powder contact time, (*b*) preheat temperature, (*c*) bed density, (*d*) powder size, (*e*) flow characteristics of the powder. Contact time may be controlled by strip speed and fluid-bed height. Preheat temperature, regulated to correspond with the thermal requirements of the coating powder, is a function of heating current and strip speed and may be readily controlled over a wide range of operational conditions. Bed density is a measure of the frequency of particle-strip collisions. In conjunction with strip temperature which determines the adhesiveness of the coating particles and contact time, bed density is an effective control of coating thickness. Bed density, of course, is controlled by air-flow rate and bed depth, both of which are measured directly and automatically controlled as just explained.

Instead of air for fluidizing, I may introduce hot combustion gases into the bed **15** or a combustible mixture of fuel and air and effect combustion in the chamber itself.

In coating strip with certain materials such as Teflon plastic (polytetrafluoroethylene), Bakelite or other thermosetting resins, which might be adversely affected by the heat of the strip, I prefer to eliminate the preheating of the strip. In that case, I effect initial adherence of the particles to the strip by electrostatic attraction and then cause final adherence by subsequent treatment such as heating of the strip with the particles thereon. Apparatus for this process is shown in FIGURE 2 and is substantially the same as that of FIGURE 1 except for the omission of preheating chamber **10**. In lieu thereof, I provide entry contact rollers **27**. A source **28** of high-voltage direct current is connected between rollers **27** and electrodes **30** mounted in chamber **11** adjacent the strip path. As the strip passes upwardly through chamber **11** at atmospheric temperature, the electrostatic force between the strip and the particles of coating material causes them to be attracted to the strip and adhere thereto. As the strip emerges from the upper portion **12** of the chamber **11**, the adhering particles are moderately heated by units **13** so as to fuse them into an adherent coating.

The control of electrostatic deposition is dependent upon essentially the same variables as those controlling

the thermodeposition process. Strip speed, air flow, bed depth and density, contact time are all of major importance. Voltage, however, replaces preheating as the prime deposition-control factor. It is more important to control the physical and electrical properties of the powder here than in the thermodeposition process. However, except when plastic reflow is desired, thermal properties of the coating materials are less important in this process than in the thermodeposition process.

My process permits rapid, continuous application of accurately controlled coatings. By heating the moving strip in an enclosed chamber only a fraction of a second before coating, I effect a drastic reduction in thermal loss. By the continuous application of heat before, during and after coating, I exercise complete control of strip temperature. Immersion time of the strip in the bed is precisely regulated by the bed height and strip speed, both of which are controlled in my process. I further control the density of the fluid bed and, therefore, have an additional processing variable which, with the alternate hot-bed and electrostatic-deposition methods, supplement process flexibility and facilitate attaining the most advantageous deposition conditions.

Many advantageous coating materials such as magnesium oxide, diatomaceous earth and bentonite, are not plastic in the lower temperature range (under 650° F.) and may require application temperatures in other processes so high as to be detrimental to the properties of the steel base. In my process, however, such materials may be applied to steel strip without undue harm to the base metal. This is accomplished not by heating the strip and requiring thermal transfer to colliding particles, but rather by the application of heat directly to the fluidized particles. By fluidizing with a combination of a suitable fuel gas and air, actual combustion may be maintained within the coating bed. The excellent agitation and mixing characteristics of such beds provide almost instantaneous transfer of heat to the suspended particles, which may be heated to a plastic or even molten condition suitable for adherence to the base metal. Although the temperature within such a bed may well be considerably above the safe treatment temperature for low carbon steels, the rapid movement of the strip through the bed limits exposure to such a short time that the steel may be coated without serious overheating.

By this method, semirefractory and other inorganic and insulating-type materials may be satisfactorily applied to steel strip. Coatings similar to those now used as separating media or core-plate coatings on electrical steel may now be applied continuously and rapidly.

Many coating materials (of which Teflon plastic is an outstanding example) are seriously degraded by heating to temperatures necessary for satisfactory adhesion to the metal and cannot be properly applied by conventional coating methods. Other coating materials, e.g., polyurethanes, are produced by instantaneous chemical reaction, preferably in direct contact with the base metal.

By permitting room temperature deposition of the thermoplastic materials or through the employment of successive deposition of reactive components, the electrostatic induction feature of my process permits the use of new coating materials that, because of their thermal or chemical properties, have not heretofore been applicable.

Although I have disclosed herein the preferred embodiment of my invention, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

1. A method of coating elongated metal product which consists in drawing the product through a mass of particles of refractory coating material, fluidizing said mass by supplying a combustible mixture of gases thereto and igniting said mixture while passing through said bed hereby heating the particles of coating material to promote their adherence to the product.

2. A method of coating elongated metal product which consists in drawing the product through a mass of particles of coating material, fluidizing the mass by the upward flow of gas therethrough while maintaining an electrostatic field between the product and the particles of the mass adjacent thereto, and heating the product at a point in its travel to a temperature at which the particles remain adherent thereto.

3. Apparatus for coating a continuous metal product comprising a coating chamber, a gas-permeable bottom plate in said chamber, said plate having an opening to admit said product, guide rolls above and below said chamber whereby the product may be drawn upwardly through said opening and a mass of coating particles in said chamber, means above said chamber for heating the product after it has traversed said means, means for introducing a gas below said plate to fluidize said mass, an electrode in said chamber spaced from the path of the product and means establishing a voltage gradient between said electrode and said product.

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