

[54] **APPARATUS FOR APPLYING  
POWERED COATING MATERIAL TO  
AN ARTICLE**

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[57] **ABSTRACT**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 802,795, Feb. 27, 1969, abandoned.

Apparatus for selectively masking surfaces of various length stator cores or the like, and applying coating material to other selected surfaces with a fluidic controlled coating nozzle. A circumferential series of ribs on a core support structure sandwich ported pads which pass coolant fluid to the selected core surfaces to prevent coating material buildup on the core. The ported pads are provided with laterally extending grooves at spaced longitudinal locations along their outer surface to restrict conductive heat transfer longitudinally therealong. Insulation between the ribs and pads restrict the conductive transfer of heat from the pads to the ribs. Fluid control signals to the coating nozzle selectively direct coating material through the nozzle to the other core surfaces or return the constantly flowing coating material to the pulverant coating material storage and supply area.

[52] U.S. Cl. .... **118/69**, 118/301, 118/312, 118/318

[51] Int. Cl. .... **B05b 7/14**

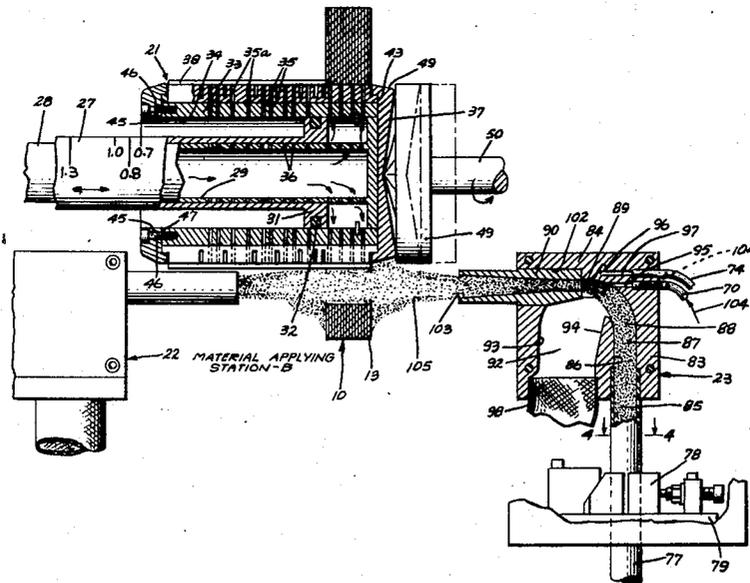
[58] Field of Search ..... 51/11, 8, 15; 118/308, 500, 118/312, 504, 301, 318, 69; 239/124, 125; 137/81.5

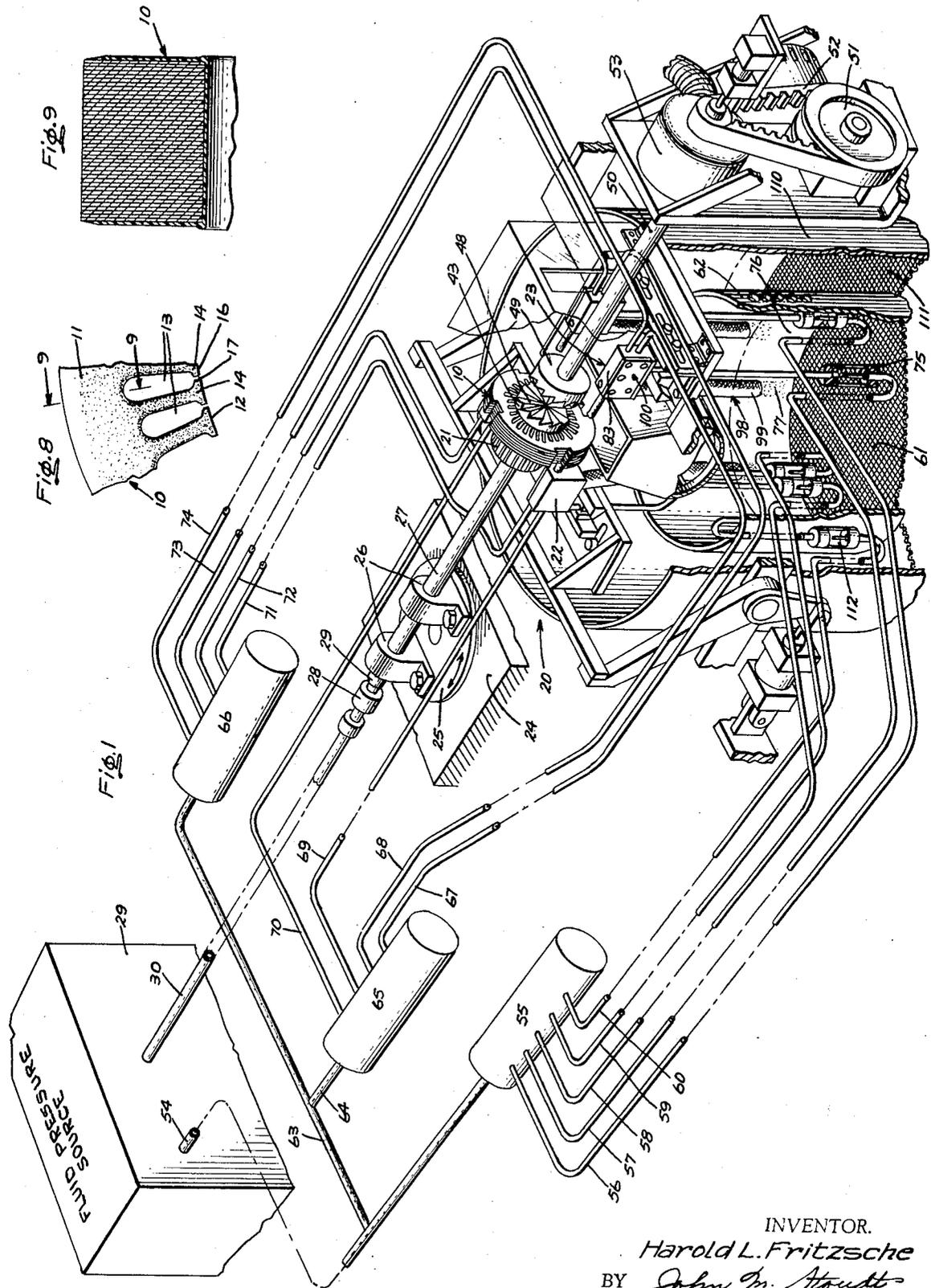
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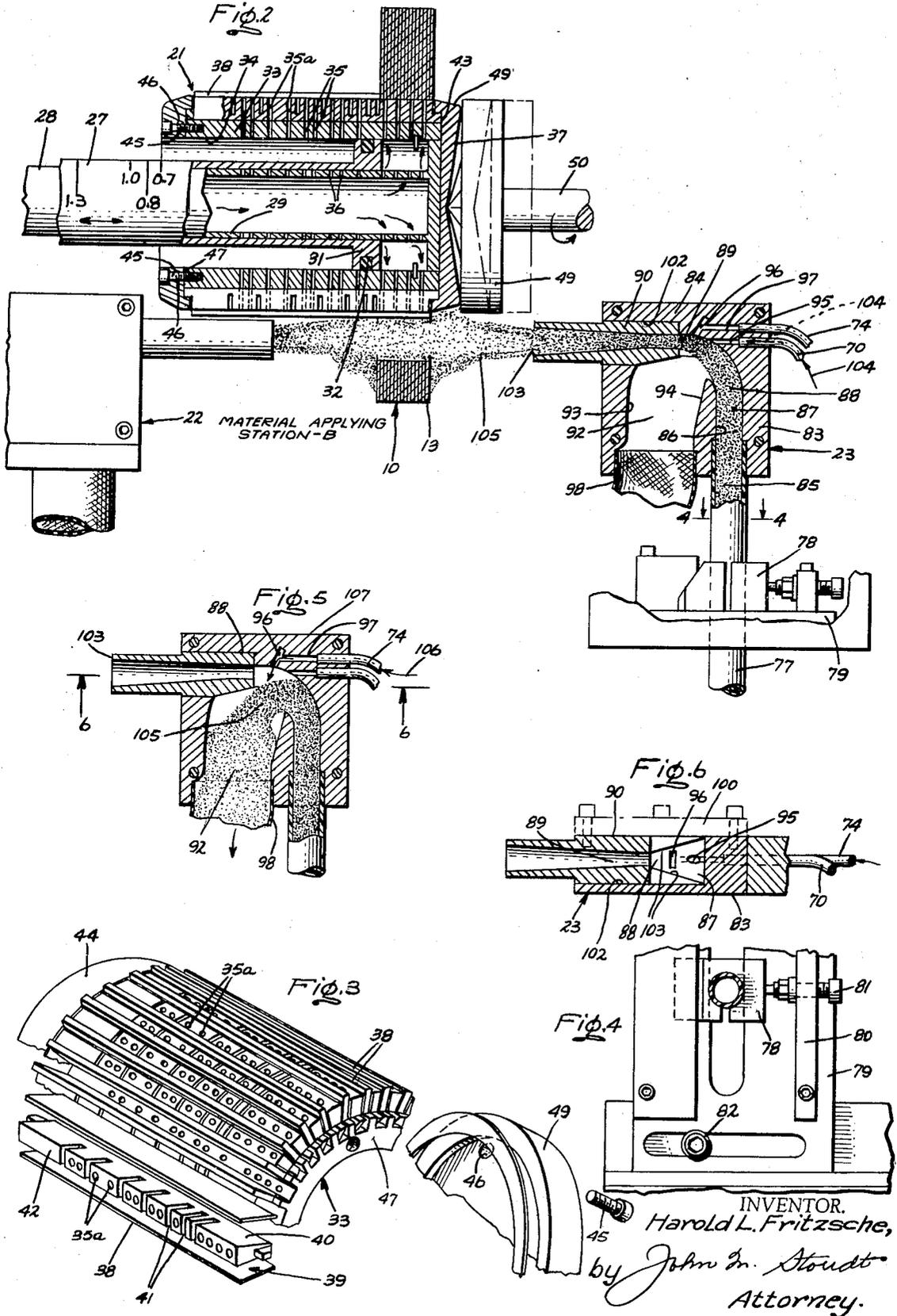
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**11 Claims, 15 Drawing Figures**

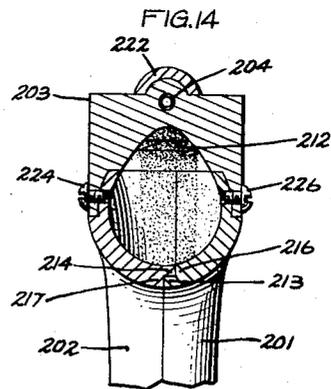
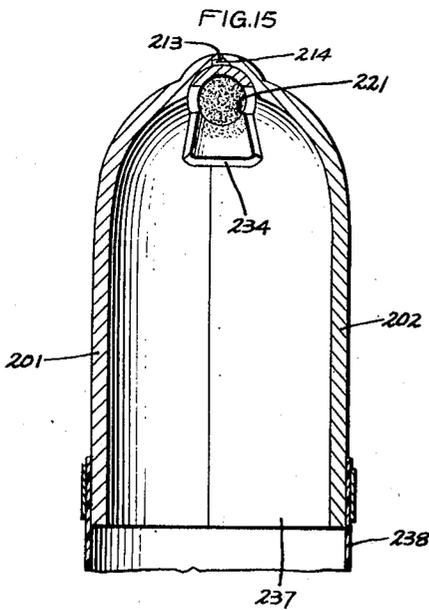
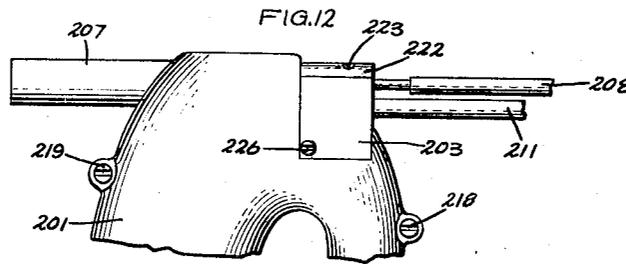
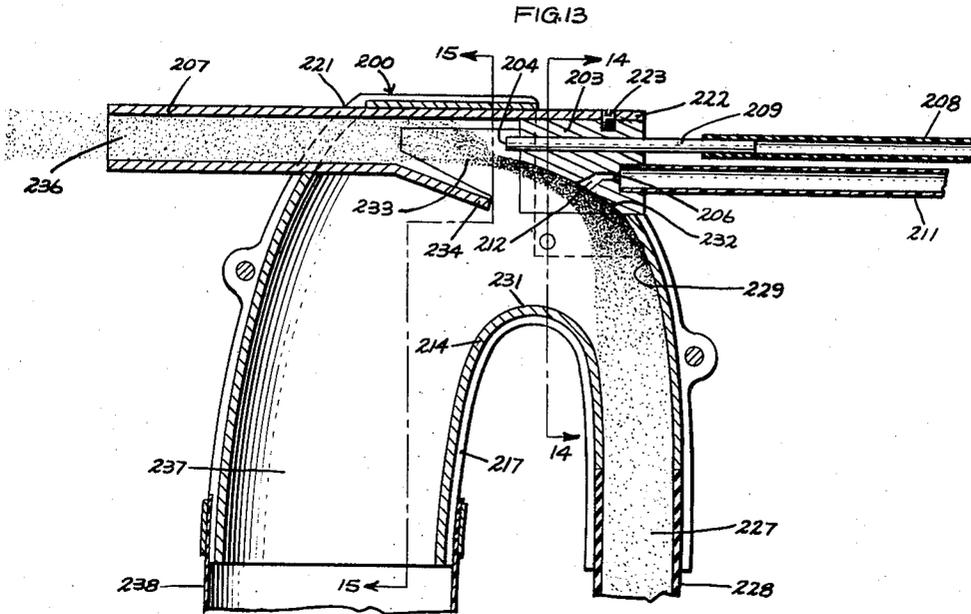




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## APPARATUS FOR APPLYING POWERED COATING MATERIAL TO AN ARTICLE

### CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part application of my co-pending application Ser. No. 802,795 filed Feb. 27, 1969, now abandoned.

### BACKGROUND OF THE INVENTION

The present invention relates to an improved coating apparatus by which the coating of selected surfaces of an article of manufacture is achieved. In particular, the invention relates to the type of coating apparatus which employs pressurized air for masking selected surfaces of magnetic cores to prevent coating material buildup at these locations, while other selected surfaces of the cores are being coated. The coating material is normally in pulverant, fluid form and discharged through coating nozzles onto the surfaces to be coated.

Certain articles of manufacture, such as motor or generator stator cores, are formed with a plurality of passageways which extend through the articles, with the passageways being in open communication with the periphery of the article through a restricted entrance. Where the articles are dynamoelectric machine stator and rotor cores, protective ground electrical insulation coatings normally referred to as "integral insulation" are bonded or fused to the passageway walls of the core, for instance, the winding-accommodating slot surfaces. U.S. Pats. Nos. 3,355,309 and 3,355,310, which issued Nov. 28, 1967, and assigned to the common assignee, are representative of these practices.

It is conventional to mount the stator or rotor core on a rotary support which also functions to mask selected surfaces, such as the peripheral surface of the stator core, opposed surfaces forming restricted entrances to associated passageways extending entirely through the article, and surfaces of the passageways disposed immediately next to or behind the opposed surfaces, while other selected surfaces are being coated with the coating material. One such device for performing this dual function is set forth in U.S. Pat. application Ser. No. 710,103, filed Mar. 4, 1968 by Louis W. Pieper et al, entitled "Apparatus for Controlling the Coating of Selected Surfaces of an Article of Manufacture and Method of Achieving the Same," and assigned to the assignee of this application. Radial slots formed in the supporting member deliver coolant fluid under pressure to the periphery of the support where it flows in the spaces between the member and the selected article surfaces to prevent material buildup on the article. In this way, the selected surfaces of the article are efficiently and effectively masked while other surfaces are being coated.

Since the stator and rotor cores which are coated. In addition, the mask may increase in temperature an amount sufficient to cause the coating material to build up on the mask itself. Furthermore, due to the existing temperature differential between the mask and core to be supported thereby, there may be difficulty in either placing the heated core on the mask prior to coating or removing the same subsequent thereto.

Conventional coating nozzles frequently fail to operate efficiently because they tend to clog at low flow rates. Conventional nozzles also often fail to pro-

vide a consistent spray pattern due to a tendency of stalagmite coating material buildup in the nozzle area which, if not removed, can completely stop nozzle operation.

Further, prior coating apparatus involves the passage of powder coating material through passages having multiple curves, in some cases undulating hoses, which may result in the formation of powder lumps during passage, causing pulsation of the powder stream during material application and uneven coating.

### SUMMARY OF THE INVENTION

It is, therefore, a principal object of this invention to provide an improved apparatus for the achievement of selective coating of articles of manufacture with increased efficiency and maximum control in the coated surface selection.

Another object of this invention is to provide an improved method and apparatus for the controlled coating of selected surfaces of an article of manufacture wherein the pressurized fluid for air masking is supplied through a calibrated valve whose position is readily adjustable and may be visually noted to correlate masking to the size of the article being masked.

A further object of this invention is to provide an improved apparatus for coating selected surfaces of an article of manufacture with powdered material which is characterized by relatively low fluid pressure throughout the coating apparatus and air passages and by a lack of fluid pulsation therein, even during start-up of the coating apparatus.

A still further object of this invention is to provide an improved fluid pressure coating apparatus for directing powdered coating material onto an article of manufacture in which the powder content, and the mixture velocity of the coating nozzle may be independently controlled.

In carrying out the objects in one form, there is provided an improved and simplified apparatus for masking selected surfaces of an article of manufacture, for example, the peripheral surface of a stator core carrying opposed surfaces forming restricted entrances to associated passageways extending entirely through the article, and surfaces of the passageways disposed immediately next to or behind the opposed surfaces, while other selected surfaces are being coated with coating material. In the illustrated embodiment, a masking medium and coolant transmitting structure includes a radially perforated inner tube which carries a sleeve valve in the form of an outer imperforate tube telescopically and sealably movable relative to a perforated core support member, shown in cylindrical form due to the configuration of the article of manufacture, the magnetic stator core. The core support member carries a plurality of elongated circumferentially positioned, ported pads in the form of radially bored sectors, whose ports are aligned with the radial openings of the support member. Thin insulation members of substantially the same radial height as the bored sectors are positioned intermediate the bored sectors, and the outer diameter of the mask assembly is dimensioned to form a slip-fit with the heated stator bore. Coolant fluid passes through the central perforated tube, and the outer imperforate tube is slid axially of the assembly to selectively and simultaneously vary the axial length of

the perforated inner tube covered by the outer tube and the total effective discharge area of the ports in the core support member. Thus the flow path of mask air is variably directed to the peripheral gap between the bore sectors and the stator.

The apparatus of the present invention is further characterized by a coating nozzle or gun, operating under fluidic principles, including a nozzle discharge opening in the form of a first coating material outlet for directing the stream of powder coating material out of a control chamber passageway and toward the selected surface of the article to be coated and supported by means adjacent to the coating nozzle. Coating material supply means are provided for directing a stream of powder coating material to coating material inlet means adjacent the chamber passageway. An inwardly curving surface forms a portion of the selected chamber passageway between the coating material inlet means and said first coating material outlet means. A second material outlet means is carried by the nozzle or gun for transferring the stream of powder coating material from the selected passageway and away from the first material outlet means for recirculation and reuse. Control means are disposed in the vicinity of the inwardly curving surface and in fluid communication with the path of travel of the coating material stream for selectively controlling or diverting the coating material stream from the first outlet means to the second outlet means or vice versa without discontinuing flow of the coating material stream into the selected passageway.

In a specific embodiment, the control means involves fluid ports terminating along the inwardly curving surface and opening into the selected passageway for selectively directing a first fluid control stream in generally the same direction as the coating material stream and into contact with the stream of coating material as it moves adjacent the inwardly curving surface for facilitating the discharge stream of the coating material through said coating nozzle and a second fluid control stream for deflecting the coating material stream from the curving surface into the second outlet means.

The subject matter which I regard as my invention is set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof may be better understood by referring to the following more detailed description taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective, partially schematic, of one form of improved apparatus illustrated with respect to the application of coating material onto selected surfaces of an article of manufacture, a dynamoelectric stator core in the exemplification.

FIG. 2 is an enlarged side elevational view, partially in cross-section, of the material applying guns and article holding and masking components seen in FIG. 1 during the application of coating material onto the desired surfaces of the stator article exemplification.

FIG. 3 is a partly exploded perspective view of the article holding and masking components shown in FIGS. 1 and 2.

FIG. 4 is a view taken along lines 4—4 in FIG. 2 in the direction of the arrows.

FIG. 5 is a sectional view of one of the material applying guns revealed in FIG. 2, during the non-material applying portion of the operating cycle.

FIG. 6 is a sectional view taken along line 6—6 in FIG. 5 in the direction of the arrows and assuming that FIG. 5 is shown in full.

FIG. 7 is a graph showing a typical effect of coating feed rate on the total weight and average coating thickness provided on the article being coated by the material applying devices under varying temperature conditions of the article.

FIG. 8 is an enlarged fragmentary view of a part of the stator article exemplification after the coating has been applied and hardened on the selected surfaces.

FIG. 9 is an enlarged scale sectional view taken along line 9—9 in FIG. 8 in the direction of the arrows.

FIG. 10 is a fragmentary side view, partly broken away and partly in section, of a modified form of an article supporting and masking arrangement especially effective when used in connection with unbonded laminated articles, for instance, magnetic cores.

FIG. 11 is a view taken along line 11—11 in the direction of the arrows in FIG. 10.

FIG. 12 is a fragmentary side view of another embodiment of a material applying gun that may be used in lieu of the material applying gun illustrated in FIG. 5.

FIG. 13 is an enlarged side elevational view, in section, of the material applying gun shown in FIG. 12.

FIG. 14 is a view taken along line 14—14 in the direction of the arrows in FIG. 13, assuming FIG. 13 to be shown in full.

FIG. 15 is a view taken along line 15—15 in the direction of the arrows in FIG. 13, assuming FIG. 13 to be shown in full.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings in more detail, the preferred embodiment of the invention is illustrated by way of exemplification in connection with an article of manufacture in the form of a laminated core 10 which may be built up from a number of conventionally held together laminations in stacked relation. The core includes an annular yoke section 11, (FIGS. 8 and 9), and angularly spaced apart tooth sections 12 which define accommodating passageways in the form of slots 13. The tooth sections each terminate at the free ends in enlarged lips 14 having curved peripheral surfaces 16 which together form an axial bore adapted to receive a not shown rotor. Opposed entrance surfaces of adjacent tooth section lips define restricted slot entrances 17 communicating between the bore and the slots 13. Initially the core 11 is preheated to a temperature above the fusing or melting point of the particular resin coating material in powder form which will form the integral coating bonded to the desired surfaces, such as the surfaces of slots 13 in the core shown. The phrase "fusing or melting" point, as used herein, denotes the temperature at which the powdered material melts, flows, and becomes sufficiently tacky to adhere to the selected heated core surfaces, the materials also being sufficiently fluid to coalesce and form a continuous coating. The type of coating material may be suitably formulated for the particular application, such as those mentioned in the Bender et al U.S. Pat. No. 3,355,309, and the F. C. Avila U.S. Pat. No.

3,136,650, issued June 9, 1964 and the copending application serial No. 803,034 entitled "Improved Composition and Process for Producing Resinous Laminations" of F. C. Avila, filed on Feb. 27, 1969. The preheating of core 10 may be accomplished in any well known manner, such as by induction heating. After the temperature of the core walls to be coated has been elevated above the melting point of the coating material to the desired degree but below the decomposition temperature of the coating material, the core 10 is positioned on apparatus 20 which incorporates one form of the present invention.

The portion of the apparatus, indicated generally at 21, both supports and masks the selected surfaces of core 10. Thus, selected surfaces of a core may be supported while other predetermined surfaces are being coated with material. With particular reference to the drawings, the portion 21 of the apparatus comprises a structure suitably supported for relative rotation with respect to generally opposed coating material or powder applying devices or guns 22 and 23 arranged in pairs on opposite sides of the rotating support 21, and a second pair of powder applying devices or guns 22a and 23a to the right side thereof. Coating devices or guns 22, 23, 22a and 23a comprise fluid-operated and controlled material discharge nozzle assemblies.

The positioning and arrangement of these nozzle assemblies and the general makeup of one embodiment of a masking medium and coolant transmitting structure illustrated as a rotatable mask and support device 21 may be seen by reference to the elevational view of FIG. 2. The bore mask and support 21 of the present invention is utilized in an integral insulation coating apparatus primarily to prevent coating of selected surfaces of the core such as the bore, opposed restricted slot entrance surfaces of the teeth, and surfaces of the teeth adjacent to the restricted slot entrances. A further desirable feature is the prevention of contamination of the mask itself. A fixed base 24 supports a circular plate 25 which carries spaced bearing members 26 receiving a rotatable inner cylinder 28 that supports, adjacent its perforated end, a control element such as a calibrated sleeve valve illustrated as a tube 27 telescopically movable relative to cylinder 28. The cylinder 28 is connected to a fluid pressure source 29 through a flexible extension tube 30 and a flexible coupling 30a. The rotatable outer tube 27 carries flange 31 at its inner end that is illustrated as including a peripheral seal in the form of O-ring 32. Stator masking is achieved by passing air at some velocity past the stator bore and teeth 12. The outside diameter of the mask 21 is machined to have a slip-fit with the cold stator bore 16 in order to achieve minimum clearance for air passage.

The mask 21 comprises an assembly which further includes a support cylinder or member 33, FIG. 2, having a bore of a diameter on the order of flange 31 such that the sleeve valve flange 31 slides therein. The cylinder 33 and inner tube 28 are provided with coolant emission ports illustrated as perforations 35, 36. The perforations 36 are formed about the periphery of tube 28 for a given length from the end thereof. The inner tube 28 culminates in a flanged end wall 37 having an outside diameter which is also on the order of cylinder bore 34. The radial height of the peripheral

edges 39a of insulation leaves 39 is substantially the same as the radial height of the ported pads 40. These insulation leaves are sandwiched between ported pads 40 and radial extensions or ribs 38 formed on the member 33. Ports shown as radial holes 35a are formed in pads 40 and aligned with radial holes 35 of support cylinder 33. The radial height of the ribs 38 is slightly in excess of the radial height of the pads and insulation leaves. The mask is, therefore, assembled from circumferential sections composed of pads, insulation leaves and ribs.

The ported pads are thermally insulated with respect to the ribs by the insulation leaves and thus the conductive transfer of heat laterally across the pads is restricted. The width of the ribs is such as to permit placement of a stator core on the mask with the ribs positioned between the restricted slot entrance surfaces of the teeth of the stator core. The upper ones of the peripheral surfaces, such as surfaces 16 of the teeth of the core 10, rest upon the ported pads and the insulation leaves are normally positioned contiguous to the slot entrances and do not contact the peripheral surfaces of the teeth. Since only the upper teeth bear against the mask, desirable minimum supporting contact therebetween is maintained. This arrangement will again be described hereinafter in connection of the with FIG. 11.

Circumferentially extending slots 41 are provided at longitudinally spaced locations along the outer surface 42 of the ported pads 40 and control the thermal gradient existing between the preheated core and the structure 21 by restricting the conductive transfer of heat longitudinally along the pads 40. The core 10 is supported on the surfaces 42 of the pads 40, and the assembly is rotated. A flanged circular end frame 43 on the right-hand end of the assembly and an annular flanged ring 44 on the left-hand end are coupled by bolts 45 and 46 to respective ends 47 of cylinder 33 and hold the alternate leaves 39 and ported pads in position on the cylinder. The outer face 49 of the circular end frame 43 is serrated to receive serrated driving disk 48 carried by the rotating drive shaft 50. A drive motor 51, sprocket belt 52 and gear reduction unit 53 rotate shaft 50. Selective rotation of the stator core 10 and the mask and support assembly 21 occurs as a result of longitudinal shifting of the serrated drive member 49 from the dotted line position in FIG. 2 to the full line position.

It is important to note that the bore mask and support assembly 21 provide a masking function involving a minimum of heat loss from the stator to the assembly to thereby promote a more uniform insulation coating with a minimum of material deposit on the mask. The mask operates at a temperature above the ambient dew point thereby preventing moisture accumulation on the mask and possible powder contamination. With the outer tube 27 performing the function of a sleeve valve, a flow path for the discharge of air through the ports is readily preselected, and the total effective emission area of the ports may be selectively adjusted. In order to facilitate visual inspection of the setting of the sleeve valve and facilitate correlation of masking action to the size of the core 10 or other article being coated, the valve is calibrated and indicia are associated therewith that indicate the setting of the valve in terms of the

stack height of various cores. In FIG. 2, the indicia are represented by the alignment marks and numerals 0.7, 0.8, 1.0, 1.3, as viewed consecutively from left to right in FIG. 2, and which correspond to various stack heights, in inches.

Another aspect of the present invention is the employment of pressurized fluid to conduct the insulative powder material to the stator surfaces, which are selectively masked for coating deposition by multiple guns or nozzle assemblies, with the material in pulverant form being fed and exclusively controlled from the single fluid pressure source 29 which also functions as a supply for the pressurized fluid mask. In this respect, turning again to FIG. 1, it is noted that in addition to the supply tube 30 coupled to the bore mask and support assembly 21 a second supply tube 54 conducts pressurized fluid, e.g., air, to a first valve assembly 55 controlling the delivery of air through conduits 56 through 60, inclusive, to various aspirating type pumps positioned within pulverant powder insulative material 61 carried at a predetermined level within a supply tank 62. Tube 54 is also connected by a cross connection tube 63 and tube 64 to spray air valve assembly 65 and to control air valve assembly 66. Valve assemblies 55, 65 and 66 are coupled in parallel. Conduits 67, 68, 69 and 70 direct spray air to the four nozzle assemblies, including nozzle assemblies 22, 23, 22a and 23a, in FIG. 1. The control air valve assembly 66 has coupled thereto conduits 71, 72, 73 and 74 which are also coupled to their respective coating nozzle assemblies.

It may be stated that the valve assemblies 55, 65 and 66 selectively pass fluid under pressure from source 29 to pump the pulverant coating material from storage container 62 to the individual nozzle assemblies and the discharge of the same from the nozzle coating outlet or alternatively, under fluidic control principles, recirculate the coating material to the supply container. In this respect, operation of the spray air valve assembly 65 is mutually exclusive from control air valve assembly 66, since delivery of pressurized fluid from the spray air valve assembly 65, for instance, to a given coating nozzle assembly has a counterpart function occurring with respect to control air valve assembly 66 such that no pressurized fluid is delivered to the same nozzle assembly. Normally, either the coating nozzles are all operating under a common mode in which the coating material is being discharged simultaneously onto the workpiece 10 from opposite sides by all four nozzle assemblies, or the pulverant coating material is being returned to supply 62 under a recirculation mode. Using nozzle assembly 23 of FIG. 2 as an example, conduit 57 passes air from the feed air valve assembly 55 to a pneumatic aspirating type pump 75 disposed beneath the surface 76 of the coating material 61. A pump discharge conduit or tube 77 extends vertically upwardly, or it may be inclined preferably with no bends greater than 90°, to fixed nozzle assembly 23. The nozzle assembly tube 77 passes through block 78 carried by a longitudinally adjustable support member 79. The support member 79 is further provided with a slotted laterally extending member 80 and includes adjustable mounting bolts 81, for instance, to permit lateral adjustment of the position of nozzle assembly 23 with respect to the longitudinal center line of the coating apparatus. Block 78 is positioned within slotted

support 79 aligned with the longitudinal axis of the assembly, and screws 82 allow adjusting of the longitudinal position of pump outlet conduit 77 which acts as a support for the nozzle assembly 23. Thus, each nozzle assembly may be adjusted in the horizontal plane along a line parallel to the longitudinal axis of the coating apparatus and at right angles thereto. Each of the improved fluid operated coating nozzle assemblies of the invention, such as nozzle 23, comprises a block of metal or plastic material having a planar surface, such as surface 84, carrying a configured recess, including an inlet or ingress channel 85, as defined by spaced walls 86 and 87, a control or fluid interaction chamber 88, as defined by curved passageway wall 87, a first outlet or egress passage 89 which, in this case, is formed by inserted coating nozzle 90 which is at right angles to the inlet passage 85 and a second outlet or egress passage 92 which is generally parallel to inlet passage 85 and oriented 90° from the first outlet passage 89. The second outlet passage 92 is defined by spaced walls 93 and 94. It is noted that the diameter or cross-sectional area of the second outlet passage 92 is much greater than that of the first outlet passage 89 or that of inlet passage 85. There is further formed within the block 80 a first pressurized fluid control or spray air passage 95 of relatively small diameter whose axis is in line with the axis of outlet passage 89 formed by nozzle 90. The small passage 95 is also generally tangential to the side wall 87, opening up into the curved portion thereof. A second control passage 96 also constitutes a small diameter bore, which is inclined to passage 89 and opens up onto curved passage wall 87, downstream from the first control passage 95. As mentioned previously, the control passageways 95 and 96 are coupled respectively to the source of spray air and control air emanating from valve assemblies 65 and 66. In this respect, the first control passage 95 receives, in a selective manner, pressurized fluid from valve assembly 65 through conduit 70, while right angle control conduit 96 is coupled through intersecting bore 97 to conduit 74 emanating from control air valve 66. It is further noted that a flexible return tube 98 has one end fluid coupled with the end of the second outlet passage 92. Tube 98 has one end carried by block 83 and the other end 99 vertically disposed within the storage and supply container 62, FIG. 1. As seen from FIG. 1, a thin cover 100 overlies the formed surface 84 of block 83 to form a sealed control or interaction chamber 88, with the exception of passages 85 and 92, control passages 95 and 96 and discharge nozzle passage 89.

Reference to FIG. 6 shows the plan configuration of the various passages within the formed or configured block 83. The coating nozzle 90 is a separately formed element of similar material to that forming block 83. In this respect, a rectangular recess 102 is formed within the block which receives the inner end of nozzle 90. It is noted that the first nozzle assembly outlet passage 89 is divergent from its inner end to the nozzle outlet end 103, while the control chamber 88, in the vicinity of the curved passage wall 87, converges as indicated by tapered side walls 103. Further, the first control passage 95 is circular in configuration at the point where it enters the chamber 88, while the second control passage is rectangular in configuration having a transverse width which is much greater than its length in the direction of fluid flow.

The operation of the improved coating nozzle assembly of the present invention may be readily seen from FIGS. 2 and 5. The coating nozzle operates under pure fluid control principles involving the employment of a control stream of relatively small flow energy controlling a power stream of much greater energy. In this respect, the arrows 104 in FIG. 2 represent the application of a spray signal in the form of a low energy pressurized fluid stream which passes from fluid pressure source 29 through conduits 54, 63 and 64 to the spray air control valve 65 and thence to the interaction chamber 88 discharging therein adjacent the curved passageway wall 87. Further, fluid air under pressure passes through feed air control valve 55 to aspirating pump 75 which acts to discharge pulverant coating material through conduit 77 into inlet passage 85 of the fluid controlled nozzle assembly 23. The application of a spray signal to the first control passage 95 causes the pulverant material to be fed at some velocity through the divergent nozzle 90 where it discharges from exit end 103 into axial passageway 13 of core 10 to coat the same.

The employment of a second control signal in the form of a low energy fluid stream causes immediate diverting of the powder stream of coating material 105 from the first outlet passage 89 to the second outlet passage 92. This changes the coating stream flow from its original 90° deflection by curved wall 87 to a full 180°, for return of the same to the supply chamber 62.

In FIG. 5, there is no longer a spray signal in conduit 70 and the first control passage 95. However, a fluid control stream, as defined by arrow 106, passes through conduit 74 and connecting passage 97 to the second control passage 96, for discharge at some angle of inclination to the curved powder stream 105 of coating material within the control chamber 88.

The low energy control stream deflects the powder stream from the first outlet passage 89 into the second outlet passage 92. Pulverant material continues to recirculate through return hose 98 to the supply chamber 62 as long as a low energy control signal 106 is applied to the second control passage. Discharge of the control signal at right angles to the path of the curved powder stream within control chamber 88 is readily shown by arrow 107. Of course, discharge of powdered material from the exit end 103 of the coating nozzle 90 ceases, without the loss of any powdered material, at maximum efficiency and with little power input required. The pulverant material is continuously recirculated allowing removal of a coated workpiece 10 and replacement of one to be coated. The remaining three nozzle assemblies 22, 22a, 23a are identical in form and operation to that of assembly 23.

While the aspirating pump which directs the powdered coating material to the control chamber and the presence of the curved passage wall 87 would be sufficient to ensure passage of some of the powder through the diverging outlet passage 89 of the nozzle 90, the employment of the first control passage 95 tangential to the passage wall allows the additional pressurized air to increase the powder velocity as it passes through the diverging nozzle and to cause further mixing and dispersion of the powder in the airstream. Thus, the system provides means for independently controlling the powder content and the mixture velocity at the exit end 103 of the coating nozzle. The conduits supplying

the pumped air, the feed air and the control air may be rigid or flexible, although flexible conduits provide a more variable geometry to the apparatus. Further, the employment of flexible tubing or conduits between the pressure source and the individual nozzles allows adjustment of the nozzle positioned in both the horizontal and vertical planes. Preferably, a fluidized bed is used to suspend and aerate the powder within supply container 60 such that the powder will flow readily into the various pump transport tubes, such as tube 77.

The operation of the system set forth in FIG. 1 involving the principal component of the improved pressurized fluid and support assembly and the fluidic coating nozzle assembly has distinct advantages over the previous systems employed for selectively coating magnetomotive cores. The fluid controlled nozzles provide maximum powder density in the selected areas to be coated with the best results occurring when the core to be coated is in the direct path of the powdered material being discharged from the discharge end of the nozzles and where there is alignment between the axis of the nozzle and the core of the part being coated. It is further noted that the return flow from the individual spray nozzle assemblies falls through the flexible connecting tube to the surface 76 of the pulverant material supply. Alternatively, flow could return from the individual nozzles to outer reservoir 110 which holds a much larger portion 111 of the pulverant coating material with the supply 61 being constantly maintained at a predetermined level 76 by an auxiliary aspirating pump 112 connected to the feed air valve assembly 55 through tubing or conduit 60. Further, since the individual nozzle assemblies are coupled by flexible tubing to the source of powdered material and the control signal, the spray nozzle assemblies, including the flexible tubing, may be readily manufactured as sub-components at reduced cost. Again, while it is preferable to position the coating nozzle assembly or gun at the same level as the articles being coated, these elements may be positioned below the center of the article, and it may be oriented at some angle with respect thereto. The system is highly desirable since it provides a consistent spray pattern, is characterized by a minimum of moving parts, and will operate under low coating flow rates and with reduced heat dissipation from the stator. Normally, the discharge of material under fluid pressure acts to cool the parts being contacted by the material. The flow rate for all of the guns or nozzle assemblies may be simultaneously controlled by the mere act of lowering or raising the inner bed height 76. For instance, a one inch change in the level 76 of the powdered material within supply container 62 results in a flow rate change of 0.60 grams per second.

While it is assumed that the fluid pressure source is controlled to ensure constant flow pressure and velocity, pulsations may occur which would tend to cause excessive wear within the nozzle assemblies and a resultant variance in orifice size for the respective nozzle assemblies. This coupled with a variable preheat condition for the individual workpiece core 10 tends to cause variation in the material buildup. Within the nozzle control chamber 88, there may be a tendency for stalagmite material buildup due to eddy current circulation, principally at the area of conflux between walls 86 and 94 opposite the curved side wall 87. Further,

with low velocity material passing through the material supply tube 77 from the aspirating pump, it is desirable that a secondary flow rate with a given velocity occur in first control passage 95. Necessarily, for proper pattern and material densities at low velocity, the application of a secondary control stream through passage 95 is imperative. The positioning of this secondary airstream in a generally tangential position with respect to curved passage 87 and immediately above the terminus of walls 86 and 94 tends to prevent stalagmite material buildup within the nozzle while maintaining the minimum material density at low velocity.

As an example, in a typical operation, with the fluidic nozzles 23 having nozzle entrance passages, such as passage 89, of a diameter of three-sixteenths of an inch and control ports one-sixteenth of an inch in diameter, epoxy resin coating material in powder form of 120 mesh, such as GE82038 was applied to workpieces having openings, such as slot 13, on the order of three thirty-seconds of an inch. The core 10 was rotated through drive means 49 at 5 to 15 rpm while operating the coating nozzle assemblies. By reference to FIG. 7, for various coating material feed rates, the total weight deposited on the representative articles, in grams, is shown at plots A1 and A2, while plots B1 and B2 show the average coating thickness in the slots 13 in mils depending upon the coating material feed rate. In a straight line fashion, by increasing the material feed rate, the total weight of deposited material increased as well as the average coating thickness. Uniformity in product coating was achieved employing the apparatus of the present invention.

It was noted that an increase in temperature causes an increase in total buildup for constant feed rate and at any given temperature level, an 11 percent variance in feed rate caused a corresponding variance in total buildup of 8 percent or 3.2 grams at the 40 gram level. The temperature of the core prior to coating is critical, and a plus or minus 5° C. temperature specification on oven preheat facilities may be excessive if minimum material is to be deposited.

The present invention has further applicability where the core is formed of unbonded laminated metal. In this case, it is desirable to maintain the laminate stack in a clamped condition in selected regions of the core during coating, by way of illustration, at the teeth terminations where there may be a tendency to flare apart. A modified bore mask and support assembly 121 is shown in FIG. 10, that includes a perforated tube 128 and an outer tube 127 with a peripheral flange 131 at the illustrated end thereof. In FIG. 10, the coolant emission ports are illustrated as radially aligned holes 135 in cylindrical casing 133, holes 135a in pads 140, and slots 170, 171 carried respectively in the cylindrical casing and pads. Abutments, exemplified as radial projections 172, slide in slots 170 and 171 and are useful in selectively maintaining stator cores in a clamped condition. The tips 174 of the projections 172 are compressively engaged by the rearmost lamination 173' when the foremost lamination of core 10' is engaged by forward end 175 of clamping fingers 176 carried by collar 177. Clamping action is effected when the collar 177 is moved from the dotted line position to the full line position in FIG. 10. Instead of using interfitting serrated faces to drive the bore mask, a positive non-slip

driving connection between bosses 185 on the bore mask and sockets 186 on a drive member rotatable with collar 177 is utilized. This arrangement substantially eliminates any tendency for fingers 176 to drive assembly 121 through the foremost lamination and the concomitant tendency for the foremost lamination to be shifted relative to the remainder of the core 10'. Pressure application for fingers 176 and rotation of drive member 187 are achieved through shaft 178, clutch mechanism 179, and solenoid or fluid drive motor 180. The driving member 181 of the clutch mechanism receives is in turn powered through belt 182 by drive motor 183.

In FIG. 10, air masking is achieved by the delivery of cooling air under pressure through the bore of inner tube 128 to the emission ports which are contiguous to the stator core 10'. As will be best understood by having reference to FIG. 11, the ported pads 140 support the upper peripheral surfaces of the teeth of the core 10' and the ribs 138 are positioned between the restricted slot entrance surfaces of the teeth of core 10'. As clearly revealed in FIG. 11, insulation leaves 139 have substantially the same radial height as pads 140, are contiguous to the slot entrances of the core, and restrict the conductive transfer of heat from the pads 140 to the ribs 138. It will be appreciated that in both embodiments the cooling air passes into a plenum chamber adjacent the support cylinder, and the air passing through the ports of the ported pads is of relatively low velocity for minimum interference with the stream of coating material.

FIGS. 12-15 reveal another embodiment of a nozzle assembly, designated at 200, that can be alternatively used in lieu of the nozzle assemblies 22, 22a, 23, and 23a of FIGS. 1, 2, 5, and 6. When the nozzle assembly 200 is used, it is connected to a discharge conduit of pump 75 and a return conduit which connects an outlet passage of the nozzle assembly to the supply chamber or outer reservoir 110 so that pulverant coating material may be selectively recirculated to the pulverant material supply when a workpiece, such as the workpiece 10 in FIG. 1, is not actually being coated.

With particular reference to FIGS. 12 and 13, the nozzle assembly 200 includes a molded or cast housing formed of two parts 201, 202, a saddle block 203 supported by the housing that defines the location of first and second control passages 204, 206, and a tube 207 supported by the housing and saddle block that provides an egress passage for directing pulverant material toward a workpiece. Conduit 208 supplies a low energy pressurized fluid stream from the fluid pressure source 29 of FIG. 1 to a tube 209 pressed into the control block and forming the first control passage 204. This fluid stream assists in providing a uniform dispersion of pulverant material in the air stream emanating from the tube 207 and also controls the discharge velocity of the pulverant material. The conduit 208 may be connected directly to the fluid pressure source 29 rather than through air valve assembly 65 since movement of pulverant material into the throat of the tube 207 is controlled by means of the second control passage 206. A pressurized fluid stream is selectively supplied to the second control passage through conduit 211 which is connected to fluid pressure source 29 through valve assembly 66. As pressurized fluid is supplied to the

second control passage 206, it is discharged in a diverging stream from a tapered outlet 212 and effects recirculation of pulverant material to the pulverant material supply as will be hereinafter more fully described.

The two housing parts 201, 202, as will be best seen in FIGS. 13 and 14, are formed with interfitting mortises 213, 214, and tenons 216, 217 that facilitate assembly of the housing. The housing parts are then held together by screws, 218, 219 secured in tapped flanges on the parts. After the housing has been assembled, the tube 207 is positioned in a tube receiving opening 221 in the front of the housing and the saddle block 203 is sandwiched between an extended upper segment 222 of the tube and the housing. The tube, saddle block, and housing are then secured together by screws 223, 224, and 226.

As best shown in FIG. 13, an inlet passageway 227 having a relatively small diameter or cross-sectional area defines an inlet channel for pulverant coating material supplied through flexible conduit 228. This channel communicates with curved passageway walls 229, 231 which define, with a contoured surface 232 of the saddle block, a fluid interaction chamber. The curved wall 229 and contoured surface 232 of the saddle block, when viewed in cross-section (e.g., as viewed in FIG. 14), form an ellipsoidal, rather than a circular channel. During operation of the nozzle assembly 200, pulverant material moves uniformly along the inlet channel and impinges, due to the inertia of the pulverant particles, against the outer wall 229 of the housing and surface 232 of the saddle block. The stream of particles is condensed as it is directed along the channel defined by surface 232, i.e., the pulverant particles are separated from the air that moved them through the inlet channel. The condensed stream follows surface 232 into the discharge tube throat area 233 between the upper portion of tube 207 and a scoop or tongue 234 formed from a bottom portion of the tube. The tongue 234 is formed by slitting the tube 207 and flattening and bending a portion thereof downwardly in the manner illustrated in FIGS. 13 and 15. As the condensed stream of pulverant particles enter the throat area, pressurized fluid emitted from the first control passage, co-axial with the first outlet passage 236, increases the velocity of the pulverant material and provides a desired uniform dispersion of pulverant particles as they are discharged from the first outlet passage. When the control stream is emitted from the control passage 204, some of the pulverant particles enter the control stream directly, whereas other pulverant particles at first swirl around and then enter the control stream, as depicted in FIG. 13.

The pulverant material may be selectively diverted to a second outlet passage 237, connected by a flexible conduit 238 to the supply of material, by the application of a stream of control air across the interaction chamber from the second control passage 206. As will be understood, the second outlet passage 237 has a cross-sectional area relatively greater than the cross-sectional area of inlet passage 227, and the pulverant material may be recirculated to the supply even when control air is continuously supplied to control passage 204. The increased cross-sectional area of outlet passage 237 relative to the inlet passage 227 prevents the build-up of a high pressure area at the juncture of

the inlet passage 227 and outlet passage 237 when control air is supplied to the second control passage 206. Thus, operation of the second control jet does not create objectionable back pressure on the pump supplying pulverant material to the inlet passage.

It will be appreciated from an inspection of FIGS. 13 and 14, the tapered outlet 212 of the second control passage discharges control air in a fan-shaped stream across the stream of pulverant material along the non-circular channel. As the control stream impinges on the pulverant material, it is diverted to the outlet passage 237.

In one actual working exemplification, a throat area corresponding to throat area 233 was formed by slitting a piece of three-sixteenths of an inch soft iron tubing and forming a tongue similar to tongue 234 that was approximately three-fourths of an inch long. The tongue was then flattened and bent at an angle of approximately 8° to the longitudinal axis of the piece of tubing. In the working exemplification, the previously referred to swirling action of the pulverant particles into the first control stream was readily observable.

It should be apparent to those skilled in the art that while I have shown and described what at present is considered to be the preferred embodiments of my invention in accordance with the Patent Statutes, changes may be made in the disclosed embodiments without actually departing from the true spirit and scope of this invention, and I therefore intend to cover in the following claims all such equivalent variations as fall within the invention. What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for applying powder coating material onto selected surfaces of an article of manufacture comprising: at least one material applying device having an interaction chamber including a selected passageway; coating material inlet means for admitting a stream of powder coating material into the selected passageway; coating material supply means for directing the stream of powder coating material to the coating material inlet means; first coating material outlet means in communication with said selected passageway and disposed in spaced relationship to the coating material inlet means, said first coating material outlet means including means for directing the stream of powder coating material out of the selected passageway and generally toward the selected surface of the article to be coated; an inwardly curving surface along the selected passageway of the chamber between said coating material inlet means and said first coating material outlet means for guiding the stream of coating material from the coating material inlet means generally toward the first coating material outlet means; a second coating material outlet means for transferring the stream of powdered coating material from said selected passageway and away from said first material outlet means for reuse; and regulating means disposed in the vicinity of said inwardly curving surface including at least one passageway terminating along the curving surface, for selectively controlling the flow of coating material stream toward either the first or second coating material outlet means whereby the stream of coating material through the first coating material outlet means may be effectively interrupted without discon-

tinuing the admission of coating material into the selected passageway through the coating material inlet means.

2. The apparatus as claimed in claim 1 in which the coating material regulating means includes a first port opening into said passageway to direct a first fluid control stream onto said coating material stream and in the direction of the first coating material outlet means to cause said stream of coating material to be fed therethrough and the at least one passageway comprises a second port opening into said passageway for directing a second control fluid stream onto said coating material stream to divert the stream of coating material away from said first outlet means and towards the second outlet means.

3. The apparatus as claimed in claim 2 in which said first coating material outlet means includes a nozzle having an axis generally in line with the article being coated, said first port has its axis in general alignment with the nozzle axis to augment the density of coating material moved toward said nozzle and said second port is positioned along said passageway intermediate said nozzle and said inwardly curving surface portion of said passage, the axis of said second port being generally in line with said second coating material outlet means to facilitate selective deflection of said stream of coating material from said first outlet means and toward said second outlet means.

4. The apparatus as claimed in claim 1 wherein at least one coating material applying device is positioned above the source of coating material, and said apparatus further includes coating material passageway means extending from the second coating material outlet means toward the coating material source, said second passageway having no bends exceeding 90° whereby the stream of coating material may be selectively returned to the source for reuse with a minimum tendency of the coating material buildup.

5. The apparatus as claimed in claim 1 in which said second outlet means has a cross-sectional area which is larger than that of said inlet means and wherein the second coating material outlet means is sufficiently large to reduce the tendency of coating material buildup in the area of said second coating material outlet means, when the stream of coating material is being fed thereto.

6. The apparatus as claimed in claim 1 in which the coating material regulating means includes a first port opening into said passageway to direct a fluid control stream onto said powdered coating material stream and in the direction of the first coating material outlet means to cause said stream of coating material to be fed therethrough and fluid pressure isolating means for increasing the fluid pressure differential between the coating material inlet means and first port and for directing powdered coating material generally toward the first coating material outlet means.

7. Apparatus for applying powdered coating material onto selected surfaces of an article of manufacture comprising: at least one material applying device having a chamber; means for supporting an article of manufacture adjacent to the at least one material applying device, coating material inlet means for admitting a stream of powdered coating material into the chamber; coating material supplying means for direct-

ing the stream of powdered coating material to the coating material inlet means; first coating material outlet means in communication with said chamber and in spaced relation to the coating material inlet means, and being adapted for directing the stream of powdered coating material out of the chamber generally toward the selected surface of an article to be coated and supported in spaced relationship to said material applying device by said means for supporting; second material outlet means in communication with said chamber for receiving coating material that is not directed out of the chamber through the first material outlet means; control means for selectively directing coating material toward the first and second outlet means; said chamber including an inwardly curving surface between said coating material inlet means and said first coating material outlet means for guiding the stream of coating material from the coating material inlet means generally toward the first coating material outlet means; and fluid supplying means having a port opening into the chamber intermediate said inwardly curving surface and said first coating material outlet means, generally behind said first coating material outlet means and in the path of travel of the stream of coating material as it is being guided through the chamber by the inwardly curving surface, for controlling the flow of the coating material stream into said first coating material outlet means for coating the selected surfaces of the article of manufacture.

8. The apparatus of claim 7 in which at least one coating material applying device is mounted above a feeding source of coating material, and the coating material supplying means includes a passageway extending between the feeding source and the coating material inlet means, said passageway having no bends exceeding 90° in order to reduce the tendency of coating material buildup therein as the stream of coating material is being supplied from the feeding source to the coating material inlet means.

9. An improved apparatus for coating powdered material on predetermined surfaces of an article of manufacture comprising: a hollow support disposed in adjacent relationship with selected surfaces of the article, means forming a plenum chamber on the side of said support opposite the article, ports formed within said support and a source of low pressure fluid connected to said plenum chamber for directing low pressure coolant through said ports and onto the selected surfaces of the article of manufacture to achieve low velocity, fluid masking of the selected surfaces, at least one fluid controlled coating nozzle in juxtaposition to the predetermined surfaces of the article of manufacture including coating material inlet means for admitting a stream of powdered coating material, a control passageway carried by said coating nozzle in communication with said inlet means, first outlet means in the form of a discharge nozzle in communication with the passage for normally discharging powdered coating material onto the other selected surfaces of said article of manufacture, second outlet means adjacent to the path of flow of powdered coating material between the inlet means and discharge nozzle for directing the stream of powdered coating material away from said discharge nozzle, control stream means for selectively discharging powdered coating material through the

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second outlet means, and for enhancing discharge of powdered material that passes the second outlet means through said discharge nozzle, and low pressure fluid means for moving powdered material to said coating material inlet means and into said control passage whereby the low pressure and said plenum chamber enhances masking of selected surfaces of the article of manufacture while said coating nozzle discharges powdered coating material under low pressure to insure uniform thickness of accumulated coating material on the predetermined surfaces of the article.

10. The apparatus as claimed in claim 4 wherein said support comprises an outer cylinder, and said plenum chamber includes said outer cylinder and further comprises a radially perforated inner tube concentrically mounted within said cylinder, an imperforate wall join-

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ing the inner end of said tube to the inner surface of said cylindrical member at one end, an imperforate outer tube slidably and sealably positioned between said cylindrical member and said perforated inner tube and to one side of said end wall whereby; movement of said outer tube simultaneously exposing the perforations of said inner tube and the radial holes carried by the outer cylinder to vary both the size of the plenum chamber and the peripheral surface of the cylinder acting as an air mask.

11. The apparatus as claimed in claim 10 further comprising a common source of low pressure fluid for both said air mask, and said fluid controlled coating nozzle.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,696,780 Dated October 10, 1972

Inventor(s) Harold L. Fritzsche

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the title change "Powered" to -- Powdered --. Column 1, line 58, before "coated" cancel "Since the stator and rotor cores which are" and insert -- Since the stator and rotor cores which are normally coated in a selective manner by this type of apparatus are necessarily heated prior to positioning on the mask, a number of problems exist. For example, the mask comprises material of good thermal conductivity and there is an immediate tendency for the mask to operate as a heat sink and reduce the temperature of the supported core with the result that the core may not be properly --. Column 2, line 5, after "Further," and before "prior" insert -- the --. same column 2, delete lines 19-25 --. Column 6, line 27, delete "of the". Column 12, line 39, after "chamber" insert -- 62 --. Column 17, in the first line of claim 10, change "4" to -- 9 --.

Signed and sealed this 20th day of August 1974.

(SEAL)  
Attest:

McCOY M. GIBSON, JR.  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents