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IRIDESCENT FOIL

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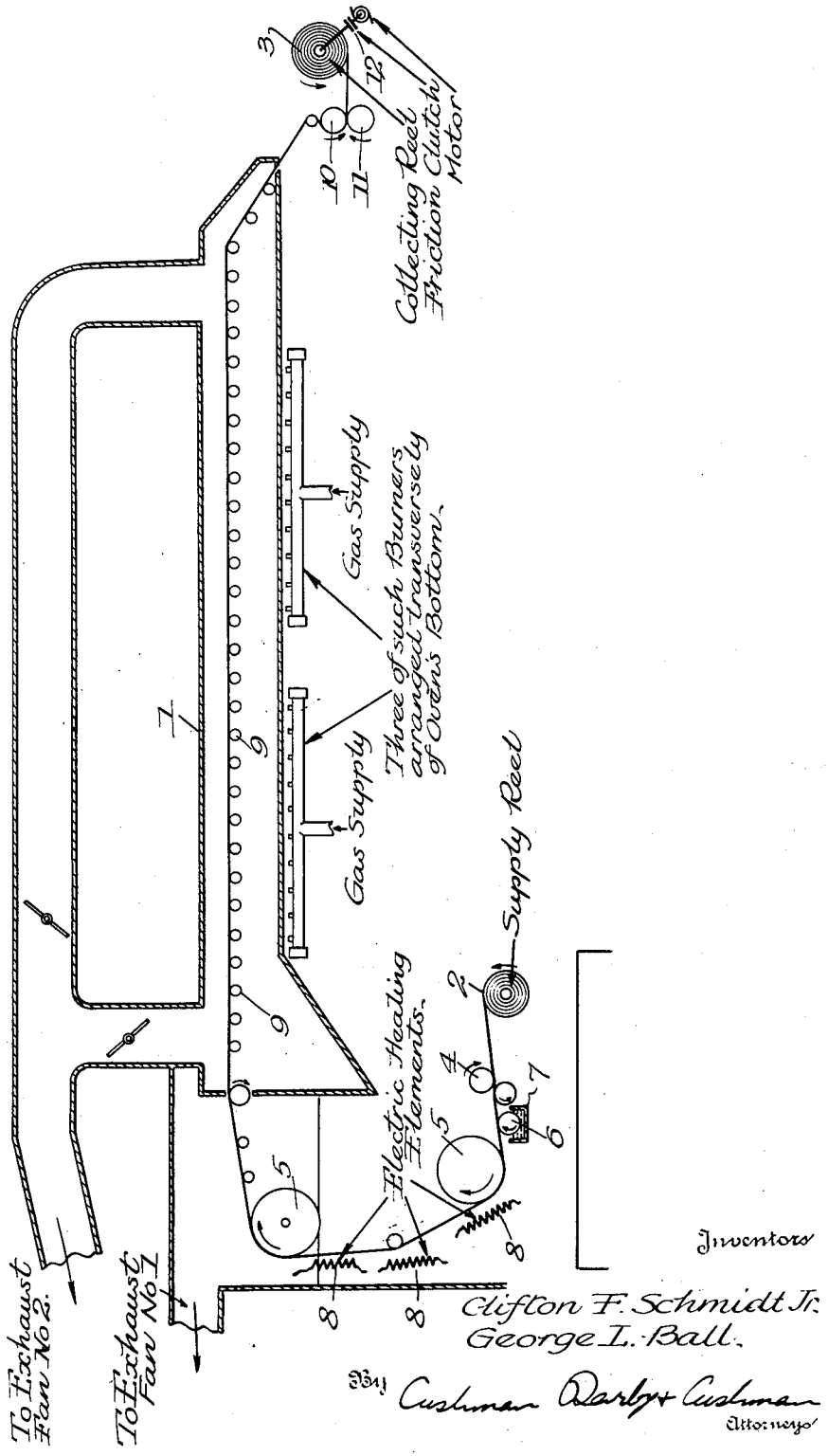

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IRIDESCENT FOIL

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13 Claims. (Cl. 91—70)

This invention relates to a composite foil.

Our invention herein disclosed bears an underlying relation to that disclosed in our co-pending application Serial No. 705,379, filed January 5, 1934. Whereas, however, our co-pending application deals primarily with the production of a coated metallic foil, such as aluminum foil, which, as coated, is so resistant to chemical action, and has other qualities in such sort, that it is suitable for use on lining elements in container caps, this invention, is directed additionally to the production of a coated foil of novel and striking ornamental apperance.

In our co-pending application, above-noted, the metallic foil has applied thereto a coating material which, as heat treated, is highly resistant to acids and alkalies, is not tacky or thermoplastic, is odorless and tasteless, and in which the coating is so elastic, and the coating and metallic base so bonded to each other, that they are in effect a single material. These qualities are of primary importance in fulfilling the purpose to which that foil is put. Incidentally, the foil as so made has a bright golden color.

In the composite foil of our present invention, we do not disregard the primary qualities of firm bonded adhesion between the metallic base and the non-metallic film thereon, nor the elasticity of the film component of the coated foil. It is also desirable that the film of our ornamental foil should not be thermoplastic; and also that, for some purposes, it be resistant to acids and alkalies.

While in our co-pending application the physical qualities of the coated foil are the chief desideratum, this invention relates to a metallic foil which is of striking novel ornamental appearance without undue sacrifice of the physical qualities of our coated foil above identified. By utilizing fundamentally the formulae and procedure as disclosed in our co-pending application, we have succeeded in producing a coated metallic foil which presents on its coated side an iridescent effect. This iridescence is obtained by varying the procedure disclosed in our copending application.

We shall first describe briefly and generally our preferred procedure in producing an iridescent foil. The accompanying drawing shows, diagrammatically, exemplary apparatus for producing our iridescent, composite foil. At an end, or ends, of an elongate heating furnace 1, there are mounted two reels 2 and 3, upon one of which is a roll of some tough and coherent foil which is to be treated, such as aluminum foil. A receiving reel 3 for the treated foil takes the foil as it comes from the furnace. The foil is carried over guiding rolls 4 and 5 into the furnace, the free end of the foil being connected with the collector reel 3. In passage of the strip of foil to the heated region of the furnace, one face thereof is contacted by an applicator roll 6, which dips into a trough 7 of coating liquid. Desirably, means such as electric heaters 8 are provided for subjecting the coated side of the foil to moderate temperature for initially drying the coating material in a region between the region at which the coating is applied and the entrance to the heated zone of the furnace through which the foil is carried.

In the exemplary apparatus shown, the foil, as it enters and is carried through the furnace, passes over a number of small diameter rolls 9. At the delivery end of the furnace, the foil is taken up by a pair of rolls 10 and 11. This pair of rolls is positively driven, and controls the rate at which the foil is carried through the furnace. The collecting reel 3 is driven through a slip-clutch 12, so that its progressively increased diameter, as the foil collects on it, does not increase the speed at which the foil travels through the furnace.

The elements which are positively driven are thus the propelling rolls 10 and 11, and the applicator roll 6. These rolls are in suitable manner drivable at variable speed; as the speed of the applicator roll 6 controls the thickness of the coating applied to the foil, and the speed of the propelling rolls is a factor of primary importance in determining the time period of heat treatment to which the foil is subjected.

It should be explained that the length of heating zone in the furnace, and more particularly the length of the high temperature zone in the furnace, plays a part in determining the time period of heat treatment. Thus if the furnace be 20 feet in length, there is only a portion of such length in which the temperature to which the foil is subjected approximates the maximum. Assuming that the length of such high temperature zone is five feet, it is such length that is to be considered in determining the time period of heat treatment of the foil.

In conducting a coating treatment of suitable metallic foil, such as aluminum foil, the coating applied by applicator roll 6 is initially set to the foil by the electric heating elements 8, and is fully set to the foil in the low temperature zone at the entering end of the furnace. It is, of course, highly desirable that the solvent thinner,

or thinners, comprised in the coating composition be thus driven off before the coated foil encounters the high temperature at which heat conversion of the film is effected. Also it is of importance so quickly to set the film on the metallic base that the film is smooth, and uninterrupted.

The coating which we prefer to use comprises coumarone resin; a resin having heat-curing properties, such as the phenolic resins; linseed oil; and China-wood oil. The composition of the coating used is, however, susceptible of considerable variation, since the production of an iridescent foil depends largely upon temperature and duration of heat treatment, and also upon the thickness with which the coating composition is applied to the foil. Taking constituents, such as those noted above, they are worked up into a relatively thin, flowable coating composition by the addition of suitable solvent thinners, such as a mixture of hi-flash naphtha and water-white kerosene. Pine oil, or its equivalent, may be added to prevent possible separation in the thinned coating liquid. Other ingredients may desirably be added, such, for example, as ozocerite wax, to provide an unwettable surface; and a small quantity of a surface-drying material, positively to prevent final tackiness, such as manganese acetate, manganese oxide, cobalt acetate, cobalt resinate, or cobalt naphthanate.

It may be stated generally that there are four factors serving to produce our iridescent, composite foil; namely, a suitable coating composition, the thickness of the coating composition as applied to the foil, the temperatures at which heat treatment of the coated foil is effected, and the duration of the period through which the metallic base and applied film is subjected to heat treatment.

It may initially be explained that the thickness of the coating applied to the metallic base, and the consequent thickness of film thereon, depends in turn on two factors. One such factor is the quantity of solvent thinner with respect to the other ingredients in the coating composition used, and the other is the quantity of coating composition applied to each unit area of the base.

As to the material used, we have successfully produced iridescent foil utilizing the base formulae given in our co-pending application Serial No. 705,379, with suitable thinners, and desirably with the other ingredients of the coating composition there disclosed.

One formula which we have utilized for the production of iridescent foil is as follows:

	Per cent
Linseed oil	52.2
China-wood oil	11.2
"Amberol" No. F7	16.8
Coumarone resin	16.8

Another typical formula which we have successfully employed is as follows:

	Per cent
Linseed oil	55
China-wood oil	11
"Amberol" ST137	11
Coumarone resin	23

The "Amberol" ST137 resin is known as a 100% heat-curing resin, and we have successfully replaced it in the formula by other phenolic resins generally understood to be 100% heat-curing, such as "Bakelite" No. 1329, "Bakelite" No. 3360, "Beckacite" No. 1001, and "Durex" No. 500.

We may use indene resins, instead of coumarone resin, and it will be understood that many commercial coumarone resins, which can be successfully used, consist of mixtures of coumarone and indene polymers. Moreover, synthetic resins having the general qualities of neutrality, adhesion, and inertness to acids and alkalies, possessed by coumarone, are to be regarded as equivalents of coumarone. As examples of equivalent resins which we have successfully substituted in like proportion for coumarone, we refer to synthetic petroleum resins, such as "Pur-o-resin", polymers of dihydronaphthalene, such as DuPont "RH–35", and polymers of cyclopentadiene and other cyclic dienes, such as "Nuba." We have also successfully used substituted and other modified coumarone-indene resins.

The "Pur-o-resin" referred to above is manufactured by the Pure Oil Company, and is designated by them as P–198. This is a solid petroleum resin having a specific gravity of 1.023–1.029, a melting range of 170°–190° F., a minimum iodine number of 200, and a molecular weight of approximately 700. It consists of reduced hydrocarbon polymers produced by the polymerization of petroleum distillates obtained by vapor phase cracking. This may be produced, for example, as disclosed in the Chittick Patent No. 1,891,079 of December 13, 1932.

The Du Pont "RH–35" referred to above is manufactured by E. I. du Pont de Nemours & Co., Inc. This is a solid resin having a specific gravity of 1.14, a melting range of 212°–248° F., and it is described and claimed in Patent No. 2,108,213 of February 15, 1938.

The "Nuba" resin is manufactured by the Neville Chemical Company. It is a solid dark stable resin differing in properties from the well known coumarone-indene resins, principally in that it is harder and tougher. We understand that it consists principally of cyclo-pentadiene and other cyclic dienes in highly polymerized state. It is manufactured and sold in three grades having the following characteristics:

	Nuba No. 1	Nuba No. 2	Nuba No. 3
Melting point range °F	176–203	212–257	275–302
Color	13 to 16	14 to 17	16 to 19
Insoluble in petroleum benzine percent	8	33	45
Insoluble in benzol percent	6	14	18
Ash percent	13	18	27
Fracture form	Grainy	Grainy	Grainy
Form	Solid	Solid	Solid

We have also used "Nevillite," a resin manufactured by the Neville Chemical Company, which has the following properties:

Specific gravity at 68° F.—1.046 (average).
Color—Water white.
Form—Glassy lumps.
Melting points (graded)—50° F. to 329° F.
Iodine value—Approximately 2.
Chemically inert—Strong acids, alkalies and salt solutions have little or no effect and it is alcohol resistant.

In each instance we utilized a mixed solvent thinner comprising 80%, 150° water-white kerosene, 10% hi-flash naphtha, and 10% pine oil. A small quantity of ozocerite wax, or a small quantity of one of the metallic driers, was in each instance included in the composition. We prefer to use, as an ingredient of the coating composi-

tion, a linseed oil which has been oxidized. We have found wholly satisfactory linseed oil which has been treated to a point at which it acquires a body as heavy as "Q-tube" by the Gardner & Holt viscosity tube test.

A preferred coating composition for our present purpose may be obtained by working up in a kettle equal proportions by volume of the thinner and the total of other ingredients. To this mixture we add three times its volume of additional thinner.

We have succeeded in obtaining an iridescent effect, in which the treated foil presents apparently all the tints of the spectrum by utilizing any one of the above-noted formulae in the manner hereinafter described. We have also obtained a foil, treated in similar manner, which presents an iridescent effect, utilizing a coating composition from which coumarone or its equivalents have been omitted.

It may be noted that such latter foil, having the coating film in which courmarone or its equivalents are not used, possesses a less perfect adhesion between the metallic base and the film than a foil having coumarone or its equivalents included in the coating composition applied to the metallic base to form the iridescent film thereon. It is not, however, either tacky or thermoplastic.

It has been explained that the speed at which the applicator roll, shown as the roll 6 of the exemplary apparatus, revolves determines the relative thickness of the coating which is applied to the foil. This is on the assumption that a composition of predetermined viscosity is applied. It should be understood that the effect of the linear speed of the applicator roll surface is effective by relation to the speed of travel of the foil. Thus utilizing a foil travel of 120 inches a minute, and a maximum furnace temperature of 600° F., while revolving the applicator roll at 65 inches a minute, the foil developed a light golden, unvariegated color. By reducing the linear speed of the applicator roll surface to 50 inches per minute, the other conditions of the process remaining identical, iridescence in the coated foil began to be observable. With the other conditions identical, a full rainbow effect including apparently the entire spectrum was obtained when the linear speed of the applicator roll was reduced 5 inches or more per minute below the speed of 30 inches per minute.

It may thus be stated generally that, in order to obtain a definite iridescence in the coated foil, the applicator roll should act at a linear speed substantially less than the linear speed at which the foil travels.

It will be noted in the above that the speed of foil travel is 10 feet per minute. Utilizing a zone of maximum furnace temperature 5 feet in length, the foil is given a heat treatment 30 seconds in duration at the maximum furnace temperature of 600° F.

We have utilized a maximum furnace temperature as high as 820° F. to obtain our iridescent effect. At temperatures of from 735° F. to 820° F. we have found that the speed at which the foil passes through the furnace should be so increased that the foil receives a treatment of no longer than 20 seconds in the maximum temperature zone of the furnace. This is for the reason that an unduly extended heat treatment at such high temperature serves to darken the foil, giving a color from bright purple to a purplish black.

With increase in the speed of foil travel, the speed of the applicator roll may also be increased, without thereby applying to the foil a coating so thick as to render it difficult to develop iridescence by heat treatment.

The coating as applied to the foil being adequately thin, and the duration of the heat treatment in the zone of maximum temperature being slightly in excess of one minute, we have observed the development of iridescence in the coated foil at a temperature as low as 550° F.

It is, of course, however, desirable for commercial reasons to utilize higher temperature, and to pass the foil through the furnace at higher speed.

We have not obtained the development of a full bright iridescence at temperatures substantially below 600° F., or substantially above 820° F. It is readily conceivable, however, that by establishing extreme conditions as to speed of foil travel, and by appropriately adjusting the linear speed of the applicator roll relatively to the speed of foil travel, the optimum effect might be obtained, both below and above that temperature range.

The coating composition being suitable, and of appropriate predetermined consistency, the other factors which have been noted may be expressed roughly as the formula

$$A=\frac{b}{c}\times\frac{c}{d}$$

In this formula, A=the conditions producing an optimum iridescent effect in the coated foil; b=the maximum temperature to which the coated foil is subjected during heat treatment; c=the speed of foil travel in given linear units; and d=the linear speed of the applicator roll in the same units. In accordance with this rough formular, and as otherwise explained above, as d approaches c, either b must be increased, or c decreased, to give a greater intensity of treatment. We have operated with a speed ratio of c to d as high as 15 to 2, and even as high as 15 to 1, to produce a coated foil in which the film is of light color, showing distinct iridescence.

It has been noted above, as a general factor, that a heat treatment too severe, either in temperature or duration, tends to the production in the coating of a dark purplish coloration, deficient in iridescence. In producing our iridescent foil, it should be further noted as a general factor that increased thickness in the coating on the foil, irrespective of any other factor or factors, tends to the production of a darker effect than the effect developed in a thinner coating.

While we are not certain as to the cause of iridescence in our composite foil, we are led to believe that it is, in part at least, due to a light dispersing thickness of the film on the metallic base; the effect being rendered readily observable by the degree of opacity produced in the film by heat treatment of appropriate severity. Certain observations bear out this theory. Thus, it has been noted that a film of undue thickness does not exhibit our desired light-dispersing effect. We also have noted that the film obtained when the applicator roll is run at exceedingly low speed to produce a film of minute thickness, fails to exhibit a readily observable iridescence. As the coating composition is spread on the metallic base, in preferred thickness, a very slight iridescence is with difficulty observable prior to subjection of the foil to heat treatment. It is in all cases to be assumed that the metallic base to which the film is applied does not function as a

complete, or substantially complete, light absorbing medium.

Every example of our iridescent foil made with a coating composition comprising coumarone resin or its equivalents, exhibits, as heat treated, perfect adhesion between the metallic base and the film, and the film itself is elastic, insoluble, is without thermoplasticity, and is highly resistant to acids and alkalies.

At a temperature of 549° F. aluminum passes through a stage of re-crystallization. Since aluminum is a metal to which coatings bond with difficulty, it may be that, when aluminum foil is used as the metallic base of the foil, such fact contributes to the perfect bond between the base and the heat treated film. In any event, it is a fact that, whether the base be of aluminum foil, or another foil, an apparently perfect, bonded adhesion between the metal and the film is obtained.

Our iridescent foil is susceptible of many uses where ornamental appearance is of importance. For example, it is useful in stage effects, and for the purposes of general mural decoration and the like. It is also highly desirable for use in wrapping confections, tobacco, and similar products, in which the attractiveness of the package possesses definite commercial value; it is further desirable as applied as an outer covering to boxes, cartons, and the like. For all these purposes the firm adhesion of the coating to the foil, and the fact that the coating as heat converted is elastic, is resistant to solvents and the like, and is without tackiness at any temperature, gives the coating qualities greatly enhancing its utility.

Because of the firm bonded adhesion between the non-metallic film of the composite foil and the metallic base of the foil, and because of the elasticity of the film, the composite foil may be creased abruptly, and may be flexed to follow complex contours, without cracking the film or perceptibly weakening the adhesion of the film to the metallic base.

While we have referred particularly to the application of the coating to metallic foils, such as aluminum foil, we have successfully applied it to other metals such as black iron, and to light-gauge sheets of aluminum and other metals which have not been worked down, or treated, to such degree that they exhibit the absolute "deadness" commonly associated with the word "foil."

The above disclosure constitutes in part a continuation of our copending application, Serial No. 24,702, filed June 3, 1935.

We claim:

1. The improved method of coating metal which comprises applying uniformly to a metallic base an oleoresinous coating composition containing a heat-curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

2. The improved method of coating metal which comprises applying uniformly to a metallic base an oleoresinous coating composition containing, in a thin flowable state, a heat curing resin and a synthetic resin having substantially the properties of neutrality, adhesion and inertness to acids and alkalies possessed by coumarone resin, said synthetic resin being selected from a group consisting of coumarone, polymers of dihydronaphthalene, and reduced hydrocarbon polymers produced by the polymerization of petroleum distillates obtained by vapor phase cracking, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

3. The improved method of coating metal which comprises applying uniformly to a metallic base an oleoresinous coating composition containing a heat curing resin and coumarone in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

4. The improved method of coating metal in strip form while it is being continuously fed which comprises applying uniformly to a metallic base an oleoresinous coating composition containing a heat curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature and regulating the thickness of the applied film, by controlling the amount of solvent thinner substantially within the range of seven parts of thinner by volume to one part of the other ingredients and by controlling the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

5. The improved method of coating metal while continuously feeding the same, which comprises applying uniformly to a metallic base an oleoresinous coating composition containing a heat curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature within the approximate range of 600° to 820° F. for a treating period of the order of one minute and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

6. The improved method of coating metal which comprises applying uniformly to a metallic base an oleoresinous coating composition containing a heat curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to a moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature within the approximate range of 600° F. to 820° F. for a treating period of the order of one minute and regulating the thickness of the applied film, by controlling the amount of solvent thinner substantially within the range of seven parts of thinner by volume to one part of the other ingredients

and by controlling the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

7. The improved method of coating aluminum foil while it is being continuously fed, which comprises applying uniformly to the foil an oleoresinous coating composition containing a heat curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

8. The improved method of coating aluminum foil while it is being continuously fed, which comprises applying uniformly to the foil an oleoresinous coating composition containing a heat curing resin in a thin flowable state, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature within the approximate range of 600° F. to 820° F. for a treating period of the order of one minute and regulating the thickness of the applied film, by controlling the amount of solvent thinner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

9. The improved method of coating aluminum foil while it is being continuously fed, which comprises applying uniformly to the foil an oleoresinous coating composition, in a thin flowable state, containing a heat curing resin and a synthetic resin having substantially the properties of neutrality, adhesion and inertness to acids and alkalies possessed by coumarone resin, said synthetic resin being selected from a group consisting of coumarone, polymers of dihydronaphthalene, and reduced hydrocarbon polymers produced by the polymerizattion of petroleum distillates obtained by vapor phase cracking, drying the coating on the metal by subjecting the same to moderate temperature, thereafter subjecting the coated metal to a substantially higher temperature within the approximate range of 600° F. to 820° F. for a treating period of the order of one minute and regulating the thickness of the applied film, by controlling the amount of solvent thiner and the speed of application, and also adjusting the temperature and duration of the heat treatment so as to produce an optimum iridescent effect in the coated foil.

10. As a new article of manufacture, an iridescent foil comprising a flexible light-gauge metallic foil base and an iridescent-exhibiting film thereon, said iridescent foil being the product resulting from the method defined in claim 1.

11. As a new article of manufacture, an iridescent aluminum foil comprising a flexible light-gauge metallic foil base of aluminum and an iridescent-exhibiting film thereon, said iridescent foil being the product resulting from the method defined in claim 2.

12. As a new article of manufacture, an iridescent aluminum foil comprising a flexible light-gauge metallic foil base of aluminum and an iridescent-exhibiting film thereon, said iridescent foil being the product resulting from the method defined in claim 3.

13. As a new article of manufacture, an iridescent aluminum foil comprising a flexible light-gauge metallic foil base of aluminum and an iridescent-exhibiting film thereon, said iridescent foil being the product resulting from the method defined in claim 9.

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