United States Patent [19]

Goodridge et al.

[11] **3,865,610**

[45] **Feb. 11, 1975**

[54] **COATING METHOD WITH PRECURE AND APPARATUS THEREFOR**

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[73] Assignee: **Electrostatic Equipment Corporation,** New Haven, Conn.

[22] Filed: **May 24, 1972**

[21] Appl. No.: **256,499**

[52] **U.S. Cl.** ..... **117/17,** 117/8, 117/17.5, 117/19, 117/21, 117/38, 117/93.1 DH, 117/102 A, 117/119.2, 118/624

[51] **Int. Cl.**..... **B44d 1/094,** B44d 1/095, B05b 5/02

[58] **Field of Search** ..... 117/8.5, 9, 17,17.5, 21, 117/38, 93.1 DH, 119.2, 119.4, 102 A; 118/624

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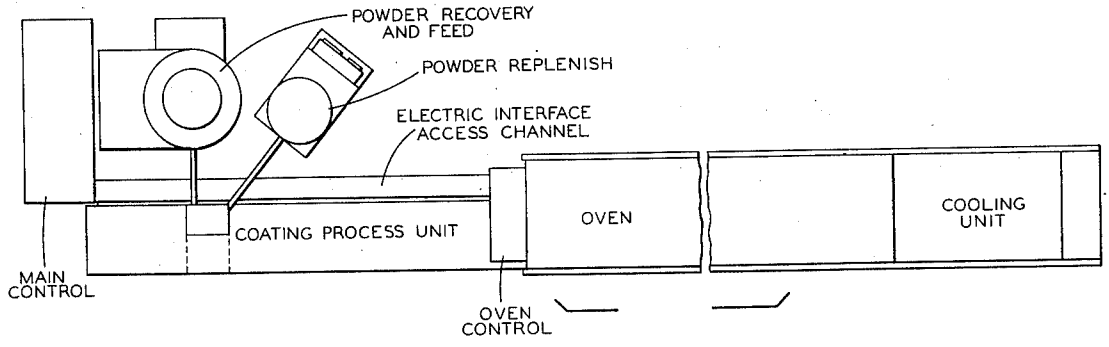
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Primary Examiner—Michael Sofocleous

[57] **ABSTRACT**

An apparatus and method are provided for producing a coating of heat fusible resinous material upon only a portion of a workpiece. The resinous material is deposited upon the workpiece as electrostatically charged particles. One zone of the workpiece is heated to cause fusion and cohesion of the particles while a second zone is simultaneously cooled to prevent such a result and to thereby facilitate removal of particles from the cooled zone. The apparatus and method are particularly adapted for producing thermoplastic coatings upon armature rotors for electric motors.

12 Claims, 17 Drawing Figures



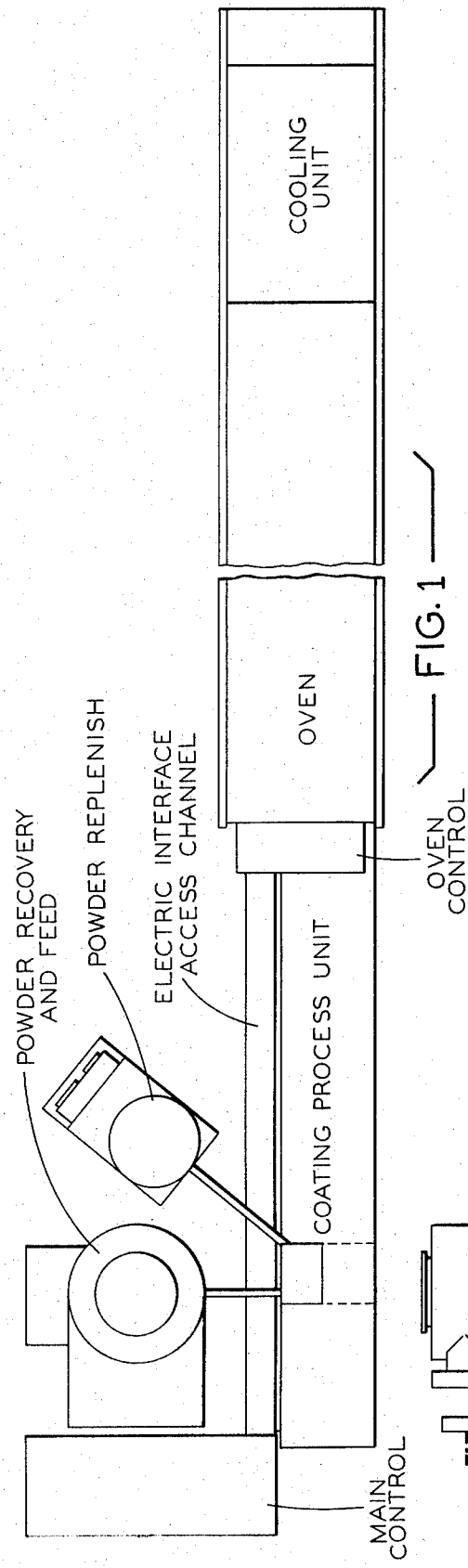

COOLING UNIT
OVEN
OVEN CONTROL
COATING PROCESS UNIT
ELECTRIC INTERFACE ACCESS CHANNEL
POWDER REPLENISH
POWDER RECOVERY AND FEED
MAIN CONTROL

FIG. 1

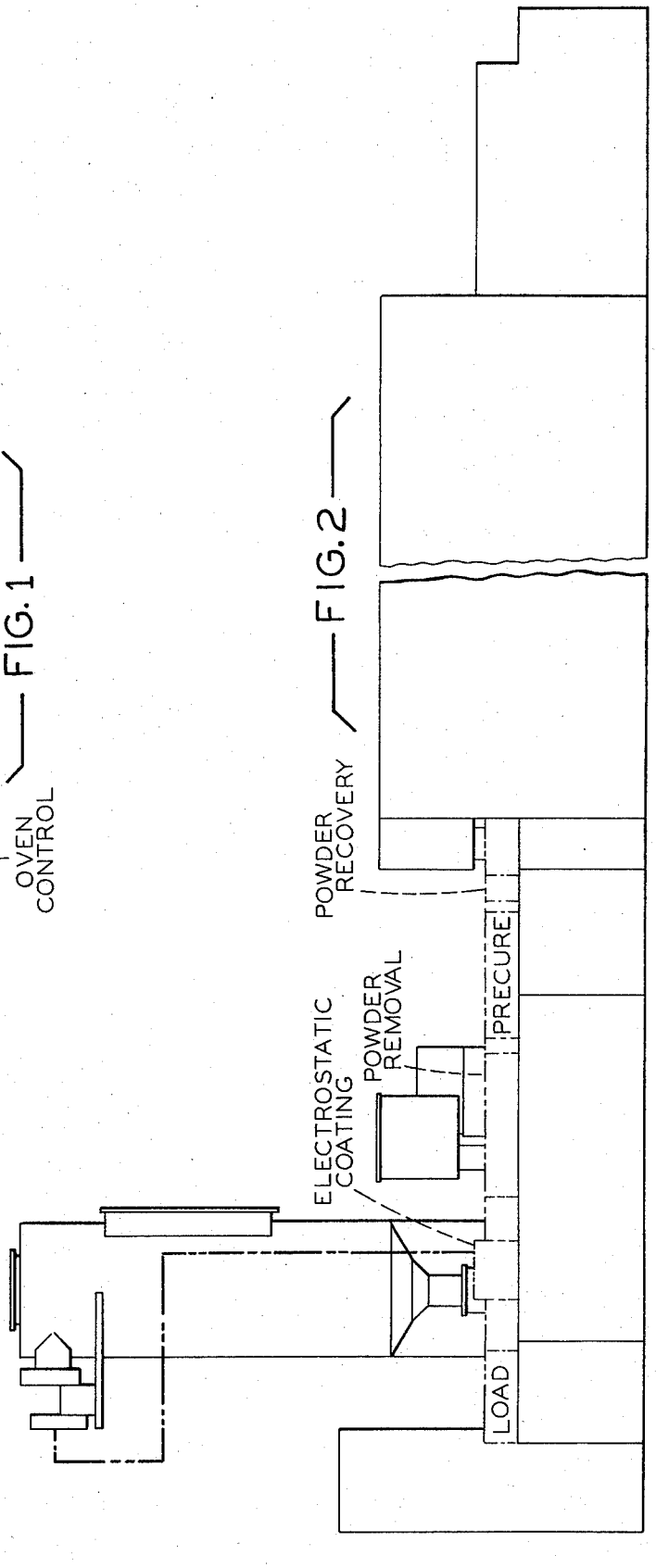

POWDER RECOVERY
PRECURE
POWDER REMOVAL
ELECTROSTATIC COATING
LOAD

FIG. 2

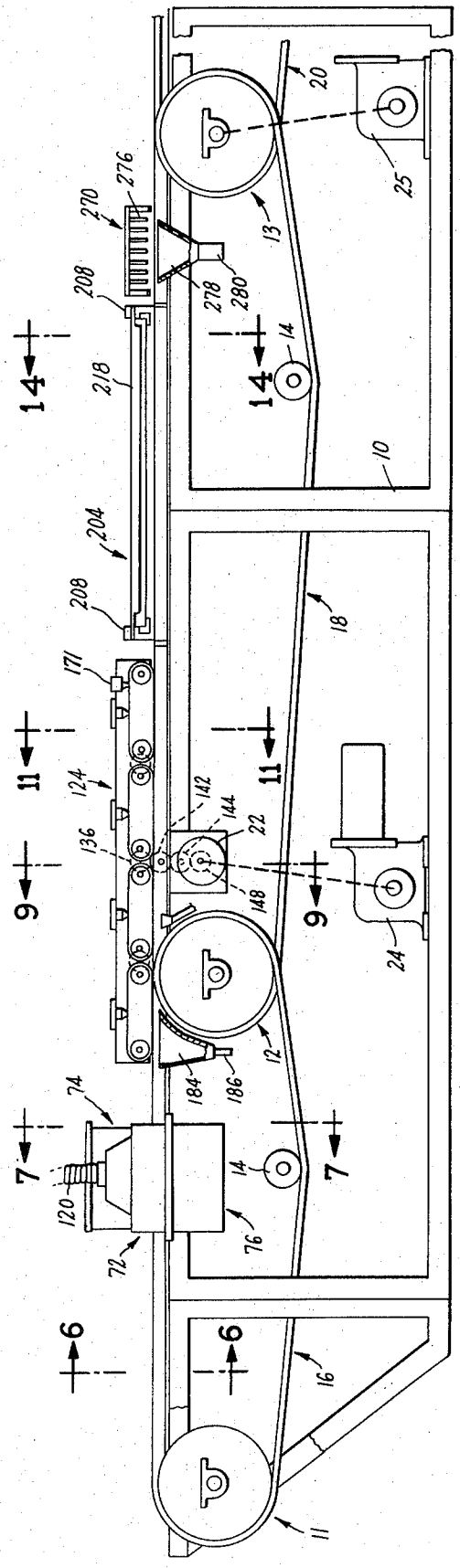


FIG. 3

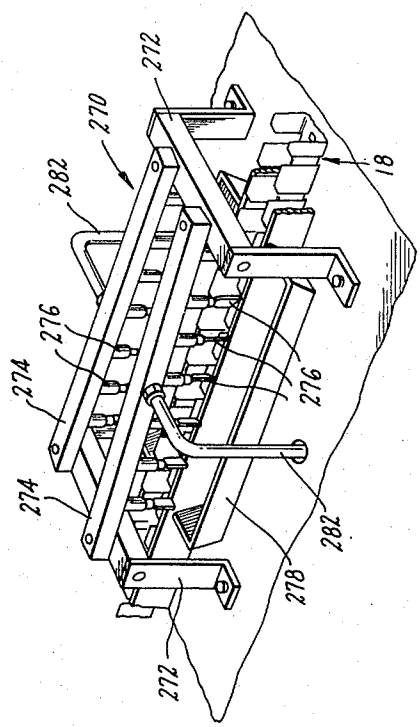


FIG. 15

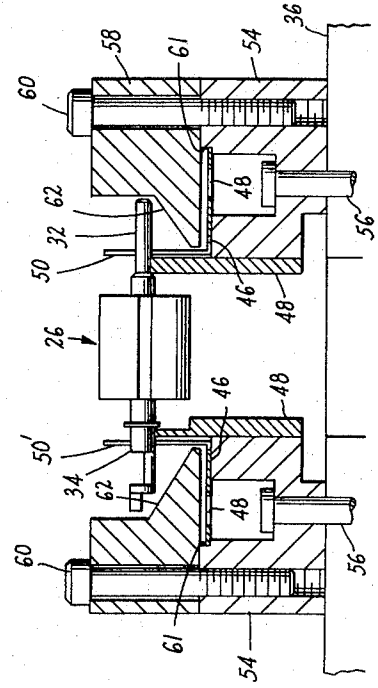


FIG. 6

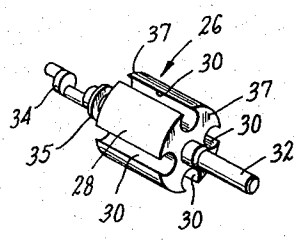


FIG. 4

FIG. 5

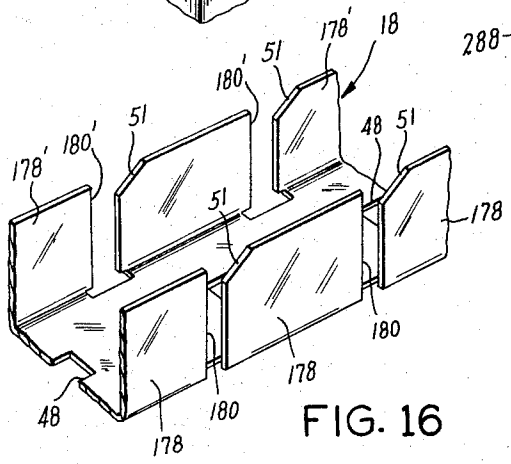


FIG. 16

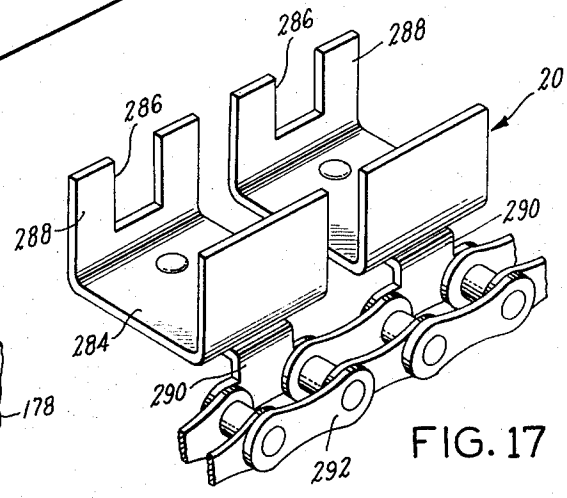


FIG. 17

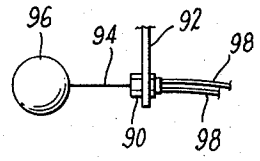

96
94
92
98
90
98

FIG. 8

120
74
72
118
104
106
103
102
116
114
100
116
122
122
115
50
26
50'
44
45
112
68
112
36
108
68
110
92
96
84
103
89
76
80
H.V.
86
87
85
78
82
88
AIR
79

FIG. 7

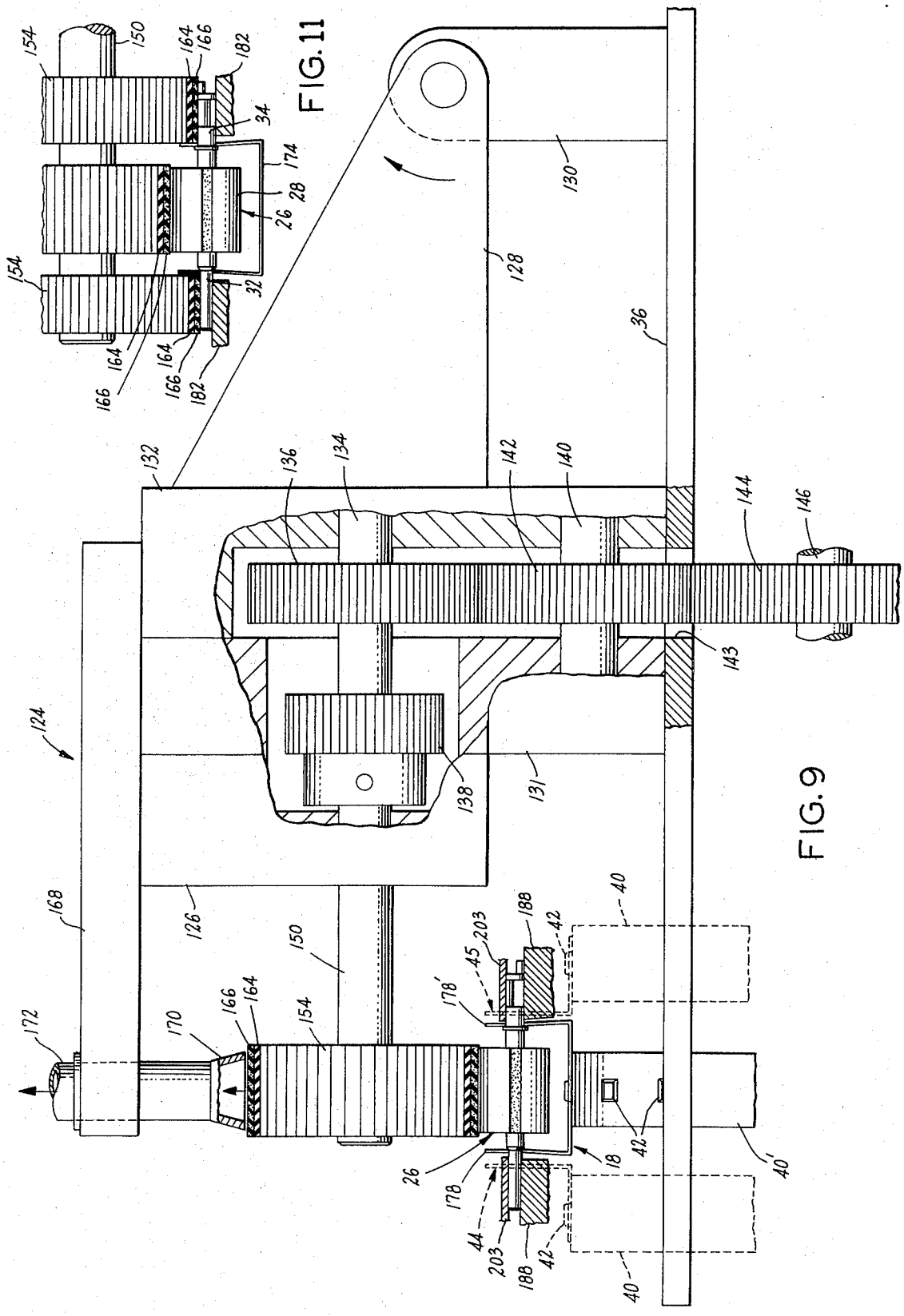

154
150
164
166
182
34
174
28
26
32
154
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142
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144
146
143
124
138
131
130
128
36
168
126
150
154
172
170
166
164
178'
45
203
188
42
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26
178
44
203
188
42
18
42
40'
40

FIG. 11

FIG. 9

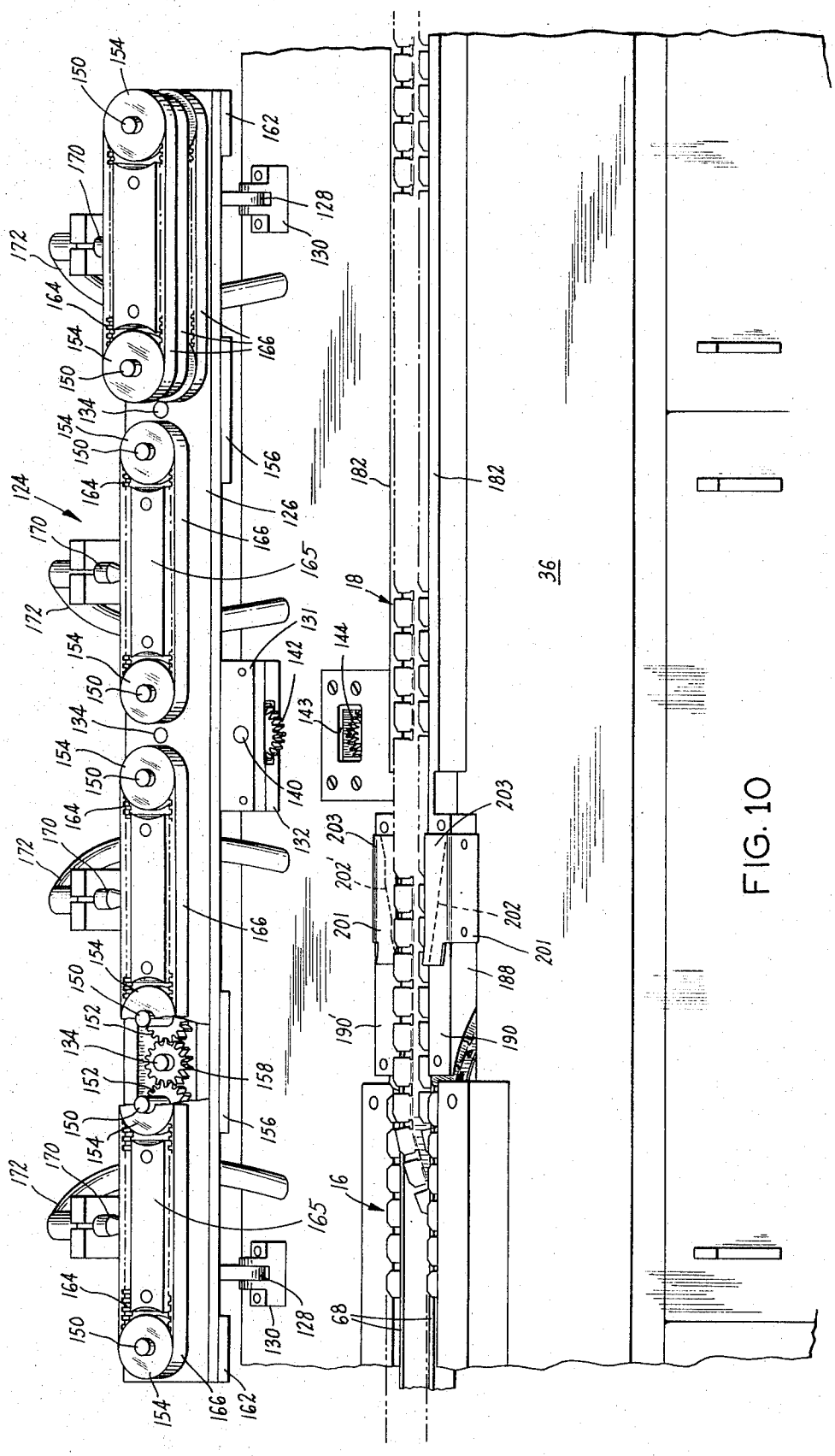


FIG. 10

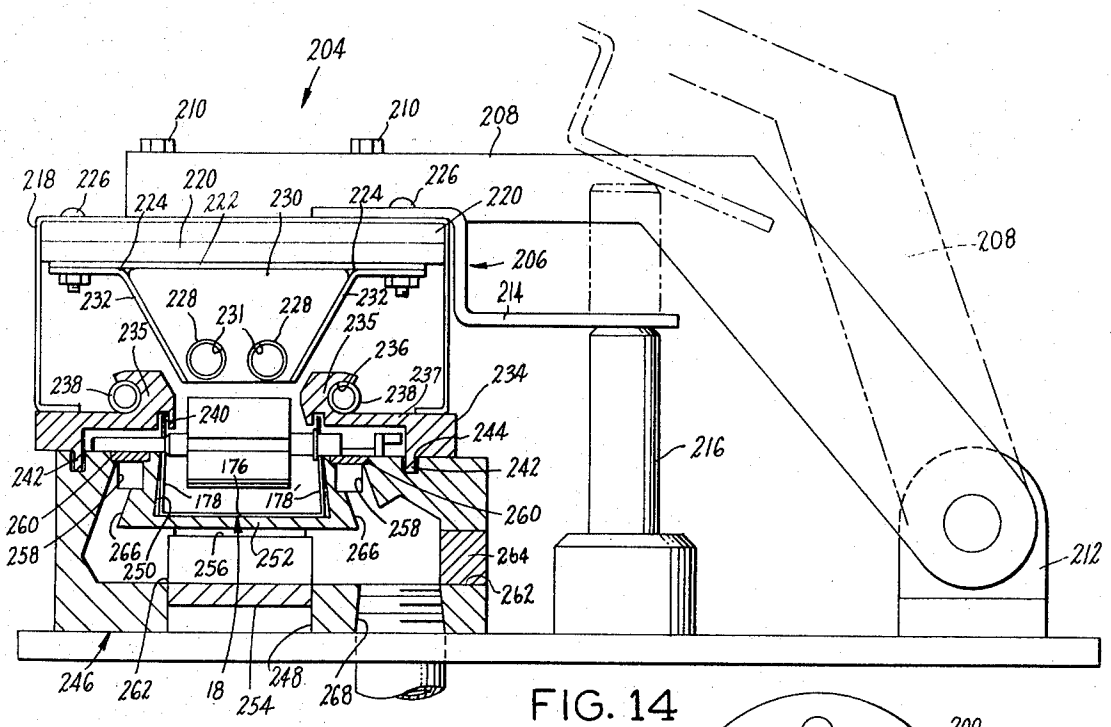


FIG. 14

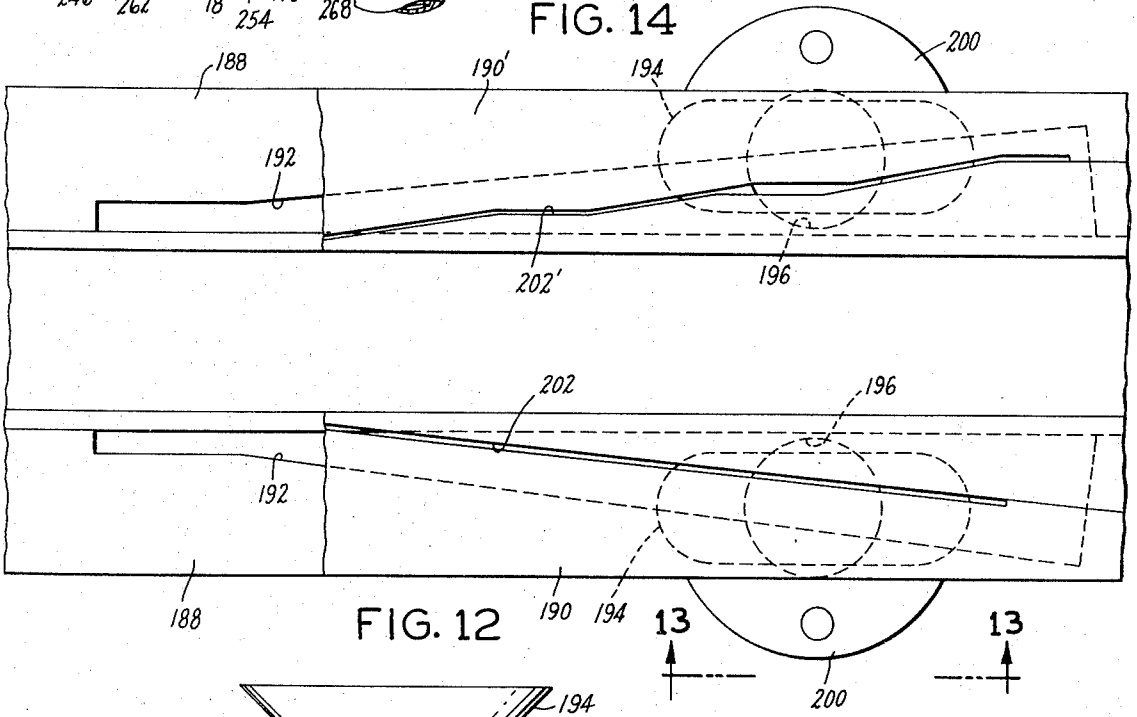


FIG. 12

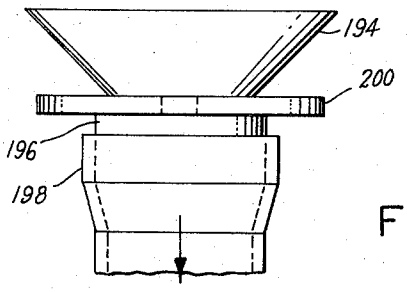


FIG. 13

COATING METHOD WITH PRECURE AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

Of the various ways in which coatings of heat fusible resinous materials are produced upon various workpieces, those in which the material is applied in particulate or powdered form are often found to be the most effective and satisfactory. Such techniques are used to produce coatings upon a wide variety of workpieces, including continuous lengths of wire and strip stock as well as individual objects which are often of a complex configuration, as would make coating by other techniques difficult or impossible. For example, attempts have been made to insulate the slots of rotors and stators for electric motors by depositing the resin in powdered form, which has proven particularly difficult due to the presence of reentrant surfaces which must be covered.

A common method of producing coatings of thermoplastic particulate materials is to utilize heat from the workpiece to cause softening and fusion of the particles upon contact. Thus, it has long been the practice to heat the article and to then submerge it in a bed (desirably fluidized) of the particulate material so as to produce a coating upon all exposed surfaces, and as far as is known prior attempts to produce coatings from powdered resins upon electric motor components have employed this technique. However, the inherent drawbacks are quite apparent, and include the need for masking of portions of the workpiece which are to remain free from the coating material and/or the need to handle or direct the resin in such a manner that contact will be avoided. Not only are such precautions time-consuming, but frequently they are difficult if not impossible to achieve in practice. Moreover, since the amount of material deposited using such a method is dependent upon the intensity of heat available from the workpiece and/or the duration of exposure, uniform thicknesses are oftentimes most difficult to obtain.

It is also well known that electrostatic forces may be utilized to cause attraction and adhesion of particles of thermoplastic materials to a wide range of workpieces, which may thereafter be heated to melt the resin and produce the final unified coating. This approach has many advantages including uniformity of coverage, ease of access to undercut or reentrant surfaces, coating thickness control, etc. Nevertheless, the production of preferential deposits upon selected areas of the object has typically relied upon the use of mechanical or air masking techniques which are not entirely satisfactory under certain circumstances, such as when it is necessary to obtain a virtually clean surface closely adjacent to one that is to be relatively thickly covered.

Accordingly, it is an object of the present invention to provide a novel method and apparatus for the production of a unified, adherent coating of a heat fusible resin upon a limited portion of a workpiece.

A more specific object of the invention is to provide such a method and apparatus for electrostatically coating the workpiece and for effecting the removal of the resinous material from selected portions thereof which are to be uncoated.

An even more specific object is to provide such a method and apparatus whereby a generally cylindrical article having reentrant surface portions may be coated with an adherent deposit upon the reentrant surface portions thereof.

Another object of the invention is to provide such a method and apparatus whereby such coatings may be produced quickly, easily and economically, which method and apparatus may be automatic and continuous.

A further object is to provide a novel precuring device which is adapted to set the coating at one zone of a workpiece while simultaneously maintaining the particulate form of the resin at a second zone to facilitate its complete removal therefrom.

SUMMARY OF THE DISCLOSURE

It has now been found that the foregoing and related objects of the invention are readily attained in an apparatus comprising, in combination, a chassis, means on the chassis for producing a cloud of electro-statically charged solid particles of resinous material, a precuring unit on the chassis, and means for carrying the workpiece along a travel path through the cloud-producing means and precuring unit. The precuring unit includes means for heating a first zone of a workpiece to be coated, and means for simultaneously cooling a second zone thereof, the zones of the workpiece being in heat conductive contact with one another. The heating and cooling means are so disposed as to enable heating of the first zone of the workpiece to a relatively high temperature above ambient while the second zone thereof is simultaneously maintained at a relatively low temperature substantially below the relatively high temperature. Exposure of the workpiece to the charged particles from the cloud-producing means, with the workpiece charged effectively opposite to the particles, causes a layer of particles to deposit thereon. In the precuring unit, the heating means at least partially fuses and coheres the particles at the first zone of the workpiece and the cooling means substantially prevents fusion and coherence of particles at the second zone thereof, removal of the particles from the second zone thereby being facilitated.

In preferred embodiments of the invention, the heating and cooling means of the precuring unit extend along substantially the same length of the travel path, and the cooling means comprises an element having a cooled support surface upon which the second zone of the workpiece rests in heat transfer contact during movement through the unit. The cooling means may additionally include an overlying element having a cooled lower surface extending substantially parallel to and in spaced alignment over the support surface to provide a convective cooling effect upon the second zone of the workpiece during passage therebeneath. In such a case, the conveyor may include an upstanding element for supporting the article with the first and second zones of the article lying on opposite sides thereof, and the conveyor element may cooperate with the underlying element of the cooling means to provide a shield against heat flow by radiation and convection to the second zone of the article.

The apparatus preferably includes cleaning means positioned on the chassis along the travel path downstream of the precuring unit for effecting the removal of particles of resinous material from the second zone of the workpiece. Most desirably, it also includes post heating means positioned along the travel path downstream of the cleaning means. The post heating means

is adapted to fully heat the workpiece so as to unify and produce from the remaining particles of resinous material an adherent coating on the first zone thereof.

The apparatus may be particularly adapted for producing a coating upon a generally cylindrical article having a central portion providing the first zone thereof and end portions extending axially from either side of the central portion together providing the second zone of the article. In such an instance, the cooling means of the precuring unit desirably comprises two elements, each having a cooled surface extending along an opposite side of the travel path and being adapted to support and cool one of the end portions of the article during movement thereof along the travel path through the unit. The heating means thereof may comprise a heating element extending along the travel path and lying generally between the cooled surfaces to heat the central portion of the article during movement through the unit.

The precuring unit may include a base providing at least in part the cooling means thereof. The base may have an elongated channel extending therein along the travel path through which at least the lower portion of the conveyor passes, the surfaces of the base defining the channel being cooled to provide a cooling effect thereabout. Preferably, the heating means employed comprises a heating element supported by a cover member which is movably mounted upon the chassis for displacement from a normal position over the travel path to a position outwardly therefrom. When the cooling means includes an overlying element having a cooled lower surface, such an element may be supported by the cover member and disposed as hereinbefore described when the cover member is in closed position.

In especially preferred embodiments of the invention the cloud producing means employed in the apparatus includes an electrostatic cloud chamber. Such a chamber may comprise a receptacle having means for producing a fluidized bed of charged particles including a gas-permeable plate extending thereacross in a generally horizontal intermediate plane and spaced above the bottom wall of the receptacle to define a plenum chamber therebelow. The receptacle also has electrode means extending thereacross to electrostatically charge particles of solid resinous material passing proximate thereto. Most desirably, the apparatus will include a particulate material reservoir having feed means communicating with the cloud chamber. In such a case, the electrode means may span a lesser area than the gas-permeable plate to provide an electrode-free vertical corridor within the receptacle through which particles of the resinous material may pass without acquiring a significant charge. A device for sensing the level of the bed of particles within the receptacle, in response to which the feed means conveys resinous material from the reservoir to the chamber when the bed level falls below a preselected height, may also be provided. The sensing device is positioned within the vertical corridor over the horizontal porous plate, to thereby minimize the effect of electrostatic charging upon the sensed level of the bed. The electrode employed may be a generally planar, grid-like structure disposed adjacent the upper surface of the gas-permeable plate, and electrode and plate may be substantially coextensive except at one area of the plate over which the electrode does not extend, thereby providing the electrode-free vertical corridor.

Certain objects of the invention may be attained by the provision of a precuring unit adapted for heating the cylindrical core portion of an electric motor armature rotor while simultaneously cooling the axially extending shaft portions thereof during passage through the unit. The unit comprises a base having an elongated, upwardly opening channel extending therein with generally horizontal upper surfaces of the base extending along each side of the channel, means being provided for cooling such surfaces to conductively cool shaft portions resting thereon. The channel is dimensioned and configured to receive the core portion of the rotor suspended therewithin with the shaft portions thereof resting upon the upper surfaces. The precuring unit also includes an elongated heating element which is normally axially aligned over the channel and is disposed to heat the core portion during passage through the channel.

Additional objects are attained in accordance with the method of the invention in which a unified, adherent coating of heat-fusible material is produced upon only a portion of a workpiece having proximate first and second zones in heat conductive contact with one another. The method involves producing a cloud of electrostatically charged solid particles of resinous material and exposing the workpiece to the charged particles with the work-piece charged effectively opposite thereto to cause a layer of the particles to deposit over the first and second zones thereof. The first zone of the work-piece is heated to a relatively high temperature above ambient while the second zone is simultaneously cooled. As a result, the particles on the first zone of the workpiece are at least partially fused and cohered while fusion and coherence of particles on the second zone are substantially prevented due to the relatively low temperature maintained thereat, which is substantially below the relatively high temperature of the first zone. Thereafter, particles of resinous material remaining on the second zone of the workpiece are removed.

Subsequent to the simultaneous heating and cooling step, the method will generally include the step of heating the workpiece to at least about the melting point of the resinous material to unify the particles thereof and to produce an adherent coating upon the first zone of the workpiece. In addition, it may include the step, effected prior to the simultaneous heating and cooling step, of removing a portion of the layer of particles deposited upon the first zone of the workpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of apparatus embodying the present invention;

FIG. 2 is a side elevational view thereof;

FIG. 3 is a side elevational view of the coating process unit of the apparatus of FIGS. 1 and 2, drawn to an enlarged scale and with housing portions removed to expose internal features thereof;

FIG. 4 is a perspective view of an armature rotor for which the illustrated apparatus is particularly adapted;

FIG. 5 is a fragmentary perspective view of the forward end of the coating process unit including the load zone and a portion of the electrostatic coating station, drawn to a scale enlarged from that of FIG. 3;

FIG. 6 is an enlarged sectional view along line 6—6 of FIG. 3 illustrating the support and positional control

structure provided at the load zone and showing an armature rotor carried on the forward conveyor for movement therethrough;

FIG. 7 is an end view of the electrostatic coating station along line 7—7 in FIG. 3 with portions of the housings broken away to illustrate the internal features thereof and drawn to a greatly enlarged scale;

FIG. 8 is a side elevational view of the sensing device employed in the cloud-coating unit of the electrostatic coating station;

FIG. 9 is a fragmentary end view along line 9—9 in FIG. 3 showing the powder removal zone of the apparatus with the contact belt unit thereof in its normal operating position, drawn to a greatly enlarged scale and having portions in vertical section to illustrate the construction thereof;

FIG. 10 is a front view of the powder removal zone at an acute angle to the upper surface of the deck, drawn to a slightly diminished scale from that of FIG. 9 and showing the contact belt unit in its raised position;

FIG. 11 is a fragmentary end view of the powder removal zone along line 11—11 of FIG. 3, drawn to the scale of FIG. 9;

FIG. 12 is a fragmentary plan view of the shaft cleaning units provided within the powder removal zone, drawn to a scale enlarged from that of FIG. 10 and with the hold-down brackets removed to expose the vacuum slots thereof;

FIG. 13 is a side elevational view of the vacuum nozzle and associated parts employed with each of the units of FIG. 12;

FIG. 14 is an enlarged sectional view along line 14—14 in FIG. 3 showing the precuring unit of the apparatus with an armature rotor passing therethrough, and in phantom line showing the raised position of the cover assembly;

FIG. 15 is a perspective view of the air knife assembly at the powder recovery zone of FIG. 3, drawn to a greatly enlarged scale;

FIG. 16 is a fragmentary perspective view to a greatly enlarged scale of the intermediate conveyor employed in the apparatus; and

FIG. 17 is a fragmentary perspective view of one band of the endmost conveyor of the apparatus, drawn to the scale of FIG. 16.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Turning now in detail to the appended drawings, therein illustrated is an armature slot-coating system embodying the present invention and details of the various units and zones thereof. FIGS. 1 and 2 illustrate the overall layout of the system, the heart of which is the "coating process unit", so designated on the drawing. Auxiliary to the coating process unit is an oven and a cooling unit, and main control and oven control facilities are furnished. Also included in the system to enable a desirable mode of operation is a power recovery and feed unit and a powder replenishment unit. As will be appreciated from FIG. 2, the workpieces are loaded in an infeed zone at the left-hand end of the coating process unit from which they pass serially through an electrostatic coating zone, a powder removal zone, a precure zone, and a powder recovery zone; they then pass into the oven and finally through the cooling unit. Excess powder from the electrostatic coating zone is recovered in the powder recovery and feed unit and is returned through an appropriate conduit to the coating unit on a substantially continuous basis, and additional powder is furnished from the powder replenishing unit as needed. An electric interface access channel runs along the rear of the coating process unit to provide power at the various zones thereof.

With specific reference now to FIG. 3, the coating process unit of the system is depicted in greater detail. It includes a frame 10 on which are rotatably supported three conveyor drive sprockets, generally designated by the numerals 11, 12 and 13 respectively from left to right in the Figure, and idler wheels 14 are positioned between adjacent sprockets. A forward endless conveyor, generally designated by the numeral 16, runs about sprockets 11 and 12 and the idler wheel 14 therebetween; a center endless conveyor, which is generally designated 18, runs about sprockets 12 and 13 and about the idler wheel 14 positioned between them, and a rearward endless conveyor, which is generally designated 20 and is fragmentarily illustrated, runs about the right-hand sprocket 13 and a cooperating sprocket which is not illustrated and is positioned adjacent the end of the cooling unit shown in FIGS. 1 and 2. A drive pulley 22 operates the powder removal unit and is driven by the electric motor 24 which is supported within the frame 10. A second motor 25 is connected to sprocket 13, thereby synchronously driving all conveyors 16, 18, 20 since they are coupled by the sprockets, 11, 12, 13.

Although the invention is not to be construed as limited to coating of any particular workpiece, and may be feasible for coating selected portions of objects which are elongated or of "continuous" length, the system illustrated is especially suited for the coating of armature rotors of the type generally designated by the numeral 26 in FIG. 4, and is intended principally for that purpose. The rotor 26 is of conventional configuration and includes a cylindrical core portion 28 having spaced about its circumference four axially extending, reentrant winding slots 30. Extending from opposite ends of the core portion 28 are simple and crank-type shafts 32, 34 respectively, and the shaft 34 has a spring clip 35 engaged upon it adjacent the end of the core portion 28.

As will be appreciated, the slots 30 of the rotor 26 are designed to receive wire windings, making it necessary to provide the slots 30 and the opposite end faces 37 of the core portion 28 with a layer of insulating material to enable magnetic poles to be defined thereon. It is also important that the outer circumferential surface of the core portion 28 and the shafts 32, 34 be free from insulating material; the present system is unique in enabling the rapid and facile production of coated rotors having deposits of insulating material which are present only at selected locations and are of substantially uniform thickness.

FIG. 5 illustrates in greater detail the loading zone of the coating process unit, whereat a narrow rectangular opening 38 is provided through the deck 36 of the frame 10 to accommodate the edge of drive sprocket 11. As can be seen, the forward conveyor 16 is comprised of two independent flexible and continuous parallel bands, generally designated by the numerals 44 and 45, and the drive sprocket 11 consists of a pair of parallel sprocket wheels 40 mounted on a common shaft for concurrent rotation. Each of the sprocket

wheels **40** has about its circumferential edge a multiplicity of small rectangular teeth **42**; the belt portion **46** of each of the bands **44, 45** is provided with a multiplicity of rectangular apertures **48** which are spaced along the length thereof, the apertures **48** meshing with the rectangular teeth **42** of the respective sprocket wheels **40** as the bands pass thereover along their travel path. Extending at a right angle from the inner edge of the belt portion **46** of each of the bands **44, 45** are a multiplicity of carrier tabs **50, 50'** respectively, and each tab **50, 50'** has bevelled shoulders **51** leading into the shaft slots **52, 52'** therebetween. As will be appreciated, the slots **52, 52'** are dimensioned to receive the shafts of the armature rotor **26,** and the tabs **50'** are slightly narrower than the tabs **50** to render the slots **52'** somewhat wider than the slots **52,** thereby enabling close-fitting engagement of shafts **32, 34,** notwithstanding their different diameters. It will be evident that the bevelled shoulders **51** facilitate insertion and removal of the shafts of the armature rotors **26** into and from the slots **52.**

As can most readily be seen by additional reference to FIG. **6,** one of a pair of elongated rectangular curb blocks **54** extends along each side of the upper flight of the conveyor **16,** with the curb blocks **54** being secured to the deck **36** by bolts **56** (fastened in an appropriate manner, not illustrated). Coextensive with each of the curb blocks **54** is a guide rail **58** which is secured upon the upper surface of the associated curb block **54** by a number of bolts **60** spaced along the length thereof. A shallow recess **61** is provided along the upper surface adjacent the inner edge of each of the curb blocks **54** enabling the belt portion **46** of the conveyor bands **44,** 45 to pass between the curb blocks **54** and the bottom surface of the guide rails **58.** The guide rails **58** have inner surfaces which extend downwardly and then at an angle inwardly to provide guide surfaces **62** sloping downwardly toward the travel path. The guide surfaces **62** define therebetween a trough which is dimensioned so that armature rotors **26** carried by the conveyor **16** extend there-across with little free space adjacent the ends, thus ensuring that the rotors **26** remain accurately positioned across the conveyor **16** and centrally positioned on the axis of the travel path of the unit.

Extending forwardly from adjacent the ends of the curb blocks **54** is a support extension **64** which underlies the conveyor **16** and provides support therefor as the bands **44, 45** disengage from the sprocket wheels **40.** Supported above the extension **64** is a loading platform portion **66** from which extend rearwardly a pair of thin support rails **68** which are secured in a parallel relationship against the inner faces of the curb blocks **54.** The loading platform **66** is provided to facilitate loading and seating of the rotors **26** in the slots **52** of the conveyor **16,** and the support rails **68** provide underlying support for the shafts **32, 34** as the rotors **26** proceed along the travel path, it being appreciated that the shafts ride upon the upper edges of the support rails **68** rather than resting at the bottom of the slots **52.** As a result, the conveyor **16** serves only to drive the rotors **26** forwardly through the system, with contact upon the rails **68** causing them to rotate as they are conveyed.

From the load zone, the armature rotors **26** are conveyed to the electrostatic coating station illustrated in detail in FIG. **7,** which is comprised of a hood, a powder feed stack, and an electrostatic coating chamber, generally designated by the numerals **72, 74** and **76** respectively. The electrostatic coating chamber **76** consists of an upwardly opening enclosure **78** secured against the bottom surface of the deck **36** and having a bottom wall opening through which air is charged from a pressurized source **79** thereof. A horizontal porous ceramic partition **80** divides the enclosure **78** into a lower air plenum chamber **82** and an upper cloud chamber **84.** The partition **80** supports an overlying grid-type electrode **86** connected to a diagrammatically illustrated high voltage source **88** and extending partially across the enclosure **78** to provide an electrode-free area **85** between its inner edge **87** and the sidewall **89,** through which extends an imaginary vertical corridor.

Within the corridor, supported upon the depending bracket **92,** is a pneumatically operated fluidic sensing device comprised (as seen in FIG. **8**) of a body **90** with a wire actuating finger **94** extending therefrom; one appropriate device is sold by Norgren Fluidics of Littleton, Colorado under the name FEATHERFLEX 5FS-**010-000.** On the outer end of the wire finger **94** is a float sphere **96** which may be fabricated of a foamed polystyrene or comparable lightweight material, and pneumatic control lines **98** extend from the body **90** and are connected to control means (not illustrated).

The feed stack **74** consists of a sifter box **100** having a screen **102** horizontally positioned across the central portion thereof and having a recycle feed conduit **104** and a replenish conduit **106** leading thereinto. As will be appreciated, the conduit **104** extends from the powder recovery and feed unit and the conduit **106** extends from the powder replenishment unit, both shown in FIGS. **1** and **2.** The conduits **104, 106** deliver thermoplastic resin powder **103** into the upper portion of the sifter box **100** from which it passes through the screen **102** and the opening **108** in the deck **36** with lumps and foreign matter being removed by the screen **102.** The powder **103** then falls upon the porous partition **80** where it becomes fluidized by air passing upwardly from the plenum chamber **82** in a conventional manner. The fluidized powder **103** exerts an upward force upon the float sphere **96** of the fluidic sensing device; when the quantity of powder **103** above the partition **80** is insufficient to urge the sphere **96** (and hence the actuating finger **94**) upwardly to the necessary extent, a signal from the sensor causes the control means (not illustrated) to deliver an additional quantity of powder **103** through the conduit **106** from the powder replenish unit, thereby correcting the deficiency.

The hood **72** is positioned over an elongated slot **110** in the deck **36** along which the parallel guide rails **68** extend. It is secured to the deck by bolts **112** and has a tunnel portion **114** with an end wall **116** forming a partial closure therefor and defining a tunnel opening **115** at each end thereof. A stack portion **118** extends upwardly from the tunnel portion **114** of the hood **72,** and has a takeoff conduit **120** which is attached to a suitable vacuum source and enables excess powder to be removed from the coating station. Such powder is returned to the recovery and feed unit for ultimate recycle through the conduit **104** leading to the feed stack **74.** An elongated baffle plate **122** is inclined downwardly from each sidewall of the tunnel portion **114** toward the travel path of the unit, and the plates **122** cooperate with the carrier tabs **50, 50'** to confine powder **103** which passes upwardly through the slot **110** to the central portion of the rotors **26** passing thereover.

As will be appreciated, the powder **103** employed for the coating operation is of such a nature that it is capable of acquiring an electrostatic charge as the particles pass through the grid electrode **86.** The rotors **26** are maintained at ground potential (such as by grounding the conveyor **17** with which they are in contact) during passage over the slot **110,** thus causing attraction and adherence of charged powder particles to the surfaces of the rotors **26,** with the electrostatic effect ensuring that all exposed surfaces, including winding slots **30,** are coated. Due to the charge on the powder particles, it is important that the fluidic sensing device be positioned over the electrode-free area **85** of the horizontal partition **80.** In this region charging of particles is minimized, as a result of which the attractive force from the grounded rotors **26** is quite insignificant and particles thereat are elevated only by the buoyant effect of the pressurized air. Otherwise, the electrostatic force on the particles would lead to an inaccurate indication of the quantity of powder present in the system, rendering control of the automatic replenishment system virtually ineffective.

Since the armature rotors **26** must be substantially free of insulating material on the circumferential surface of the core portion **28** and along the shafts **32, 34,** and since in the coating step powder deposits upon all exposed surfaces, the method and apparatus of the invention require that means be provided for removing powder from selected surfaces of the rotor **26** where it is unwanted. To that end, the illustrated apparatus is provided with a powder removal station which includes the contact belt unit, generally designated by the numeral **124,** and shown in FIGS. **3, 9** and **10.** The contact belt unit **124** includes an elongated forward frame member **126** from which extend rearwardly triangular mounting brackets **128** which are pivotally supported upon posts **130** projecting upwardly from the deck **36.** In this manner, the unit **124** is hingedly supported for ready displacement from the position over the deck **36** shown in FIG. **9** to its open position in FIG. **10.** Affixed in a central location behind the forward frame member **126** is a pinion block **131** which, in turn, has a gear train block **132** mounted behind it. A short central shaft **134** is journaled at its ends by appropriate means to extend transversely through the forward frame member **126,** the pinion block **131,** and the gear train block **132,** and it has a drive gear **136** affixed on it within the gear train block **132.** The shaft **134** also has a drive pinion **138** affixed to it in front of the gear **136,** with the pinion **138** residing generally within the pinion block **131.** A lower shaft **140** is journaled at its ends and extends transversely between the pinion block **131** and the gear train block **132;** on it is affixed, in meshing engagement with the drive gear **136,** an upper transfer gear **142.** The transfer gear **142** communicates through a deck opening **143** with a lower transfer gear **144** which is supported upon a shaft **146** positioned and appropriately journaled (by means not shown) below the deck **36.** As can be seen in FIG. **3,** the lower transfer gear **144** meshingly engages a gear **148** which is affixed to the shaft on which the drive pulley **22** is supported. In this manner, power is delivered from the motor **24** through the drive pulley **22** and the train of gears **148, 144, 142** ultimately to the drive gear **136** for the contact belt unit **124.** As can be seen, pivoting the unit **124** upwardly about the posts **130** simply disengages the gears **142** and **144,** discontinuing operation of the unit **124** and permitting access to the normally covered portion thereunder.

A belt pulley shaft **150** is journaled in the forward frame member **126** and pinion block **131** on either side of the central shaft **134,** and a pulley pinion (not exposed but identical to pulley pinions **152** to be discussed hereinafter) is affixed to the inner end of each of the shafts **150** and is in meshing engagement with the drive pinion **138.** (It will be understood that the pulley pinion on shaft **150** to the left of shaft **134** in FIG. **10** lies behind pinion **138,** as viewed in FIG. **9,** and that the pulleys and belt assembly at the left side of FIG. **9** are shown along a section line somewhat forward of line **9—9.**) To the opposite ends of the pulley shafts **150** are affixed belt pulleys **154.** Spaced to either side of the central pinion block **131** is an auxiliary pinion block **156** in which is contained a pair of belt pulley shafts **150** and a transfer pinion shaft **134** therebetween. The inner ends of the pulley shafts **150** have affixed to them pulley pinions **152** (as can be seen in the left-hand auxiliary pinion block **156** in FIG. **10**) and the transfer pinion shaft **134** has affixed to its inner end a transfer pinion **158** in meshing engagement with each of the pulley pinions **152** on either side thereof. Adjacent each end of the forward frame member **126** is a rectangular bearing block **162** in which is journaled, by appropriate means, a belt pulley shaft **150.** A belt pulley **154** of the type previously referred to is secured on the outer end of each belt pulley shaft supported in either the auxiliary pinion blocks **156** or the bearing blocks **162.**

The eight pulleys **154** function as four sets with adjacent pairs of pulleys supporting a belt assembly consisting of an underlying support element **164** and an outwardly exposed contact element **166.** The contact element is of foamed polyurethene or a comparable material providing a cellular outer surface. Such a structure enables the contact element **166** to pick up powder from the surface of the core portion **28** simply by contact therewith, with no wiping or brushing action being necessary or desirable. The support element **164** may be a timing belt (i.e., having transversely extending ridges about its inner surface) with the pulleys **154** being provided with corresponding ridges and grooves, or square teeth, to cooperate therewith. Drive power is transferred from the motor **24,** through the gears **148,** 144, 142, 136, to the pinion **138** within the central pinion block **131,** and to the innermost belt pulleys **154.** Due to the interconnection through the pulley pinions **152** and transfer pinion **158** within each of the auxiliary pinion blocks **156,** the belt assemblies on the outer sets of pulleys **154** are simultaneously driven, with all belt assemblies rotating at precisely the same rate and in the same direction.

As is seen in FIG. **9,** a central sprocket wheel **40'** having rectangular circumferential teeth **42** is supported on a common shaft (not shown) with two outside sprocket wheels **40.** The outside wheels **40** correspond to the sprocket wheels bearing the same numeral which constitute drive sprocket **11,** and the three commonly supported wheels **40, 40'** provide the intermediate drive sprocket **12.** Endless conveyor **18** has the construction illustrated in FIG. **16** and passes about the central sprocket wheel **40'.** The conveyor **18** consists of a central band **176** having carrier tabs **178, 178'** extending at right angles from the side margins thereof. The tabs **178'** are slightly narrower than the tabs **178,** again to render the slots **180'** there-between slightly

wider than the slots **180** between the tabs **178** to snugly receive the shafts **34, 32** of the rotor **26**, respectively. The following edges of each of the tabs **178, 178'** have bevelled shoulders **51** to facilitate entry of the shafts **32, 34** thereinto; however, it will be noted that the forward edges of the tabs **178, 178'** are not bevelled, and the reason therefor will be explained directly.

As can be seen in FIG. **10** a transfer of the rotors **26** occurs within the powder removal zone with the rotors **26** shifting from the forward conveyor **16** to the intermediate conveyor **18.** Engagement of both conveyors **16, 18** on different sprocket wheels **40, 40'** of the common drive sprocket **12** and the construction employed permits conveyor **18** to pass between the bands **44, 45** of the conveyor **16.** At the point of common tangency of the conveyors **16, 18** to sprocket **12** the respective slots **52, 180** thereof are substantially aligned, causing the shafts **32, 34** of the rotors **26** to momentarily reside in slots of both conveyors simultaneously. As the bands **44, 45** of the forward conveyor **16** pass downwardly about the sprocket **12,** the upper corners of the tabs **180, 180'** of the intermediate conveyor **18** engage behind the shafts **32, 34** to smoothly and effectively carry them out of the slots **52** with the bevelled shoulders **51** at the following edges of the tabs **50, 50'** facilitating withdrawal. Thereafter, the rotors **26** are propelled through the system by the center conveyor **18.**

Assuming movement to be in a left to right direction, contact of the ends of the shafts **32, 34** upon the support rails **68** causes rotation of the rotors **26** in a clockwise direction. If the motor **25** also drives the belt assemblies of the contact belt unit **124** in a clockwise direction, the direction of rotation of the rotors **26** will reverse upon encountering the lower flight of element **166** at the entrance of the unit **124** (the relationship at contact being as depicted in FIG. **9**). Such contact causes a significant proportion of the powder on the outer circumferential surface of the cylindrical core portion **28** of the rotors **26** to be displaced therefrom and to fall into the powder recovery hopper **184,** which is positioned at an appropriate location beneath the deck **36** (as may be seen in FIG. **3**). The hopper **184** is connected to the powder recovery and feed unit through a vacuum system (not illustrated) by a conduit **186.** Most of the remaining powder on the surface of the core portion **28** is picked up by the contact element **166** of the belt assembly, as previously described, with any additional powder being removed by the successive belt cleaning effects in the same manner. As will be appreciated, since the rotors **26** are supported for free rotation, after contact with the contact element **166** they turn at precisely the same speed under the influence thereof. This prevents relative wiping or brushing action between the element **166** and the rotors **26,** such as would tend to cause uneven deposits to be produced at the edges of the slots **30.** The nozzles **170** and associated vacuum conduits **172** are adjustably supported in the bifurcated end portions of the nozzle support arms **168** with the nozzles **170** lying closely adjacent the contact elements **166.** In this way, the powder picked up by the elements **166** is withdrawn from the cells thereof and is conveyed to the recovery portions of the system for recycle.

Positioned within the powder removal zone near the forward end of the second belt assembly of the unit **124** is a pair of vacuum blocks **188,** which are secured to the deck **36** along the sides of the travel path. As can best be seen in FIG. **12,** each of these blocks has a face plate **190, 190'** secured upon its upper surface and of an elongated vacuum channel **192** extending lengthwise therein. As can be seen with additional reference to FIGS. **3** and **13,** a vacuum nozzle **194** of generally oval cross section is secured against the lower surface of each of the vacuum blocks **188,** each nozzle **194** having a circular throat portion **196** about which is positioned an annular mounting collar **200** by which it is secured against the associated vacuum block **188** (by means not shown). Secured over the throat portion **196** of each nozzle **194** is a vacuum hose **198** which is connected to a vacuum source (not shown) and ultimately to the powder recovery and feed unit illustrated in FIGS. **1** and **2.**

The face plates **190, 190'** on the vacuum blocks **188** are provided with elongated slots **202, 202',** each of which extends in a generally angular relationship outwardly from the travel path. These slots **202, 202'** register over the channels **192** in the blocks **188** and serve to define a flow passage for air under the influence of vacuum drawn through the conduits **198.** As the armature rotors **26** travel between the vacuum blocks **188** with the shafts **32, 34** thereof in rolling contact upon the face plates **190, 190'** respectively, the vacuum effect from below thoroughly cleans the shafts **32, 34** of any powder which may have become deposited thereon. Normally, powder will be present in the shafts **32, 34** as a result of the initial electrostatic coating operation and/or due to displacement from the circumference of the cylindrical core portion **28** during powder removal by the first belt assembly in the contact belt unit **124.** The divergent disposition of the slots **202,** 202' will cause particles of powder to be removed first from the portions of the shafts **32, 34** adjacent the core portion **28** and progressively outwardly therealong. It will be appreciated that the nonlinear and nonuniform configuration of the slot **202'** is necessitated by the configuration of the crank shaft **34** which passes thereover. As can be seen in FIGS. **9** and **10,** a hold-down bracket **201** is secured to each of the vacuum blocks **188.** Each bracket **201** includes a pressure plate element **203** which overlies the slot **202, 202'** of the associated block **188** and serves to engage the tops of the shafts **32, 34** as they are conveyed thereunder, thereby forcing the shafts against the face plates **190, 190'** to ensure efficient powder removal therefrom.

After travelling past the vacuum blocks **188,** the armature cores **26** are conveyed beneath the third of the series of belt-cleaning assemblies while being supported upon parallel side rails **182.** The fourth contact belt effect is similar in design to the first three, with the exception that it is provided with contact belt assemblies for the shafts **32, 34** as well as for the cylindrical core portion **28** of the rotors **26.** The construction of this portion of the contact belt unit **124** is most clearly illustrated in FIG. **11,** wherein it can be seen that a set of three belt pulleys **154** are mounted on a common shaft **150** for simultaneous rotation. Each of the pulleys has a belt assembly consisting of a support belt **164** and a contact belt **166** constructed as hereinbefore described, and it will be appreciated that the belts extend between two of such sets of three belt pulleys **154** (as can be seen in FIG. **10**).

From the contact belt unit **124,** the armature rotors **26** pass into a precuring unit, generally designated by the numeral **204** and shown in FIGS. **3** and **14.** With

specific reference to the latter figure, it can be seen that the precuring unit **204** consists of a cover assembly, generally designated by the numeral **206,** which has affixed thereto a pair of angle brackets **208,** only one of which is visible in FIG. **14.** The brackets **208** are secured at one end to the cover assembly **206** by appropriate bolts **210,** and the opposite ends thereof are pivotally supported upon posts **212** which are mounted upon the deck **36** of the machine. Also secured to the cover assembly **206** is a right angle contact arm **214** which has an element extending over the end of a spring-loaded plunger assembly **216.** In normal operation the cover assembly **206** will be maintained in the position illustrated in full line in FIG. **14** by fluid pressure means acting against the upward force of the plunger assembly **216.** If the machine stops or if some emergency situation occurs, the fluid pressure force is disrupted, permitting the plunger assembly **216** to immediately raise the cover assembly **206** to the position shown in phantom line.

The cover **218** of the cover assembly **206** is elongated (as can be seen in FIG. **3**) and is of inverted, generally U-shaped configuration (as is shown in FIG. **14**). It has a number of layers **220** of insulating material lining the top wall thereof, which are secured, along with a metal sheet reflector **222** and a pair of elongated angular baffle plates **224,** to the cover **218** by appropriate bolts **226.** Heating elements **228,** which may be CALROD units, extend longitudinally within the cover **218** and are supported therein by a number of inserts **230,** which are spaced along the length of the cover **218** and have pairs of apertures **231** to receive and support the heating elements **228.** The baffle plates **224** are constructed with inclined walls **232** which slope downwardly and inwardly toward one another and toward the travel path; the walls serve to support the inserts **230** as well as their primary function of reflecting and concentrating heat from the elements **228** upon the central portion of the travel path.

Supported along each side of the cover **218** at the lower edges thereof is one of a pair of configured cooling blocks **234,** which may be constructed of aluminum or another suitable material having a high heat transfer coefficient. It will be appreciated that these cooling blocks are elongated and extend along substantially the entire length of the cover **218.** The cooling blocks **234** have inner upstanding elements **235** which are configured to define behind them circular recesses **236,** in which are supported cooling tube portions **238.** Small, downwardly opening U-shaped channels **240** are defined along the lower inner edges of the upstanding elements **235,** and a depending ridge **242** is provided on each of the cooling blocks **234** adjacent the lower outer edge thereof.

The ridges **242** of the cooling blocks **234** are received in narrow, upwardly opening U-shaped channels **244** defined in the upper surface of the base of the precuring unit **204,** the base being generally designated by the numeral **246.** A relatively large, upwardly opening U-shaped channel **250** extends axially in the base **246** along its entire length to define the travel path therethrough. The underside of the base **246** has a U-shaped channel **248** of a similar size running along its length, with the opposed relationship of the channels creating a relatively thin floor portion **252** therebetween. A rectangular base block **254** is seated in the downwardly opening channel **248** and is welded in place with its upper surface spaced a short distance downwardly from the lower surface of the floor portion **252** to define a shallow water channel **256** therebetween. Upwardly opening U-shaped slots **258** are formed in the upper surface of the block and along the entire length thereof between the central channel **250** and each of the relatively narrow channels **244,** and each of the slots **258** has a cover strip **260** engaged over its open end to thereby define closed conduits therewithin.

At each end (only one end being shown) the base **246** is provided with a transverse bore **262** which communicates with the opposite ends of the shallow water channel **256.** To facilitate manufacture, the bores **262** are simply drilled inwardly from the side of the base **246,** with plugs **264** being inserted afterward to close the ends. Extending upwardly and inwardly from the opposite ends of the bores **262** are short connecting channels **266** (only two of the four of which are seen because only one end of the base **246** is illustrated), one of which communicates with each of the U-shaped slots **258** at one end thereof. Finally, an inlet port **268** communicates from the lower surface of the base **246** with the transverse bore **262,** and it will be appreciated that the other end of the base **246** has a similar port **268** communicating with the associated bore **262** provided thereat.

In operation, the precure unit **204** heats the cylindrical core portion **28** of each of the armature rotors **26** while simultaneously cooling the shafts **32, 34** thereof. Heat is generated by the elements **228,** with the reflector **222** and the baffle plates **224** effectively directing the heat inwardly toward the core portion **28** and concentrating it thereat. The simultaneous cooling effect is provided by passing water through the base **246** and the configured cooling blocks **234.** With respect to the base **246,** water passes inwardly through illustrated port **268,** transversely across the block in the bore **262,** and thence along the length of the base **246** within the shallow water channel **256** and the U-shaped slots **258** to pass outwardly through the transverse bore and port not illustrated. In this manner, a cooling effect is transmitted through the thin floor portion **252** to cool the central band **176** of the conveyor **18** and the surrounding area. Water passing through the slots **258** serves not only to cool the sides of the conveyor **18,** but has the primary function of producing a cooling effect through the cover strips **260.** The shafts **32, 34** of the armature rotors **26** contact these strips **260** directly, so that the cooling water passing therebeneath very effectively lowers the temperature of those portions. The configured blocks **234** are cooled by water passing into one of the cooling tube portions **23** and out of the other, the portions **238** being parts of a continuous conduit. As a result, the horizontal part **237** of each of the blocks **234** is cooled and cooperates with the base **246** to effectively maintain the shafts **32, 34** at a relatively low temperature. The upper ends of the carrier tabs **178, 178'** of the conveyor **18** extend into the downwardly opening U-shaped channels **240** adjacent the lower inner edges of the blocks **234,** and are cooled thereby. In addition, the engagement of the depending ridges **242** in the upwardly opening channels **244** increases the effectiveness of cooling by unifying the cover **218** and base **246** of the precure unit **204.** A low temperature shell is thereby defined about the travel path through the precuring unit **204,** except in the limited area thereabove at which the heating effect is concentrated. Ac-

cordingly, the unit **204** very effectively cools parts of the rotors **26** which lie outwardly of the cylindrical core portion **28**, while the portion **28** is heated to a relatively elevated temperature. As a result, only resin on the core portion **28** is melted and fused, with any powder remaining on the shafts **32, 34** being maintained in a solid particulate state. This permits removal of unwanted powder from the shafts **32, 34** while simultaneously producing a relatively adherent coating in the slots **30** of the core portion **28**, the circumferential surface of the core portion **28** having been freed from powder by the action of the belt assemblies in the contact belt unit **124.**

Turning now in detail to FIG. **15**, therein illustrated is an air knife assembly, generally designated by the numeral **270**, which is positioned immediately downstream from the precure unit **204**, as can be seen in FIG. **3.** The air knife assembly **270** consists of a pair of spaced, inverted U-shape bridge members **272** which have mounted thereon a pair of spaced air manifold bars **274.** The manifold bars **274** are adjustable (by means not shown) to vary their spacing and angular attitude relative to one another, and each of them has a number of flattened nozzles or air knives **276** extending downwardly therefrom toward the deck **36** of the machine. In general alignment under each of the manifold bars **274** is an upwardly opening elongated trough **278** which is connected to a vacuum source (not shown) through vacuum conduits **280** attached to the lower ends thereof. As will be readily appreciated, armature rotors **26** pass from the precuring unit **204** beneath the bridge members **272** of the air knife assembly **270** with their shafts **32, 34** extending outwardly over the troughs **278.** Air is charged under pressure into the manifold bars **274** through the air conduits **282** and is blown at high velocity upon the shafts **32, 34** through the air knives **276** as the rotors **26** travel through the assembly **270.** Due to the discrete form in which the particles are maintained as a result from the cooling effects of the precuring unit **204**, the air from the knives **276** effectively dislodges any particles present on the shafts **32, 34** and propels them into the troughs **278.** In this manner, the shafts are thoroughly cleaned prior to entry of the rotor **26** into the oven, with the excess powder being returned to the system through the conduits **280.**

Uncoated armature rotors **26** are loaded in successive pairs of slots **52, 52'** of the conveyor bands **44, 45** at the infeed station of the apparatus, and enter the oven with at least partially fused and cohered coatings of resin in the slots **30** and on the end faces **37** thereof. The circumferential surfaces of the cylindrical core portions **28** of the rotors **26** are virtually devoid of any powder particles. This is accomplished by the contact belt elements **166,** which effectively remove all powder deposited thereon without causing significant amounts of the resin to be removed or built up at the edges of the slots **30,** which is achieved due to the absence of any wiping effect.

The shafts **32, 34** are preliminarily cleaned in the belt contact unit **124** by passage over the slotted face plates **190, 190'** of the vacuum blocks **188,** and by the contact elements **166** of the fourth set of belt assemblies, as illustrated in FIG. **11.** However, it should be appreciated that either or both of these effects might be eliminated, with reliance being placed entirely upon the action in the precuring unit **204** to permit powder removal, but preferably both the contact belt unit **124** and also the precuring unit **204** will be provided as illustrated. From the precuring unit **204** the rotors **26** are carried to the air knife assembly **270** for a final cleaning, through the oven for complete fusion, and finally to the cooling unit for solidification of the resin.

Subsequent to the air knife assembly **270** and ahead of the oven is a second transfer point which occurs over the rearmost drive sprocket **13.** Since the transfer is quite comparable to that which occurs over the sprocket **12,** a detailed explanation is not believed to be necessary. However, as illustrated in FIG. **16,** the construction of the conveyor **20** to which the cores are transferred at this point is somewhat different from any described previously. More particularly, the conveyor **20** consists of a pair of spaced chain assemblies, generally described by the numeral **283** (only one being shown in FIG. **16**) which, at the point of transfer, lie to either side of the conveyor **18.** Each of the chain assemblies **283** includes an endless sprocket chain **292** on which is mounted a multiplicity of U-shaped cradles **284.** Each of the cradles **284** has in its inner wall **288** an upwardly opening U-shaped socket **286** in which the shafts of the rotors are received. The cradles **284** have a depending flange element **290** secured thereto, and the flange elements constitute part of the sprocket chain **292** while affording the means of attachment thereto. As will also be appreciated, drive sprocket **13** will consist of a pair of sprocket wheels similar to those employed for the drive sprocket **12,** one wheel being used to support and drive each of the chain assemblies **283.**

The particular fusible resin used may vary greatly; however, of the types of materials which are suitable, thermoplastics, and particularly synthetic thermoplastic resins, are preferred. Exemplary of such thermoplastic resins are the vinylidenes and vinyls (e.g., polystyrene and polyvinyl chloride), the olefins (e.g., polyethylene, polypropylene and copolymers thereof), the cellulosics, polyamides (e.g., nylons), etc.

As will be appreciated by those skilled in the art, many changes may be made in the illustrated apparatus without departing from the concept of the invention hereof. For example, heating may be by any appropriate means, and may employ convection, conduction, infrared, induction, or like effects. Similarly, cooling may be accomplished in any appropriate manner, such as by the use of cooled air or other fluid, conventional refrigeration, etc. The proper electrical circuitry will also be readily apparent and of the type conventionally employed in the electrostatic coating and electromechanical arts. It should be appreciated that, although good practice and safe operating procedures will normally dictate electrical grounding of the apparatus and of the workpiece by contact therewith, no special provision need normally be made for grounding of the workpiece to ensure adequate electrostatic attraction and adhesion. The high voltage charging of the particles will usually suffice to establish an adequate potential relative to the workpiece, regardless of the measures taken with respect to the latter; however, independent connections may be made to the workpiece if so desired.

As used herein, the terms "partial fusion" and "coherence" are intended to connote a state in which the individual particles of the resin have been affected by heat sufficiently to at least loosely join them together,

so as to resist separation. In such a condition individual particles may be discernible, whereas upon complete fusion or melting the particles are no longer identifiable as such. Due to the variety of resinous materials that may be employed in the practice of the invention, it is not possible to place specific values upon the temperatures involved for fusion or melting without unduly limiting the scope thereof. Moreover, the conditions of operation that are appropriate in each instance will be readily apparent to those skilled in the art in view of the foregoing detailed information.

Thus it can be seen that the present invention provides a novel method and apparatus for the production of a unified, adherent coating of a heat fusible resin upon a limited portion of a workpiece. More specifically, it provides such a method and apparatus for electrostatically coating the workpiece and for effecting the removal of the resinous material from selected portions thereof which are to be uncoated, and the method and apparatus are particularly adapted for coating reentrant surface portions of generally cylindrical articles. The coatings are produced quickly, easily and economically, and on an automatic and continuous basis if so desired. A novel precuring device is also provided which is adapted to set the coating at one zone of a workpiece while simultaneously maintaining the particulate form of the resin at a second zone to facilitate its complete removal therefrom.

Having thus described the invention we claim:

1. A method for the production of a unified, adherent coating of heat-fusible material upon only a portion of a workpiece having proximate first and second zones in heat-conductive contact with one another, comprising the steps of:

a. producing a cloud of electrostatically charged solid particles of heat-fusible resinous material;

b. exposing said workpiece to said charged particles with said workpiece charged effectively opposite thereto to cause a layer of said particles to deposit upon said first and second zones thereof;

c. heating said first zone of said workpiece to a relatively high temperature above ambient while simultaneously cooling said second zone thereof to cause at least partial fusion and coherence of said particles on said first zone while maintaining said second zone at a relatively low temperature substantially below said relatively high temperature to substantially prevent fusion and coherence of particles on said second zone to thereby facilitate removal therefrom;

d. thereafter removing from said second zone any of said particles of resinous material remaining thereon,

said simultaneous heating and cooling step producing a relatively steep temperature gradient between said first and second zones, so that the margins of said layer of particles on said first zone are relatively sharply defined.

2. The method of claim 1 additionally including the step of heating said workpiece subsequent to said simultaneous heating and cooling step to at least about the melting point of said resinous material to melt said particles thereof and to produce a unified and adherent coating upon said first zone of said workpiece.

3. The method of claim 1 additionally including the step of removing a portion of said layer of particles deposited upon said first zone of said workpiece prior to said simultaneous heating and cooling step.

4. The method of claim 1 additionally including the step of removing said layer of particles deposited upon said second zone of said workpiece prior to said simultaneous heating and cooling step.

5. The method of claim 1 wherein said resinous material is a synthetic thermoplastic resin.

6. The method of claim 1 wherein said workpiece is an armature rotor having a cylindrical core portion with axially extending slots about the circumference thereof, the surfaces of said slots comprising said first zone of said workpiece.

7. A method for the production of a unified, adherent coating of heat-fusible material upon only a portion of a work-piece having proximate first and second zones in heat-conductive contact with one another, comprising the steps of:

a. producing a cloud of electrostatically charged solid particles of heat-fusible resinous material;

b. exposing said workpiece to said charged particles with said workpiece at about ambient temperature and charged effectively opposite to said particles to cause a layer thereof to deposit upon said first and second zones of said workpiece;

c. thereafter heating said first zone of said workpiece to a relatively high temperature above ambient while simultaneously cooling said second zone thereof to cause at least partial fusion and coherence of said particles on said first zone while maintaining said second zone at a relatively low temperature substantially below said relatively high temperature to substantially prevent fusion and coherence of particles on said second zone to thereby facilitate removal therefrom; and

d. thereafter removing from said second zone any of said particles of resinous material remaining thereon,

said simultaneous heating and cooling step producing a relatively steep temperature gradient between said first and second zones, so that the margins of said layer of particles on said first zone are relatively sharply defined, said step (d) being effected immediately after said step (c).

8. The method of claim 7 additionally including the step of heating said workpiece subsequent to said simultaneous heating and cooling step to at least about the melting point of said resinous material to melt said particles thereof and to produce a unified and adherent coating upon said first zone of said workpiece.

9. The method of claim 7 additionally including the step of removing a portion of said layer of particles deposited upon said first zone of said workpiece prior to said simultaneous heating and cooling step.

10. The method of claim 7 additionally including the step of removing said layer of particles deposited upon said second zone of said workpiece prior to said simultaneous heating and cooling step.

11. The method of claim 7 wherein said resinous material is a synthetic thermoplastic resin.

12. The method of claim 7 wherein said workpiece is an armature rotor having a cylindrical core portion with axially extending slots about the circumference thereof, the surfaces of said slots comprising said first zone of said workpiece.

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