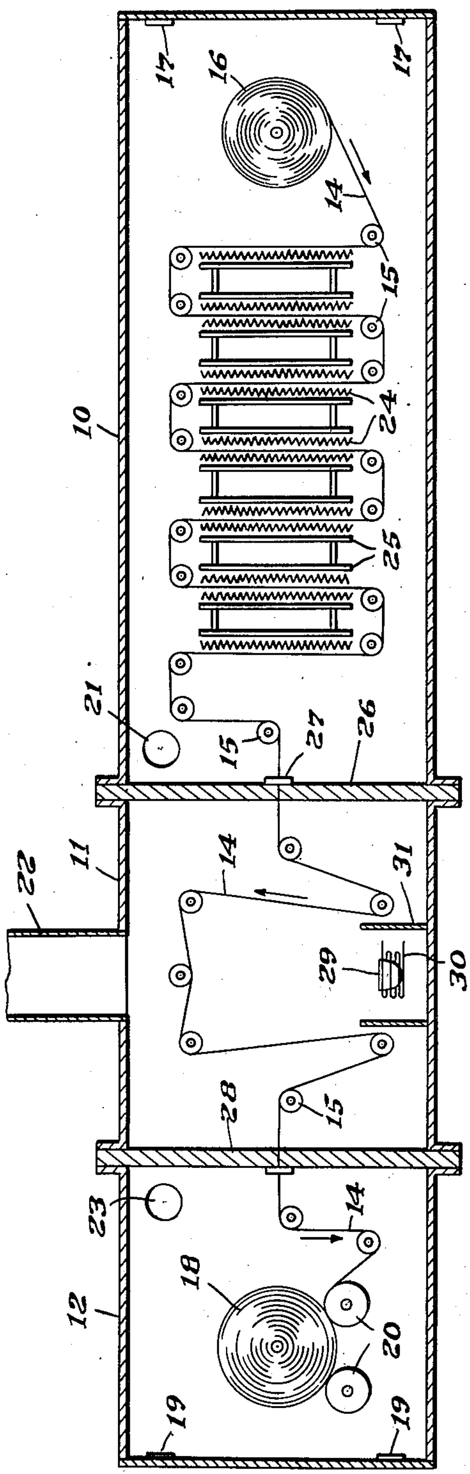
Dec. 16, 1952 P. GODLEY, 2ND 2,622,041

DEPOSITION OF METAL ON A NONMETALLIC SUPPORT

Filed Aug. 3, 1948



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Patented Dec. 16, 1952 **2,622,041**

UNITED STATES PATENT OFFICE

2,622,041

DEPOSITION OF METAL ON A NONMETALLIC SUPPORT

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Application August 3, 1948, Serial No. 42,288

2 Claims. (Cl. 117—60)

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This invention relates to the deposition on suitable supports or bases of materials, particularly metals, by processes involving thermal evaporation of the material deposited in an attenuated atmosphere and embraces improvements both in method and apparatus. The invention is particularly concerned with the deposition of metals on surfaces or supports containing occluded gases or other volatiles or substances which yield gases or vapors when heated.

The invention is considered especially significant as applied to the coating of cellophane in strip or sheet form with aluminum and it will be described with specific reference to that application, it being understood that the specific description will not be held limitative. By means of the invention an aluminum coating can be applied to cellophane more evenly than heretofore and at a substantially faster rate with fewer operational difficulties.

It has been previously recognized that materials such as cellophane and other plastic sheeting, sheeting formed by vinyl chloride or vinyl acetate polymer or vinyl chloride-vinyl acetate copolymer, for example, tend to give off hydrogen, water vapor and possibly other gases and vapors when contacted with a vaporized metal in a vacuum chamber, and that this gas and vapor evolution interferes with the coating operation by rendering it difficult to maintain the vacuum. The hydrogen evolution is especially pronounced in the case of cellophane where aluminum is employed as the coating metal, due perhaps to reaction of the aluminum with hydroxyl-containing compounds in the cellophane.

Prior investigators have proposed that the cellophane sheet or web, prior to the coating operation, be preheated under reduced pressure on the side to be coated to remove surface volatiles, it being contended that when this is done, the necessary vacuum in the coating chamber can be maintained without difficulty. These investigators caution that the heating should be superficial only, that is that it should be carefully confined to the surface of the cellophane support and not extended to the body thereof. Should the heating at the temperature of the superficial heating be so extended, it is asserted that the cellophane becomes seriously embrittled, largely losing its desirable physical and chemical properties, and that its handling in the coating apparatus and subsequently, becomes complicated.

In testing the proposal of the prior investigators, I found that the improvement provided by the superficial heating is something less than is

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desirable. In seeking a reason for this it occurred to me that the volatiles removed from the surface of the web by the superficial heating are replaced during the early stages of the coating operation from within the body of the strip and that a greater improvement in results might be attained by heating the strip throughout at a temperature below the temperature resulting in its serious embrittlement. I tried this and discovered that the results are indeed superior. The improvement being far out of proportion to that which might conceivably be expected to follow from a longer heating at lower temperature, it was my first thought that the heat treatment operated to selectively remove a high vapor pressure plasticizer from the cellophane most responsible for the vacuum difficulties in the coating department. I soon discounted this theory, however, on finding that the improvement also obtains in the case of materials of a nature entirely different from cellophane and for the further reason that it did not seem reasonable to me that the complete removal of a plasticizer could be effected without seriously embrittling the web.

My invention will be better understood by reference to the accompanying drawing illustrating schematically, in sectional elevation, a system of apparatus suitable for its practice when the material to be coated is in strip or web form, as is preferred.

The apparatus, as disclosed, will be seen as constituted of three compartments **10**, **11** and **12**, through which the strip to be coated, indicated by the numeral **14**, is consecutively passed, the course of the strip through the compartments being determined by rollers or idlers **15**. The strip **14** is fed from a feed roll **16** suitably supported within compartment **10**. This compartment should be equipped with a pressure tight door for which hinges **17** are indicated. A receiving roll **18** is mounted in end compartment **12**, which should also be provided with a pressure tight door, for which hinge elements **19** are indicated, and may be driven in the conventional manner by rotating drums **20** maintained in frictional engagement with the periphery of the roll.

Each of the compartments **10–12** is maintained under a subatmospheric pressure, vacuum lines or conduits **21**, **22** and **23** being provided for this purpose. Assuming the material of the strip is cellophane and that the coating metal is aluminum, compartment **11** is best maintained at a pressure not exceeding .4 micron of mercury and each of compartments **10** and **12** at a pressure of from 50 to 500 microns. A mechanical vacuum pump, not shown, suffices in the case of compartments 10 and 12, but conduit 22, by means of which compartment 11 is evacuated, should connect with a diffusion pump system, not shown.

In compartment 10, the strip or web 14 is passed over and under heating elements 24 which may be spaced and supported as by insulating members 25, the strip being thereby thoroughly heated by radiation, volatiles being driven from the body of the strip as well as from the surfaces. Both the intensity and duration of the heating are dependent on the particular material of the strip. In all cases the heating is controlled to avoid substantial impairment of the properties of the strip which adapt it for the ultimate use contemplated. Unlike cellophane cellulose acetate sheeting does not become embrittled, but softens and distorts if the heating is carried out at too high a temperature. Other supports may actually decompose if their heat capacity is substantially exceeded. The heat capacity of any particular strip material can be readily determined by experimentation. In the case of cellophane I have found that not substantially more than 20–30% of the contained volatiles should be removed if adequate plasticity is to be retained.

Compartment 10 is separated from compartment 11 by a partition 26 conforming to the cross sectional outline of the two compartments through which the strip 14 is passed. Placed over the slot is a sealing element 27 which substantially prevents equalizing of the pressures in the compartments. A similar sealing element is secured over a slot in partition 28, separating and partially delineating compartments 11 and 12. These elements may be formed of natural or synthetic rubber or other suitable material of a similar nature. Where the material of the strip and the coating operation are not adversely affected thereby, mercury or other liquid seals may be substituted.

In compartment 11, the coating compartment, the strip is passed over a cup 29, shown as heated by a resistance coil 30, and shielded by an annular baffle 31. Cup 29 serves to evaporate the metal deposited on the surface of the strip presented for coating. Where it is desired to coat both surfaces or sides of the strip, two cups may be used and certain obvious rearrangements made with respect to the course of the strip through the compartment. If desired, the strip may be cooled during coating, as by a cooled metal plate, for example, under which the strip is caused to ride.

In some instances, it may be necessary or desirable to interpose a fourth compartment between compartments 11 and 12. This fourth compartment may represent a spare or additional coating compartment, for example. An additional compartment or compartments may also be interposed between compartment 10 and the coating compartment, it being advantageous at times to apply a preliminary non-metallic coating before the metal coating is applied. Any intervening compartment is preferably maintained at a pressure intermediate the pressures in the compartments between which it is positioned, a pressure gradient being generally necessary for best results.

Exemplary of metals other than aluminum which may be employed in coating operations carried out in accordance with the invention may be mentioned: magnesium, silver, copper, gold, tin, zinc, etc. Other supports or base materials in addition to those previously mentioned, which, like cellophane, tend to give off water vapor and/or gases, include paper, textile fabrics, whether constituted of animal, vegetable or mineral fibers, e. g., silk, wool, cotton, rayon, asbestos cloth, fiber glass cloth, etc., artificial leather and the like.

The invention is not limited to the application of metal coatings, being highly useful in the coating of a support with a wax, for example.

The specific heating means shown in the drawing is not critical as the strip can be successfully heated in a variety of ways. Thus, it may be passed around hot rolls or over heated metal plates, for example. It is important only that heating extend to the body of the material of the strip, i. e., that volatiles be driven from the body of the strip and that it be so controlled as to avoid substantial loss of the original properties of the strip.

I claim:

1. The process of vacuum deposition of a metal on a nonmetallic, flexible substrate which yields gases or vapors when heated, said process comprising the steps of passing said substrate through a heating zone evacuated to a pressure on the order of 50 to 500 microns Hg, heating both sides of said substrate during passage through said heating zone to drive from said substrate occluded gases and other volatiles resulting from said heating, said heating being accomplished by advancing said substrate along a circuitous path between a plurality of heating elements so that relatively large areas on both sides of said substrate are being subjected to heat simultaneously, said substrate being advanced through said heating zone at a rate sufficient to permit thorough heating of the body of said substrate, the substrate being heated to a degree sufficient only to drive out volatiles from the body of said substrate, removing said substrate from said heating zone prior to the time when the removal of said volatiles is sufficient to cause substantial embrittlement of said substrate, substantially immediately thereafter advancing said substrate into a coating zone evacuated to a pressure lower than the pressure in said heating zone, generating metal vapors in said coating zone, condensing said metal vapors on said substrate, and shielding said substrate in said coating zone from vapors driven from said substrate in said heating zone, the area of substrate being heated at any instant of time being greatly in excess of the area of substrate being coated at any instant of time.

2. The process of vacuum deposition of a metal on a nonmetallic, flexible substrate comprising cellophane, said process comprising the steps of passing said substrate through a heating zone evacuated to a pressure on the order of 50 to 500 microns Hg, heating both sides of said substrate during passage through said heating zone to drive from said substrate occluded gases and other volatiles resulting from said heating, said heating being accomplished by advancing said substrate along a circuitous path between a plurality of heating elements so that relatively large areas on both sides of said substrate are being subjected to heat simultaneously, said substrate being advanced through said heating zone at a rate sufficient to permit thorough heating of the body of said substrate, the substrate being heated to a degree sufficient only to drive out volatiles from the body of said substrate, removing said substrate from said heating zone when only 20% to

30% of the contained volatiles have been removed therefrom, substantially immediately thereafter advancing said substrate into a coating zone evacuated to a pressure lower than the pressure in said heating zone, generating metal vapors in said coating zone, condensing said metal vapors on said substrate, and shielding said substrate in said coating zone from vapors driven from said substrate in said heating zone, the area of substrate being heated at any instant of time being greatly in excess of the area of substrate being coated at any instant of time.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,322,327	Minton	Nov. 18, 1919
2,079,784	Williams	May 11, 1937
2,344,138	Drummond	Mar. 14, 1944
2,382,432	McManus et al.	Apr. 14, 1945
2,384,500	Stoll	Sept. 11, 1945
2,402,269	Alexander et al.	June 18, 1946