

Dec. 24, 1957

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METHOD OF MAKING TRANSPARENT ELECTROCONDUCTIVE
SURFACED PLASTIC ARTICLES
Filed March 4, 1953

2,817,604

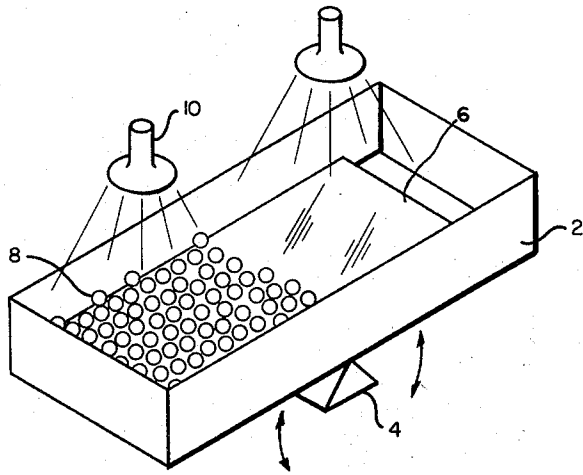


Fig 1

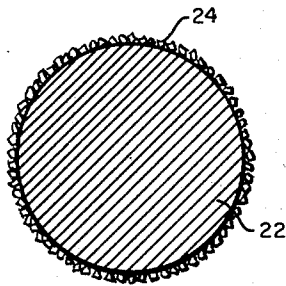


Fig 2

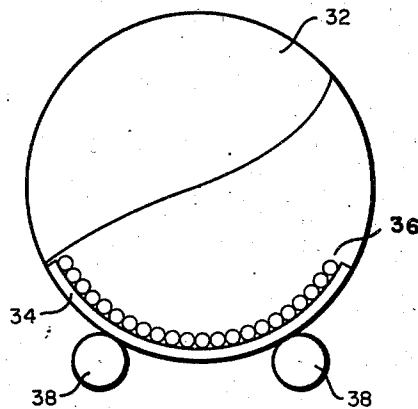


Fig 3

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METHOD OF MAKING TRANSPARENT ELECTRO-CONDUCTIVE SURFACED PLASTIC ARTICLES**Arnold S. Louis, New York, N. Y., assignor to
Myron A. Coler, Scarsdale, N. Y.****Application March 4, 1953, Serial No. 340,314****4 Claims. (Cl. 117-211)**

This invention relates to methods of making electrically non-conductive articles having an adherent electrically conductive coating, and in particular such coatings which are transparent.

In my copending applications entitled "Improved Electrically Conductive Articles and Method of Making Same," Serial No. 256,516, filed November 15, 1951, now U. S. Patent No. 2,788,297, and "Improved Electrically Conductive Articles and Method of Producing Same," Serial No. 340,313, filed of even date, there is disclosed an electrically non-conducting article having an electro-conductive surface.

There is disclosed herein a method of coating an electrically non-conductive surface with conductive material by a simple process which may be used on even relatively soft readily scratchable surfaces such as polished polymethylmethacrylate and other plastics and which permits the treating of large sheets.

The term "plastics" as used herein is intended in its chemical sense and not in its physical sense.

The term "plastics" embraces any one of a large and varied group of materials commonly referred to as plastics and resins, such as polymethylmethacrylate, polyvinylchloride, polyethylene, polystyrene, polyvinylidenechloride and their copolymers.

In many applications for electrical insulators such as plastics it is desirable that an electrically conductive surface be provided in order to eliminate electrostatic charges. In electrical measuring apparatus electrostatic charges cause disturbances to sensitive meters. Accordingly, a conductive surface is sought for the meter casing observation window. In another typical case, that of aircraft, the electrostatic charging of the plastic cockpit canopy and electrically non-conductive plastic surfaces covering radio and radar antennas create electrical interference with radio communication and radar signals.

An electrically conductive coating applied to an electrically non-conductive surface can be used as a resistive heater element to maintain the electrically non-conductive surface or its surroundings at a desired temperature.

The prior art shows various partially successful methods of applying carbon and other conductive films. Thus, surfaces possessing sufficient inherent adherence such, for instance, as the surface of a wax object, will readily attach to itself a relatively continuous graphite layer which can be electroplated. Such films are rather delicate and usually completely opaque.

Again, it is conventional to apply graphite in dispersion in film forming adhesives to the surfaces of insulator objects. It has not been possible to obtain such coatings which are sufficiently conductive, and at the same time reasonably transparent. Furthermore, there are problems connected with peeling and loose adherence of the coating and with crazing of insulator plastics to which they are applied.

A conventional device to obtain transparent conductive coatings is the application of organic films containing wa-

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ter soluble electrolytes. Such films are generally very unstable as to their electrical properties and can be easily washed from the insulator base. This invention, by contrast, is concerned with obtaining a coating which is sufficiently thin to be transparent and yet sufficiently adherent to withstand considerable abrasion and washing.

Accordingly, it is an object of this invention to provide an improved method for applying an electrically conductive coating to a non-conductive plastic article.

Another object of this invention is to provide a method of obtaining a uniform electro-conductive surface on large electrically non-conductive surfaces.

A particular object of this invention is a method of applying a transparent electrically conductive surface to electrically non-conductive articles.

Other objects and advantages of this invention will appear more fully and clearly from the following description of illustrative embodiments thereof taken in connection with the appended drawings in which:

Figure 1 shows an apparatus for coating articles.

Figure 2 shows in section an enlarged view of a typical applicator.

Figure 3 shows a rotary apparatus used for coating articles.

Briefly stated, the process of this invention comprises coating spherical bodies with finely divided electrically conductive material and then rolling the coated spheroids over a surface to be coated so that the electrically conductive material is transferred thereto.

In one method of this invention a tray 2 is pivoted on a fulcrum so that it may be rocked see-saw fashion. An electrically non-conductive article such as a sheet of polymethylmethacrylate 6 is placed on the bottom of the tray 2 and at least partially covered by a layer of applicators comprising coated spheres 8. The tray is then oscillated about fulcrum 4 causing the applicators to roll from one end of the tray to the other. After a period of time a uniform coating is formed on the surface.

A typical applicator is shown in greater detail in Figure 2 wherein sphere 22 is coated with finely divided particles 24 of electrically conductive material.

In general, it is preferred that the applicator particles be round rather than angular in shape to avoid scratching of the insulator surface and to permit uniform rolling. Larger and heavier applicators are preferred, the harder the surface to be coated and the higher the conductivity which it is desired to impart to the treated surface.

Thus, polystyrene beads about 1 mm. in diameter have been found effective in coating polymethylmethacrylate sheet. Steel balls, 1/8 inch in diameter, have been effective in applying rather heavy conductive coatings to polymethylmethacrylate.

In general, applicators should not be smaller than 0.0025 inch nor larger than 0.25 inch. Smaller applicators lack the necessary mass to be effective. With larger applicators it is inconvenient to obtain the multitudinous contacts which are needed to secure the full advantage of this invention.

Applicators may be made of any material which is stable physically and chemically under the conditions of use. They should not have such an adhesive surface as to bond the conductive material inextricable to themselves. Suitable applicator materials include glass, polystyrene, steel balls and ceramics.

The electrically conductive coating material must be finely divided and chemically stable under conditions of impact. The range of fineness is critical and the particles should not be coarser than ten microns and preferably finer than two microns in the smallest dimension. Par-

ticles of laminar habit are particularly convenient for the practice of this invention.

Applicator particles may be coated with conductive material by any of several techniques, as for instance, by exposure to the sooty products of the incomplete combustion of carbonaceous gaseous fuels or by wetting with a suspension of conductive material in a liquid followed by drying of the coated particles. The preferred method involves tumbling the applicators with finely divided conductive material until a uniform coating is obtained.

Only a small amount of conductive material, usually 0.01 to 0.5% by weight of the quantity of applicator used is needed. After applicators have been used for some time it will be necessary to replenish the coating of conductive material.

Figure 3 discloses a typical tumbling barrel 32 in which is jiggered a sheet of thermoplastic 34 which has been heated and bent to conform with the interior configuration of barrel 32. A limited number of coated impactors 36 are introduced into the barrel and the barrel slowly rotated as by rotation of rollers 38 so that the applicators slowly roll over the surface of the plastic without cascading as occurs in the normal operation of a tumbling barrel as in burnishing operations. After treating, the plastic sheet may be reheated and flattened to its original shape.

The invention has been described with respect to flat sheeting however it is applicable to treating of any complex shape over or in which the applicators may be rolled.

Plastics which may be treated by the method of this invention include polymethylmethacrylate, polystyrene, phenolformaldehyde, polyvinylchloride and polyvinylidene chloride, it being understood that this listing is merely representative and not to be construed as limiting.

The following examples illustrate the invention:

Example 1

3000 grams of polystyrene beads and 3 grams of graphite (grade 200-10 made by Dixon Crucible Company) were charged to a 10 gallon drum and the whole rotated at 40 revolutions per minute for 10 hours. At the end of this time a sheet of polymethylmethacrylate was mounted so as to occupy a section of the circumference of the drum, all of the charge in the drum being placed on one side of the sheet. Rotation was continued for 10 hours at 20 R. P. M., the speed of rotation being such that only a rolling motion of the charge took place. The sheet had a relatively uniform coating having a resistance of 0.6 megohms per square and a light transmission of 70%.

Example 2

5 grams of graphite and 1000 grams of XXX grade polystyrene beads made by Kopper Co., Inc. were charged to a 2000 cc. bottle which was rotated at about 40 revolutions per minute for 13 hours.

A porcelain lined metal tray 16 inches long and 10 inches wide was arranged to pivot about the mid point of its length while one end was moved up and down through a stroke of 2 inches at a rate of about 50 cycles per minute. A sheet of polymethylmethacrylate $\frac{1}{16}$ " thick and 4 inches square was taped to the bottom of the pan. The polystyrene beads, coated as described above, were placed on top of the sheet. The pan was started oscillating.

The beads moved back and forth on the sheet with a rolling motion. The oscillation was continued for 2½ hours after which the sheet was removed, washed with soap and water, dried and examined. The sheet bore a uniform conductive coating having a resistance of 4 megohms per square and light transmission of 84%. The sheet was free of scratches.

This Example 2 represents my best present judgment as to the preferred embodiment of my invention.

Example 3

2 grams of graphite of the 200-10 grade and 2000 grams of $\frac{1}{8}$ " steel balls were charged into a 500 cc. bottle which was then tumbled for 5 hours at 40 revolutions per minute so as to form applicators. The applicators were then charged into a 16" x 10" x 1" tray having a $\frac{1}{8}$ " polystyrene sheet on the bottom. The tray was tilted about 5000 times causing the applicators to roll across the polystyrene each time.

After washing with soap and water the polystyrene was found to have a light transmission of 75% and a resistance of 100,000 ohms per square on the coated face. The surface was not pitted or scratched as a result of the treatment.

Although it has been pointed out that adhesives are not required in carrying out this invention, it is to be noted that pretreatment of the surface before coating may be helpful under some circumstances. Such treatment may include the cleaning of the surface or the heating of the surface until it is tacky.

There is shown in Figure 1 infra-red heat lamps 10 which may be used to heat the surface of the plastic.

In carrying out the invention the atmosphere within the rotating barrel may be adjusted to meet the requirements of the particular combination of the coating material and article to be coated such as low or high ambient temperature and/or a reducing gas atmosphere to prevent oxidation of the various surfaces.

In the referenced copending application entitled "Improved Electrically Conductive Articles and Method of Making Same" filed of even date, it was disclosed that the coated plastic articles may be advantageously treated with a solvent, for the plastic, to fix the coating more permanently. This treatment may be used on the product of this process.

Although preferred embodiments have been disclosed, it will be understood that modifications may be made within the spirit and scope of the invention.

I claim:

1. The process of coating a transparent substrate selected from the group consisting of synthetic resins and cellulose acetate with an electrically conductive adherent coating of graphite, consisting of the steps of coating a plurality of substantially spherically shaped particles with finely divided graphite and then gently rolling said plurality of coated spherical particles over said transparent substrate solely by their own weight so as to avoid impacting said coated particles against said substrate, and maintaining said rolling step until the substrate has deposited thereon a transparent electrically conductive coating.

2. The process of claim 1 wherein said substrate is polystyrene.

3. The process of claim 1 wherein said substrate is polymethyl methacrylate.

4. The process of claim 1 wherein said substrate is cellulose acetate.

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