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APPARATUS FOR COOLING ARTICLES WITH PARTICULATE MATERIAL

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FIG. 1

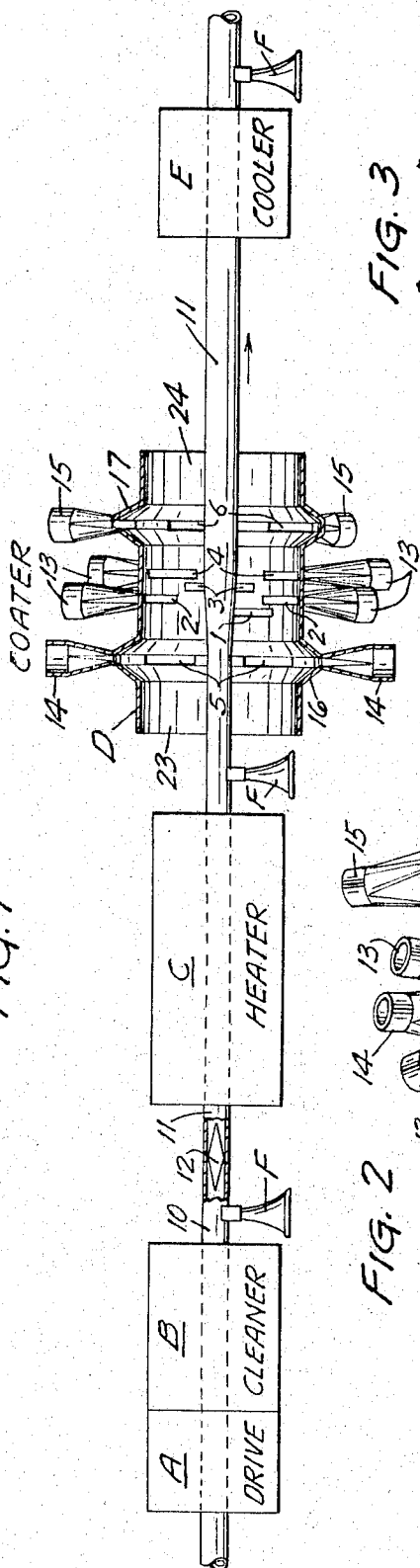


FIG. 3

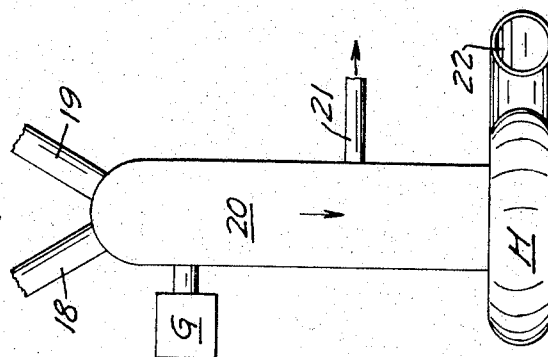
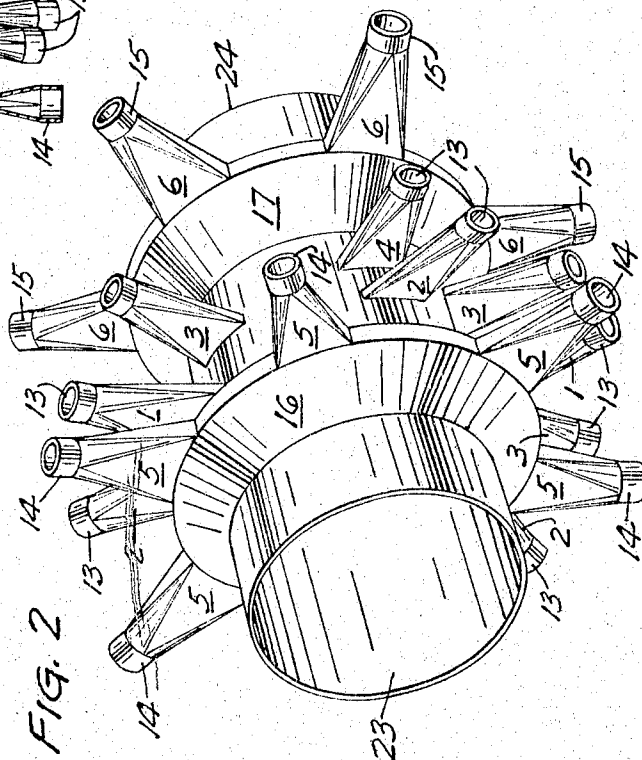


FIG. 2



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3 Claims. (Cl. 118—309)

This invention relates to an apparatus and method for handling materials to accomplish coating of articles, and more particularly relates to apparatus and a method for continuous coating of articles with dust-like particles without severe dust escape and resultant unhealthy environment.

The coating apparatus of the invention, in its preferred embodiment, is designed so as to permit articles to be passed through a mist of dust-like coating material in a continuous manner while suspended free of physical contact with any part of the apparatus forming the coating chamber. No seals are required at the inlet or exit ports or openings of the coating chamber; and yet escape of dust particles from the chamber is largely prevented and may be entirely prevented.

The apparatus is particularly useful for continuous coating of elongated articles such as pipes, angle irons, structural members such as those required in bridge construction, and flat articles or even small parts.

Suspension coating techniques such as spray coating or fluidized bed coating are well known, and permit the coating of articles with smooth uniformly-thick layers of thermoadhesive materials, despite irregularities such as corners, angular projections or other irregular high spots on articles. Known methods generally require that the article first be heated to a temperature at which the solid thermoadhesive particles used in coating will coalesce and fuse upon the surface of the article.

These existing methods, however, suffer from several disadvantages. Ordinary spray gun application of thermoadhesive particles upon a pre-heated article creates dust problems. Employment of a fluidized bed for coating inherently limits the size of an article to be coated to the size of the fluidized bed into which the article must be dipped; and fluidized bed techniques also are not free of dust problems. Enclosure of the dust-like coating mist within a conventional spray coating chamber may serve to reduce dust problems, but continuous coating of articles moving into and out of that chamber necessitates that ports be provided for ingress and egress. Even operation of a conventional dust chamber at a reduced pressure does not entirely obviate escape of dust from the inlet and outlet ports. Further, in the conventional spray coating chamber, eddy currents are created which entrain the particulate or dust-like thermoadhesive particles and cause some surfaces of a pre-heated article to be contacted with excessive amounts of dust and other surfaces to be starved. Rotation of an elongated article as it passes through such a chamber may serve to minimize excessive or inadequate coating on various portions of the article; but to effectively accomplish this, a rather high rate of rotation for smaller-diameter elongated articles is generally required. Rotation of elongated articles such as pipe tends to introduce an additional handling problem for the pipe coater, one which becomes the more serious when smaller diameter pipe is to be coated.

This invention largely overcomes problems such as mentioned in the foregoing paragraph and permits continuous rapid coating of articles with a uniformly-thick layer of coating material on all surfaces thereof without the necessity of rotating the article during its passage through the coating zone. Rotation of the article thus

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becomes optional. The coating zone is defined by the flow of the dust material itself, and not by seals at ingress and egress ports of a coating chamber as conventionally used.

Flow of particulate coating material into the coating chamber of this invention and upon an article to be coated is such that the coating material, in a converging curtain substantially entirely surrounding the article, strikes the article (e.g. pipe) at an angle essentially perpendicular to its line of travel through the coating chamber. Vacuum removal of excessive particulate material occurs in annular zone areas on each side of the coating zone of the coating chamber. Thus, eddy currents as well as inrushes of external air are not present in the coating zone and do not have an opportunity to cause particles of the coating material to be blown away from the article to be coated. Such problems exist, however, when the coating curtain of particles is next to a port opening and the vacuum removal means is most remote therefrom. Indeed, when the coating curtain is between the open port and internal vacuum removal means, it becomes impossible to effectively coat a mixture of different types of particles (e.g., pigment or spheroidal filler particles separate from thermoadhesive particles) without phase separation caused by in-rushing air and its effect on particles of different density in the coating curtain.

The invention will be described with particular reference to a drawing, made a part hereof, wherein:

FIGURE 1 is a schematic representation of the association of various elements of apparatus particularly useful for coating long articles such as pipe, with the coater itself illustrated in sectional elevation;

FIGURE 2 is a schematic perspective view of the coater; and

FIGURE 3 is a schematic illustration of a conduit system for control of the flow of dust particles through the coating chamber.

Referring to FIGURE 1, the over-all operation of coating articles, e.g., pipe, with a protective resin layer, using the apparatus and method of the invention will be described. Two lengths of pipe 10 and 11, joined together by double cone coupler 12, are moved from left to right in FIGURE 1, by a drive unit A of conventional manufacture. External surfaces of the pipe to be coated are subjected to a cleaning action (e.g., sandblasting) in cleaner B, also of conventional manufacture. Just prior to being coated, the pipe passes through a heater C, where the temperature of the pipe is raised above the lowest temperature at which the dust-like or pulverulent thermoadhesive material used in coating is fused, but no higher than the temperature at which the pulverulent material tends toward decomposition on contact with the heated pipe in coater D. Where dust-like thermoadhesive particles which coalesce and thermoset rapidly on contacting a properly pre-heated pipe are employed, it is to be understood that the pre-heat temperature employed may desirably be such that adequate heat is introduced into the pipe and therefore available to effect the rapid thermosetting of such thermoadhesive particles without need for subsequent auxiliary heat. This concept will be explained further in detail below.

Directly from the heater C, the pipe is passed into the coater D, as this arrangement permits of maximum control of the temperature of the pipe (or other article to be coated) as it passes through coater D. Of course, if desired, induction heating of articles to be coated may be accomplished essentially within the area where coating with the thermoadhesive particles is done. The particular expedient employed to gain proper article heating for coalescence and even thermosetting of pulverulent thermoadhesive materials in coating may vary, as will be evident to those skilled in the art.

In coater D, particles of thermoadhesive contacting the heated pipe adhere to its surfaces and coalesce to form an essentially uniformly-thick coating which, when preferred thermosetting pulverulent particles are employed with appropriate pre-heating of the article to be coated, autogenously thermosets in situ. After leaving coater D, the pipe preferably is free of any supporting means for a short distance, the time for traversing that distance preferably being just sufficient for the thermosetting action of coalesced thermoadhesive particles especially designed to rapidly cure at elevated temperatures, or just sufficient to allow non-thermosetting particles to cool adequately to a non-tacky state after coalescence and fusion. The distance that the coated article traverses after leaving the coater without being contacted on its coated surface by any supporting element may vary; and if desired, the coated article may be passed through a cooler E prior to being contacted on its coated surface with any elements such as a support member F.

Also, if desired for the purpose of checking freedom of the coating from flaws, the coated article may be passed centrally through a circular electrode as it emerges from the coating zone of the coating chamber. For this purpose, it is suitable to use a circular conducting member having inwardly projecting conductive needles (i.e., electrodes). The coated article is grounded and passed centrally through this circular member, free of contact with the inwardly projecting needles; and the voltage applied to the circular member with its inward projecting electrodes is sufficient to form an intense electrical field with corona discharge from the needle electrodes to the article, such as pipe, passing through the field. At bare spots, pinholes or places of inadequate coating deposit, the air in the field breaks down and an arc discharge occurs. The arc discharge may be used to actuate, in timed relationship, one or more of several spray guns spaced concentrically about the path of travel of the coated article. Thus a spray of patching thermoadhesive particles may be applied to repair any defect promptly, if such were ever to become necessary.

The voltage applied to the needle electrodes may vary depending on spacing from the coated article, thickness of coating desired to be maintained, etc. Illustratively, one may use about 11,000 to 16,000 volts at a one-half inch air gap for many pipe coating operations. With a "jeep" test arrangement as described, it will be evident that smudging or disruption of the hot and therefore somewhat plastic coating on the article is avoided, since the coating is not contacted by any member associated with the test electrode (a deficiency of heretofore-used "jeep" testing apparatus); and yet testing of the coating is effectively accomplished promptly after its formation so that remedial measures, if ever necessary, may be accomplished promptly while the article is still hot and without the necessity of a subsequent special heating cycle.

Referring now to the sectional view of FIGURE 1, and perspective view of FIGURE 2, the coater will be described. It is essentially cylindrical in general shape, and is oriented horizontally in a production line such that metal pipe articles for coating are passed essentially through the center or axis of the cylindrical chamber. Each end of the cylindrical chamber is open: one serves as the entrance and the other as the exit for the pipe or other article to be coated. The total length of the coater along its axis generally will not exceed 9 or 10 feet, with coaters as short in length as 6 or 4 (or even 2) feet being usually preferred.

Intermediate the open ends of the coater is a coating zone into which inlet conduits 13 empty, preferably with the conduit connection to the mid-section of the chamber being flared or fanned in a circumferential direction (as distinguished from an axial direction). Flaring of the conduit in this manner causes its opening into the mid-section of the chamber to be elongated also in a circumferential direction.

A multiplicity of inlet conduits emptying into the mid-section of the coating chamber is required; and by this is meant that at least 4, even at least 6, conduits must open into the mid-section of the chamber. As many as 20 or 30 inlet conduits are useful and even preferred. Further, these conduits must be staggered about and encompass the entire circumference of the mid-section of the chamber. It is the large number of inlet conduits and the staggered encompassing orientation in the mid-section that permits the necessary large volume of dust coating material to be supplied to the chamber in a discharging mass or sheath essentially perpendicular to the axis of the coater and centripetally directed within the coater. No extraneous or secondary air plays a significant part in affecting the flow pattern of dust particles discharged in the mid-section of the coater by the inlet conduits 13. The particles so discharged are, of course, carried or entrained by air currents from the conduit system. But extraneous or secondary air does not play any significant part in the flow pattern of the discharge particles. They proceed uninterruptedly toward the center of the mid-section of the coater; and as they reach this portion, their concentration and the concentration of the air carrying them is such that axial spreading of the flow pattern occurs.

It should be recognized that the pattern for staggering the inlet conduits 13 is desirably rather uniform. For example, the openings for the inlet conduits 13 may be spaced in 4 compact circumferential groups 1, 2, 3 and 4, each defined by planes perpendicular to the axis of the mid-section of the coater. Each group may, for example, consist of 3 inlet openings spaced about 120° apart about the circumference of the mid-section of the coater. Preferably, the openings of different groups of inlet conduits are staggered from the openings of adjacent groups (e.g. by 30-40°) such that the quantity of particulate fed toward the axis of the coater is approximately the same from all radial angles. For convenience of association between FIGURES 1 and 2, the openings in FIGURE 1 and the conduit flares in FIGURE 2 are numbered the same.

Axially to each edge of the coating zone (containing the multiplicity of inlet conduit openings) is located a withdrawal zone or exhaust zone from which excess particulate material not deposited or coated upon an article is removed. Exhaust conduits numbered 14 are connected to the exhaust zone nearest the entrance opening 23 of the chamber; and exhaust conduits numbered 15 are connected to the exhaust zone nearest the exit opening 24 of the chamber. Exhaust conduits likewise have circumferentially elongated openings 5 and 6 in preference to circular ones; and the exhaust conduits themselves are preferably circumferentially fanned in their connection to these elongated openings. As in the case of the inlet openings and the fanned inlet portions, the numbers given in the drawing for the exhaust openings and the fan portion of the exhaust conduits are the same.

A plurality (e.g., at least 3, preferably at least 5 or 6 up to about 10—or optionally more) of exhaust conduits are connected in circumferentially spaced (preferably approximately equidistantly circumferentially spaced) fashion about each exhaust zone of the coater. They may also be staggered in different planes transverse to the axis of the coater. Several exhaust conduits have been found to be required as a practical matter in order to remove the necessary volume of air, with entrained excess coat-able particles, so as to prevent or substantially prevent escape of the particles out of the entrance and exit ports of the coater. Preferably the exhaust zones are located in expanded annular portions 16 and 17 of the coater; but these expanded portions are not equipped with restricted openings. Quite the reverse is true in that the expanded annular portions provide enlarged areas for free movement of air and entrained particulate. Thus, manifolds as such are lacking. Pressure in the exhaust

zones is maintained at a reduced level (e.g., an inch of water below normal air pressure) as compared to environmental pressure outside the coater and as compared to the pressure in the coating zone.

A major advantage of a coater formed as described is that it may be made large enough (e.g., 1 or 2 feet in diameter) to accommodate the largest pipe or other elongated article to be coated and yet be versatile enough to be used to coat all smaller sizes. If desired, use may be made of baffle discs having diameters about equal to the internal diameter of the coater and having central axial openings large enough to allow free non-contacting passage of an article to be coated. Such discs may be placed at the entrance and exit ports of the coater, particularly when a large diameter coater is used to coat small diameter pipe; and they do aid, in combination with the exhaust operation, in preventing escape of particulate from the open ends of the coater. Such discs also may be placed between the coating zone and the exhaust zones of the coater. Their use is optional.

It should be recognized that both the inlet and outlet or exhaust conduits connected to the coater are illustrated in the drawing as terminating a short distance from the coater. This mode of illustration has been done for convenience only. Were the conduits shown in their entirety, only confusion would result. Thus, they have been terminated to permit ready comprehension of the invention.

The path taken by the coating particulate material will now be described. It leaves the coater through conduits 14 and 15; and these conduits are joined together at Y-junctions (not shown) at various stages until the final stage of merging as by conduits 18 and 19 into enlarged conduit or flow chamber 20. The larger conduit 20 is connected intermediate its ends with a filtered vacuum pump G (graphically illustrated) for removal of air and collection of any dust-like particles entrained with that air. Also, at the end of that larger conduit 20, opposite the introduction point of material from conduits 18 and 19, is a fan H which serves also to draw air from the "vacuum" or exhaust zones of the coater. Just prior to the position of the fan H in large conduit 20 is a conduit 21 for the introduction of additional pulverulent material into the system. From blower fan H, material is thrown through conduit 22 which divides into multiple sets of individual conduits 13 for feeding the pulverulent material into the coating zone of the coater. Thus, it will be evident that the apparatus for handling the pulverulent coating materials constitutes a closed system and is capable of operation free of dust escape.

Many different types of solid pulverulent thermoadhesive coating materials (e.g., epoxies, phenolics, polyethylenes, etc.) may be employed in using the apparatus and materials handling system of the invention. Even thermoadhesive particles such as inorganic enamel frit particles may be employed. As used herein, "thermoadhesive particles" refers to particles which fuse together on heating and remain so fused after cooling. Such particles may or may not also exhibit thermosetting properties. Preferred illustrative thermoadhesive particles which also are extraordinarily rapid in their ability to thermoset or cure within seconds at elevated temperatures, are those wherein each particle comprises a uniform blend of epoxy resin, latent heat-activatable epoxy-reactive hardener and accelerators or catalysts for the reaction between the epoxy resin and hardener. A useful illustrative formulation for this type of rapidly-reactive epoxy resin thermoadhesive particles, remaining stable for long periods at room temperatures or even slightly higher temperatures, is as follows: 591.4 parts of solid epoxy resin (equal parts of "Epon 1001" and "Epon 1002"), 51 parts of isophthalyl dihydrazide, 10 parts of dicyandiamide, 2.3 parts of tris(dimethyl-aminomethyl) phenol, 5.3 parts of alkyl ammonium bentonite ("Bentone-38"), 350 parts of finely divided mica filler, and 10 parts of chrome oxide pigment. Generally, it is desired that the particles of this resin mix

should pass through a 40 mesh screen; and they may be as small as 200 mesh, or even smaller (e.g., minus 325 mesh). Particles of about 80 mesh or smaller are preferred. The particles of this composition melt or fuse at about 300° F., and within a minute or so after fusing at this temperature, the mass gells and cures to a thermoset infusible state. At 450° F. (a suitable pre-heat temperature for articles to be coated with this powder) the particles of this composition melt, fuse and cure to a thermoset infusible state within seconds.

The coater of the invention is particularly useful in the application of thermoadhesive particles as a uniform coating on appropriately heated articles, usually, but not necessarily, of metal. However, organic filler dusts (e.g. wood flour), or inorganic grit or other particulate material (e.g. talc) may be applied with thermoadhesive particles during a coating operation; or such particulate may be applied over a previously applied thermoadhesive layer by using the coater of the invention. Indeed, the coater of the invention may be used to apply non-thermoadhesive particulate material over a tacky substrate article (or a tacky coating on an article), wheher tackification is gained by heating or is exhibited under normal room temperature conditions. Different layers of material (e.g., a thermoadhesive coating, followed by a coating of grit particles) may be applied sequentially over a base article using a series of "annular" coater means as described.

While the invention has been described with particular reference to coating elongated articles such as pipe, it will also be evident that the coater here described may be useful for coating discrete articles on a continuous conveyor basis (or even possibly on a piece basis such as by dipping the article within the confluence of particles in a vertically oriented coater).

Also, if desired, pipe or like articles may further be wrapped with paper or other strip material after they are coated. Such wrapping is conveniently accomplished by rotating the pipe during the coating operation and spirally applying the strip material as the rotating coated pipe emerges from the coater.

Sometimes vibration of the coater during the coating operation serves as a desirable adjunct to air and powder flow to obviate clogging of the apparatus.

That which is claimed is:

1. Apparatus for coating articles with particulate material comprising an elongated horizontally-oriented essentially-cylindrical chamber open at opposite ends for entrance and exit of articles passed therethrough for coating, a multiplicity of staggered inlet conduits emptying into the mid-zone of said chamber intermediate said open opposite ends, said inlet conduits being adapted to empty particulate material carried by air into said chamber in a direction essentially perpendicular to a line through the center of said chamber from the entrance to the exit opening thereof, a group of exhaust conduits connected to an exhaust zone of said chamber located intermediate said mid-zone and said entrance end of said chamber, a group of exhaust conduits connected to a second exhaust zone of said chamber located intermediate the mid-zone of said chamber and said exit opening of said chamber, said exhaust conduits being effective to remove air and non-coated particulate from said chamber so as to obviate significant escape of said non-coated particulate from the open ends of said chamber, and means to support articles passing through said horizontally-oriented chamber from the entrance to the exit opening thereof without physical contact between said articles and said chamber.

2. Apparatus for coating articles with particulate material comprising an elongated horizontally-oriented essentially-cylindrical chamber open at opposite ends for entrance and exit of articles passed therethrough for coating, a multiplicity of staggered inlet conduits emptying into the mid-zone of said chamber intermediate said open opposite ends, said inlet conduits being adapted to empty particulate material carried by air into said chamber in

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a direction essentially perpendicular to a line through the center of said chamber from the entrance to the exit opening thereof, a group of exhaust conduits connected to an exhaust zone of said chamber located intermediate said mid-zone and said entrance end of said chamber, a group of exhaust conduits connected to a second exhaust zone of said chamber located intermediate the mid-zone of said chamber and said exit opening of said chamber, at least one of said exhaust zones being defined by an expanded annular portion of said chamber, said exhaust conduits being effective to remove air and non-coated particulate from said chamber so as to obviate significant escape of said non-coated particulate from the open ends of said chamber, and means to support articles passing through said horizontally-oriented chamber from the entrance to the exit opening thereof without physical contact between said articles and said chamber.

3. Apparatus for coating articles with particulate material comprising an elongated horizontally-oriented essentially-cylindrical chamber open at opposite ends for entrance and exit of articles passed therethrough for coating, a multiplicity of staggered inlet conduits emptying into the mid-zone of said chamber intermediate said open opposite ends, said inlet conduits being adapted to empty particulate material carried by a gaseous stream into said chamber in a direction essentially perpendicular to a line

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through the center of said chamber from the entrance to the exit opening thereof, a group of exhaust conduits connected to an exhaust zone of said chamber located intermediate said mid-zone and said entrance end of said chamber, a group of exhaust conduits connected to a second exhaust zone of said chamber located intermediate the mid-zone of said chamber and said exit opening of said chamber, said exhaust conduits being effective to remove gases and non-coated particulate from said chamber so as to obviate significant escape of said non-coated particulate from the open ends of said chamber, conduit means for carrying said non-coated particulate to means for reintroducing said non-coated particulate into said chamber through said inlet conduits, and means to support articles passing through said horizontally-oriented chamber from the entrance to the exit opening thereof without physical contact between said articles and said chamber.

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