

April 4, 1961

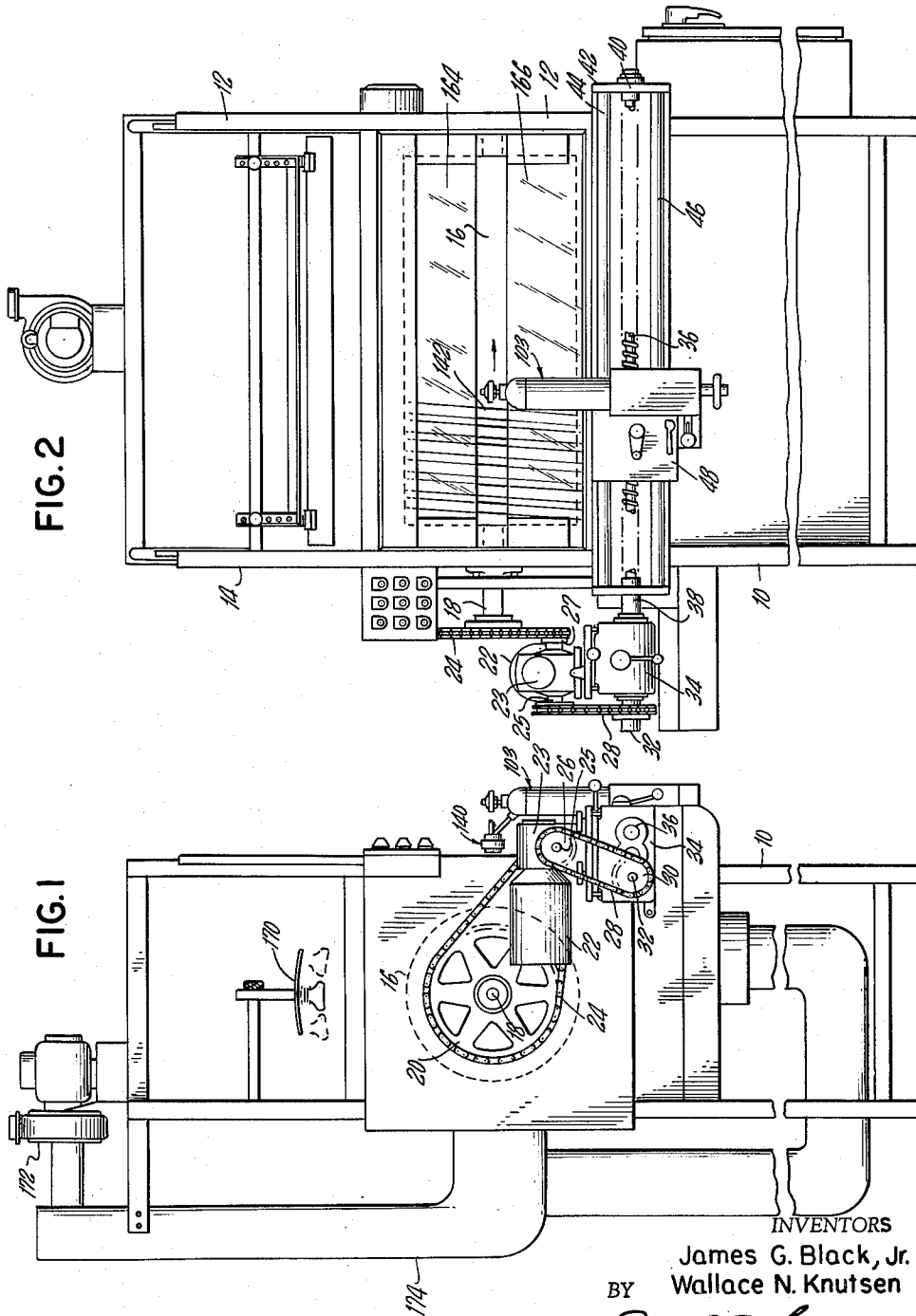
W. N. KNUTSEN ET AL

2,977,928

RESISTOR TAPE SPRAYER

Filed Aug. 15, 1958

3 Sheets-Sheet 1



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RESISTOR TAPE SPRAYER

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3 Sheets-Sheet 2

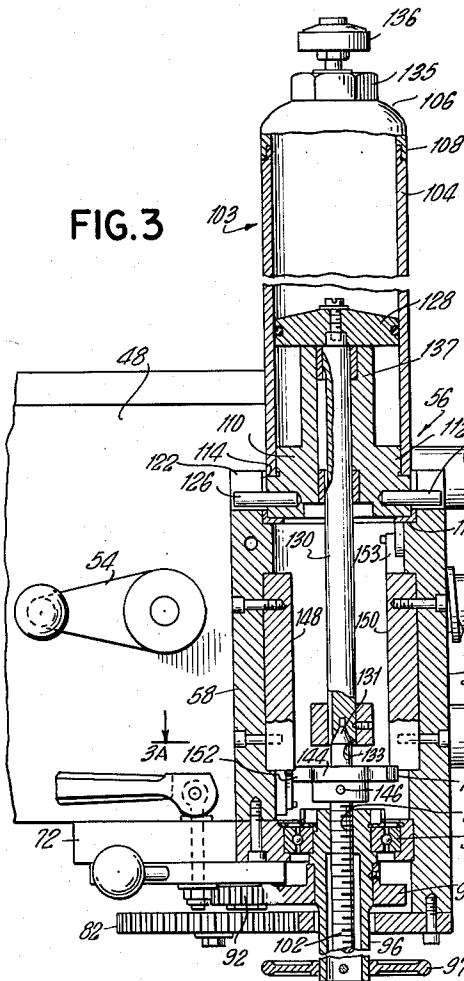


FIG. 3

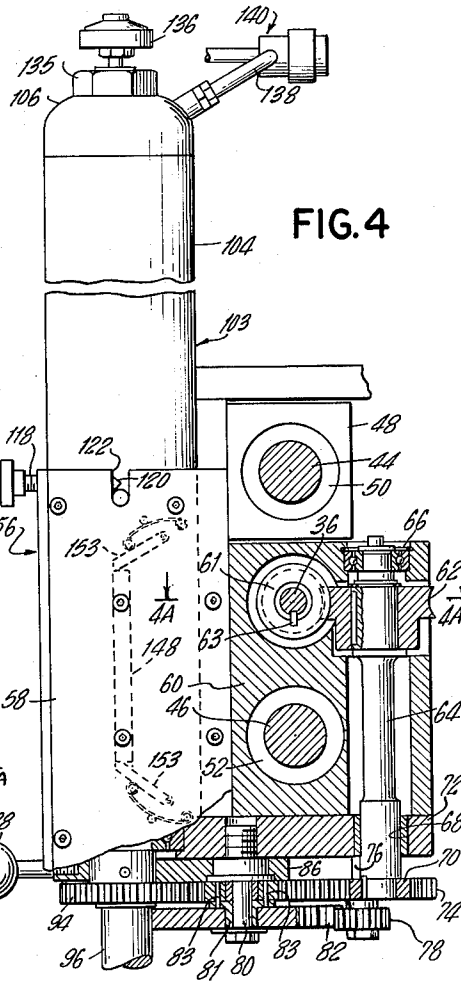


FIG. 4

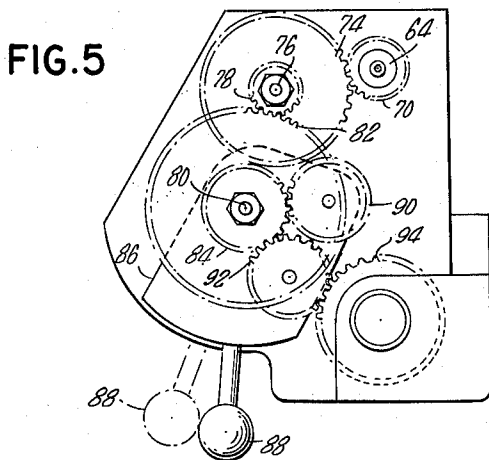


FIG. 5

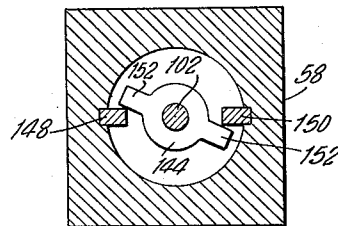


FIG. 3A

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FIG. 6

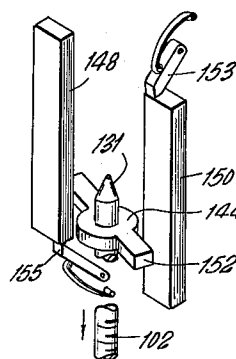
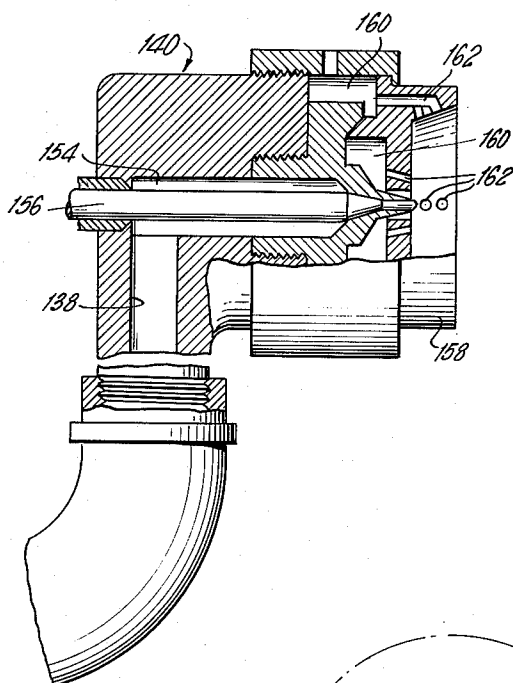


FIG. 8

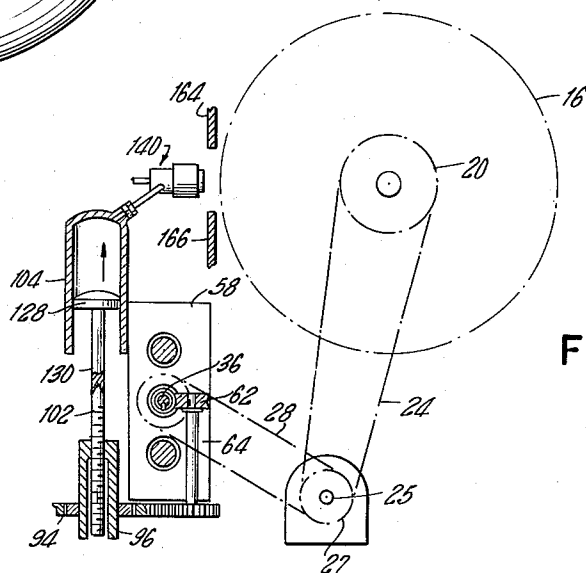


FIG. 7

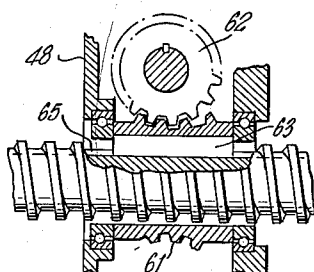


FIG. 4A

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RESISTOR TAPE SPRAYER

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Filed Aug. 15, 1958, Ser. No. 755,320

9 Claims. (Cl. 118—321)

This invention is directed to a device for spraying resistive material onto a flexible tape.

Certain circuit assemblies utilizing printed circuits or other structures often use resistors formed of a partially conductive i.e. resistive coating on a flexible backing tape. The resistive coating is frequently sprayed onto the backing tape and may consist of powdered carbon and binders such as thermosetting resins suspended in a volatile liquid and combined with a nonconductive filler material, such as sodium silicate.

One of the problems in making tape resistors is obtaining uniformity of resistivity over all portions of the sprayed tape material. The individual resistors are cut from the sprayed tape and it is of course desirable that resistors of the same size and shape have substantially the same resistance. Uniformity of resistance from resistor to resistor is difficult to obtain due to the non-uniformity of the spray deposit on the tape. Normally, such resistor tapes are sprayed by machines comprising a conventional spray gun. In the past, it has been found difficult to maintain uniformity of spray from such devices due to the partial clogging and opening of the spray gun which results in thin and thick coating areas on the sprayed tape. Because of this it is necessary to make multiple passes of the spray gun across the tape material to obtain a minimum thickness of the coating material but which does not provide a uniform coating thickness over all areas of the tape.

Resistor tape made in the manner described does not lend itself to the rapid fabrication of individual resistors. The nonuniformity of coating on the resistor tape results in a great variance in the value of the resistance of individual resistors. Because of this, it has been necessary in the past to spray coat the resistor tape with a thicker coating than is necessary, after which the individual resistors are processed to have a resistance within a required range by grinding away some of the resistive coating in order to raise the resistance of the resistor. Such a procedure is time consuming and expensive.

It is, therefore, an object of this invention to provide a novel device for fabricating resistor tape.

It is another object of this invention to provide a novel device and technique for fabricating resistor tape with uniform resistance.

It is a further object of the invention to provide a novel device and technique for spray coating a backing material with a uniform coating of resistive material.

It is another object of the invention to provide a novel device and technique for spray coating a resistor tape material to form a uniform coating having a predetermined resistance.

The invention is in a resistor tape spray machine having a supporting carrier for holding material such as a tape to be coated by a resistance coating. The machine includes a spray gun which is mounted for movement along a fixed path adjacent to the material carrier. The resistive spray material is fed as a fluid to the nozzle

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of the spray gun from a cylindrical chamber, housing a piston. The fluid spray material is forced by action of the piston into the spray nozzle at a rate proportional to the area of the surface to be coated. The motion of the piston is synchronized with the movement of the spray gun by positive linkage or drive between the spray gun and the piston. Thus, as the spray gun is moved adjacent to the supporting carrier at a fixed rate, a constant amount of spray material is forced through the spray gun and onto the backing material which is being spray coated.

Fig. 1 is a view in elevation of the novel spray machine in accordance with the invention.

Fig. 2 is a side elevational view of the novel spraying machine of Fig. 1.

Fig. 3 is an enlarged front elevational view partly in section of the fluid reservoir and pump of the novel spray machine of Figs. 1 and 2.

Fig. 3A is a partial sectional view taken along the section lines 3A—3A of Fig. 3.

Fig. 4 is an enlarged elevated side view partly in section of a portion of the spray machine of Fig. 3.

Fig. 4A is a schematic sectional view showing substantially the structure along lines 4A—4A of Figure 4.

Fig. 5 is a sectional view of a portion of Fig. 3 and taken along the section lines 5—5.

Fig. 6 is an enlarged partially sectioned view of the spray nozzle used in the novel machine of Figs. 1 and 2.

Fig. 7 is a schematic representation of the mode of operation of the device of Figs. 1 and 2.

Fig. 8 is an elevational showing of part of the structure shown in Fig. 3.

One type of resistive component used in electrical circuits is that in which the individual resistors are formed from a resistive coating supported on a tape-like material of paper or plastic. The resistive material may be powdered carbon mixed with a filler material such as sodium silicate in a volatile liquid binder, which is applied in any conventional way on the backing material. A common method of applying the resistive material is by use of a spraying apparatus, in which the supporting tape is spray-coated with the resistive material.

Fig. 1 discloses a spray machine, in accordance with the invention, which consists of a supporting frame 10 having side plates 12 and 14. A drum 16 is supported between and journaled in the side plates 12 and 14 for rotation about a horizontal axis. A shaft 18 extends from one end of drum 16 and has fixed at its outer end a sprocket wheel 20. Motor 22 drives through a gear box 23 a shaft 25, to one end of which is fixed a small sprocket wheel 27, connected by a drive chain 24 to sprocket wheel 20. As shown in Fig. 2, drive chain 24 passes around and meshes with the teeth of wheel 20.

Mounted on the outer end of shaft 25 is a second toothed sprocket wheel 26, which drives a second chain 28 meshed with to drive another sprocket gear 30 fixed to and mounted on a shaft 32. Shaft 32 extends through a gear box 34, where it is geared directly to a lead screw shaft 36 extending horizontally from the gear box 34 and supported by journal bearings 38 and 40. The journals 38 and 40 are fixed in a frame mounting 42 rigidly fixed to the supporting frame 10. Also mounted between frame mounting 42 in horizontal positions and equally spaced from the lead screw shaft 36 are an upper guide rod 44 and a lower guide rod 46. Guide rods 44 and 46, and the lead screw shaft 36 are fixed in a common vertical plane.

A support block 48 is mounted for sliding movement on support rods 44 and 46, which pass through block 48 in contact with bearing bushings 50 and 52, respectively (Figure 4). Sufficient play is allowed between bushings

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50 and 52 and the respective guide rods 44 and 46 to enable the block 48 to freely move along the supporting guide rods. Block 48 is driven in both directions along the guide rods 44 and 46 by a well known lathe action. The drive of block 48 is produced from the lead screw shaft 36 by its meshing with a half nut mounted on block 48. A control lever 54 is operated to move the half nut into and out of engagement with the lead screw shaft 36. The turning of lead screw shaft 36 will drive the supporting block 48 along the guide rods 44 and 46 in one direction. Reversing the direction of rotation of lead screw shaft 36 will drive the support block 48 in the opposite direction.

As disclosed above, the support block 48 is thus directly joined by positive linkage to the shaft 25 of the gear box 23. Also, drum 16 is positively linked through sprocket wheel 20 and chain 24 to shaft 25. In this manner then the speed of rotation of drum 16 has a fixed ratio to the horizontal speed of support block 48.

Fixed to the support block 48 and for movement therewith is a proportional displacement pump 56. The pump comprises a housing 58 rigidly mounted to the support block 48. Housing 58 has a portion 60 through which guide rod 46 and lead screw shaft 36 pass. Supported within housing portion 60 is a worm gear 62, in operative contact with a worm 61, which is in turn driven by a captive key 63, that slides in a keyway 65 in lead screw shaft 36 (Fig. 4A). The worm gear 62 is keyed to and supported by a shaft 64 vertically mounted and supported by bearings 66 and bushing 68 in the housing portion 60. At the lower end of shaft 64 there is fixed to the shaft a gear 70. Supported from a bottom plate portion 72 of housing 58, as shown in Figs. 4 and 5, is a gear 74 fixed to a bushing (not shown) mounted on a short shaft 76. At the lower end of the bushing is fixed a small gear 78. Shaft 76 is fixed to plate 72. Both of the gears 74 and 78 are keyed to shaft 76 to rotate therewith. Gear 74 is meshed with gear wheel 70 to be driven thereby. A second shaft 80 is fixed to and is suspended from plate 72. Rotatably mounted on shaft 80 is a shear pin drive plate 81 keyed to a gear 82 meshed with gear 78. Shear pins 83 extend from shear pin drive plate 81 into gear 84 rotatably mounted on shaft 80 to drive gear 84.

A shift plate 86 is mounted for rotational movement about the axis of shaft 80 from the lower surface of housing plate 72. Shift plate 86 is manually moved by a lever 88 fixed to the plate. Mounted for rotation on plate 86 are a pair of meshed gears 90 and 92, respectively. Gear 90 is meshed with gears 84 and 92. A driven gear 94 is mounted on a drive nut 96 (Fig. 3). Driven gear 94 is positioned so that the rotational movement of the shift plate 86 about the axis of shaft 80 will bring either gear 90 or 92 into driving contact with the gear 94. In this manner gear 94 may be driven in either rotational direction depending upon the position of shift plate 86. Also there is an intermediate position of plate 86, in which neither of the gears 90 or 92 is in contact with the driven gear 94. This provides then a neutral or non-driven position for the drive gear 94. The driven gear 94 is keyed to or fixed in an equivalent manner to the drive nut 96. Drive nut 96 is supported within housing 58 by the bearing assembly 98 and is internally threaded at 100 to receive within the driving nut a jack screw 102.

Mounted on the top of housing 58 (Figs. 3 and 4) is a cylinder and piston assembly 103 consisting of a cylindrical housing 104 having a top cap 106 welded at 108 to the upper end of the cylindrical housing 104. Fixed within the lower end of cylindrical housing 104 is a cylinder base block 110, which may be screw threaded into the lower end of housing 104. The cylinder housing 104 is mounted within the upper end of housing 58 by positioning the cylinder base block 110 within cylindrical opening 114 in housing 58. The bottom portion of base block 110 rests on a supporting ledge 116, within the housing 58. The cylinder housing 104 is locked to housing

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58 by means of a pair of screw threaded detents 118, of which one is shown in Fig. 4 and has an end portion 120 extending into a slot opening 122 in the upper edge of housing 58. A pair of pins 124 and 126 are fixed in the lower portion of cylinder base block 110 and extend outwardly therefrom so as to enter the slots 122 when the cylinder housing 104 is mounted on housing 58. Threading the detents 118 into housing 58 will bring the ends 120 of the detents into engagement with pins 124 and 126, respectively, to securely fix the cylinder housing 104 to housing 58. Mounted within the cylinder housing 104 is a piston 128. Affixed to and suspended from piston 128 is a piston rod 130 having its lower end in contact with the upper end of the screw jack 102. As shown specifically in Fig. 3 the upper end of screw jack 102 has a conical end 131 which extends loosely into a conical aperture 133 formed in the lower end of the piston rod 130.

The center portion of the cap 106 is apertured to receive a filler cap 135 to which a pressure relief and bleeder valve 136 is hermetically joined to the cylinder 104. Cap 106 is apertured to receive appropriate fittings to which a conduit 138 is joined connecting the cylinder 104 to a spray nozzle 140.

The cylinder housing 104 together with piston 128 constitutes a pump device for forcing a liquid spray material under pressure through the conduit 138 to the spray nozzle 140. In operation, a pump assembly 103 is first filled with the spray material with piston 128 at its lowermost position against an upper extension 137 of cylinder base block 110. Cylinder 104 may be filled by removing the filler cap 135, after which the pump assembly 103 is positioned on and locked to the housing 58 in the manner described above. Filler cap 135, with bleeder and relief valve 136, is attached to cylinder 104 and conduit 138 is connected to screw cap 106 to provide a conduit connection between the cylinder 104 and the spray nozzle 140.

The resistive spray material, with which cylinder 104 is filled, may consist of carbon black or graphite in a resin solution with a filler. One form of resin solution used is an epoxy resin solution containing 35% solids which are a condensation product of epichlorohydrin and diphenol and a curing agent in a solvent such as toluene and diacetone alcohol. Such a curing agent as a melamine or an urea polymer resin may be used. A successfully used resistive material of this type may comprise by weight carbon black 1.17%, resin solution 81.05% and filler 17.78%.

In operation, the material to be coated is in the form of a plastic tape containing inorganic fillers, such as asbestos impregnated with epoxy or silicone resin. The tape is wrapped around the drum 16, as indicated at 142 (Fig. 1). The support block 48 is first released from the lead screw 36 by the manual release lever 54 and the block 48 together with the pump assembly 56 is moved to a position to the left of drum 16 as viewed in Fig. 1. Operation of motor 22 simultaneously drives drum 16 in rotation about its axis and also drives the lead screw shaft 36. When it is desired to initiate spraying of tape 142, block 48 is meshed to the lead screw 36. The turning of lead screw 36 advances block 48 and the pump assembly 56, slowly toward the right, as viewed in Fig. 1. Motion of block 48 along the lead screw 36 turns the worm gear 62 through worm 61 causing the drive shaft 64 to drive the chain of gears, shown in Fig. 5, which turn the drive nut 96. Rotation of drive nut 96 forces the jack screw 102 to move upwardly and carry with it piston 128 by the piston rod 130.

However, to enable the drive nut 96 to raise the jack screw 102, it is necessary that the jack screw be prevented from rotating with the drive nut 96. This is accomplished by using a cam element 144 fixed to the jack screw 102 by a set screw 146. On opposite sides of the inner surface of the housing 58 are fastened a pair of

guide plates 148 and 150, respectively. The cam element 144 has a plan configuration as shown in Fig. 3A with end portions 152 extending radially a distance sufficient to contact the guide plates 148 and 150, which prevent rotation of cam element 144 and thus rotation of the jack screw 102 by the drive nut 96.

The cam element 144 and the guide plates 148 and 150 constitute a means to render the jack screw inoperative when the piston 12 reaches the top of cylinder 104. The cam element 144 will move upwardly along the length of guide plates 148 and 150 as the jack screw 102 is forced upwardly. As the ends 152 of the cam element 144 pass beyond the upper edges of guide plates 148 and 150, the ends 152 of the cam element 144 will slip under the free end of a pawl 153 in contact with the top end of cam plate 150. The cam element 144 now rotates and will not prevent jack screw 102 from also rotating with drive nut 96. At this point the jack screw 102 will not rise any farther. The disability feature prevents piston 128 from being forced against the top cap 106 of the cylinder, and thus prevents damage to the gear linkage between the drive nut 96 and the worm shaft 36.

The shift plates 86, as described above, will bring either gear 90 or gear 92 into contact with the drive gear 94. This enables the use of the spray when the supporting block 48 is moved in either direction, and enables the drive gear 94 to rotate in the same direction irrespective of the direction or rotation of the gear 62. In this manner then, piston 128 is positively driven upwardly as the spray device moves either to the left or right, as shown in Fig. 1.

The shear pins in gear 84 prevent damage to the gears if drive nut 96 should accidentally be jammed before the cam element 144 reaches a self-releasing position.

The action of the jack screw 102 is reversed when nut 96 is turned in the other direction either by the use of gear plate 86, or by reversing motor 22 or by hand action on wheel 97 attached to drive nut 96. Cam 144 will also reverse and ride along opposite surfaces of plates 148 and 150. If cam 144 is above the top ends of plates 148 and 150, an end 152 of the cam plate 144 will now strike the face of pawl 153 to stop rotation of plate 144 and jack screw 102. In reverse, the drive nut 96 will run the jack screw 102 downwardly. To prevent the jack screw from jamming cam plate 144 onto the drive nut 96, the action of the drive nut 96 on jack screw 102 is similarly disabled, when the cam element 144 passes below the lower edges of the guide plates 148 and 150. When cam element 144 passes beyond the end of plates 148 and 150, the ends 152 will ride over the free end of pawl 155 to permit cam plate 144 to rotate and disable the jack screw 102. On rotating in the opposite direction, the end 152 of cam 144 contacts the face of pawl 155 and is stopped in rotation and moves upwardly off the pawl face onto the faces of plates 148 and 150.

In operation, piston 128 forces the resistive spray material through conduit 138 into the spray nozzle 140. Because of the direct gear linkage, schematically shown in Figure 7, between piston 128 and the worm shaft 36, the speed of piston 128 has a direct relationship or ratio to the speed of the support block 48 along the guide rods 44 and 46. Also the speed of piston 128 will always bear the same ratio to the speed of rotation of drum 16. In this manner then, there will always be a given amount of material issuing from spray 140 for the same distance that the spray gun is driven laterally and for a specific distance that the drum 16 turns. Thus, a fixed amount of spray material will always be used to coat equal areas of the drum 16 and the resistive coating put down on the tape 142 supported by drum 16 will be of constant thickness and uniformity. Since the liquid spray material is delivered to the spray nozzle 140 at a constant rate, there is little likelihood that nonuniformity in the spray coating will result due to clogging of the spray nozzle for any reason. The constant feed of the spray

pump will eliminate any tendency of the nozzle to clog to cause thin areas in the spray coating.

The spray nozzle itself is of a conventional design and is only briefly described and shown in Fig. 6. The fluid conduit 138 extends into a chamber 154 of the nozzle which houses a needle valve 156, which meters the spray liquid to the cap 158 of the spray nozzle. Air under pressure is supplied, by means not shown, to an air chamber 160, from which it is led by passages 162 to the spray nozzle cap 158. The air and spray material passing under pressure into the air cap causes the liquid spray material to become atomized and to issue as a spray onto the cylinder 16. The structure and operation of spray nozzle 140 are conventional and will not be further described.

Between the spray nozzle 140 and cylinder 16 are positioned a pair of transparent shields 164 and 166, fastened between supporting plates 12 and 14. The adjacent edges of shields 164 and 166 are spaced at the level of the spray nozzle 140 (Fig. 7) so that the spray may pass between the shields onto cylinder 16.

A battery of lamps 170 may be positioned above drum 16 to dry the spray-coated tape 142. To carry off the volatile gases a ventilating system consisting of a motor driven blower 172 is used to ventilate the space about drum 16 through piping 174.

Thus the device disclosed is one which sprays a material at a rate that is in proportion to the amount of surface material presented to be sprayed. In the specific device described the synchronizing of the piston of the pump, with both the movement of the spray gun and the rotation of the cylinder provides a uniform coating of spray material with a minimum of variation in the thickness of the spray coating.

What is claimed is:

1. A spray machine comprising a support, means on the support for holding material to be spray coated, a spray gun, means mounting said spray gun on said support for movement along a fixed path adjacent to said material holding means, means for moving said spray gun along said path, said spray gun including a spray nozzle, a cylinder and a piston mounted for movement within said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle, and duct means connecting said cylinder to said spray nozzle, means for moving said piston within said cylinder, and interconnecting means interposed between said spray gun moving means and said piston moving means for synchronizing the motion of said piston with that of said spray gun.

2. A spray machine comprising a support, means on said support for holding material to be spray coated, a spray gun, means mounting said spray gun on said support for movement along a fixed path adjacent to said material holding means, motor means for moving said spray gun along said path, said spray gun including a spray nozzle and a cylinder for holding a liquid spray, a piston mounted for movement within said cylinder to engage said liquid spray to positively force said liquid spray through said spray nozzle at a fixed, uniform rate and quantity, duct means connecting said cylinder to said spray nozzle, said motor moving means including driving structure connected to said piston for moving said piston within said cylinder, said piston driving structure including interconnecting means interposed between said motor means and said piston driving structure for synchronizing the motion of said piston with that of said spray gun.

3. A spray machine comprising a support, means on said support for holding material to be spray coated, a spray gun, means mounting said spray gun on said support for movement along a fixed path adjacent to said material holding means, motor means for moving said spray gun along said path, said spray gun including a

spray nozzle and a cylinder for holding a liquid spray, a piston mounted for movement within said cylinder to engage said liquid spray to positively force said liquid spray through said spray nozzle at a fixed, uniform rate and quantity, duct means connecting said cylinder to said spray nozzle, a positive drive structure interconnecting said motor means and said piston for moving said piston within said cylinder, said positive drive structure including means for simultaneously moving said piston and said spray gun at respective speeds having a fixed ratio.

4. A spray machine comprising a support, a carrier for holding material to be sprayed, means mounting said carrier on said support for movement in a fixed direction, a spray gun, guide means mounting said spray gun on said support for movement along a fixed path adjacent to said carrier and transverse to said direction of movement of said carrier, motor means for moving said carrier and said spray gun, said spray gun including a spray nozzle, a cylinder and a piston mounted for movement within said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle, duct means connecting said cylinder to said spray nozzle, a positive drive structure interconnecting said motor means and said piston for moving said piston within said cylinder, said positive drive structure including means for simultaneously moving said piston and said spray gun at respective speeds having a fixed ratio.

5. A spray machine comprising a support, a carrier for holding material to be sprayed, means mounting said carrier on said support for movement in a fixed direction, guide means mounted on said support adjacent said carrier, a spray gun mounted on said guide means for movement along a fixed path adjacent said carrier, said spray gun including a spray nozzle, a cylinder, a piston mounted for movement within said cylinder, duct means connecting said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle to said spray nozzle, motor means, and positive drive structure interconnecting said motor means to said carrier, said spray gun and said piston, for simultaneously moving said carrier, said spray gun and said piston at respective speeds having fixed ratios.

6. A spray machine comprising a support, a carrier for holding material to be sprayed, means mounting said carrier on said support for movement in a fixed direction, guide means mounted on said support adjacent said carrier, a spray gun mounted on said guide means for movement along a fixed path adjacent said carrier and transverse to said direction of movement of said carrier, said spray gun including a spray nozzle, a cylinder, a piston mounted for movement within said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle, duct means connecting said cylinder to said spray nozzle, motor means, and positive drive structure interconnecting said motor means to said carrier and to said spray gun, said drive structure including means for simultaneously moving said carrier and said spray gun at respective speeds having a fixed ratio.

7. A spray machine comprising a support; a carrier for holding material to be sprayed; a spray gun; guide means mounting said spray gun on said support for movement along a fixed path adjacent to said carrier; said spray including a spray nozzle, a cylinder and a piston mounted

for movement within said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle, and duct means connecting said cylinder to said spray nozzle; motor means; positive drive structure connecting said motor means to said spray gun and said piston for simultaneously moving said spray gun and said piston at respective speeds having a fixed ratio; said positive drive structure including a screw jack connected to said piston to push said piston through said cylinder, a nut threaded to said screw jack to drive said screw jack, gear means driven by said motor means to turn said nut, and means to render said nut inoperative when said piston is pushed to either end of said cylinder.

8. A spray machine comprising a support, a carrier on said support for holding material to be sprayed; a spray gun; guide means mounting said spray gun on said support for movement along a fixed path adjacent to said carrier; said spray gun including a spray nozzle, a cylinder and a piston mounted for movement within said cylinder to positively engage material to be sprayed to afford a fixed, uniform rate and quantity of spray material emanating from said spray nozzle, and duct means connecting said cylinder to said spray nozzle; motor means; positive drive structure connecting said motor means to said spray gun and said piston for simultaneously moving said spray gun and said piston at respective speeds having a fixed ratio; said positive drive structure including a screw jack connected to said piston to push said piston through said cylinder, a nut threaded to said screw jack to drive said screw jack, gear means driven by said motor means to turn said nut, and means to render said nut inoperative when said piston is pushed to either end of said cylinder, said last means including an element fixed to said cylinder wall to prevent said jack screw from turning during passage of said piston between the ends of said cylinder.

9. A spray machine comprising a support; a carrier on said support for holding material to be sprayed; a spray gun; guide means mounting said spray gun on said support for movement along a fixed path adjacent to said carrier; said spray gun including a spray nozzle, a cylinder and a piston mounted for movement within said cylinder, and duct means connecting said cylinder to said spray nozzle; motor means; positive drive structure connecting said motor means to said spray gun and said piston for simultaneously moving said spray gun and said piston at respective speeds having a fixed ratio; said positive drive structure including a screw jack connected to said piston to push said piston through said cylinder, a nut threaded to said screw jack to drive said screw jack, gear means driven by said motor means to turn said nut, and means to render said nut inoperative when said piston is pushed to either end of said cylinder, said last means including coacting elements fixed to said cylinder and said jack screw to prevent said jack screw from turning during passage of said piston between the ends of said cylinder.

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