

[54] DRYING SYSTEM

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[52] U.S. Cl..... 34/1, 34/44, 34/52,
219/10.77

[51] Int. Cl. B01k 5/00

[58] **Field of Search** 34/1, 44, 48, 52;
219/10.77

[56]

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ABSTRACT

A system for continuously applying paint to a continuously moving metal strap and thereafter continuously drying the paint on the metal strap. The system disclosed herein includes a drying station disposed above the paint pot includes a number of induction coils through which the painted metal straps pass and have induced therein eddy currents which heat the metal strap to dry the paint thereon. Means are provided automatically to maintain the level of the paint and the concentration of solids in the paint contained in the paint pot, and means are provided automatically to vary the output from the induction coils in response to the speed and temperature of the metal strap to maintain constant the temperature of the metal strap exiting from the drying station.

5 Claims, 8 Drawing Figures

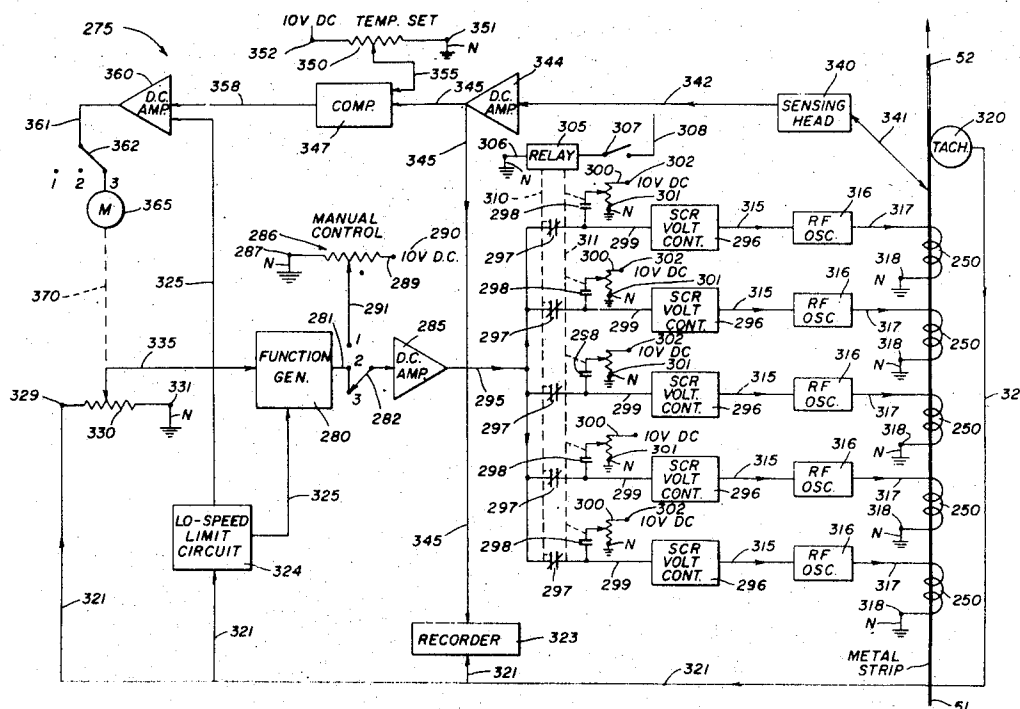


FIG. 1

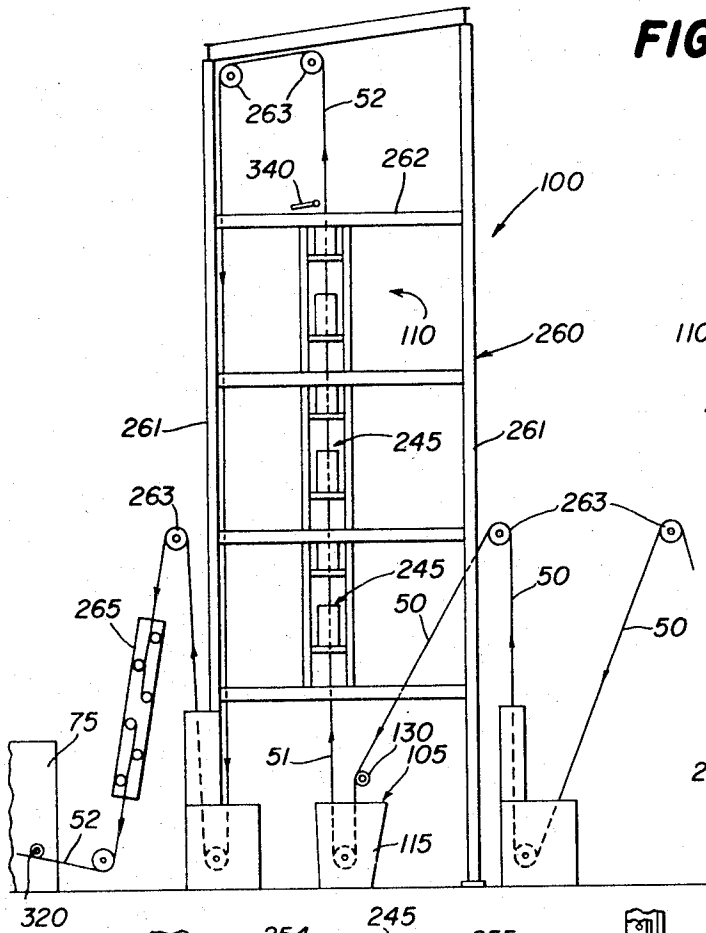


FIG. 5

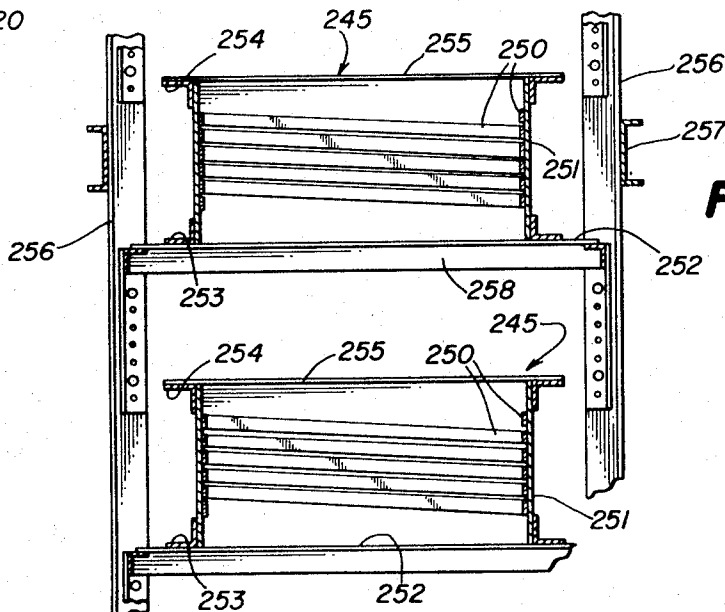
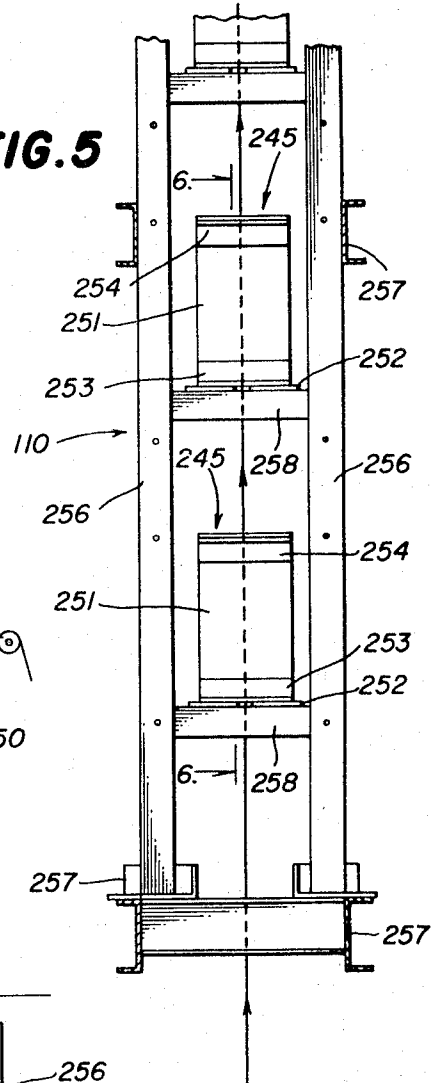
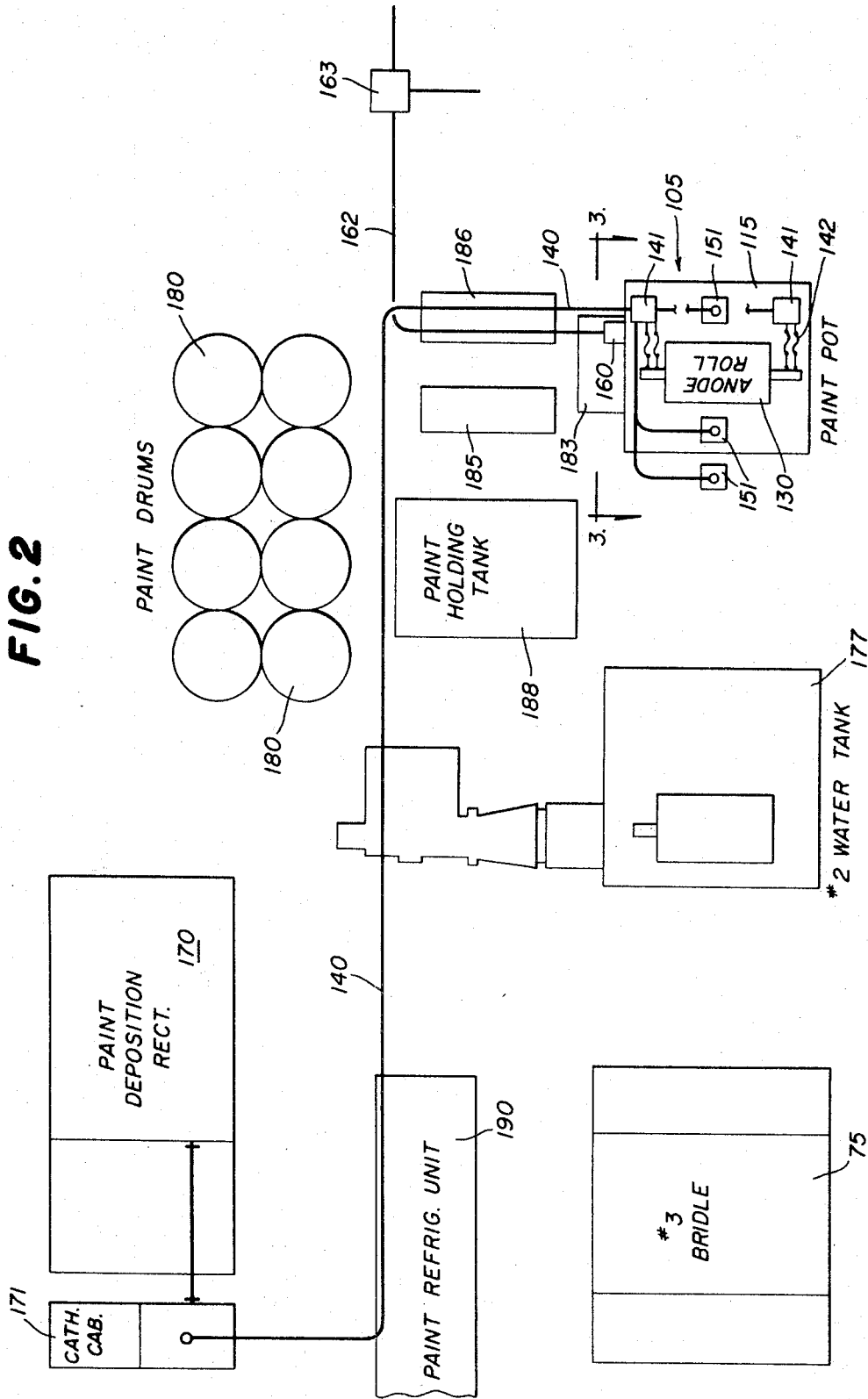


FIG. 6

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FIG. 2



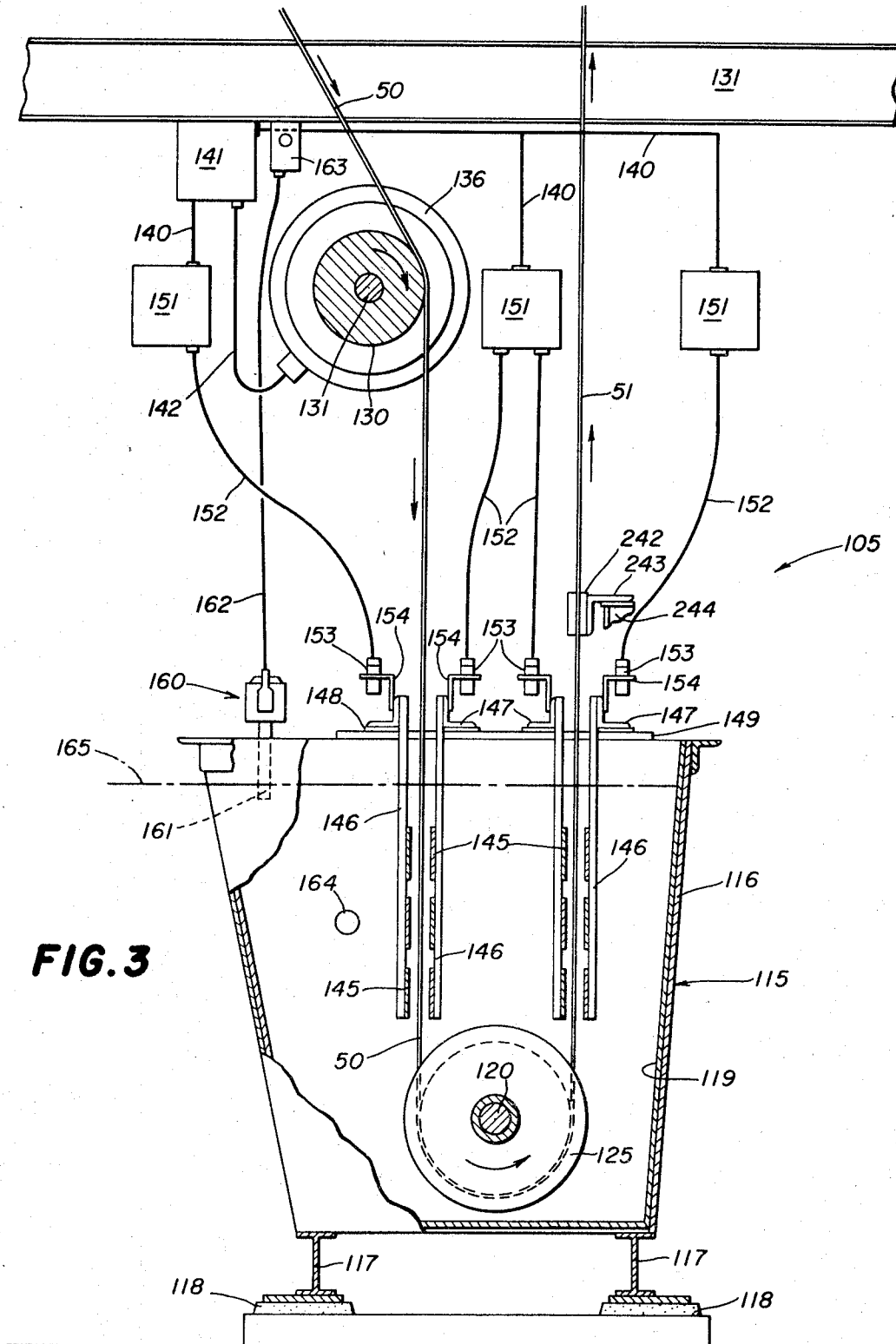


FIG. 7

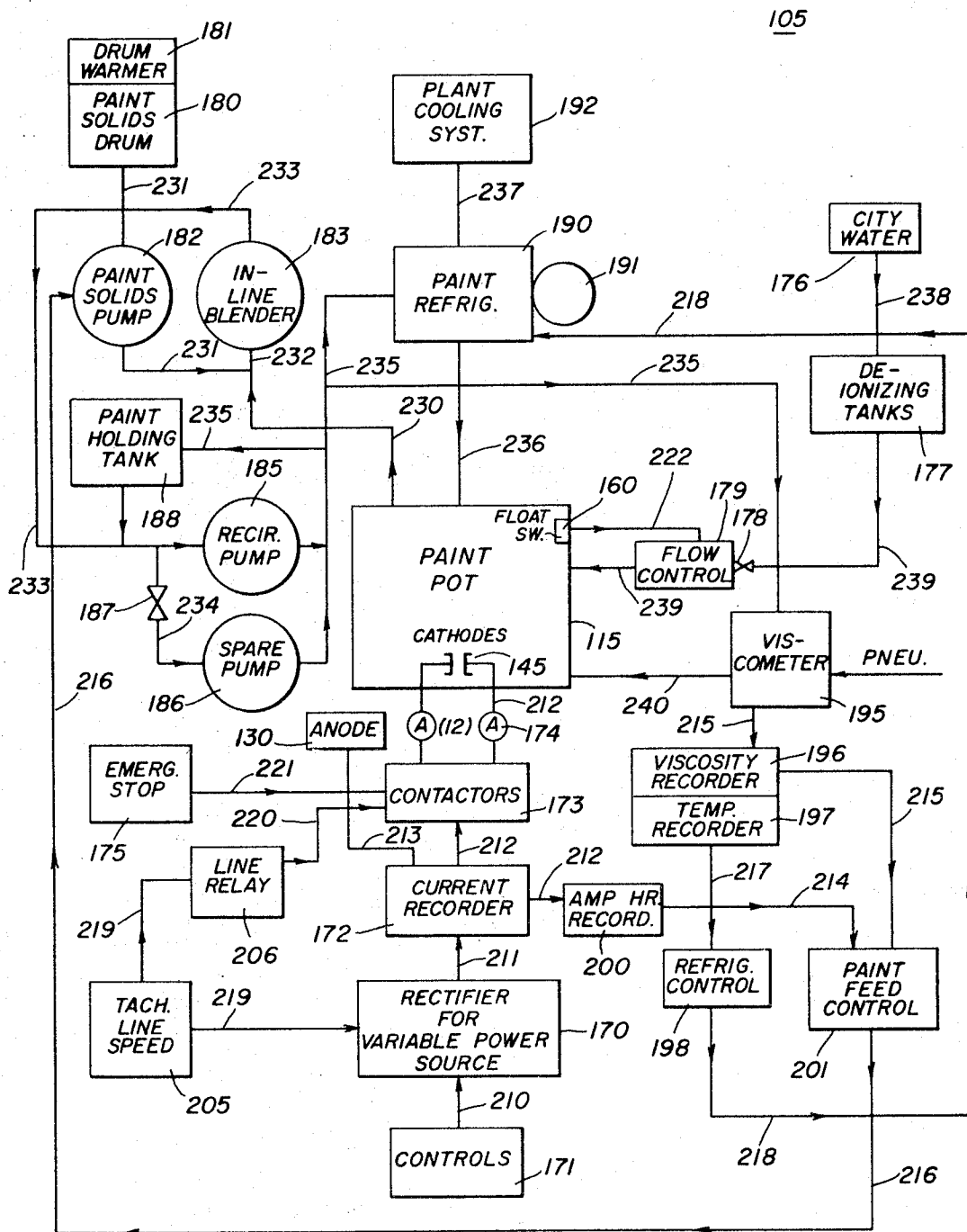
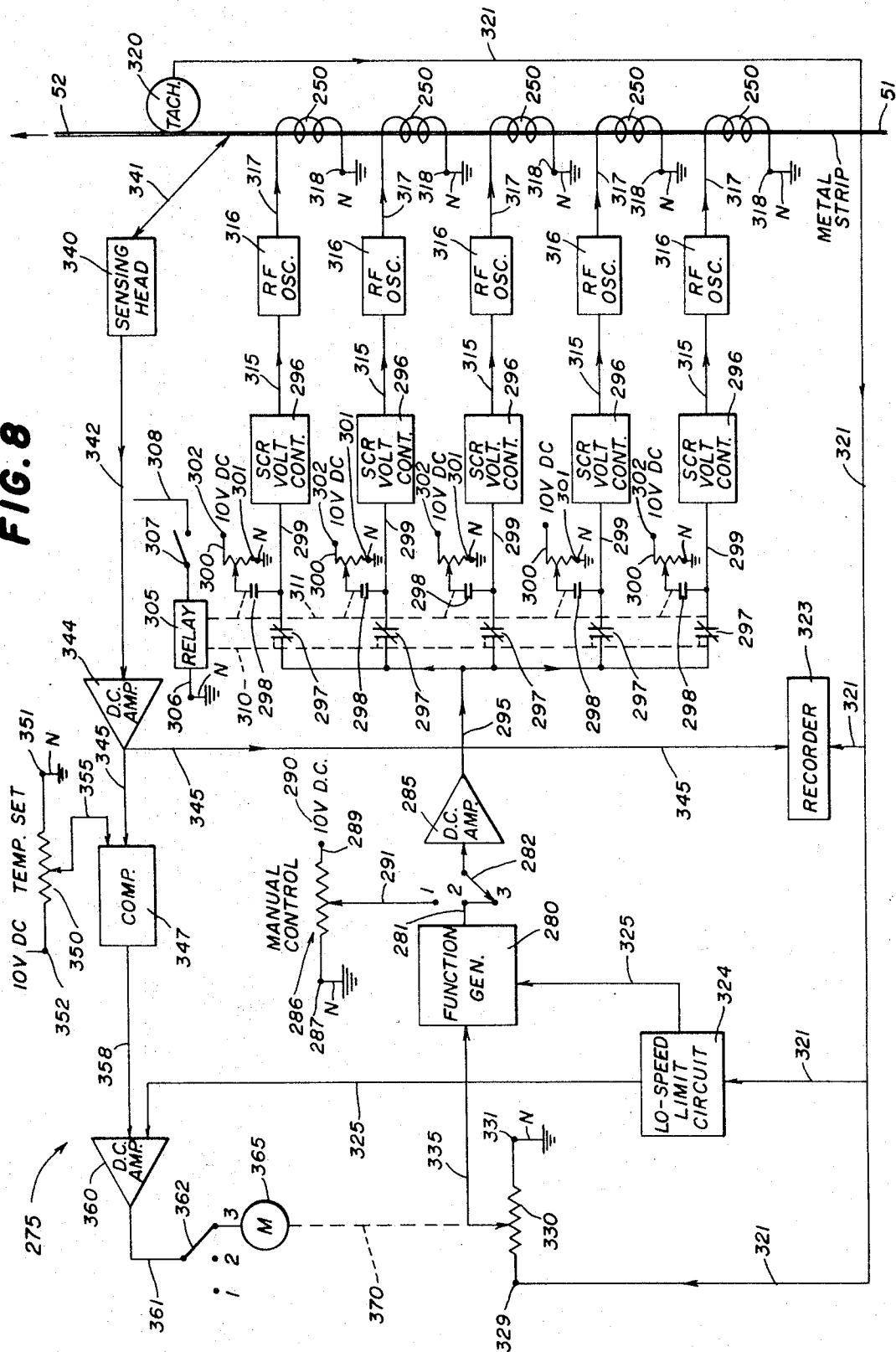


FIG. 8



DRYING SYSTEM

This application is a division of copending application Ser. No. 888,215, filed Dec. 29, 1969 and now U.S. Pat. No. 3,616,459 for PAINT APPLYING AND DRYING SYSTEM.

This invention relates to a system for continuously applying paint to a continuously moving metal strap and continuously drying the paint thereon, and more particularly, this invention relates to a system for induction heating the paint by heating the metal strap which carries the paint thereon.

An important object of the present invention is to provide a system for continuously drying a painted continuously moving metal strap, said system comprising a drying station including an induction coil for heating the metal strap to dry the paint thereon, drive mechanism for continuously passing the metal strap through the induction heating coil, a variable power supply for the induction heating coil for controlling the output therefrom, means for sensing the speed of movement of the metal strap with respect to the induction heating coil, means for sensing the temperature of the painted metal strap immediately after the passage thereof from the induction heating coil, and a control circuit responsive to the metal strap speed sensing means and to the painted metal strap temperature sensing means for controlling the variable power supply and thus the heating produced by the induction heating coil to heat the painted metal strap to a predetermined temperature at the temperature sensing means, whereby to dry the paint on the metal strap throughout the length thereof passing through the induction heating coil.

A still further object of the present invention is to provide a system for continuously drying a painted continuously moving metal strap in which the control circuit includes limit means responsive to the metal strap sensing means for de-energizing the induction heating coil when the speed of the metal strap with respect to the induction heating coil is below a predetermined value.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings in which:

FIG. 1 is a schematic and diagrammatic illustration of the system of the present invention for continuously applying paint to a continuously moving metal strap and continuously drying the paint thereon;

FIG. 2 is a schematic and diagrammatic view of the continuous paint-applying system of the present invention;

FIG. 3 is a side elevational view partly in section of the electrophoretic paint distributing apparatus shown in FIG. 2 taken along line 3—3 thereof;

FIG. 4 is a front plan view of the electrophoretic paint distributing apparatus shown in FIG. 3;

FIG. 5 is a side elevational view of the continuous drying station of the present invention;

FIG. 6 is a view partially in section of the drying station shown in FIG. 5 taken along line 6—6 thereof;

FIG. 7 is a block diagram of the control system for the continuous paint applying system of the present invention; and

FIG. 8 is a block diagram of the control system for the paint drying station of the present invention.

There is disclosed hereinafter a system 100 for continuously applying paint to a continuously moving metal strap 50 and continuously drying the paint thereon, the metal strap 50 being driven along a predetermined path by a drive mechanism 75 through a paint applying station 105 and then through a paint drying station 110. As seen particularly in FIG. 1, the metal strap 50 passes along the predetermined path into a paint pot 115 in which paint is electrophoretically applied to the metal strap 50, and thereafter a painted metal strap 51 passes upwardly through a plurality of heating units 245 where the paint uniformly applied in the paint pot 115 is dried by the induction heating of the painted metal strap 51 to produce a metal strap 52 having a uniform coating of paint applied thereto and dried thereon.

FIG. 2 shows the spatial relationship between some of the apparatus connected with the electrophoretic deposition of paint on the metal strap 50, the paint applying station 105 including a paint pot 115, a variable power supply source 170, a paint solids source 180, a paint refrigeration unit 190 and a paint diluent source 177. There is further shown a drive mechanism or bridle 75 for continuously moving the metal strap 50 along its predetermined path, a paint holding tank 188 for storage of paint during maintenance periods in which the paint pot 115 is serviced and a pair of recirculating pumps 185 and 186, for a purpose hereinafter explained.

With particular reference to FIGS. 2, 3 and 4, there is shown the paint applying station 105 including the paint pot 115, the paint pot 115 including an enclosed metal container 116 supported by two spaced-apart generally parallel I-beams 117 each of which rests on a grouting 118, the paint pot 115 being provided with a synthetic plastic resin liner 119 on the inside thereof and firmly connected to the metal container 116. A rotatable shaft 120 is disposed within the paint pot 115 near the bottom thereof and is positioned generally horizontally, the shaft 120 being journaled at either end thereof in a bearing 121, the bearings 121 are connected to and supported by a flange 122, the flange 122 being fixedly secured to the metal container 116. A plurality of flanged wheels 125 are fixedly connected to the shaft 120 and are rotatable therewith, the flanged wheels 125 each supporting a metal strap 50 as particularly shown in FIG. 4. The metal strap 50 may be a single strap having a substantial width or, as in the case herein shown, the metal strap 50 may comprise a plurality of individual straps arranged side by side in a row, 12 such straps being shown. The flanged wheels 125 serve to maintain the straps 50 in their spatial relationship one to the other, thereby to prevent them from becoming disoriented.

The metal straps 50 enter the paint applying station 105 by passing over and in contact with an anode roll 130, the anode roll 130 being journaled on a shaft 131 positioned above the paint pot 115 and held in place by a pair of spaced-apart supports 132 fixedly connected to several I-beams 133 hung from a mezzanine floor or rafters 134. The anode roll 130 receives its charge through the shaft 131 which passes through each of the supports 132 and is electrically insulated therefrom by the insulators 137, the shaft 131 carrying at both ends thereof a connector 135, each of the connectors 135 being connected to a slip ring 136. The slip rings 136 are connected to the variable power supply 170 by

means of a cable 140 which leads from the power supply 170 to a pull box 141, there being two pull boxes 141, each one of which being associated with a respective slip ring 136. A pair of connecting cables 142 serve to transmit the current from the pull boxes 141 to the slip rings 136, the slip rings 136 being of conventional construction and operating in a conventional manner to provide a charge from the variable power supply 170 to the anode roll 130. The slip rings 136 serve to transmit a positive charge to the anode roll 130 and thereby a positive charge to the metal strap 50 contacting and passing over the anode roll 130.

There is further provided a plurality of cathode plates 145, the cathode plates 145 being positioned within the paint pot 115 and arranged vertically in two sets each containing three pairs of cathode plates 145, each pair including two plates 145 spaced apart and generally parallel one to the other. The cathode plates 145 are fixedly secured at each end thereof to vertically disposed frame member 146, the frame members 146 being electrical conductors each depending from an angle iron 147 resting on an insulator 148 all of which is disposed on a support member 149. The support member 149 extends entirely across the top of the paint pot 115 thereby to support the cathode plates 145 in their positions within the paint pot 115 and electrically to insulate the cathode plates 145 therefrom. To this end, the liner 119 also insulates the paint pot 115 from the electrically charged paint therein. As may be seen, there are two sets of cathode plates 145, each set being disposed to one side of the flanged wheels 125 so that the metal strap 50 passes between the cathode plates 145 when entering the paint pot 115 from the anode roll 130 and when exiting the paint pot 115 to be transported to the paint drying station 110.

The cathode plates 145 are electrically connected to the variable power supply 170 and the cable 140 leading therefrom by a plurality of pull boxes 151, there being three such pull boxes disclosed herein. The cable 140 from the variable power supply 170 leads to each of the pull boxes 151 and a cable 152 thereafter leads from the pull box 151 to each of the frame members 146 supporting, as shown herein, three vertically spaced-apart cathode plates 145, each of the cables 152 leading to a connector 153 disposed on an angle iron 154 suitably connected to a corresponding one of the angle irons 147, such as by welding. It is seen therefore, that the cathode plates 145 are electrically connected to the variable power supply 170 due to the electrical conducting frame 146 which is electrically connected to the cables 152 and thereby the cable 140 leading from the variable power supply 170.

There is further disclosed a paint level sensing device 160 positioned above the paint pot 115 for sensing the paint level therein, the paint level being denoted by the line 165 in phantom, the paint level sensing device 160 including a sensor 161 extending downwardly into the paint pot 115 and a cable 162 leading from the sensing device 160 to a junction box 163 and thereafter to a recorder (not shown). There is further provided an aperture 164 in the paint pot 115 for various piping connections, for instance, a paint-return pipe. When the painted metal strap 51 leaves the paint pot 115 after having paint electrophoretically applied thereto it passes through a sponge 242 positioned above the paint pot 115, the sponge 242 serving to wipe excess paint from the painted metal strap 51, the sponge 242 being

suitably connected to an angle iron 243 and a support 244.

As is known, in the electrophoretic deposition of paint, the substrate to which the paint is to be applied, in this case the metal straps 50, is provided with a positive charge and the paint solid particles are provided with a negative charge. In the present case the metal straps 50 pass over the anode roll 130 to have imparted thereto a positive charge and the paint particles in the paint pot 115 come in contact with the cathode plates 145 to have imparted thereto a negative charge. When the paint particles carrying a negative charge come into proximity to the metal straps 50 carrying a positive charge the negatively charged paint particles are attracted thereto, the advantage of the electrophoretic deposition of paint being that the paint is attracted to all the surfaces of the metal straps 50 to provide uniformly coated metal straps 51. As the paint builds up on the metal straps, the current density in the metal straps 51 drops as the film thickness increases until current flow stops and there is no more deposition of paint solids on the painted metal straps 51. The variables which must be controlled in order adequately to provide for the electrophoretic deposition of paint on continuously moving metal straps 50 are the solids concentration of the paint, the temperature of the paint, the speed of the metal straps 50 passing through the paint and the voltages used to produce the current densities applied to the metal straps 50. The control system for the aforementioned variables will hereinafter be explained.

It can be seen therefore that there is provided herein a paint applying station 105 including a paint pot 115 into which the unpainted metal straps 50 are passed. After contacting an anode roll 130 which imparts to the straps 50 a positive charge, the straps 50 pass through a cathode area around a flanged wheel and upwardly through a second cathode area to have electrophoretically deposited thereon paint solids from a paint contained within the paint pot 115 and maintained at a level 165 to produce uniformly painted metal straps 51. The control system for varying the current fed to the anode roll 130 and the cathodes 145, for maintaining the paint level as at 165, for maintaining the paint composition at a predetermined paint solids concentration and for maintaining the temperature of the paint at a predetermined level will be hereinafter disclosed.

After the painted metal straps 51 exit from the paint applying station 105 with a uniform coating of paint thereon, the paint containing a substantially uniform amount of paint solids therein, the painted metal straps 51 pass upwardly to the paint drying station 110, the paint drying station 110 including a plurality of spaced-apart heating units 245, there being five such heating units shown herein. Each of the heating units 245 include an induction heating coil 250, each of the induction heating coils 250 being in the form of a hollow metal strap having a rectangular cross section. The induction heating coils 250 are positioned inside the heating unit 245, the heating units 245 including two spaced-apart vertically disposed end walls 251 resting on two spaced-apart horizontally disposed bottom insulating boards 252, the bottom insulating boards 252 forming therebetween a slit for the passage of the painted metal straps 51 therethrough. Bottom angle irons 253 serve to connect the end walls 251 with the bottom insulating boards 252 and top angle irons 254

serve to connect the end walls 251 with a pair of horizontally disposed spaced-apart top mounting boards 255, the top mounting boards 255 also being spaced apart to form therebetween a slit for the passage therethrough of the painted metal straps 51. Each of the heating units 245 is held in place above the paint applying station 105 by a support structure including four vertical support frame members 256 interconnected by horizontal support frame members 257 and a pair of coil support brackets 258 suitably supporting a respective one of the bottom insulating boards 252. The entire support structure is positioned within a tower 260 surrounding both the paint drying station 110 and the paint applying station 105, the tower 260 including vertical support members 261 and horizontal support members 262. The tower 260 further includes a plurality of idler rollers 263 which serve to position the straps 50 upon entering the paint applying station 105 and then exiting the paint applying station as painted straps 51 and pass upwardly through the paint drying station 110 and exiting therefrom as dried painted straps 52.

The dried metal straps 52 thereafter pass over several of the idler rollers 263 and out of the tower 260 for further processing down the line, there being provided a plurality of aligning wheels 265 further to maintain the straps 52 in their side by side arrangement. As the painted metal straps 51 passes upwardly through the slits formed by the bottom insulating boards 252 and the top mounting boards 255 and through the induction heating coils 250, eddy currents are induced in the metal straps 51 by the passage thereof through the fields of the induction heating coils 250, as hereinafter explained, to provide heating within the straps 51, thereby to dry the paint thereon from the inside of the paint coating to the outside to provide a uniform paint coating without the usual blisters caused by trapped air and the like formed when paint dries from the outside in. The power supplied to the induction heating coils 250 together with the amount of metal passing through the fields and the speed of the straps determine the amount of heating induced in the painted metal straps 51, the power supplied to the induction heating coils 250 being controlled both by the speed of the metal straps 51 as measured by a tachometer 320 and by the temperature of the dried metal straps 52 as it exits from the paint drying station 110 as measured by an infrared sensor 340, all as hereinafter explained.

With particular reference to FIG. 7, the control system for the paint applying station 105 will hereinafter be described, the control system including a rectifier for a variable power source 170 connected as by a conductor 210 to a control 171 therefor, the control 171 serving to provide means for manually varying the output from the variable power source 170. The output from the power source 170 is transmitted as by a conductor 211 to a current recorder 172 and thence by conductor 213 to the anode 130 and by conductor 212 to contactors 173. The contactors 173 are connected to a plurality of ammeters 174, there being one ammeter 174 for each cathode plate 145. An emergency stop 175 is provided and is connected as by a conductor 221 to the contactors 173 thereby to provide manual means for halting the flow of current to the cathodes 145.

There is further provided a paint diluent source 176, as shown here the city water supply, connected by a pipe 238 to deionizing tanks 177, the deionizing tanks 177 serving to deionize and demineralize the city wa-

ter. The deionized water from the deionizing tanks 177 flows through a pipe 239, into the paint pot 115, via a solenoid valve 178, controlled by a flow control 179, the flow control 179 being suitably connected by a conductor 222 to the float switch 160 disposed within the paint pot 115. A paint solids source in the form of the paint solids drums 180 is provided, and since the paint solids are extremely viscous as provided there is also a drum warmer 181 for warming the paint solids within these paint solids drums 180. A pipe 231 connects the paint solids drums 180 with a paint solids pump 182, that paint solids pump 182 serving to withdraw paint solids from the drums 180. The paint solids pump 180 may be an air driven motor mounted on the drums and pumps the paint solids from the drums 180 through the piping 231 to an in-line blender 183. Paint in the paint pot 115 is withdrawn therefrom through a pipe 230 by the action of a recirculating pump 185, there also being provided a spare recirculating pump 186 suitably isolated from the line by a valve 187. The paint coming from the paint pot 115 in the line 230 is mixed with solids withdrawn by the paint solids pump 182 and fed as at 232 to the in-line blender 183. The mixed paint solids and paint exits from the in-line blender as at 233 and flows through the recirculating pump 185 (unless the valve 187 is open in which case the mixed paint and paint solids flows through line 234 and the spare recirculating pump 186) via the line 235 to the paint refrigerator 190 wherein the paint is cooled and returned to the paint pot throughout the pipe 236. The paint refrigerator 190 is run by a motor 191 and is connected to the plant cooling system 192 by means of piping 237. There is further provided a paint holding tank 188 connected to the pipes 233 and 235, the paint holding tank 188 serving to hold the paint when the paint pot 115 is being serviced. As the recirculating pump 185 or the spare pump 186 is continuously running, paint is constantly being withdrawn from the paint pot 115 and circulating through the aforementioned piping.

A connection to the line 235 is provided to bleed a small part of the paint from the line 233 to a viscometer 195, the viscometer 195 being of the pneumatic type and serving to measure the viscosity of the paint in the paint pot. Paint is returned to the paint pot from the viscometer 195 by the pipe 240 thereby to provide a closed loop through the viscometer 195. A signal from the viscometer 195 is fed as by an electrical conductor 215 to a viscosity recorder 196 and a temperature recorder 197, the output from the temperature recorder 197 being fed by conductor 217 to a refrigerator control 198, which control 198 is connected as by conductor 218 to the paint refrigerator 190, thereby to control the temperature of the paint in the paint pot 115. The output from the viscosity recorder 196 is carried as by the conductor 215 to a paint feed control 201, the paint feed control 201 also receiving an input from an amp-hour recorder 200, the amp-hour recorder 200 receiving an input from the current recorder 172 connected to the amp-hour recorder 200 by a conductor 212. The output from the amp-hour recorder 200 is carried as by a conductor 214 to the paint feed control 201, the paint feed control 201 receiving inputs from both the amp-hour recorder 200 and the viscosity recorder 196 and generating a signal which is carried by a conductor 216 to the paint solids pump 182. There is further provided a tachometer 205 to measure the speed of the metal strap 50 entering the paint pot 115, the tachometer 205

having an output therefrom fed to the rectifier for the variable power source 170 as by conductor 219 and having an output therefrom also fed as by a conductor 219 to a line relay 206 and from there by a conductor 220 to the contactors 173.

In operation, the amount of paint deposited on the metal strap 50 is controlled in part by the amount of current fed to the cathodes 145 and the anodes 130 which is fundamentally controlled by the tachometer 205. Since the faster the metal strap 50 passes through the painting station 105 the less time it will reside in the paint pot 115 the greater will have to be the current fed to the anode 130 and the cathodes 145 to deposit the same amount of paint on the straps 50 as would be deposited on the metal straps 50 if passed through the paint pot 115 at a slower speed with a lower current being supplied to the anode 130 and the cathodes 145. It is seen therefore that the principal control for the amount of power supplied from the variable power source 170 is provided by the tachometer 205 which measures the line speed of the metal straps 50. The amount of current fed to the anode 130 and the cathodes 145 determines, for the most part, the amount of paint deposited on the metal straps 50, current densities in the strap 50 being from about 0.1 to about +5 amp/ft., the power supply 170 producing from about 50 to about 250 volts. In the electrophoretic deposition of paint the solids content of the deposit coating is generally between 80 and 95 percent with only from about 5 to 15 percent of the coating being the paint diluent; therefore, it is seen that as the paint coating is deposited on the metal strap the paint will become deficient as paint solids, thereby necessitating the addition of paint solids to the paint to maintain the concentration of solids in the paint between about 5 and about 15 percent. To this end the amp-hour recorder 200 records the amount of current fed to the anode 130 and the cathode 145, which amount of current is proportional to the amount of paint being deposited on the metal strap 50 as it passes through the paint. The amp-hour recorder 200 sends a signal to the paint feed control 201 which counts the signals from the amp-hour recorder 200 and at a predetermined time sends a signal to the paint solids pump 182 which activates the same to withdraw a predetermined amount of paint solids from the drum 180. The paint solids pump 182 operates for a predetermined time to withdraw the predetermined amount of paint solids from the drum 180 and feeds the paint solids to the in-line blender 183 which mixes the withdrawn paint solids with the paint withdrawn from the tank by the recirculating pump 185. The mixed paint solids and the paint are thereafter pumped to the paint refrigerator 190. Since the electrophoretic deposition of paint creates heat, it is necessary to remove heat from the paint in order to maintain it at the desired temperature, which temperature is between about 75° F. to about 100° F., the paint refrigerator 190 being controlled by the refrigerator control 198 which in turn receives its signal from a temperature recorder 197 associated with the viscosity recorder 196. The temperature of the paint is important not only because of the electrophoretic deposition process but also because the viscosity measurement of the paint will vary according to the temperature thereof, thereby it being important that the paint be within a certain temperature range to provide the proper viscosity measurement.

The level of paint in the paint pot 115 is maintained at a predetermined level by the addition of the paint diluent, in this case water because water soluble paint solids are used herein, as controlled by the float switch 160. The sensor 161 sends a signal when the paint level 165 falls below a predetermined point at which time the float control 179 is operated by a solenoid 178 to admit deionized water or paint diluent into the paint pot 115. When the paint level reaches a certain point, the float switch 160 sends a signal which causes the solenoid valve 178 to close thereby stopping the addition of paint diluent to the paint pot 115.

The viscosity of the paint in the paint pot 115 is fundamentally maintained by the addition of diluent in response to the level of the paint in the paint pot 115 and the periodic addition of paint solids by means of activation of the paint solids pump 182 in response to a certain amount of current as recorded by the amp-hour recorder 200. When the paint viscosity remains within a predetermined range, the paint feed control 201 sends a signal to the paint solids pump 182 in response to the amount of current fed to the cathodes 145 as recorded by the amp-hour recorder 200; however, if a malfunction occurs or an unusual circumstance occurs and the viscosity of the paint varies beyond a predetermined amount, a signal from the viscosity recorder 196 to the paint controller 201 will cause the addition of a larger amount of paint solids to the paint, when the viscosity of the paint is too low, or will result in fewer additions of paint solids to the paint when the viscosity of the paint is too high. Since the paint solids pump 182 is essentially a batch operation in which the paint solids pump 182 operates for a given amount of time in response to a signal from the paint feed controller 201, variation in the paint viscosity is easily attained either by adding an additional batch operation of the paint solids pump 182 in response to a signal from the viscosity recorder 196 through the paint feed control 201 or by the skipping of a cycle of the paint solids pump 182 thereby to add fewer paint solids to the paint.

It is seen therefore, that there has been provided a system for continuously applying paint to a continuously moving metal strap 50. The system comprises a paint applying station 105 including a paint pot 115 and an electrophoretic distributing apparatus including cathode plates 145 for applying a uniform coating of paint to the metal strap 50, drive mechanism 75 for continuously passing the metal strap 50 from a source thereof through the paint pot 115 and the electrophoretic distributing apparatus. The system further includes a source of paint solids, such as drums 180 in communication with the paint pot 115 and a source of paint diluent such as tanks 177 in connection with the paint pot 115, a paint solids pump 182 in communication with the paint solids source 180 for withdrawing a predetermined amount of paint solids from the paint solids source 180, a blender 183 in communication with the paint solids pump 182 for mixing the paint solids withdrawn by the paint solids pump 182 from the paint solids source 180 with the paint in the paint pot 115. The control system includes the amp-hour recorder 200 for continually sensing the power consumed in the electrophoretic paint distributing apparatus, the viscometer 195 for continually sensing the concentration of the paint solids in the paint pot 115, and a first control circuit responsive to the amp-hour recorder 200 and to the viscometer 195 for activating the paint

solids pump 182 to withdraw a predetermined amount of paint solids from the paint solids source 180 for maintaining the concentration of paint solids within a predetermined value. A level sensing device 160 is provided for continually sensing the level of paint in the paint pot 115, and a second control circuit responsive to the level sensing device 160 for connecting the source of paint diluent 177 to the paint pot 115 for maintaining the level of paint within a predetermined value is also provided to apply to the metal strap 50 throughout the length of the strap 50 passing through the paint pot 115 a uniform coating of paint containing a substantially uniform amount of paint solids therein.

The wet painted straps 51 upon exiting from the paint applying station 105 are transported to the paint drying station 110. Referring now to FIG. 8, there is disclosed therein a control circuit 275 for the heating station 110, the control circuit 275 including a variable power supply in the form of a function generator 280 connected by an electrical conductor 281 to a three-position switch 282. The three-position switch 282 is here shown in the automatic position in which the function generator 280 is connected to a DC amplifier 285 by an electrical conductor from the common terminal of the switch 282; however, the DC amplifier 285 may also be controlled by a signal from a manual control 286 in the form of a potentiometer, the potentiometer 286 having one terminal 287 thereof connected to a ground and the other terminal 289 thereof connected to a control voltage 290, the control voltage 290 herein being illustrated as a 10 volt DC source. The sliding contact on the potentiometer 286 is connected as by connector 291 to the switch 282, whereby the DC amplifier 285 may receive an input signal from the manual control of the circuit 275.

The output from the DC amplifier 285 is fed through a conductor 295, normally closed switch contacts 297 and conductors 299 to each of five SCR voltage controls 296, there being one SCR voltage control for each and every induction heating coil 250. The normally closed switch contacts 297 provide automatic operation of the control circuit as hereinafter explained. There is also provided for each and every SCR voltage control 296 a pair of normally open switch contacts 298, one of the switch contacts 298 being connected to the conductor 295 and the other of the switch contacts 298 being connected to the sliding arm on a potentiometer 300, the potentiometer 300 having one terminal 301 thereof connected to ground, and the other terminal 302 thereof connected to a control voltage from a 10 volt DC source. A relay 305 has one terminal 306 thereof connected to ground and the other terminal 307 thereof connected to a normally open switch 308, the switch 308 being connected to a 120 volt AC source and being normally open so as to maintain the relay 305 in a position such that the switch contacts 297 are normally closed and the switch contacts 298 are normally open, all as hereinafter explained. The relay 305 has a mechanical connection 310 to each pair of the normally closed switch contacts 297 and a mechanical connection 311 to each pair of the normally open switch contacts 298, whereby closing of the normally open switch 308 energizes the relay 305 to open the normally closed switch contacts 297 and to close the normally open switch contacts 298, thereby to provide each of the SCR voltage controls 296 with a manually selected voltage from the potentiometers 300 in-

stead of the automatically selected voltage from the function generator 280 through the DC amplifier 285, all as hereinafter explained.

The output from each of the SCR voltage controls 296 is fed via conductor 315 to an associated RF oscillator 316 and the output from the RF oscillator 316 is connected via a conductor 317, which may be a coaxial cable, to the respective induction heating coil 250, the induction heating coil 250 being connected as at 318 to ground. As the wet painted metal straps 51 exit from the paint applying station 105 and pass upwardly through the respective ones of the induction heating coils 250, the straps 51 are dried and exit from the topmost of the induction heating coils 250 as dried metal straps 52, the speed of the dried metal straps 52 relative to the induction heating coil 250 being measured by a tachometer 320. The tachometer 320 sends a signal along a conductor 321 indicating the speed of the dried metal straps 52 to a recorder 323 and to a low-speed limit circuit 324 and to one terminal 329 of a potentiometer 330. The potentiometer 330 has the other terminal 331 thereof connected to ground and the output from the potentiometer is fed from the sliding contact thereof by a conductor 335 to the function generator 280. Temperature sensing means is provided near the topmost of the induction heating coils 250 for sensing the temperature of the dried painted metal straps 52 upon leaving the drying station 110, the temperature sensing means being an infrared sensing head 340 for sensing the infrared radiation given off by the dried metal straps 52 as at 341 and sending a signal along a conductor 342 to a DC amplifier 344. The output from the DC amplifier 344 is conducted via a conductor 345 to the recorder 323 and to a comparator 347, the comparator 347 also receiving an input signal from a potentiometer 350. The potentiometer 350 is the temperature set potentiometer which feeds to the comparator 347 a signal indicative of the desired temperature of the dried metal straps 52 upon exiting from the topmost induction heating coil 250. The temperature set potentiometer 350 has one terminal 351 thereof connected to ground and the other terminal 352 thereof connected to a 10 volt DC source. The output from the sliding contact of the temperature set potentiometer 350 is fed by a conductor 355 to the comparator 347 and the output from the comparator 347 is fed via a conductor 358 to a DC amplifier 360. The DC amplifier 360 also receives an input from the low-speed limit circuit 324 via a conductor 325. The DC amplifier 360 has its output signal fed via a conduction 361 to a multi-position switch 362, the switch 362 connected in its third position, as is herein shown, to a reversible motor 365, the reversible motor 365 having its output fed, as shown by dotted line 370, mechanically to position the slide on the potentiometer 330, thereby to combine in the output signal from the potentiometer 330 the signal from the tachometer 320 and the signal from the temperature sensor 340.

As the metal straps 51 exit from the paint applying station 105 and pass upwardly through the successive induction heating coils 250, the amount of heat generated therein is partly dependent upon the speed of travel of the metal straps 51 and the voltage fed to the induction heating coils 250. In the configuration as shown in FIG. 8, the control circuit 275 is in its automatic mode, wherein the control circuit 275 automatically adjusts for variations in speed and temperature of

the metal straps 51 as they pass through the successive heating coils 250. The automatic mode of the control circuit 275 is shown herein, wherein the function generator 280 is connected to the DC amplifier 285, the switch contacts 297 are in the closed position thereof, the switch contacts 298 are in the open position thereof, and the switch 362 is in the position illustrated. With the control circuit 275 in the automatic mode thereof, the tachometer 320 senses the speed of the dried painted metal straps 52 and sends the signal to the potentiometer 330 which thereafter sends the output signal thereof via the conductor 335 to the function generator 280. The function generator 280 automatically generates a larger signal in response to increased speed of the metal straps 52 through the induction heating coils 250, thereby to cause the output of the heating coils 250 to be greater and the heating of the metal straps 52 passing therethrough to be the same regardless of the speed of the metal straps 52, the preferred speed of the metal straps 52 being about 500 feet/min. and the induction heating coils being preferably operated at about 200 kilohertz. If the speed of the metal straps 52 is too low, for instance below about 50 ft./min., the low speed limit circuit 324, which also receives an input from the tachometer 320, sends the output signal therefrom via the conductor 303 to the function generator 280, thereby to cease the heating, via the induction heating coils 250, of the metal straps 52. As is seen, the output signal from the function generator 280 is fed to the DC amplifier 285 which controls the SCR voltage controls 296 that in turn control the RF oscillators 316, thereby directly to control the output of the induction heating coils 250 in response to the speed of the metal strap 52 therethrough.

As a final control, the infrared sensing head 340 senses the temperature of the metal straps 52 upon leaving the topmost induction heating coil 250. The recorder 323 which receives inputs from both the tachometer 320 and the infrared sensor 340 via the DC amplifier 344 provides a visual record of the temperature of the metal straps 52 as compared to the speed of the metal straps 52 as the metal straps 52 leave the topmost induction heating coil 250. In the comparator 347, the output from the DC amplifier 344, which reflects the temperature of the metal straps 52 leaving the topmost induction heating coil 250, is compared with a signal from the temperature set potentiometer 350, which signal sets a range for the desired temperature of the metal straps 52 leaving the topmost induction heating coil 250. When the temperature of the dried metal straps 52 is greater or less than the predetermined temperature range set in the potentiometer 350, the comparator 347 produces a signal which after amplification by the DC amplifier 360 activates the reversible motor 365 which mechanically varies the position of the sliding contact on the potentiometer 330, thereby to vary the input signal to the function generator 280 in response to the temperature of the metal straps 52 leaving the topmost induction heating coil 250. As is seen therefore, when the control circuit 275 is in the automatic mode thereof, the output from the induction heating coils 250 is controlled both by the speed of the dried painted metal straps 52 as they pass through the paint drying station 110 and the temperature of the dried painted metal straps 52 as they exit from the topmost induction heating coil 250.

When the control circuit 275 is in the manually controlled mode thereof, the DC amplifier 285 is connected to the manually controlled potentiometer 286, whereby the signal from the DC amplifier 285 may be manually controlled by adjustment of the sliding contact of the potentiometer 286. Manual control of the control circuit 275 is also provided by energizing the relay 305 to open the normally closed switch contacts 297 and close the normally open switch contacts 298 to permit manual control via manipulation of the sliding contacts on the potentiometers 300 of the SCR voltage controls 296 and hence, the RF oscillators 316 and the output from the induction heating coils 250. The control circuit 275 is operable both manually to adjust the output of the induction heating coils 250 or automatically to adjust the output of the induction heating coils 250, the control circuit 275 in the automatic mode thereof varying the output of the induction heating coils 250 in response both to the speed of the metal straps 52 and the temperature of the metal straps 52 leaving the topmost of the induction heating coils 250.

It is seen therefore, that there has been provided a system for continuously drying a painted continuously moving metal strap 52. The system comprises a drying station 110 including an induction heating coil 250 for heating the metal strap 52 to dry the paint thereon, drive mechanism 75 for continuously passing the metal strap 52 through the induction heating coil 250 and a variable power supply in the form of a function generator 280 for the induction heating coil 250 for controlling the output therefrom. The system further includes the tachometer 320 for sensing the speed of the movement of the metal strap 52 with respect to the induction heating coil 250, the infrared sensor 340 for sensing the temperature of the painted metal straps 52 immediately after the passage thereof from the induction heating coil 250, and a control circuit 275 responsive to the tachometer 320 and to the infrared sensor 340 for controlling the function generator 280 and thus the heating produced by the induction heating coil 250 to heat the painted metal strap 52 to a predetermined temperature at the temperature sensing means. The control circuit 275 also includes limit means in the form of the low-speed limit circuit 324 responsive to the tachometer 320 for deenergizing the induction heating coil 250 when the speed of the metal strap 52 with respect to the induction heating coil 250 is below a predetermined value, to dry the paint on the metal strap 52 throughout the length thereof passing through the induction heating coil 250 without burning the metal strap 52 or the paint thereon.

The term "electrophoresis" as used herein includes electrodeposition wherein the paint solids exist as discrete particles, as in an emulsion, and electrodeposition wherein the paint solids are in solution. The term "strap" as used herein includes strips, wires and other forms of continuous metal work pieces.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A system for continuously drying a painted continuously moving metal strap, said system comprising a

drying station including an induction coil for heating the metal strap to dry the paint thereon, drive mechanism for continuously passing the metal strap through said induction heating coil, a variable power supply for said induction heating coil for controlling the output therefrom, means for sensing the speed of movement of the metal strap with respect to said induction heating coil, means for sensing the temperature of the painted metal strap immediately after the passage thereof from said induction heating coil, and a control circuit responsive to said metal strap speed sensing means and to said painted metal strap temperature sensing means for controlling said variable power supply and thus the heating produced by said induction heating coil to heat the painted metal strap to a predetermined temperature at said temperature sensing means, whereby to dry the paint on the metal strap throughout the length thereof passing through said induction heating coil.

2. The system set forth in claim 1, wherein said induction heating coil is operated at a frequency of about 200 kilohertz.

3. The system set forth in claim 1, wherein said drive mechanism is adapted to pass the metal strap through said induction heating coil at a speed of about 500 feet/min.

4. A system for continuously drying a painted continuously moving metal strap, said system comprising a drying station including an induction coil for heating

the metal strap to dry the paint thereon, drive mechanism for continuously passing the metal strap through said induction heating coil, a variable power supply for said induction heating coil for controlling the output therefrom, means for sensing the speed of movement of the metal strap with respect to said induction heating coil, means for sensing the temperature of the painted metal strap immediately after the passage thereof from said induction heating coil, and a control circuit responsive to said metal strap speed sensing means and to said painted metal strap temperature sensing means for controlling said variable power supply and thus the heating produced by said induction heating coil to heat the painted metal strap to a predetermined temperature at said temperature sensing means, said control circuit including limit means responsive to said metal strap speed sensing means for deenergizing said induction heating coil when the speed of the metal strap with respect to said induction coil is below a predetermined value, whereby to dry the paint on the metal strap throughout the length thereof passing through said induction heating coil.

5. The system set forth in claim 4, wherein said limit means is operative to deenergize said induction heating coil when the speed of the metal strap is below about 50 feet/min.

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