Dec. 9, 1969 J. M. BIDDISON 3,482,545

SPRAY COATING APPARATUS

Filed Aug. 9, 1965 3 Sheets-Sheet 1

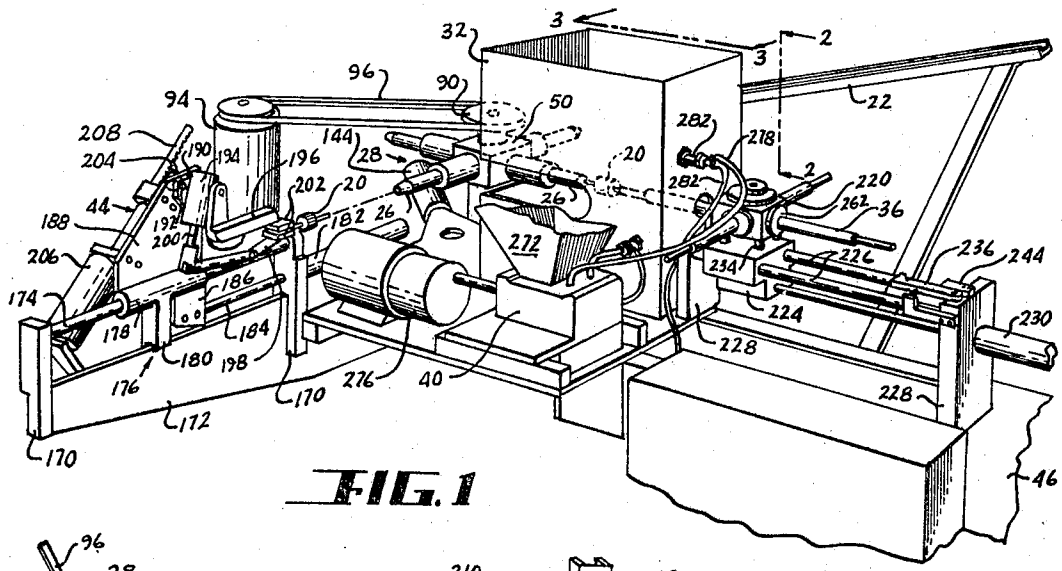


FIG. 1

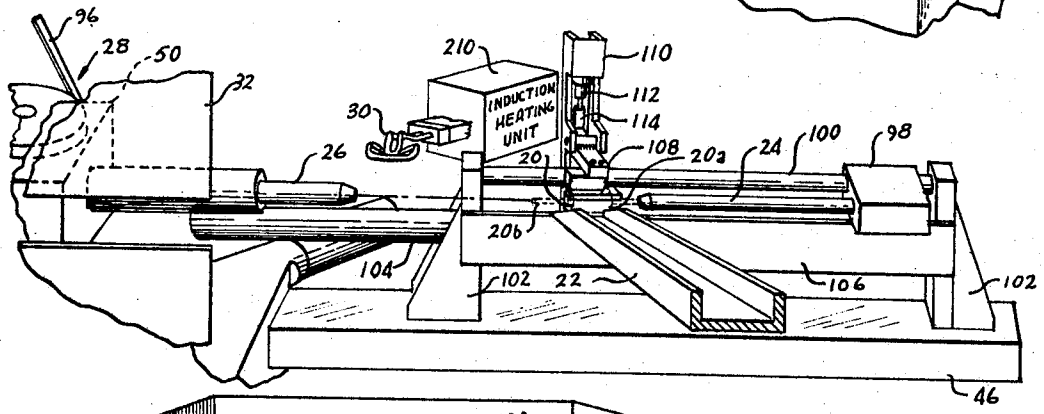


FIG. 2

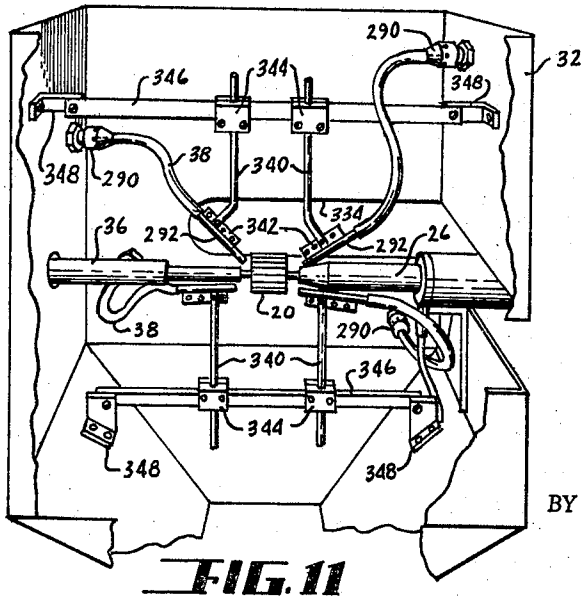


FIG. 11

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SPRAY COATING APPARATUS

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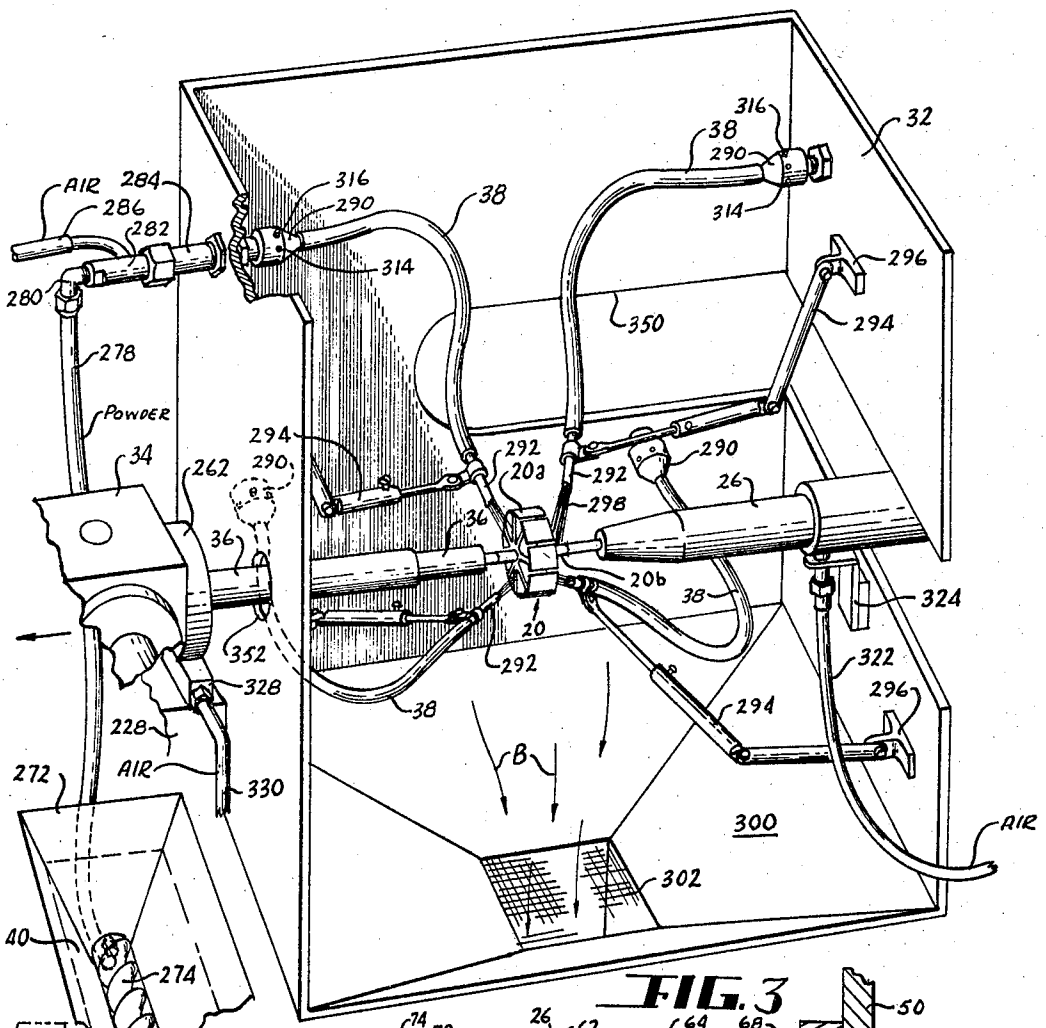
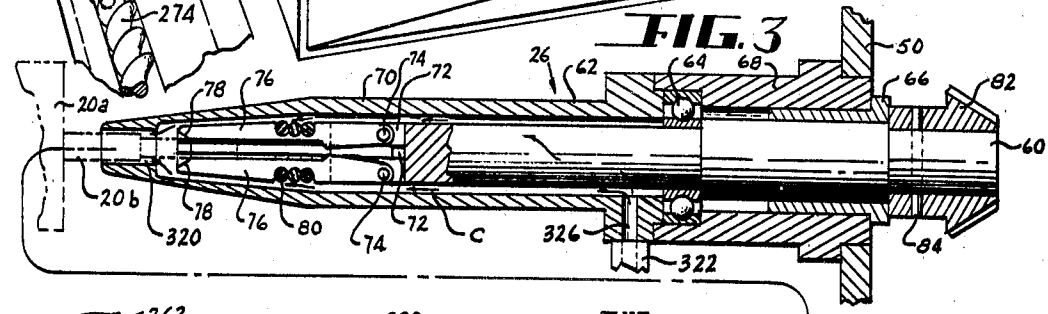


FIG. 3



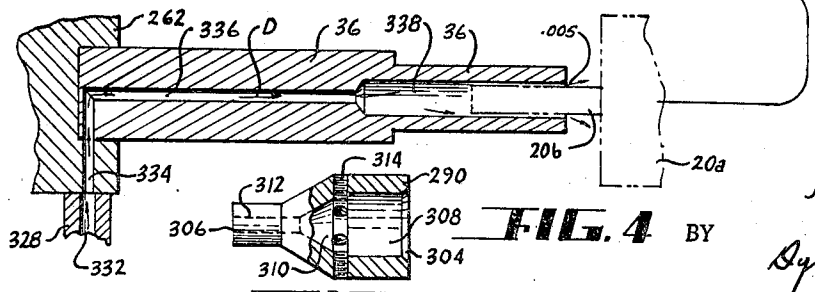


FIG. 4

FIG. 5

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SPRAY COATING APPARATUS

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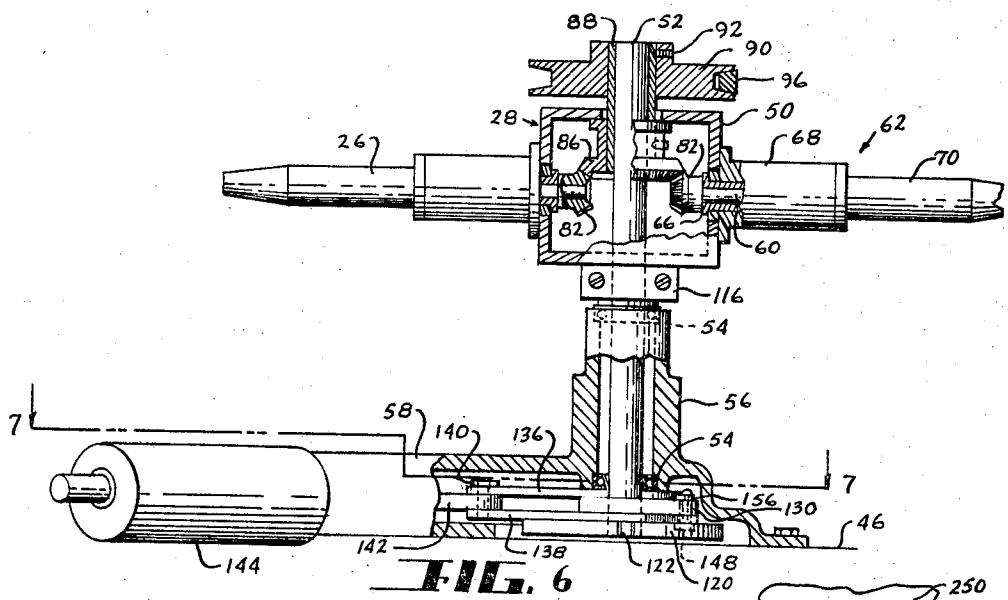


FIG. 6

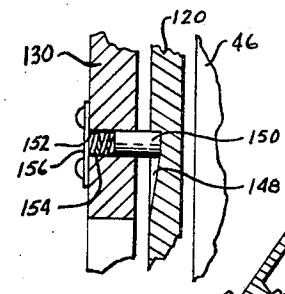


FIG. 8

FIG. 7

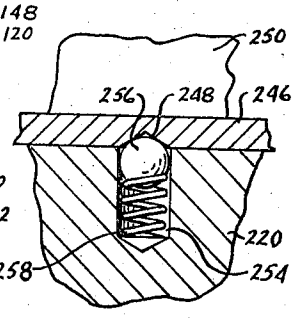


FIG. 10

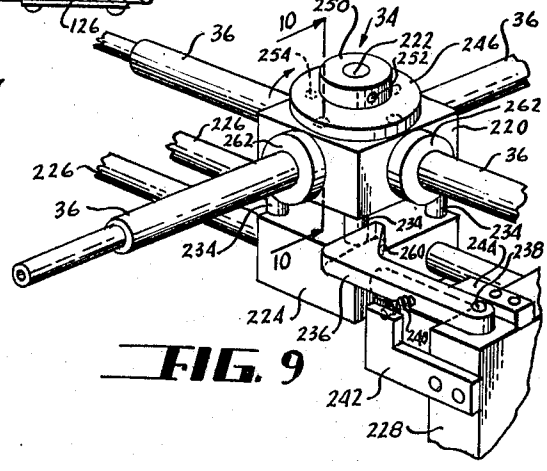


FIG. 9

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United States Patent Office 3,482,545
Patented Dec. 9, 1969

3,482,545

SPRAY COATING APPARATUS

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Filed Aug. 9, 1965, Ser. No. 478,200
Int. Cl. B05c 11/16, 5/02
U.S. Cl. 118—301 9 Claims

ABSTRACT OF THE DISCLOSURE

An end of an armature shaft to be coated is clamped to a spindle shaft of a headstock and received within the sleeve of a tailstock. Automatic loading of the armatures on the spindle shaft is disclosed as well as a spray cabinet with spray lines. The spray lines include air control devices for relieving the pressure of mixture streams formed by compressed air and coating powder. The headstock has four spindles and the tailstock has four sleeves, the headstock and tailstock both being rotatably indexed to align different spindles and sleeves.

This invention relates to a spray coating apparatus and especially to apparatus for spraying an insulating coating upon surface portions of armatures for dynamoelectric devices. As will become apparent from the ensuing description, features of the invention described herein will be useful in the spraying of powdered coating materials on a variety of other articles; other features will be useful generally in the handling of armatures or similar articles. Hence, the invention described herein consists of the entire apparatus and in portions thereof and is not limited to the spray coating of armatures.

An object of this invention is to provide an improved apparatus for applying a spray coating to articles.

A further object of this invention is to provide improved apparatus for handling armatures or similar articles, and especially for handling articles which are heated while being handled.

A more specific object of this invention is to provide simple, reliable apparatus for handling armatures or similar articles which must be moved or indexed to a variety of positions and rotated while being indexed.

Still another object of this invention is to provide an improved masking useful in spray coating apparatus involving the use of air or other gas passing through portions of mechanisms for handling the devices to be coated.

Yet another object of this invention is to provide readily adjustable, rugged, inexpensive means for controlling the pressure of a mixture stream of powdered material and air or another gas. This object is of utmost importance when the mixture stream is formed by drawing powdered material from a container through a suction tube of a venturi suction system since the air pressure required to create an adequate suction of powdered material often exceeds the maximum pressure usable to maintain a useful mixture stream.

Other objects and advantages reside in the construction of parts, the combination thereof, as will become more apparent from the following description.

Referring to the drawings:

FIGURE 1 is a perspective view of a machine for applying a powdered coating material to armatures as viewed primarily from the rear of the machine.

FIGURE 2 is a perspective view of a portion of the machine of FIGURE 1 as viewed in the direction of arrows 2—2 thereof and illustrates mechanisms for handling armatures prior to the coating operation.

FIGURE 3 is a perspective view taken in the direction of arrows 3—3 of FIGURE 1 of a spray cabinet forming

part of the machine. FIGURE 3 also diagrammatically illustrates a coating powder container and associated air lines.

FIGURE 4 is a split, cross-sectional view of devices for handling an armature during the spray operation.

FIGURE 5 is a side elevational view, partly in cross-section, of an air control device used in each of the spray lines.

FIGURE 6 is an elevational view, with parts in cross-section, of a headstock forming part of the mechanism of FIGURE 1.

FIGURE 7 is a cross-sectional view of the base of the headstock taken along line 7—7 of FIGURE 6.

FIGURE 8 is a cross-sectional view of a detent mechanism used in controlling the position of the headstock of FIGURE 6 and is taken along the line 8—8 of FIGURE 7.

FIGURE 9 is a perspective view of a tailstock used in the machine of FIGURE 1 illustrated in a position different from that illustrated in FIGURE 1.

FIGURE 10 is a cross-sectional view of a portion of the tailstock taken along line 10—10 of FIGURE 9.

FIGURE 11, on the first sheet, is a perspective view of a spray cabinet usable in the apparatus of FIGURE 1 employing modified spray apparatus.

GENERAL DESCRIPTION

Referring to the drawings in greater detail, the machine illustrated in FIGURE 1 incorporates not only mechanisms for applying an insulating coating to armatures or other electrical apparatus but also includes mechanisms for handling armatures or the like prior to and immediately after application of the coating. Prior to the winding of coils of wire in armatures for electric motors or the like, the surfaces of the teeth forming the radially extending, coil-receiving slots are almost invariably covered by an insulator. Typically, the insulator is in sheet form appropriately formed to fit snugly against the teeth surfaces. Insulating sheets closely resembling the laminations forming the armature core are also mounted contiguous to each end of the core. Finally, a pair of insulating sleeves are placed over the armature shaft in abutment with the sheets on each end of the core. As apparent, several operations are normally required to position the numerous insulations. The application of an insulating coating on armatures and similar electrical articles or devices appears to present considerable advantages when compared with the use of insulating sheets. Commercially available resins provide an excellent and durable insulating coating and can be applied to all surfaces to be insulated in a single operation.

The apparatus to be described herein is intended for spraying powdered coating material, say an epoxy resin, on selected surfaces of an armature to be insulated. When spraying, care must be taken to avoid coating surfaces which do not require insulation. The periphery of the armature core should normally not be coated because the subsequent assembly tolerances do not ordinarily provide space for such a coating. Similarly, the ends of the armature shaft should remain uncoated because these ends are used as bearing surfaces. At the same time, care must be taken in handling the armature assembly because the powdered resins form an insulating coating by contacting a heated metallic surface, melting and fusing. Some cure time is also required after the coating is applied. Hence, the surfaces of the mechanisms which handle the armatures may become sufficiently hot to melt resin particles falling thereon. A continual build-up of coating on such surfaces, of course, could not be tolerated. The manner in which the apparatus described herein obviates these difficulties will be discussed in detail below.

With reference to FIGURE 2, an armature assembly, designated 20, having a core 20*a* and a shaft 20*b*, is shown

at the base of a loading ramp or track **22** with one end of the armature shaft **20***b* engaged by a transfer rod **24**. It will be understood that a plurality of armature assemblies **20** would be placed on the loading ramp **22** and that the armature assemblies **20** would sequentially slide down the ramp **22** in position to be engaged by the transfer rod **24**. Upon operation, the transfer rod **24** moves the armature assembly **20** from that position as shown in FIGURE 2 into engagement with a spindle **26** of a rotatable headstock **28**. For convenience, the term "loading station" is used herein to refer to the position of the spindle **26** illustrated in FIGURE 2. As will be described below, the spindle **26** imparts rotation to the armature assembly **20** engaged therewith. When first engaged with the spindle **26** at the loading station, the armature assembly **20** may be heated by an induction coil **30**. Although not important to this invention, some details relating to the heating process will be discussed in greater detail below.

After the armature assembly **20** is heated to a temperature sufficient to cause the powdered coating material to melt, the headstock **28** is rotated or indexed about its vertical axis through 90° to the position of the armature assembly **20** shown by the phantom lines in FIGURE 1 and in full lines in FIGURE 3 in a spray cabinet **32**. This position of the spindle **26** is called the "spray station." A rotatable tailstock **34** carrying four sleeves **36** is advanced toward the armature assembly **20** in the cabinet **32** whereupon one of the sleeves **36** moves into surrounding relationship to one end of the armature shaft **20***b*. The spray cabinet **32** is provided with a plurality of spray lines **38**. As will be described, mixture streams of air and powdered particles from a powder container **40** pass through the spray lines **38** onto the surfaces of the armature assembly **20** to be coated. After the coating operation is complete, the headstock **28** is again rotated or indexed through 90° about its vertical axis whereupon the armature assembly **20** is positioned (as shown in full lines in FIGURE 1) to be grasped by a clamp mechanism **42** of a movable unloader transfer mechanism, generally designated **44**. This position of the spindle **26** is termed the "unloading station" herein. After the armature assembly is unloaded from the spindle **26**, the headstock **28** is again rotated to a "cooling station." Upon subsequent index, the spindle **26** returns to the loading station of FIGURE 2 whereupon it receives another armature assembly **20**. The various parts of the machine briefly described above will now be described in detail under separate headings.

SPINDLES 26 AND ARMATURE HANDLING WITH HEADSTOCK 28

With reference to FIGURES 1 and 6, there are four spindles **26**, one at each of the aforementioned stations, mounted on the sidewalls of a gear housing **50** forming part of the headstock **28**. The spindles **26** are equally spaced by 90° one from another along radial lines projecting from the vertical centerline of the headstock **28** which also coincides with the vertical centerline of a rotatable headstock drive shaft **52** journalled for rotation in spaced bearings **54** housed in a vertically oriented, hollow cylindrical support member **56** which projects upwardly from a headstock base **58**. The base **58** is fixedly mounted upon a support structure **46**. It is to be understood that the mechanisms to be described herein will be mounted on cabinets or suitable tables. Throughout, the various support structures which are fixed in relation to the floor will be designated by reference character **46**.

As shown best in FIGURES 4 and 6, each spindle **26** includes a spindle shaft **60** mounted for rotation in a spindle sleeve **62** as by a roller bearing **64** and a bearing sleeve **66**. For convenience in manufacturing, each spindle sleeve **62** may be made in two parts. One part, designated **68**, is affixed to a sidewall of the housing **50** and receives the bearing sleeve **66** while the other part, designated **70**, projects from the outer end of the part **68**. As illustrated, the roller bearing **64** may be confined between the two parts **68** and **70** of the sleeve **62**. The sleeve **62** completely covers the portions of the spindle shaft **60** projecting out of the gear housing **50** and the parts attached thereto for purposes which will be described below. The free end of each spindle shaft **60** is provided with crossed slots **72** in which are located pivot pins **74** for four clamp blades **76**, the free ends of which are beveled as indicated at **78**. The clamp blades **76** are biased into engagement with one another by any suitable resilient means, such as the three rubber bands **80** shown in FIGURE 3. The beveled surfaces **78** permit the insertion of one end of an armature shaft **20***b* in between the free ends of clamp blades **76**, forcing them apart. With this construction, the entire armature assembly **20***a* will be firmly clamped relative to the spindle shaft **60**.

To the innermost end of each spindle shaft **60** is affixed a bevel gear **82** as by a locking pin **84**. The several bevel gears **82**, as shown in FIGURE 6, are engaged with a main bevel drive gear **86** pinned to a bearing sleeve **88** projecting out of the top of the gear housing **50**. A pulley **90** affixed to the bearing sleeve **88** as by a set screw **92** serves to drive the bearing sleeve **88** and, accordingly, the drive gear **86** and the four bevel gears **82**. The pulley **90** is in turn driven by an electric motor **94** (FIGURE 1) connected to the pulley **90** by a belt **96**.

With reference to FIGURE 2, it will be appreciated that the transfer rod **24** may be quite simple and that it is merely necessary to force the free end of the armature shaft **20***b* illustrated therein against the beveled surfaces **78** in order to clamp the armature assembly **20** to the spindle **26**. Hence, the transfer rod **24** may simply be a generally solid rod having a hollow free end for receiving an end of the armature shaft **20***b*. The rod **24** is shown monuted upon a transfer carriage **98** that is slidable on a transfer guide rod **100** mounted upon spaced standards **102** on the support structure **46**. An air cylinder **104** or the like, which may be mounted on one of the standards **102**, is connected in any suitable fashion to the carriage **98** for advancing the carriage **98** from that position shown in FIGURE 2 toward the left whereby one end of the armature shaft **20***b* is picked up by the hollow end of the transfer rod **24**. Continued movement of the carriage **98** toward the left, as viewed in FIGURE 2, causes the opposite end of the armature shaft **20***b* to be forced into clamping engagement with the spindle **26** at the loading station. To insure that the armature assembly **20** will be picked up by the transfer rod **24**, it is temporarily clamped at the base of the loading ramp **22** upon a loading deck **106** by a clamp arm **108** pivoted between spaced sides of a clamp support member **110**. An air cylinder **112** connected to the clamp arm **108** by a link **114** is pivotally supported by the member **110** for actuation along a generally vertical axis. As apparent, the air cylinder **112** can be used to control the position of the clamp arm **108** and can be timed to operate to hold an armature assembly **20** against the loading deck **106** until one end of the armature shaft **20***b* is fully received within the hollow end of the transfer rod **24**.

After the loading of an armature assembly **20** into the spindle **26**, as shown in FIGURE 2, and the subsequent heating of the armature assemby **20**, the gear housing **50** is rotated or indexed through 90° to position the loaded spindle **26** in the spray station by a headstock indexing mechanism best shown in FIGURES 6, 7 and 8. The housing **50** is affixed to the headstock drive shaft **52** by suitable clamp pieces **116**. The indexing mechanism rotates the drive shaft **52** and includes a circular clutch disc **120** affixed at its center to the lowermost end of the drive shaft **52**. Four notches **122** are cut in the outer periphery of the clutch disc **120** along equally spaced radial lines to correspond to the four positions of the spindles **26**. The clutch disc **120** and, accordingly, the headstock drive shaft **52**, the gear housing **50**, and the spindles **26** are accurately locked in the various positions by a shot pin **124** which is biased into engagement with one of the

notches 122 by a spring 126 located in an inwardly projecting spring housing portion 128 of the headstock base 58. The disc 120 and, accordingly, the gear housing 50 are rotated by an actuating plate 130 mounted for rotation on the headstock drive shaft 52. The plate 130 has a lost motion slot 132 therein through which passes an actuating pin 134 which, in turn, is affixed to an upper actuating arm 136 and a lower actuating arm 138. Both actuating arms 136 and 138 are pivotally connected by a pin 140 to the free end of a piston rod 142 of an air actuating cylinder 144 mounted externally of the headstock base 58. The lower actuating arm 138 is generally C-shaped, having a hook portion 146 near the shot pin 124 which serves as a release bar for removing the shot pin 124 from engagement with the adjacent notch 122. Release of the shot pin 124 occurs upon initial retraction of the piston rod 142, that is movement generally to the left as viewed in FIGURE 7 while the actuating pin 134 is traveling through the lost motion slot 132. When the actuating pin 134 reaches the terminal end of the lost motion slot 132, the shot pin 124 is fully biased against the spring 126 out of the adjacent notch 122. Therefore, the clutch disc 120 is free to rotate.

The clutch disc 120 is provided with four equally spaced cam grooves 148 having lower surfaces which slope increasingly downwardly beneath the top surface of the disc 120 in the direction of rotation imparted to the plate 130 upon continued movement of the piston rod 142 after the pin 134 reaches the terminal end of the lost motion slot 132. A cylindrical pawl 150 is mounted for sliding movement within an aperture 152 projecting through the actuating plate 130. The pawl 150 is biased by a coil spring 154 confined in the aperture 152 between the upper end of the pawl and a cap plate 156 affixed to the top surface of the actuating plate 130. When rotation is first imparted to the plate 130, the pawl 150 is lodged within the deepest end of one of the cam grooves 148. Accordingly, the clutch disc 120 will rotate with the actuating plate 130. Such rotation continues for 90° in the direction of the arrows A in FIGURE 7. During rotation of the actuating plate 130 and the clutch disc 120, the hook portion 146 of the lowermost actuating arm 138 has moved to the left and downwardly as viewed in FIGURE 7 and therefore moves away from engagement with the shot pin 124. To this end, the free end of the hook portion 146 constitutes a sloping cam surface, designated 158. Accordingly, the shot pin 124 will enter the notch, designated 122*a*, which will now be positioned adjacent the shot pin 124, whereby the various parts of the headstock 28, including the spindles 26, will again be locked in place. The piston rod 142 is subsequently extended, causing the actuating plate 130 to return to the position illustrated in FIGURE 7 during which time the pin 150 rides over the top surface of the disc 120 until it falls in another groove 148. During extension of the piston rod 142, the arms 136 and 138 return to the beginning end of the slot 132. Hence, the hook portion 146 moves away from and beyond the shot pin 124. Ultimately, the parts return to the position illustrated in FIGURE 7 in readiness for further operation.

After the spraying operation is complete, as will be described in detail below, the headstock 28 is again indexed by the mechanism shown in FIGURES 6, 7 and 8 whereupon the spray coated armature is positioned at the unloading station and removed from the spindle 26 by the unloading transfer mechanism 44. With reference to FIGURE 1, the mechanism 44 is supported by a pair of spaced standards 170 mounted on a vertical plate 172 attached to the support structure 46. This mechanism 44 includes a guide rod 174 fixed between the spaced standards 170 upon which is slidably mounted an unloader carriage 176 having a sleeve portion 178 encircling the guide rod 174 and a depending guide bracket 180, the lower end of which straddles the top of the vertical plate 172 to prevent rotation of the carriage 176. The carriage 176 is driven along the guide rod 174 by an air actuator 182 mounted on one of the standards 170 and having a piston rod 184 connected to the carriage 176 by a bracket 186 depending from the sleeve portion 178. The carriage 176 further includes an upwardly projecting support plate 188 upon which is mounted for rotation a clamp mounting plate 190. The clamp mounting plate 190 may be supported for rotation by a pivot pin 192 affixed to the plate 190 and journalled in the support plate 188. Mounted on the clamp mounting plate 190 is a clamp assembly comprising a small air clamp cylinder 194 which is fixed in position upon the plate 190. A first scissor arm 196 is rigidly mounted on the cylinder 194 and a second scissor arm 198 is mounted on the lower end of a piston rod 200 controlled by the air clamp cylinder 194. A pair of clamp plates 202 are mounted on the free ends of the first and second scissor arms 196 and 198, respectively. The clamp plates 202 have suitably notched or grooved cooperating surfaces (not shown) for clamping the end of an armature shaft 20*b* opposite the end of the armature shaft 20*b* which is held by the spindle 26.

The operation of the unloader transfer mechanism 44 as thus far described is believed obvious. The air actuator 182 is used to advance the entire carriage 176 toward the headstock 28 when an armature assembly 20 is to be removed from a spindle 26 at the unloading station. During such advancement of the carriage 176, the second scissor arm 198 is lowered away from the first scissor arm 196 by the clamp cylinder 194. As soon as the clamp plate 202 on the first scissor arm 196 rides over the adjacent end of an armature shaft 20*b*, the clamp cylinder 194 is actuated to bring the second scissor arm 198 upwardly toward the first scissor arm 196 whereupon the clamp plate 202 on the second scissor arm 198 moves into clamping engagement with the armature shaft 20*b* and the first scissor arm 196. After the armature assembly 20 has been clamped by the clamp plates 202, the air actuator 182 is again energized to retract the carriage 176 whereupon the armature assembly 20 clamped between the clamp plates 202 is withdrawn from the clamp blades 76 within the adjacent spindle 26. The transfer mechanism 44 then occupies the position illustrated in FIGURE 1. For convenience in subsequently handling the coated armature assembly 20, a pinion gear 204 is mounted on the end of the pivot pin 192 opposite that to which the clamp mounting plate 190 is fixed. A rack actuating cylinder 206 mounted on the carriage 176 drives a rack 208 meshed with the pinion 204. The travel of the rack 208 is sufficient to pivot the entire clamp structure mounted on the clamp mounting plate 190 in a counterclockwise direction, as viewed in FIGURE 1, about the axis of the pivot pin 192 whereupon the armature assembly 20 shown in full line in FIGURE 1 will be displaced approximately 180° about the pivot pin 192 from that position shown in FIGURE 1. The armature assembly 20 can be held at this point until a subsequent cycle is required, or the armature assembly 20 can be simply released by actuation of the clamp cylinder 194 to move the second scissor arm 198 away from the first scissor arm 196. The manner of handling the coated armature after this point forms no part of the invention and is not described in detail herein. As an example, the coated armature 20 could be dropped on a suitable conveyor system. To return the clamp structure to the position of FIGURE 1 in readiness to repeat the operating cycle described above, the rack actuating cylinder 206 is merely actuated to extend the rack 208 and return the plate 190 to its starting position.

PRE-HEATING

Just after an armature assembly 20 has been loaded into a spindle 26 at the loading station and the transfer rod 24 retracted to that position shown in FIGURE 2, the induction heating coil 30, which is shown schematically mounted upon an induction heating unit 210, is

lowered into straddling relation with the armature core **20***a*. The electric motor **94** is operating at this time to rotate the spindle shafts **60** whereupon the armature assembly located at the loading station will be rotated while being heated. The temperature to which the armature core **20***a* is brought will depend upon the melting point of the powdered coating materials being used. Some epoxy resins, for example, will melt and fuse at about 450° F. and completely cure in several minutes, say five or ten minutes, if the temperature of the armature assembly **20** drops to no lower than approximately 425° F. Commercially available induction heating units can be readily obtained for accomplishing this purpose and will adequately heat the armature cores within a few seconds. After an armature core **20***a* is adequately heated, the coil **30** will be elevated away from the armature assembly **20** at the loading station which will now be in readiness for a subsequent index of the headstock **28**. Depending upon the time allotted for the subsequent spraying operation and the rapidity with which the armature cores will cool, the energization of the induction heating unit **210** may be delayed to appropriately heat the armature core at the loading station just prior to index of the headstock **28**.

It will be appreciated that heaters other than induction heating units may be used. For example, a radiant heating unit could be located at the loading station which operates in timed relation to the initial loading of an armature assembly **20***a* on a spindle **26**. The type of heating unit will depend upon the armature design and the melting point of the powder coating material.

TAILSTOCK 34

With reference to FIGURES 1 and 9, the tailstock **34** includes a box-shaped main body member **220** having four rectangular side faces upon each of which is mounted a tailstock sleeve **36**. The main body member **220** is journalled for rotation upon a vertical, center tailstock shaft **222** passing centrally therethrough and fixedly mounted on a tailstock carriage **224**. The carriage **224** is slidably mounted on a pair of guide rods **226** which in turn are supported on spaced standards **228** such that the carriage **224** can move back and forth with respect to the side of the cabinet **32** upon actuation of an air cylinder **230** having a piston rod **232** connected to the tailstock carriage **224**. The main body member **220** of the tailstock **34** is supported above the carriage **224** by four indexing pins **234**, there being one indexing pin secured at each of the four corners of the bottom face of the main body member **220**. The lowermost surfaces of the indexing pins **234** are adapted to slide along the top surface of the tailstock carriage **224**. An indexing pawl **236** is mounted by a pivot pin **238** on top of the standard **228** furthest from the spray cabinet **32**. A coil spring **240** mounted on a bracket **242**, which in turn is mounted on the side of the last mentioned standard **228**, biases the pawl **236** against a fixed stop plate **244**, which also is mounted on top of the last mentioned standard **228**, whereupon the free end of the pawl **236** is positioned in the path of movement of one of the indexing pins **234** furthest from the spray cabinet **32**. Accordingly, upon each retraction of the tailstock **34** the main body member **220** is forced to rotate about the vertical tailstock shaft **222** after the last mentioned indexing pin **234** strikes the free end of the indexing pawl **236**. The length of the indexing pawl **236** is such that the tailstock **34**, when fully retracted, is indexed or rotated through 90°.

When not forced to rotate by movement toward the indexing pawl **236**, the main body member **220** is frictionally held fixed relative to the tailstock carriage **224** by a detent lock mechanism illustrated in FIGURES 9 and 10. The detent lock mechanism includes a ball element **256** biased by a coil spring **258** housed in a detent well **254** recessed in the top of the member **220** into engagement with the bottom surface of a circular locking plate **246** having a hub **250** connected to the tailstock center shaft **222** as by a set screw **252**. As obvious, there could be as many as four such ball elements **256** in separate wells **254**. Four locating notches or detents **248** are spaced at 90° intervals in the bottom surface of the locking plate **246** in position to receive the ball element **256**. As the body member **220** reaches the end of an index, the ball element **256** snaps into one of the notches or detents **248**, thereby retaining the body member **220** in a fixed position.

After rotation of the main body member **220**, as described above, and subsequent advancement of the tailstock **34** toward the spray cabinet **32** upon energization of the air cylinder **230**, the particular indexing pin **234** now located in position to strike the pawl **236** strikes a sloping cam surface **260** intermediate the ends of the indexing pawl **236** and therefore cams the pawl **236** generally to the left as viewed in FIGURE 9 against the bias of the coil spring **240**. Accordingly, the indexing pawl **236** does not affect the position of the tailstock **34** as it is advancing toward the spray cabinet **32**.

The tailstock sleeves **36**, being dead sleeves, may conveniently be mounted upon the side faces of the main body member **220** by set screws or the like (not shown) lodging the inner ends of the sleeves **36** within sockets **262**, there being one socket **262** on each face of the main body member **220**. With reference to FIGURES 3 and 4, after the tailstock has been fully advanced toward the spray cabinet **32**, whereupon one of the sleeves **36** receives the free end of an armature shaft **20***b*, the various parts are now appropriately positioned for the spray coating operation.

SPRAYING OPERATION

With reference to FIGURES 1 and 3, the powder container **40** may be fed by a hopper **272** and, for purposes of illustration, may be provided with a screw feeder **274** driven by an electric motor **276**. On the left side of FIGURE 3, which shows the powder container **40** location schematically and in a different position from that shown in FIGURE 1, a flexible suction tube **278** is shown with its free end adjacent one end of the screw feeder **274**. The other end of the suction tube **278** is connected by a piping fixture **280** to a venturi throat **282** mounted on one side of the spray cabinet **32** by a piping fixture **284**. Air under pressure from an air compressor (not shown) is introduced into the throat **282** through a pressurized air line **286**. The fixture **284** is in turn connected to one of the spray lines **38** by an air control member **290** to be described in detail below. A spray nozzle **292** is located at the free end of each of the spray lines **38** adjacent surface portions of the armature **20** held within the cabinet **32**. Each nozzle **292** is held in a desired position by an adjustable mounting arm **294** attached to an internal face of the spray cabinet **32** by a bracket **296**. There are four spray lines **38** illustrated and accordingly four nozzles **292** in four adjustable holding arms **294** mounted within the cabinet **32**.

When air under pressure is introduced into the throat **282** from the air line **286**, powder will be forced from the container **40** upwardly through the suction tube **278** into the throat **282** whereupon it mixes with the air and enters as a mixture stream into one of the spray lines **38** and subsequently out through its nozzle **292**. The mixture streams are schematically illustrated at **298** impinging upon various surface portions of the armature assembly **20** located at the spray station in FIGURE 3. Powder containers such as container **40** are commercially available which could be used in connection with all four of the spray lines **38** shown in FIGURE 3. Of course, there could be separate powder containers **40** for each of the spray lines **38**. In any event, there would be a separate pressurized air line **286** and a separate venturi throat **282** for each of the spray lines **38**.

Not all of the powdered coating material in the mixture streams **298** will come into contact with heated surfaces of the armature assembly **20**. A portion of the powdered material will escape from the mixture streams and float about the area of the armature assembly **20**. Accordingly, the bottom of the spray container **32** is formed as a hopper **300** provided at its lowermost end with a screen **302** which covers an exhaust air duct (not shown). An exhaust blower (not shown) in the exhaust duct creates a directional ambient air flow within the spray cabinet **32**, as indicated by the arrow B in FIGURE 3, about and around the armature assembly **20** located at the spray station, whereupon the powdered particles which escape from the mixture streams **298** are drawn through the screen **30** to the exhaust system. These particles may be reclaimed and reused.

Before initiating operation of the apparatus described above, the spray nozzles **292** are first adjustably positioned and then tested to insure a complete coating of the side faces of the armature core **20***a*, and the faces of the radial extending teeth defining the radial slots which receive the coils of wire. At the same time, at least a pair of the nozzles will be adjusted so as to spray a portion of the armature shaft **20***b* adjacent the core **20***a*. The armature assembly **20** shown in FIGURE 3 has relatively large slots in a relatively narrow core. Hence, there would be no particular difficulty in so arranging the nozzles **292** that the slots will be adequately coated during the spraying operation. However, the difficulty is often encountered that the air pressure required to draw the powdered material from the container **40** through a suction tube **278** may cause an excessive air blast to impinge upon the armature assembly **20**. If, for example, the radially extending slots in the armature core are very narrow because of close spacing of the teeth, the initial coating caused by the extreme speed with which the particles impinge upon the armature assembly **20** may close up ends of the slots rendering it impossible to coat the internal portions of the armature core teeth. Also the blast of air may be sufficient that portions of the armature assembly **20** not to be coated are, in fact, coated as the mixture stream, because of traveling so fast, creates a turbulent flow of powdered material all around the armature assembly **20**. Of course, the directional ambient stream of exhaust air is a rather light stream; otherwise it would alter the paths of the mixture streams **298**. For these reasons, the air control devices **290** are located in the path of the mixture streams **298** and are used as connecting fixtures between the fixtures **284** and the spray lines **38**. With reference to FIGURE 3, each control device **290** comprises a hollow body member having an enlarged inlet opening **304** snugly receiving a fixture **284** and a reduced diameter, discharge opening **306** inserted in one end of a spray line **38**. The internal cavity, designated **308**, of the control device **290** is generally cylindrical, but terminates in a truncated cone portion **310**, the reduced diameter end of which communicates with the end opening **306** through a small passageway **312**. A plurality of radially extending threaded relief ports **314** extend through the body of the relief valve **290** and serve to reduce or relieve the pressure of the mixture stream passing therethrough. Set screws **316** or the like (see FIGURE 1) serve as plugs for closing the apertures **314**. When initially adjusting the spray equipment for spray coating a particular type of armature, the set screws **316** are either inserted into or removed from selected apertures **314** to adjust the pressure of the mixture stream emitted from the nozzles **292**. Powdered particles carried by the mixture streams escaping through the apertures **314** which are not plugged with set screws **316** are drawn through the screen **302** by the exhaust, ambient air stream. In any event, it is unlikely that these particles will come into contact with any heated surface and cause unwanted coating.

As already noted, the free end of each spindle sleeve **62** projects beyond the outer end of the enclosed clamp blades **76**. The aforesaid end of the spindle sleeve **62** is provided with an enlarged central bore **320** which receives a portion of the armature shaft. The free end of the spindle sleeve **62** and a bore **338** in the free end of the tailstock sleeve **36** serve to mask portions of the armature shaft **20***b* to remain uncoated. Such masking, however, cannot be perfect since a sufficient tolerance must be provided to permit automatic handling of the armature assemblies **20**. That is, the bores **338** and **320** in the ends of the sleeves **36** and **62** cannot be so small as to snugly receive the armature shaft **20***b*. Further, if the bores **338** and **320** were sufficiently small that portions of the sleeves **36** and **62** would contact the armature shaft **20***b*, the ends of the sleeves **36** and **62** would become so hot that escaped powdered particles landing on these parts would coat them. In time, the coating build-up on the sleeves **36** and **62** would render them useless.

With reference to FIGURES 3 and 4, the masking of the extreme ends of the armature shaft **20***b* by the ends of the sleeves **36** and **62** is aided by directing air under pressure through the sleeves **36** and **62** and out through their bores **338** and **320**. With respect to the sleeve **62**, an air line **322** is mounted by a bracket **324** on the inner face of a sidewall of the spray cabinet **32** in position to be aligned with an air passageway **326** in the sleeve **62** when the sleeve **62** is positioned for holding an armature assembly **20** at the spray station. Air under pressure from a suitable source (not shown) passes through the air line **322** and the passageway **326** into the cavity within the sleeve **62** around the spindle shaft **60**, as indicated by the arrows C in FIGURE 4, and ultimately out through the bore **320** around the end of the armature shafft **20***b* located therein. Similarly, an air conduit member **328** is mounted on top of the standard **228** closest to the spray cabinet **32**. An air line **330** connected to a suitable source of air under pressure (not shown) communicates with an air passageway **332** within the member **328**. A bore **334** in the socket **262** of the tailstock **34** provides an air passageway from the terminal end of the passageway **332**. The bore **334** communicates with a passageway **336** extending the length of the sleeve **36** to the central bore **338**. As apparent, a stream of air will flow through the various passageways as indicated by the arrows D in FIGURE 4 around the end of the armature shaft **20***b* received within the bore **338**. Desirably, approximately .005 inch spacing is left between the end of the armature shaft **20***b* and the surrounding surface of the bore **338**. A similar spacing is provided by the bore **320** of each sleeve **62**.

The spray cabinet **32**, shown in FIGURE 1, is cut away at **350** along adjacent sidewalls to permit movement of the spindle **26** carrying an armature assembly **20** and also is apertured at **352** to permit insertion and removal of a tailstock sleeve **36**. The top of the spray cabinet **32** is open. The front of the spray cabinet **32** illustrated in FIGURE 3 may be covered with another sidewall or can be left open since there is little danger that particles of powdered coating material will escape from the cabinet **32**.

Referring now to FIGURE 11, which shows a modified spray cabinet **32**, and in which like reference characters are used to identify like parts, the nozzles **292** are supported in a fixed position by support rods **340** connected to the nozzles **292** by welded brackets **342**. The support rods **340** are mounted in clamps **344** supported in the spray cabinet **32** by cross-bars **346** attached by brackets **348** to opposed sidewalls of the cabinet **32**. There are two nozzles **292** mounted above the spindle **26** and the sleeve **36** and two mounted below the elements **26** and **36**. Hence, only two cross-bars **346** are required. The adjustable arms **294** used to hold the nozzles **292** in the FIGURE 3 embodiment are useful for applications requiring adjustment of the position of the nozzles **292** for different styles of armature assemblies **20**. However,

it is difficult to rigidly maintain the position of the nozzles **292** when supported by the adjustable arms **294**. Hence, if it is desired to use the spray equipment for only one style of armature, the embodiment of FIGURE 11 is preferred. Note that the position of the nozzles **292** can easily be pre-set by suitably bending the support rods **340**.

In FIGURE 11, the uppermost pair of nozzles **292** are directed angularly downwardly along the end faces of the armature core and against the armature shaft. The lowermost nozzles **292** are directed against one another in order to fully coat the teeth which define the radial extending slots. In operation, the mixture streams emitted from the lowermost pair of nozzles **292** will impinge upon one another causing a great deal of turbulence within the slots in the armature core. This turbulence will cause the powdered materials within the mixture streams to be thrown about so as to come in contact with the entire surface portions of the teeth of the armature core.

OPERATION

The handling of an armature assembly **20** sequentially from the loading station to the spraying station and then to the unloading station by one of the spindles **26** has already been described. After an armature assembly **20** has been unloaded, the headstock **28** is again rotated whereupon the spindle **26** which had held the coated armature assembly **20** is positioned at the cooling station. A time delay between the unloading station and the loading station is of value in preventing the surfaces of the spindle sleeves **62** from getting so hot that they are coated. Once cooled, a spindle **26** can be re-positioned at the loading station for handling an uncoated armature. Because there are four spindles **26** on the headstock **28**, three armature assemblies **20** can be handled while one of the spindles **26** is cooling.

From the foregoing, it will be appreciated that the armature handling procedures, although quite positive, are relatively simple. The headstock **28** acts as a rotatable turret, sequentially aligning the axes of the spindles **26** with the axis of the transfer rod **24**, a tailstock sleeve **36**, and the unloader clamp plates **202**. Because of the method of holding the armature shafts **20***b* by the biased clamp blades **76**, the electric motor **94** can be constantly rotating the spindle shafts **60**. Parts of the apparatus designed to contact or nearly contact the heated armature in the area of the spray station are permitted to cool. The headstock spindles **26** cool at the cooling station while the tailstock sleeves **36** cool for a longer period, since a given sleeve **36** enters the spray cabinet **32** once in each four spraying operations. The only other parts likely to become hot are the clamp plates **202** which are remote from the spray station.

By the use of a direct spray controlled by the simple, pressure relieving air control devices **290**, armature assemblies can be coated in a very short handling time. Since the spindle shafts **62**, and accordingly, the armature assemblies **20** handled thereby are continuously rotating, a complete coating of all desired surface portions is assured. Armature assembly surfaces not to be coated remain uncoated if the positions of the nozzles **292** are accurately pre-set because of the established, directional ambient exhaust air passing about and around the armature assemblies **20** in the spray station.

The method of timing the energization of the various air actuators used to control the mechanisms for handling and masking the armature assemblies has not been described herein. Conventional control circuitry including limit switches located in the path of movement of the various mechanisms can be used not only to control the air actuators but also the spraying operation. The electric motor **94**, since continually operating, need only be controlled by a simple on-off switch.

In this description and claims, the term "air" is intended to refer to any gas suitable for functioning as air. For example, gases other than air could be used to form the mixture streams and to accomplish the armature shaft masking described herein.

Having thus described my invention, I claim:

1. In apparatus for spray coating armatures, the combination comprising: a headstock having a plurality of horizontally extending spindle shafts mounted for rotation about their longitudinal axes, means rotating said spindle shafts about their respective axes, clamp means on said spindle shafts adapted to clamp an armature shaft thereto, means intermittently indexing said headstock about a vertical axis sequentially to position one of said spindle shafts at a first station wherein an armature is loaded onto said one of said spindle shafts, a second station wherein a powdered coating material is applied to said armature, and a third station wherein said armature is removed from said one of said spindle shafts, means directing powdered coating material onto an armature supported at said second station, a tailstock having a main body member rotatable about a vertical axis and a plurality of horizontally extending tailstock sleeves, each adapted to receive the free end of an armature shaft, said tailstock being mounted for movement toward and away from said second station, means aligning one of said tailstock sleeves with a spindle shaft located at said second station, said last mentioned means aligning others of said tailstock sleeves with others of said spindle shafts when located at said second station, and means intermittently advancing said tailstock toward said second station whereby the one of said tailstock sleeves aligned with one of said spindle shafts at said second station moves over one end of an armature shaft clamped to said last mentioned spindle shaft partially to mask said last mentioned armature shaft.

2. The structure of claim **1** wherein each of said spindle shafts and said clamp means are covered by spindle sleeves, and wherein air passageways are located in said tailstock sleeves and in said spindle sleeves, said air passageways terminating at the ends of said sleeves receiving an armature shaft, and further including means supplying pressurized air to said passageways at said second station to direct powdered coating material away from said ends of said sleeves.

3. The structure of claim **1** further including a spray cabinet at least partially confining said second station, and wherein said means directing powdered coating material includes a plurality of spray lines within said cabinet, each of said spray lines including nozzles through which the powdered coating material emerges, and nozzle support means supporting said nozzles in predetermined positions to direct powdered coating material onto selected surfaces of an armature supported at said second station.

4. In apparatus for spray coating armatures, the combination comprising: a headstock having a plurality of spindle shafts mounted for rotation about their longitudinal axes, means rotating said spindle shafts about their respective axes, clamp means on said spindle shafts adapted to clamp an armature shaft thereto, means intermittently indexing said headstock sequentially to position one of said spindle shafts at a first station wherein an armature is loaded onto said one of said spindle shafts, a second station wherein a powdered coating material is applied to said armature, and a third station wherein said armature is removed from said one of said spindle shafts, means directing powdered coating material onto an armature supported at said second station, a tailstock having a main body member and a plurality of tailstock sleeves, each adapted to receive the free end of an armature shaft, said tailstock being mounted for movement toward and away from said second station, means aligning one of said tailstock sleeves with a spindle shaft located at said second station, said last mentioned means aligning others of said tailstock sleeves with others of said spindle shafts

when located at said second station, and means intermittently advancing said tailstock toward said second station whereby the one of said tailstock sleeves aligned with one of said spindle shafts at said second station moves over one end of an armature shaft clamped to said last mentioned spindle shaft partially to mask said last mentioned armature shaft, a transfer rod axially aligned with a spindle shaft at said first station, means to advance said transfer rod toward said last mentioned spindle shaft, and means for releasably holding an armature to be coated in the path of said transfer rod.

5. In apparatus for spray coating armatures, the combination comprising: a headstock having a plurality of spindle shafts mounted for rotation about their longitudinal axes, means rotating said spindle shafts about their respective axes, clamp means on said spindle shafts adapted to clamp an armature shaft thereto, means intermittently indexing said headstock sequentially to position one of said spindle shafts at a first station wherein an armature is loaded onto said one of said spindle shafts, a second station wherein a powdered coating material is applied to said armature, and a third station wherein said armature is removed from said one of said spindle shafts, means directing powdered coating material onto an armature supported at said second station, a tailstock having a main body member and a plurality of tailstock sleeves, each adapted to receive the free end of an armature shaft, said tailstock being mounted for movement toward and away from said second station, means aligning one of said tailstock sleeves with a spindle shaft located at said second station, said last mentioned means aligning others of said tailstock sleeves with others of said spindle shafts when located at said second station, and means intermittently advancing said tailstock toward said second station whereby the one of said tailstock sleeves aligned with one of said spindle shafts at said second station moves over one end of an armature shaft clamped to said last mentioned spindle shaft partially to mask said last mentioned armature shaft, a spray cabinet at least partially confining said second station, and wherein said means directing powdered coating material includes a plurality of spray lines within said cabinet, each of said spray lines including nozzles through which the powdered coating material emerges, and nozzle support means supporting said nozzles in predetermined positions to direct powdered coating material onto selected surfaces of an armature supported at said second station, and air control devices located in each of said spray lines, each air control device including a generally cylindrical body member having a plurality of apertures opening to atmosphere, and removable means closing at least some of said apertures.

6. In apparatus for spray coating armatures: a headstock having a plurality of spindle shafts mounted for rotation about their longitudinal axes, means for rotating said spindle shafts about their longitudinal axes, clamp means on one end of each of said spindle shafts adapted to clamp an armature shaft thereto for rotation therewith, and a plurality of spindle sleeves, there being one spindle sleeve surrounding said one end of each of said spindle shafts and said clamp means; a tailstock having a plurality of tailstock sleeves adapted to receive the free ends of armature shafts clamped by said clamp means, said tailstock for intermittently rotating said headstock and said from said headstock, means intermittently advancing said tailstock toward said headstock to receive the said free ends of said armature shafts; index means associated with said headstock and index means associated with said tailstock for intermittently rotating said headstock and said tailstock, respectively, about parallel axes to align different ones of said tailstock sleeves with different ones of said spindle shafts and sleeves, and air supply means supplying air to said spindle sleeves and said tailstock sleeves for directing jets of air onto armature shafts immediately adjacent the ends of aligned ones of said spindle shafts and said tailstock sleeves.

7. In apparatus for spray coating armatures of the type wherein surface portions of an armature to be coated are rotated past a spray nozzle of a spray line from which a mixture stream of coating powder and air under pressure is discharged, the mixture stream of powdered material and air being formed by passing a stream of compressed air adjacent one end of a tube having its other end in a powder cotainer, the improvement comprising an air control device connected to said spray line between said nozzle and said tube for relieving the pressure of said mixture stream by exhausting part of said mixture stream to atmosphere, said air control device including a hollow body member through which said mixture stream passes, said body member having a reduced diameter discharge opening and a plurality of relief ports adjacent said discharge opening, and means for closing selected ones of said relief ports.

8. The structure of claim 7 wherein said means comprises removable plugs insertable into said relief ports.

9. The structure of claim 8 wherein said relief ports extend radially through the wall of said body member.

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U.S. Cl. X.R.

118—312, 318, 319, 326

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,482,545 Dated February 13, 1970

Inventor(s) John M. Biddison

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

Claim 6, column 14, line 5, "intermittently rotating said headstock and said from said headstock," should read ---being mounted for movement toward and away from said headstock,---.

SIGNED AND
SEALED
JUN 23 1970

(SEAL)
Attest:

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