June 29, 1971 J. H. BLEWETT ET AL **3,589,938**

METHODS FOR APPLYING LIQUID TO ARTICLES WITHOUT TOUCHING THE ARTICLES

Filed July 11, 1968 12 Sheets-Sheet 1

FIG-1

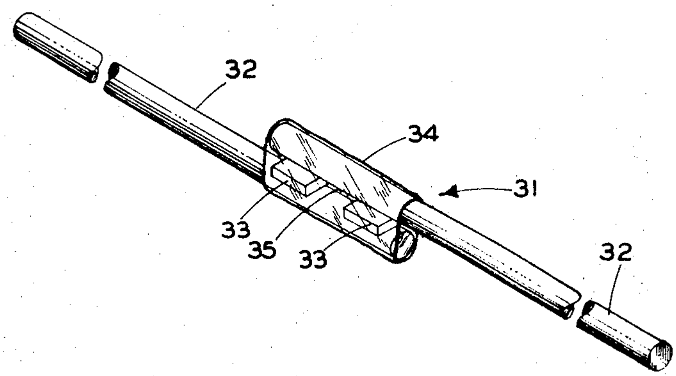


FIG-2

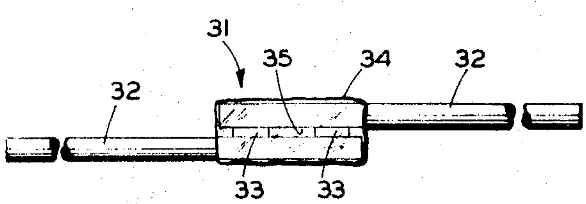


FIG-3

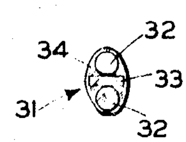
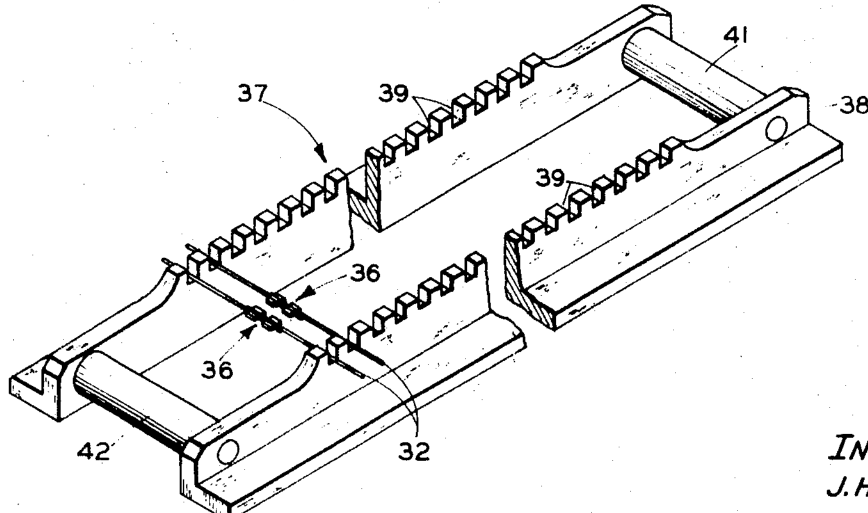


FIG-4



INVENTORS
J. H. BLEWETT
H. K. NAUMANN
BY [signature]
ATTORNEY

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METHODS FOR APPLYING LIQUID TO ARTICLES WITHOUT TOUCHING THE ARTICLES

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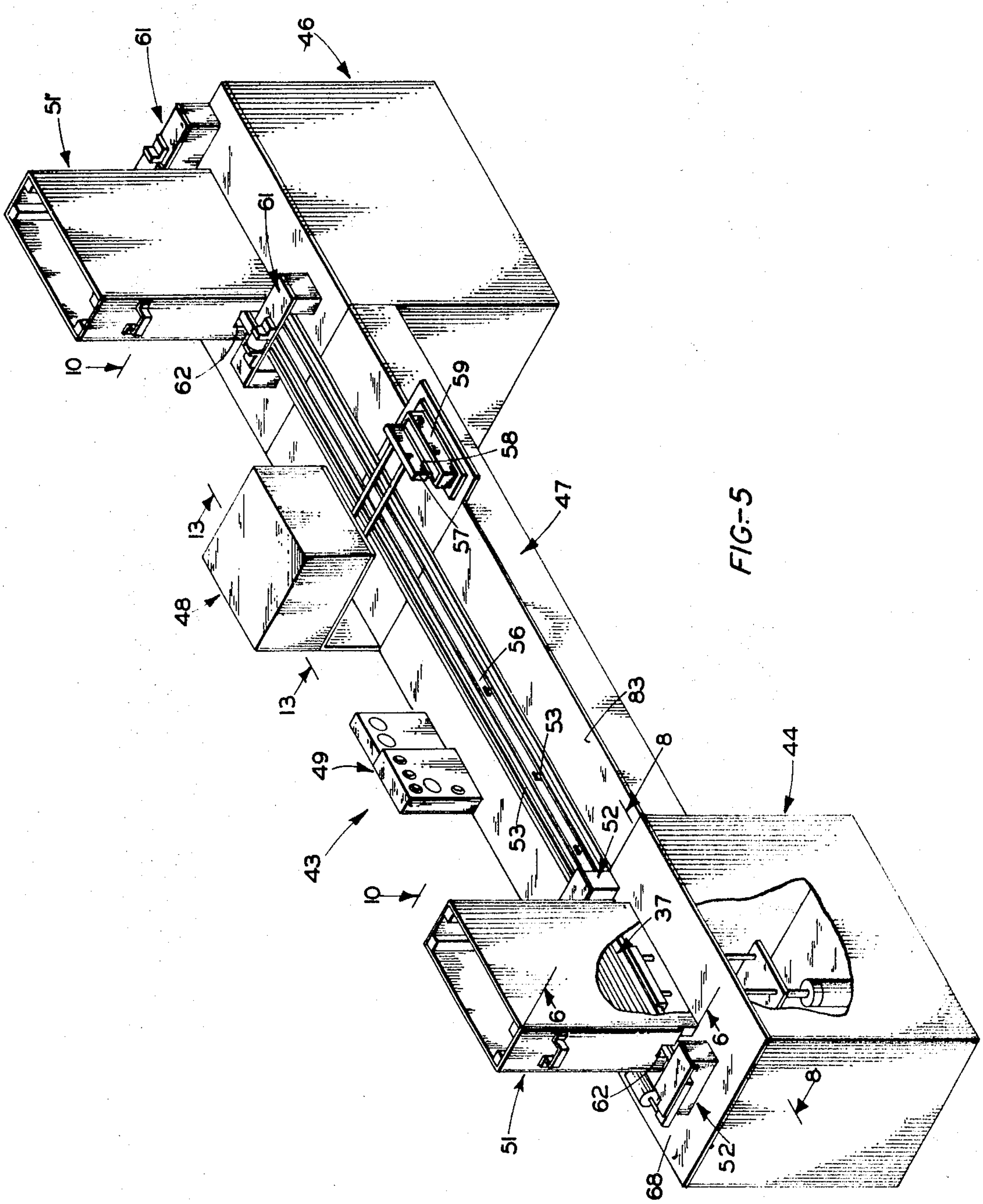


FIG-5

FIG.-6

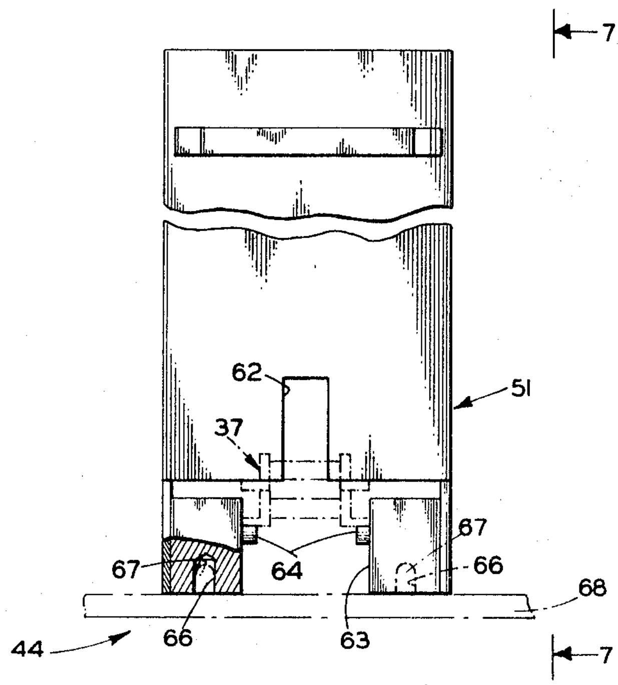


FIG.-7

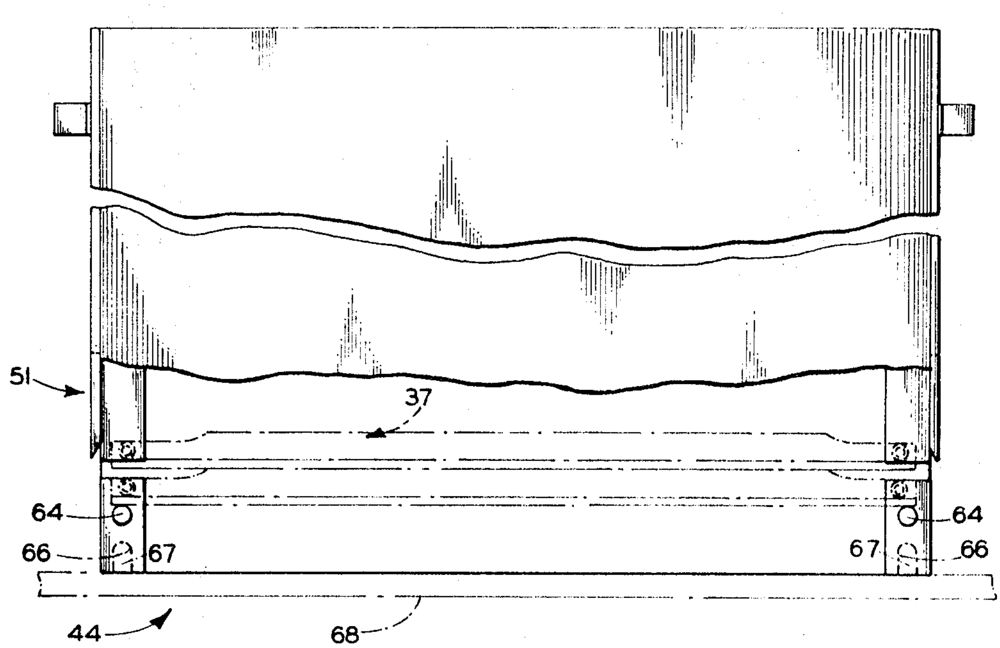


FIG.-8

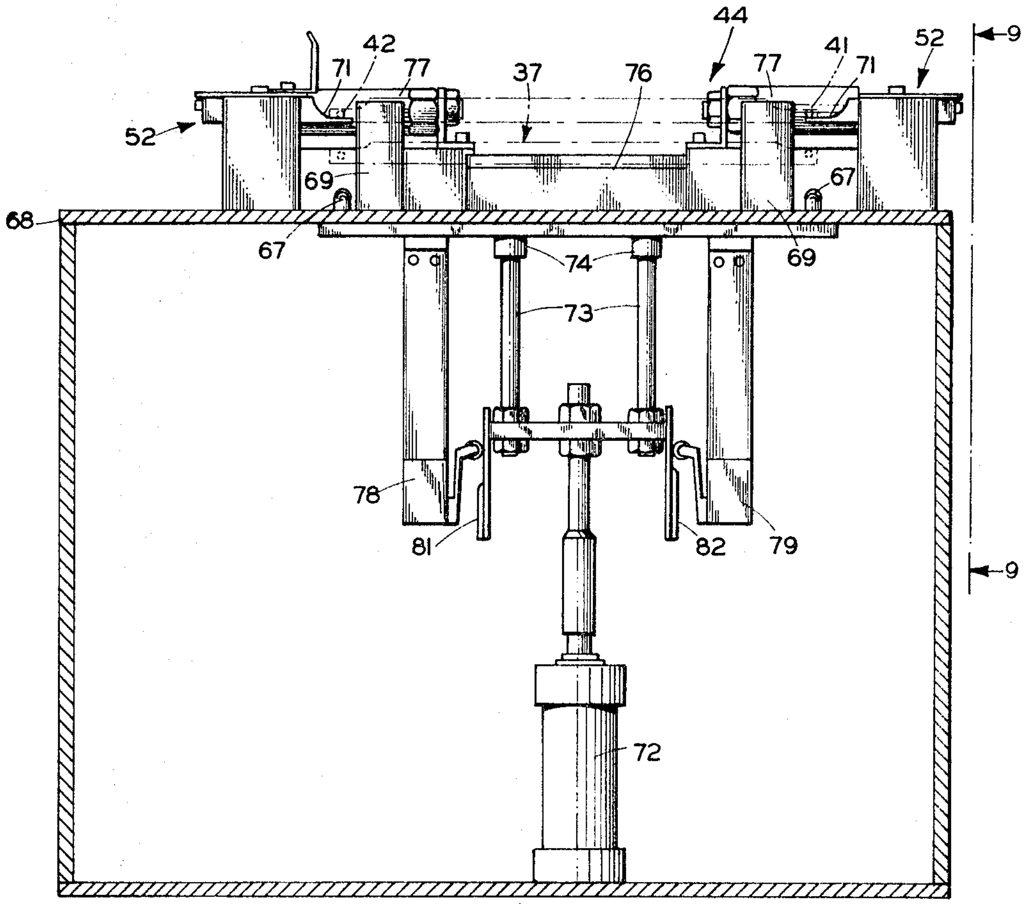
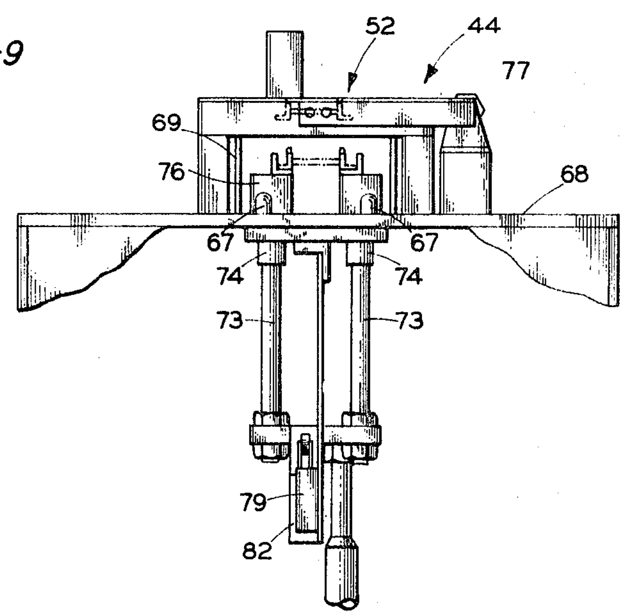

44
42
71
77
37
76
77
41
71
52
9
52
69
67
68
67
74
69
73
78
81
82
79
9
72

FIG.-9


52
44
77
69
76
68
67
67
74
74
73
73
79
82

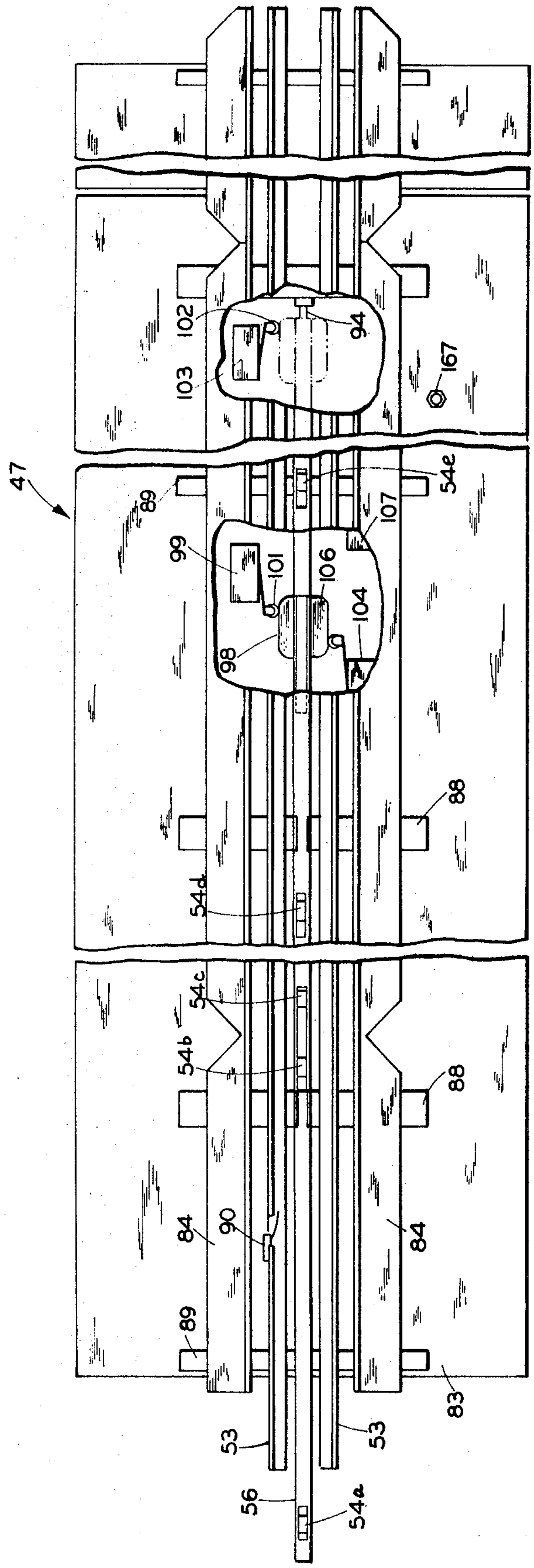

47
89
99
101
106
104
98
102
94
103
167
54e
107
88
54d
54c
54b
84
90
89
83
53
56
54a

FIG-10

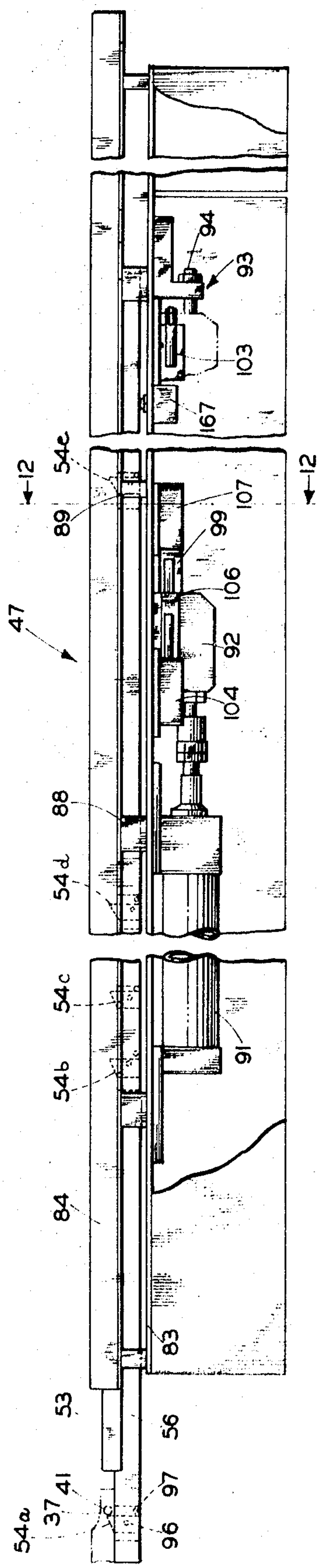

94
93
103
167
12
54e
89
107
99
106
47
92
104
88
54d
54c
54b
91
84
83
53
56
41
37
54a
97
96

FIG-11

FIG.-12

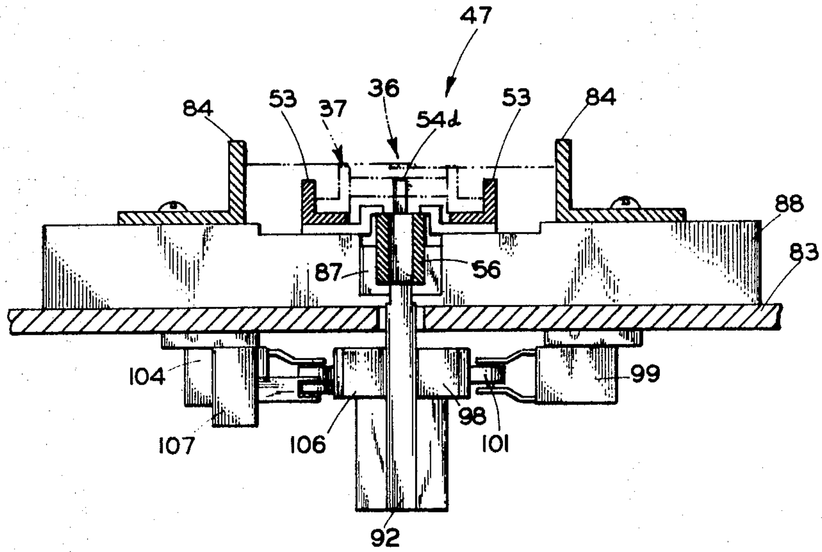

47
36
84
53
37
54d
53
84
88
83
87
56
104
99
98
107
106
101
92

FIG.-15

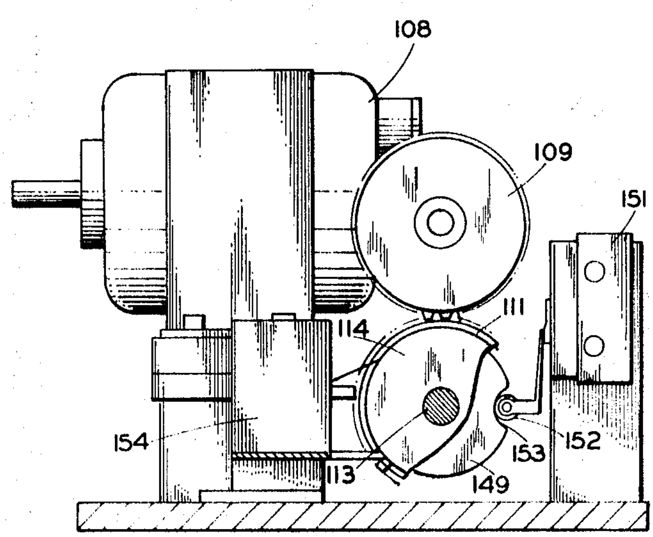
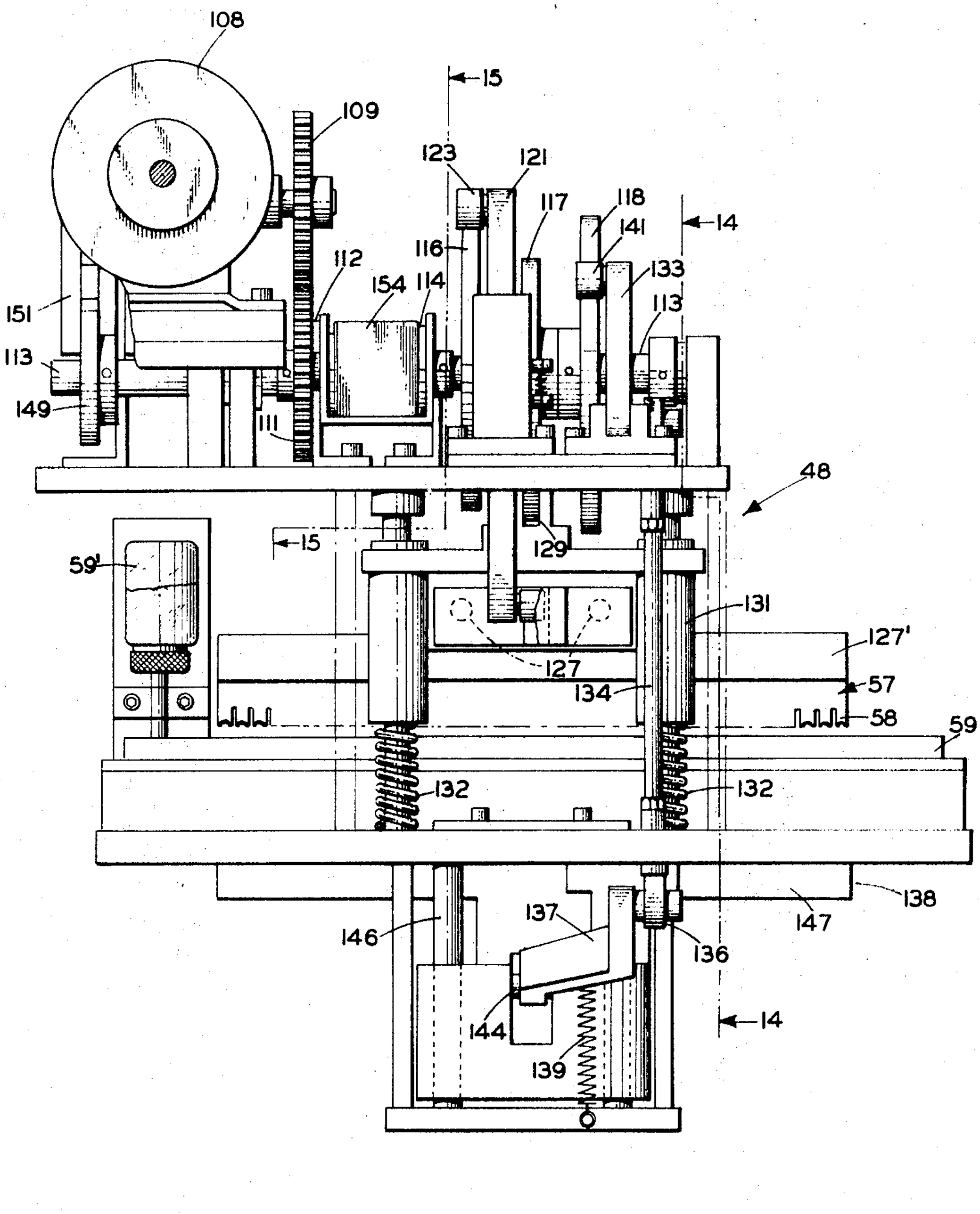

108
109
151
111
114
154
152
153
113
149

FIG.-13


108
109
123
121
117
118
141
14
116
112
154
114
133
113
151
113
149
111
48
129
15
59'
131
127'
127
134
57
58
59
132
132
138
147
137
146
136
144
14
139
15

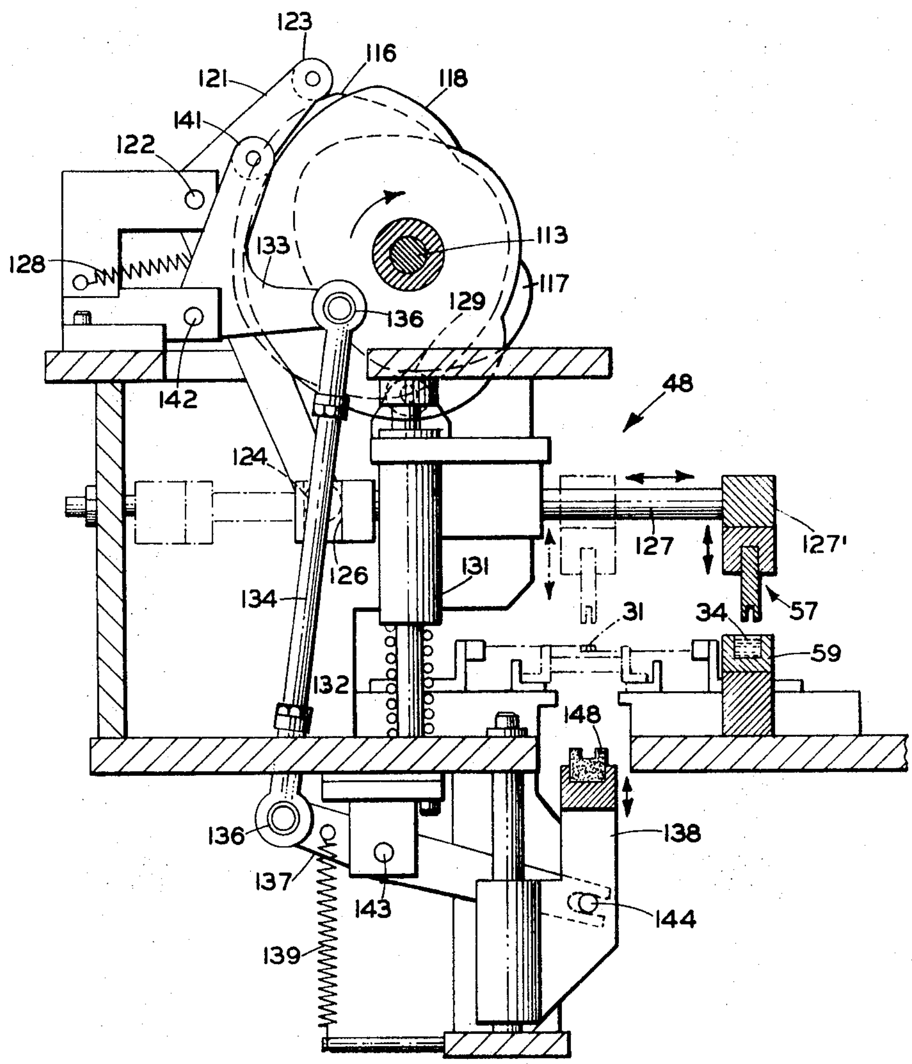

123
116
118
121
141
122
113
133
128
117
129
136
142
48
124
127
127'
131
126
134
57
31
34
59
132
148
138
136
137
143
144
139

FIG.-14

METHODS FOR APPLYING LIQUID TO ARTICLES WITHOUT TOUCHING THE ARTICLES
Filed July 11, 1968 12 Sheets-Sheet 9

FIG.-16

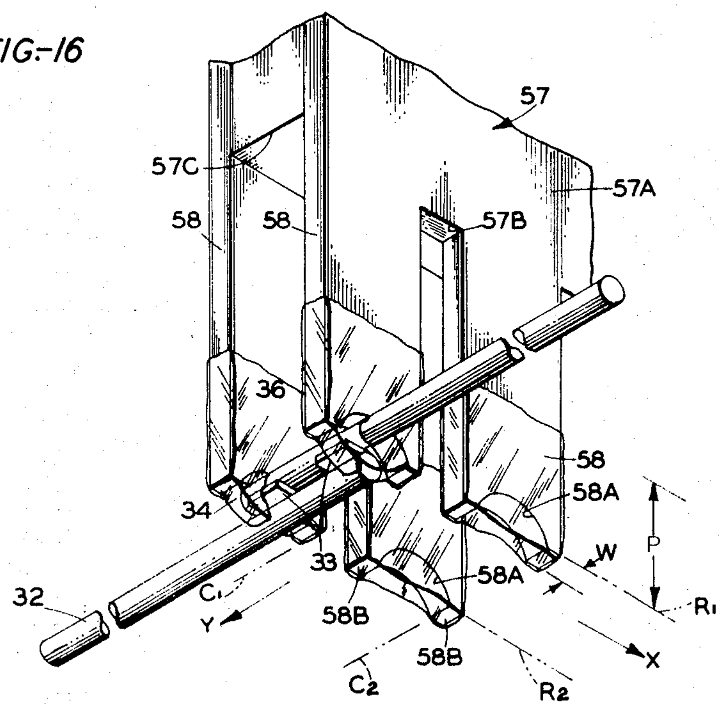


FIG.-18

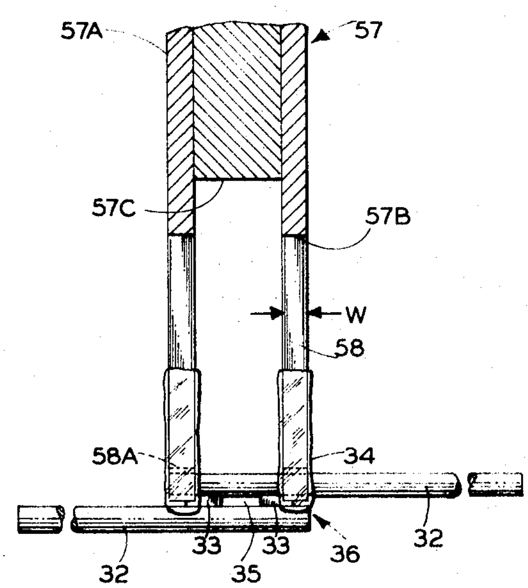


FIG.-17

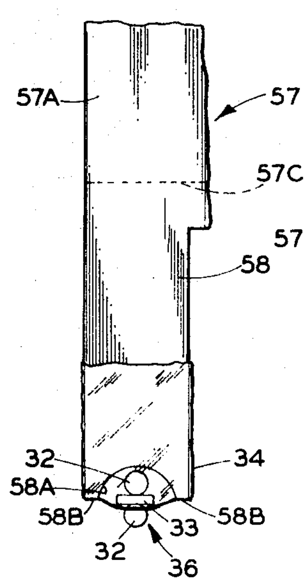


FIG-19

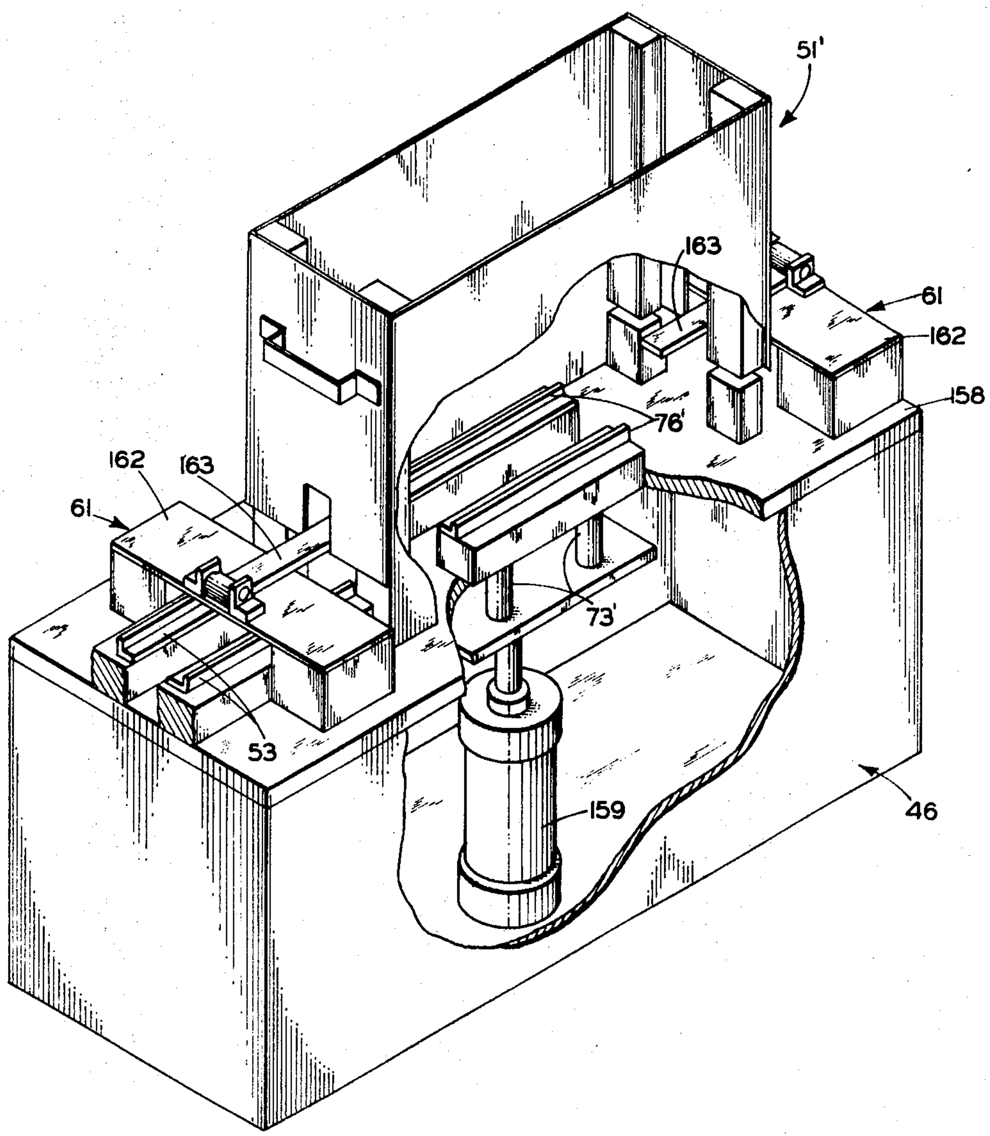


FIG-20

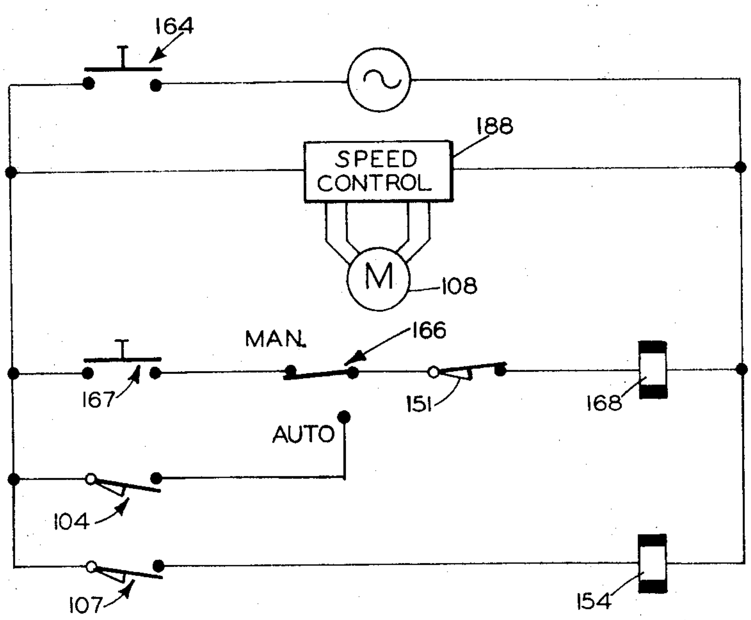
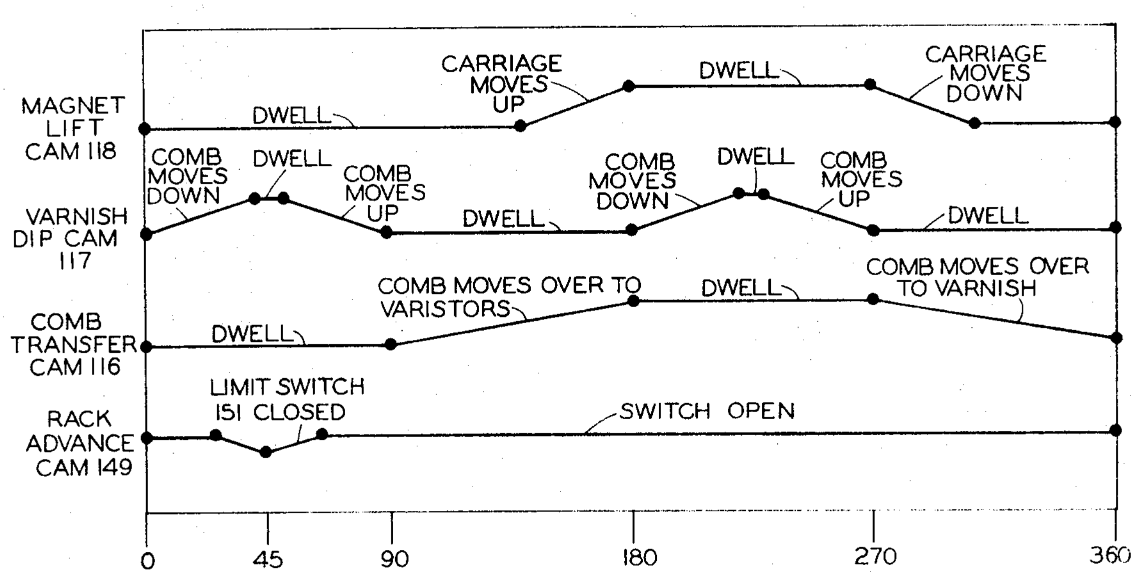

164
188
SPEED CONTROL
M
108
MAN.
166
167
151
168
AUTO
104
107
154

FIG-21


MAGNET LIFT CAM 118
DWELL
CARRIAGE MOVES UP
DWELL
CARRIAGE MOVES DOWN
VARNISH DIP CAM 117
COMB MOVES DOWN
DWELL
COMB MOVES UP
DWELL
COMB MOVES DOWN
DWELL
COMB MOVES UP
DWELL
COMB TRANSFER CAM 116
DWELL
COMB MOVES OVER TO VARISTORS
DWELL
COMB MOVES OVER TO VARNISH
RACK ADVANCE CAM 149
LIMIT SWITCH 151 CLOSED
SWITCH OPEN
0
45
90
180
270
360

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METHODS FOR APPLYING LIQUID TO ARTICLES WITHOUT TOUCHING THE ARTICLES

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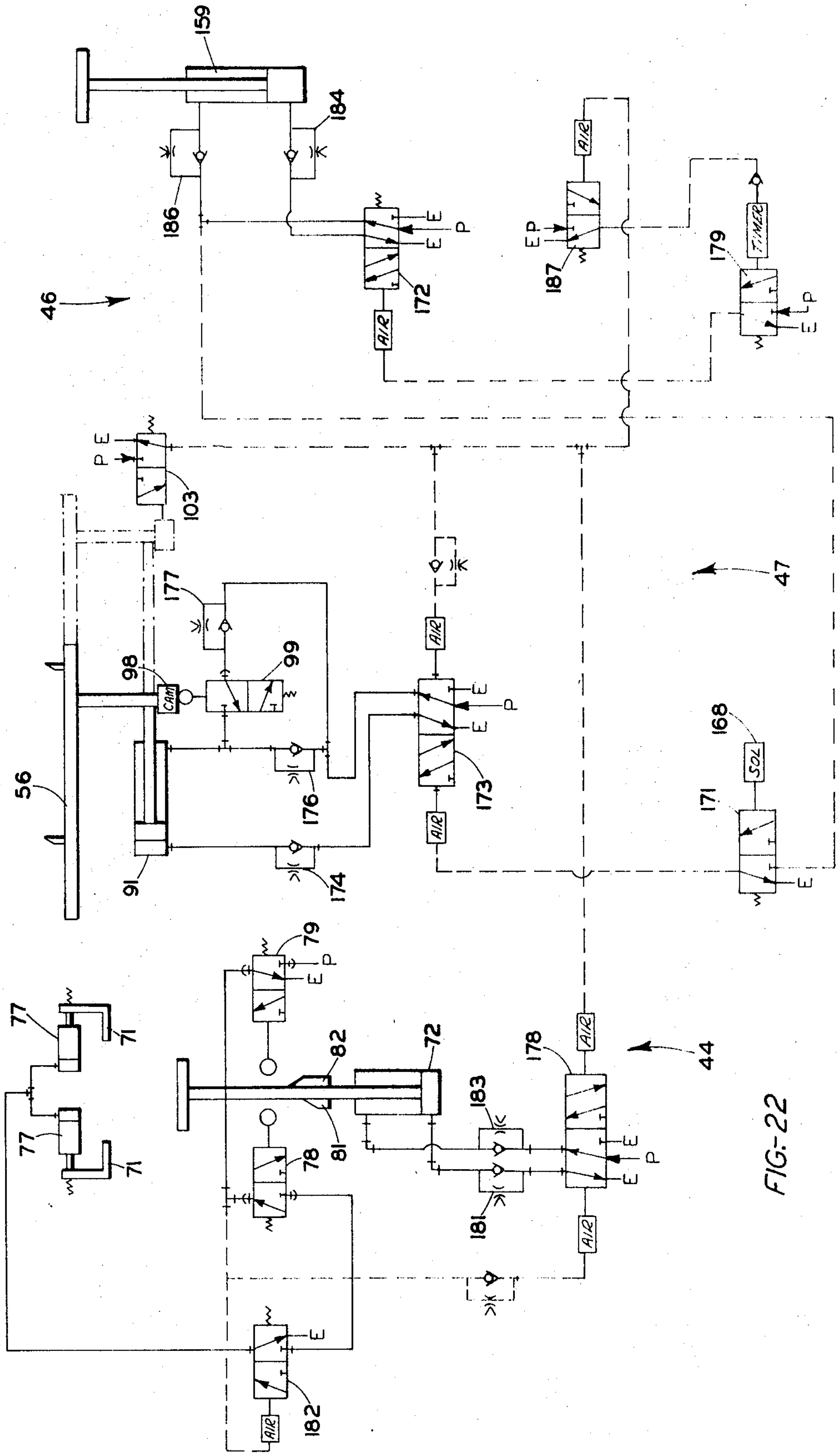

FIG-22

United States Patent Office

3,589,938

Patented June 29, 1971

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3,589,938
METHODS FOR APPLYING LIQUID TO ARTICLES WITHOUT TOUCHING THE ARTICLES

John H. Blewett, Reading, and Harry K. Naumann, Wernersville, Pa., assignors to Western Electric Company, Incorporated, New York, N.Y.

Filed July 11, 1968, Ser. No. 744,082
Int. Cl. B05c *1/00, 3/00, 3/02*
U.S. Cl. 117—212 5 Claims

ABSTRACT OF THE DISCLOSURE

Coating fluid is applied to an article, without contacting a body of the article with means other than the fluid to be applied. An applicating member, having at least one tooth with a concavity therein, is dipped into a bath of coating fluid, retracted and fluid retained in and about the concavity by capillarity. The member is then brought into noncontacting relation with the article so that a portion of the article lies within the fluid-filled concavity. A quantity of fluid within the concavity contacts and flows about the article, coating it. Simultaneous coating of a plurality of paramagnetic-leaded electrical devices utilizes magnetic holding of the devices, during the coating process, and an applicator with a plurality of spaced teeth arranged in a comblike array.

BACKGROUND OF THE INVENTION

This invention relates geenrally to methods for applying liquid coatings to articles. In a specific example, the invention relates to applying a protective varnish coating to each of a multiplicity of varistors, simultaneously and automatically, without contacting the varistors other than with the coating material. Accordingly, the general objects of the invention are to provide new and improved methods for such purposes.

In the past, a protective junction-coating resin, hereinafter called "varnish," was applied to electrical devices, such as varistors, by means of a hypodermic needle and syringe. With the syringe filled, an opertaor forced a small amount of the varnish out of the hand-held syringe and directed it at the varistors, one at a time. One disadvantage of this technique is that the amount of varnish exuded from the syringe depends on the operator's sense of feel and may vary from varistor to varistor as well as from operator to operator.

Another disadvantage is that the operators would frequently touch the varistors with the end of the hypodermic needle and cause contamination of or possible damage to the varistor.

Still another disadvantage is the slow speed of manually applying the varnish to the varistors one by one. Accordingly, specific objects of this invention are to overcome the aforementioned problems and disadvantages by providing new and improved methods for applying controlled amounts of varnish to a plurality of varistors without contacting them.

Other objects are to provide new and improved methods:

(1) for applying a liquid coating, such as varnish, in such a way that the liquid is caused to flow around the article being coated;

(2) for applying such a coating to a multiplicity of articles automatically; and

(3) for applying the coating to the articles without touching them.

SUMMARY

The foregoing and other objects are accomplished, in accordance with certain features of the invention, by providing an applicator member having a concave recess, in one surface, of a size somewhat larger than a portion of an article to be coated. First, the applicator is engaged with a coating liquid such that a quantity of the liquid is retained in the recess by capillary action. Then, the applicator member and article are brought into close, noncontacting proximity, so that the recess surrounds a portion of the article to be coated and the liquid contacts the article. The liquid then flows from the applicator member onto the article, to coat the article without touching it with the applicator member.

In specific embodiments of the invention, the applicator member is dipped into a bath of coating liquid, to coat both the recess and surrounding portions of the member, and is brought into proximity to an article to be coated so that liquid flows onto the article both from the recess and the surrounding portions of the member. Preferably, the article is held down during application of the liquid. For simultaneous coating of many articles, and/or spaced portions of one article, a plurality of the applicator members are arranged in a comblike array of teeth on an elongated support member. Preferably, the teeth are spaced by slots, which are longer than the depth of immersion of the teeth in the coating liquid, to prevent liquid from flowing from one tooth to the next. In accordance with a specific embodiment, for automatically applying varnish to a plurality of varistors, apparatus is provided for automatically extracting racks of varistors from a canister, guiding the racks to a varnish-applying station, applying varnish simultaneously to all varistors in the rack, and inserting the rack of coated varistors into another canister. The varistors rest in evenly spaced notches, formed along the length of the racks, and are held down magnetically during the coating operation.

Other objects, advantages and features of the invention will be apparent from the following detailed description of specific examples and embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is an isometric view of a coated varistor;

FIGS. 2 and 3 are front and end elevations, respectively, of the coated varistor;

FIG. 4 is an isometric view of a rack loaded with unvarnished varistors;

FIG. 5 is an isometric view, with portions broken away, showing the overall arrangement of the major machine components;

FIG. 6 is an end elevation, with two racks shown in phantom, of a canister from which the racks of uncoated varistors are withdrawn, viewed along line **6—6** of FIG. 5;

FIG. 7 is a front elevation of the same apparatus, viewed along line **7—7** of FIG. 6;

FIG. 8 is a front cross-section along line **8—8** of FIG. 5, with the canister removed, illustrating a station for unloading the racks from a canister;

FIG. 9 is a partial end elevation of the same apparatus, viewed along line **9—9** of FIG. 8;

FIG. 10 is a plan view of the transfer table, viewed along line **10—10** of FIG. 5;

FIG. 11 is a front elevation of the same mechanism, viewed along line **11—11** of FIG. 10;

FIG. 12 is a cross-section taken along line **12—12** of FIG. 11;

FIG. 13 is a rear elevation of the varnish-applying station, viewed along line **13—13** of FIG. 5;

FIG. 14 is a cross-section viewed along line **14—14** of FIG. 13;

FIG. 15 is a cross-section of the varnish-applying station motor drive, viewed along line **15—15** of FIG. 13;

FIG. 16 is an isometric view of a portion of the varnish-applying comb, showing the relation of the comb to a varistor at the time of varnish application;

FIGS. 17 and 18 are front and end views, respectively, of one pair of applicator teeth, with portions of FIG. 18 broken away for clarity;

FIG. 19 is an isometric view of the load station, partly in cross-section, for returning the racks to a canister;

FIG. 20 is a schematic drawing of an electrical control circuit;

FIG. 21 is a cam timing chart; and

FIG. 22 is a schematic drawing of a pneumatic circuit.

DETAILED DESCRIPTION

In the following detailed description of a specific embodiment of the invention, the process to be performed will be described generally with reference to FIGS. 1–4, following which the relation among the major component mechanisms of an automatic machine for performing the process will be described with reference to FIG. 5. After that, the specific method steps and the mechanical movements of each mechanism will be described separately, in the sequence in which they perform the process, with reference to FIGS. 6 through 19. Finally, the operation of the complete machine will be described with reference to the control circuits and mechanisms illustrated schematically in FIGS. 20–22.

Process performed

Referring to FIGS. 1–3, a coated varistor **31** in accordance with the invention consists of two parallel overlapping wire leads **32—32** (of solder-coated, copper-plated steel), between which two back-to-back semiconductor diode chips **33—33** have been soldered. As best seen in FIGS. 2 and 3, the chips **33—33** plus the entire area where the leads overlap is coated with a varnish **34,** such as Dow Corning Semiconductor Junction Coating Resin type XR–61–043–A. This resin is a fairly viscous fluid having a consistency similar to ordinary varnish, of the order of 100 to 150 centipoises at 25° C. The varnish must flow around and coat the entire exposed surfaces of both diode chips, as well as flow into a generally rectangular space **35** between the chips.

Referring to FIG. 4, a plurality of uncoated varistors **36—36** (fifty in the specific example) are placed in a rack **37** which holds them in an accurately spaced relationship for the coating process. The rack **37** consists of two notched sides **38—38,** having aligned notches **39—39** for supporting the varistor leads **32—32,** and front and rear tie rods **41–42** for holding the sides together. The varnish coating **34** is applied to all the uncoated varistors **36—36** in the rack simultaneously, without touching the uncoated varistors with the varnish-applying mechanism and, as a consequence, without contaminating or damaging the varistors.

Relation among major machine components

A complete varnish-coating apparatus **43,** as shown in overall outline in FIG. 5, is comprised of an unloading station **44** connected to a loading station **46** by a rack transfer table **47.** A varnish-applying station **48** is placed at an appropriate position on the transfer table **47,** between the unload and load stations, and a panel **49** with the electrical controls is positioned to the rear of the rack-transfer table **47.** Pneumatic and electrical circuits to air cylinders and an electric motor complete the apparatus.

A canister **51.** containing a supply of vertically stacked racks **37—37** of uncoated varistors is placed in position on the unloading station **44.** The lowermost rack **37** is released by escapements **52—52** and is lowered into alignment with guide tracks **53—53** on the transfer table **47,** so that it is in a position to be engaged by a reciprocable transfer bar **56.** When the transfer bar **56** is shifted to the left, it engages one of the racks **37** and, when next shifted to the right, draws it from the canister onto the guide tracks **53—53.** Successive operations of the transfer bar **56** withdraw additional racks from the canister **51** and, at the same time, push the preceding racks along the guide tracks **53—53** beneath the varnish-applying station **48** and finally into a canister **51′** on the load station **46.**

The transfer bar **56** moves from left to right and back again, as viewed in FIG. 5. During the return stroke and the following pause, the varnish coating **34** is applied at the varnish-applying station **48.** The varnish-applying station **48** is operated in synchronism with the cycle of the transfer bar such that one rack of uncoated varistors is coated for each cycle of the transfer bar **56.** Specifically, completion of the cycle of the transfer bar **56** initiates the varnish application, and completion of the varnish application initiates the next transfer bar cycle.

The varnish coating **34** is applied to the uncoated varistors **36—36** by causing an applicator member, in the specific example comprising the comb **57** having a pair of applicator teeth **58—58** for each uncoated varistor in the rack **37,** to be dipped into and withdrawn from a trough **59** containing the varnish **34.** The comb **57** is then shifted rearward, as viewed in FIG. 5, with the varnish **34** clinging to the teeth **58—58,** so that it is positioned over the varistors **36—36** resting in the rack **37.** The comb **57** is then lowered toward the varistors so that the varnish **34** touches the uncoated varistors **36—36,** but the teeth **58—58** do not, and a predetermined amount of the varnish flows onto each varistor as will be described in further detail hereafter. A magnet (not shown in FIG. 5) holds the varistors down in the rack **37** so that, when the comb **57** is lifted and returned to the varnish trough, the varistors will not stick to it and be lifted from the rack.

When the varnishing cycle is completed, transfer of the racks **37—37** is once again initiated. The rack **37** of varistors just coated is pushed from beneath the varnish-applying stations **48** into the bottom of the loading canister **51′.** When the rack **37** of coated varistors **31—31** is in position within the canister **51′,** it is raised until it is held by latch mechanisms **61—61** above the next rack to be pushed into the canister **51′.** This completes one cycle of operation. When the canister **51** is empty, it is replaced by a full one and when the canister **51′** is full, it is replaced by an empty one.

METHODS AND MECHANICAL MOVEMENTS

Unload station

Referring to FIGS. 6 and 7, the canister **51,** from which the racks **37—37** are unloaded, is shown; it being understood that the loading canister **51,** has the same construction. The canister **51** has end openings **62—62** to clear portions of the escapements **52—52.** The end openings **62—62** in the canister **51′** clear portions of the latch mechanisms **61—61.** The canisters **51** and **51′** also have lower and wider end openings **63—63** to permit the racks **37—37** to be withdrawn or inserted into the canisters. Four spaced pins **64—64** support the lowermost rack **37,** and thus the column of racks above, when canisters **51** and **51′** are not on the varnish-coating apparatus **43.** A set of four locating holes **66—66** in the bottom sections of each canister **51** serve to locate the canister precisely on the unload station **44.** Specifically, as the canister **51** is placed on the unload station **44,** the locating holes **66—66** fit over a set of four correspondingly spaced mounting pins **67—67** projecting upward from a table top **68,** as shown fragmentarily in phantom in FIGS. 6–7. This serves to position the canister **51** precisely with respect to the unloading apparatus next to be described.

Referring now to FIGS. 8–9, as a canister (not shown) is first lowered into position on the locating pins **67—67,** the tie rods **41** and **42** of the lowermost rack **37** temporarily come to rest on a pair of escapement fingers **71—71** which are a part of the escapements **52—52** previously mentioned. The canister **51** continues to descend, leaving the racks **37—37** suspended on the escapement fingers **71—71**, until it rests on the table top **68**. In this position, the supporting pins **64—64** are situated at a level below the bottom of a rack **37** when it is cradled in the rack support guides **76—76** in their lowermost position.

When an air cylinder **72** (FIG. 8) is actuated, its piston raises rack support rods **73—73**, which pass through bearings **74—74** in the table top **68** and terminate in rack support guides **76—76**, until the column of racks **37—37**, for which the two lowermost racks are shown in phantom, is lifted slightly clear of the escapement fingers **71—71**. After this, the escapement fingers **71—71** are withdrawn by air cylinders **77—77** from beneath the rack tie rods **41** and **42** and the piston of the air cylinder **72** is lowered. As it descends, and after the tie rods **41** and **42** of the lowermost rack **37′** reach a position just below the withdrawn escapement fingers **71—71**, the escapement fingers are returned by springs in the cylinders **77—77** to their initial positions in time to catch and support the next rack **37** by its front and rear tie rods **41** and **42**. The piston of the air cylinder **72** continues its downward movement, with a rack **37—37** cradled in its rack support guides **76—76**, until the piston reaches its lowermost position. At this point, the rack **37′** is aligned with the transfer table **47** and is ready to be pulled onto it.

Valves **78** and **79**, which are shown in FIG. 8 and operate from cam surfaces **81** and **82** respectively, control the operation of the escapement fingers **71—71** and the return of the piston of air cylinder **72** to its bottom position.

Transfer table

Referring now to FIGS. 10–12, the transfer table **47** consists of a flat plate **83** on which the rack guides **53—53** and guard rails **84—84** are mounted. Midway between the rack guides **53—53**, the transfer bar **56** is mounted in slide bearings **87—87** (FIG. 12) which are fastened in supports **88—88**. Additional supports **89—89** are provided for the rack guides **53—53** and the guard rails **84—84**. A plurality of leaf springs **90—90** (one shown in FIG. 10) are mounted at intervals along the rear guide **53**, to urge the racks **37—37** lightly against the front guide **53** so that the racks will always be exactly positioned at the varnish-applying station **48**. The guard rails **84—84** limit axial movement of the uncoated varistors **36—36** so that they too will be accurately located at the varnish-application station **48**.

The transfer bar **56** is moved from left to right and returned by the piston of an air cylinder **91**, which is connected to the transfer bar **56** by a connecting link **92**. A stop **93** determines the end of the stroke of the piston of the air cylinder **91** and permits adjusting the end-of-the-stroke position of the transfer bar **56** within the limits of a stop screw **94**.

The transfer bar **56** is slotted in appropriate places to receive a set of five pawls **54*a*–54*e***. The pawls **54*a*–54*e*** may rotate freely about pivot pins **96—96** (one shown at the left of FIG. 11), each pawl being so constructed that its center of gravity is below the point of rotation. This causes the pawls **54*a*–54*e*** to stand with their points oriented in an upward direction. A plurality of stop pins **97—97** limit the rotation of pawls **54*a*–54*e*** to a clockwise direction as viewed in FIG. 11. Consequently, when the transfer bar **56** moves to the right, the pawls **54*a*–54*e*** engage the rack tie rods **41** or **42**. Since they cannot rotate counterclockwise because of the stop pins **97—97**, the pawls **54*a*–54*e*** pull the racks **37—37** along the guides **53—53** by means of the pawls engaging the tie rods **41** and **42**. However, when the transfer bar **56** returns to the left, the tips of the pawls **54*a*–54*e*** strike the tie rods **41** and **42**, rotate clockwise (because there is nothing to prevent this), and then slide beneath the tie rods **41** and **42**. Consequently, movement of the transfer bar indexes the racks **37—37** from left to right only.

Referring now to FIG. 11, and starting with one rack **37** (shown fragmentarily in phantom) in position to be withdrawn from the canister **51**, the transfer bar **56** is actuated and moves its first full stroke from left to right. In so doing, the pawl **54*a*** engages the front tie rod **41** of the first rack **37** and pulls it into position to be engaged by the pawl **54*b***. The transfer bar **56** is returned to its starting position so that (a) the pawl **54*a*** engages the front tie rod **41** of a second rack **37** to be withdrawn from the canister **51** and (b) the pawl **54*b*** engages the front tie rod **41** of the first rack already withdrawn. The second full stroke of the transfer bar **56** to the right positions the second rack **37** in the place formerly occupied by the first one and moves the first one into position so that its rear tie rod **42** can be engaged by the pawl **54*c***. The transfer bar **56** is then returned leftward to its starting position. The third full movement of the transfer bar **56** to the right will withdraw a third rack **37** from the canister **51** and move the second rack **37** into position so that its rear tie rod **42** can be engaged by the pawl **54*c*** and move the first rack into position so that its rear tie rod **42** can be engaged by a pawl **54*d***. This sequence of operations continues until the pawl **54*e*** has pushed the rear tie rod **42** of the first rack **37**, and consequently the rack itself, as far as it can to the right. At this point, one rack **37** is in position in the varnish-applying station **48**. After coating, the racks are pushed out of the varnish-applying station **48** and into the load station **46** by the following racks **37—37** of varistors to be coated.

At the start of the stroke of the piston of the air cylinder **91**, a speed control cam **98** (FIGS. 10 and 12) holds a pilot valve **99** closed and continues to hold it closed until the speed control cam **98** (which is mounted on the transfer bar connecting link **92**) is moved to the right beyond a cam follower **101**. During the time the pilot valve **99** is closed, air flow is restricted and the piston of air cylinder **91** moves slowly. When the pilot valve **99** opens, the air flow restriction is removed and the piston moves rapidly.

At the end of the stroke, when the transfer bar connecting link **92** strikes the stop screw **94**, the cam **98** strikes a cam follower **102** (FIG. 10) and actuates another pilot valve **103**. This admits air to the right end of the air cylinder **91** and fully returns its piston to the left end of the air cylinder for the next cycle. An interlock limit switch **104** assures that the piston has returned to its starting position. The limit switch must be held closed by an interlock cam **106** in order to start the next cycle. When a limit switch **107** is actuated by the cam **106**, as the return stroke of the piston of the air cylinder **91** is completed, it starts the varnish-application cycle which will be described next.

Varnish-applying station

Referring now to FIGS. 13–15, the varnish-applying station **48** is driven by an electric motor **108** through drive gears **109** and **111**. The gear **111** is fastened to a driving member **112**, which is connected to a camshaft **113** through a single-revolution, solenoid-operated clutch **114**. A comb-shifting cam **116**, a varnish-dipping cam **117** and a magnet-lift cam **118** are fastened to the camshaft **113**.

The comb **57** is shifted by the cam **116** acting through a bell crank **121** which pivots about a fixed pin **122**. One end of the bell crank **121** has a cam roller **123** which bears on the comb-shifting cam **116** and, on the other end, a cam roller **124** is mounted, which cooperates with a slot **126** in a member attached to a pair of parallel comb support rods **127—127**. A spring **128** holds the cam roller **123** against the cam **116** so that the ends of the bell crank **121** will follow the motion of the cam and cause the comb **57**, suspended in a comb support **127′**, to dwell over the varnish trough **59** for dipping into the varnish **34** or over the varistors for applying the varnish **34** in accordance with the comb transfer cam diagram (see FIG. 21). A timing mechanism (not shown) can be incorporated into the system for stopping the cam shaft **113**, and hence the cam **116**, so that the duration of dwell can be specifically controlled.

The comb **57** is moved up and down, in order to dip it into the varnish **34** in the varnish trough **59**, by means of the varnish-dipping cam **117**, a cam follower **129** and a comb support carriage **131**. The level of the varnish **34** in the trough **59** is maintained by a varnish supply **59'**. Springs **132—132** hold the comb-support carriage **131** and the cam follower **129** against the varnish-dipping cam **117**, so that the comb-support carriage **131** follows the motion of the cam **117**. Accordingly, the comb **57** moves down into the varnish; dwells slightly to pick up the varnish; moves up out of the varnish and dwells while it is shifted to a position over the varistors by the comb-transfer cam **116**; moves down to the varistors and dwells slightly to give the varnish time to transfer to the varistors; and finally moves up to clear the varistors, all as shown by the varnish-dipping cam diagram in FIG. 21.

The coated varistors **31—31** tend to stick to the varnish comb **57** and to be lifted from the rack **37** when the comb is retracted after coating. In order to prevent this, the varistors **31—31** (shown in FIG. 14) are held down in the rack **37** by a channel-shaped bar magnet **148** which is as long as the comb **57**. The magnet **148** is raised into position beneath the varistors **31—31** by means of the magnet-lift cam **118**, acting through a bell crank **133**, a connecting rod **134** with ball joints **136—136**, a lever **137** and a magnet-lift carriage **138**. A spring **139** applies downward force on the lever **137** and, through the connecting rod **134** and the bell crank **133**, holds a cam roller **141** against the cam **118** so that the magnet-lift carriage **138** will follow the motion of the cam **118**. The magnet-lift carriage moves up to a position in close proximity to the varistors (see FIG. 18); dwells during the application of the varnish; moves back down to clear the varistors and dwells during the rack advance according to the magnet-lift cam diagram of FIG. 21. The bell crank **133** pivots about a fixed pin **142**, while the lever **137** pivots about a fixed pin **143** and is forked to engage a pin **144** fixed in the magnet-lift carriage **138**. The downward movement of the connecting-rod end of the lever **137**, due to rotation of the cam **118**, results in upward movement of the forked end of the lever **137** and the magnet-lift carriage, and vice versa. The length of the connecting rod **134**, in cooperation with the ball joints **136—136**, is adjusted so that, in the extreme upward position of the magnet-lift carriage **138**, the magnet **148** is held just beneath (e.g., ⅛ to ¼ inch away from) the varistors **31—31**. In this position, the magnetic force is great enough to overcome the opposing attractive force of the varnish which tends to lift the varistors.

The drive motor **108** continuously rotates the driving member **112**. A cam **149** is a circular one attached to the cam shaft **113**, as shown in FIG. 15, and cooperates with a limit switch **151**. The limit switch **151** is held open by the cam **149**, except when a cam follower **152** drops into a notch **153** in the cam **149** for a moment. This actuates the piston of the rack-transfer air cylinder **91**, which at the end of its stroke, energizes a clutch solenoid **154** through the limit switch **107**. Energizing the clutch solenoid **154** actuates the single-revolution clutch **114** which connects the driving member **112** to the camshaft **113** and, therefore, they rotate together for one revolution.

The cams **116**, **117**, and **118** are fixed to the camshaft **113**. Their relationship and shape is such that, starting with the comb **57** in the varnish **34**, the cam **117** withdraws the comb **57** from the varnish **34**, the cam **116** shifts the comb **57** to a position over the varistors **31—31** where it dwells, and the cam **118** moves the magnet-lift carriage **138** upward beneath the varistors and dwells. During the dwell of the shift and lift cams **116** and **118**, respectively, the comb-dipping cam **117** lowers the comb **57** to its final position over the uncoated varistors **36—36**, with the teeth

58—58 partially surrounding but not touching the varistors to coat the varistors. Further rotation of the camshaft **113** causes: (1) the dip cam **117** to raise the comb **57**, (2) the magnet-lift cam **118** to lower the magnet-lift carriage **138**, and (3) the comb-shifting cam **116** to move the comb **57** toward the right. Completion of rotation of the camshaft **113** returns the comb **57** to its starting position in the varnish trough **59** and the magnet-lift carriage **138** to its lowermost position.

The events which occur during varnishing of the varistors can best be understood by referring to FIGS. 16–18, showing the details of construction of the applicator member and its relationship to the articles being coated. In the specific embodiment, the applicator member resembles a comb comprising an elongated horizontal body member **57—A** from which the individual applicator teeth **58—58** project downward in two spaced, parallel rows, **R1** and **R2** extending in the X direction indicated in FIG. 16. In the Y direction, the teeth are arranged in spaced columns (**C1**, **C2**, etc.) of two teeth per column, running perpendicularly to the rows. The lower faces of the teeth are flat, generally rectangular, and lie in a common horizontal plane, as illustrated in FIG. 16.

Each individual tooth **58** is formed with a concave recess **58–A** in its lower face, comprising a generally semicircular groove in the specific embodiment, running in the Y direction such that the recesses of each pair of teeth in each column are aligned in the Y direction as shown. The recesses divide the lower face of each tooth into two parts, forming flat, rectangular land areas **58–B**, **58—B**, one on each side of each recess along the X direction. The comb body is formed with a plurality of elongated vertical slots **57–B**, **57–B**, which define the teeth in each row and isolate the teeth from each other. Also, the comb body is of inverted U-shaped cross section, as shown in FIG. 18, which defines, in effect, further elongated vertical slots **57–C**, **57–C**. These slots define and isolate the individual teeth in each column **C1**, **C2**, etc.

As best seen in FIG. 17, each recess **58–A** is large enough to encompass the portion of the article to be coated (in the specific example, one of the diode chips **33—33** and the portions of the leads **32—32** soldered thereto), and is of such generally fitting curvature that the recess may be placed over the portion of the article to be coated and surround the upper portion of the same fairly closely, without touching the article. The size and shape of a recess **58–A** are two of the factors which affect the amount of varnish that the associated tooth can carry and transfer to the article being coated.

As best illustrated in FIG. 18, the width W of each tooth (also a fatcor which affects the quantity of varnish being transferred), and thus each recess, is approximately the same as that of the chip **33** to be coated so that each tooth, when lowered, covers one of the chips. For other sizes and shapes of articles to be coated, the recess is similarly made a little larger than the article and shaped to fit fairly closely over the portion of the article to be coated. As is apparent from FIGS. 17 and 18, the teeth are separated (1) in the X direction by the slots **57–B**, **57–B** in accordance with the spacing of the uncoated varistors **36—36** in the rack **37** (FIG. 4) such that each column of two teeth covers portions of a corresponding varistor, and (2) in the Y direction by the slots **57–C**, **57–C** in accordance with the spacing of the chips **33—33** such that the two teeth in each column encompass the two chips of a corresponding varistor. In general, the number and spacing of the teeth are selected by the number and spacing of the articles to be coated where more than one article is coated at a time, and/or by the number of separate portions of each article to be coated, where spaced portions of each article are to be coated. In the specific example, each of fifty varistors are simultaneously coated, with one hundred teeth being provided, arranged in fifty rows of two columns each.

In coating the varistors, the comb **57** is first dipped into the trough **59** of varnish **34** and then raised by the lifting mechanism previously described. The depth of immersion (distance D in FIG. 16), and the rate of withdrawal are among the factors which determine the amount of varnish adhering to the teeth **58—58**. As depicted in the drawing, fairly large "drops" or menisci of varnish are retained in the recesses by capillary action, and a substantial additional quantity of varnish is retained on the surrounding portions of each tooth. The slots **57–B** and **57–C** are made longer than the maximum expected depth of immersion of the teeth (thus substantially longer than the depths of the recesses **58–A**, **58–A**) so that the upper ends of the slots are never filled with varnish. With this arrangement, the varnish **34** is prevented from flowing from one tooth to another, ensuring that each tooth carries essentially the same amount of varnish (for a given depth of immersion and withdrawal rate), regardless of any slight deviations from horizontal in the attitude of the comb **58**.

As the teeth **58—58** move into proximity with the portions of the uncoated varistors **36—36**, the varnish flows from the cavities **58–A**, **58–A** and adjacent portions of the teeth to coat the entire surface of the surrounded portions of the varistor with the desired quantity of the varnish. The varnish also flows inwardly between the two teeth of each column along the varistor, as viewed in FIG. 18, to entirely fill the small space **35** between the diode chips **33—33** to capillary action.

As the teeth are withdrawn from the proximity of the varistors, the varnish no longer receives support by adherence to the teeth **58—58** and, therefore, drops are released to flow completely around the varistors **31—31**. The final result is a shell of varnish **34**, as shown in FIGS. 1–3, surrounding the varistors.

Loading station

Referring now to FIG. 19, a canister **51′**, which is identical to the canister **51** except that it is empty, is placed on a load station table **158**. Alignment of the canister **51′** with the cooperating apparatus is obtained in the same manner previously described for the unload station **44**. The racks **37—37** of coated varistors are pushed along the guide tracks **53—53** onto rack support guides **76′—76′**. A piston of an air cylinder **159** is connected to the rack support guides **76′—76′** by means of support rods **73′—73′** which pass through the load station table **158**.

Latch mechanisms **61—61** are mounted on the load station table **158** at both ends of the canister **51′**. The latch mechanism **61—61** consist of latch supports **162—162** and latches **163—163** which can rotate upward from their horizontal position but not downward. The latches **163—163** are long enough to extend into the canister **51′** beyond front and rear tie rods **41** and **42** of a rack **37** (FIG. 4).

When the piston of the air cylinder **159** moves upward, it lifts the rack **37** by means of the support rods **73′—73′** and the rack support guides **76′—76′**. The upward movement of a rack **37** causes its front and rear tie rods **41** and **42** to engage the latches **163—163** and rotate the inner ends upward. When the rack **37** has been raised far enough, its tie rods **41** and **42** clear the ends of the latches **163—163** permitting the latches **163—163** to fall back (rotate) of their own weight to the horizontal position. When the piston of the air cylinder **159** is retracted, the rack **37** descends until its front and rear tie rods **41** and **42** rest on the tops of the latches **163—163**. The racks **37—37** previously lifted remain supported at a level higher than the top of the next rack **37** which will enter the canister **51′**. The piston of the air cylinder **159** continues to descend until the rack support guides **76′—76′** are in aligned position with guide tracks **53—53** to receive another rack **37**.

AUTOMATIC OPERATION

Electrical circuit

The automatic operation of the varnish apparatus can be understood best in conjunction with the electrical schematic FIG. 20, the cam chart FIG. 21, and the air schematic FIG. 22.

In operation, when a master selector switch **164**, FIG. 20, is turned to the "on" position, power is applied to the drive motor **108** of the varnish-applying station **48**. The drive motor **108** then rotates the driving member **112** continuously (see FIG. 15) as long as the master selector switch **164** is in the "on" position. The cam **149** holds the limit switch **151** open during each revolution of the camshaft **113** except for a short dwell at the start of the cycle as shown by the rack advance cam diagram in FIG. 21.

The apparatus, in the preferred embodiment, is set in automatic operation by turning a selector switch **166** (FIG. 20) to the "automatic" position, which disconnects a manual push-button switch **167** from the circuit and connects the interlock limit switch **104** (FIGS. 10–12) into the circuit. Since the piston of the rack transfer air cylinder **91** is in its retracted position, the interlock limit switch **104** is held closed by the interlock cam **106** (see FIG. 10). The limit switch follower **152** rests in the notch **153** (FIG. 15) and, therefore, the limit switch **151** is closed. This establishes a current path through the switches **104**, **166**, and **151** and a solenoid **168**, as shown in FIG. 20. Energizing the solenoid **168** actuates air valves which admit air to the rack-transfer cylinder **91** and cause the racks **37—37** to be transferred one position to the right. When the piston of air cylinder **91** reaches its fully extended position to the right, it actuates an air valve which: (1) causes the piston to return to its starting position and (2) causes the pistons of unload and load air cylinders **72** and **159** (FIG. 22) to ascend and descend.

Near the end of the return stroke, to the left, of the piston of air cylinder **91**, the interlock cam **106**, on the piston rod, closes a limit switch **107** (FIG. 10) momentarily and energizes the solenoid **154** of the single-revolution clutch **114** (see FIG. 15) causing it to drive the camshaft **113** and the cams **116**, **117**, **118** and **149** through one revolution. This, in turn, causes the varnish station **48** to go through one varnish-applying cycle, i.e., apply varnish **34** to one rack **37** of the varistors **36—36** with the events taking place in the timed relationship shown in FIG. 21. At the end of the varnish-applying cycle, the limit switch follower **152** drops into the notch **153** of the rack advance cam **149**, closes the limit switch **151** and establishes a current path through the limit switch **104**, the selector switch **166**, the limit switch **151** and the solenoid **168**. Energizing the solenoid **168** actuates air valves which admit air to the rack transfer cylinder **91**, thus repeating the cycle. Cooperation and control of the other apparatus components are achieved through a pneumatic control circuit which is described next.

Pneumatic circuit

When the solenoid **168** is energized, refer to FIG. 22, it shifts a valve **171** and admits pilot line air (previously filtered and regulated), flowing from a source P through a load-cylinder valve **172**, through the valve **171**, to a rack-transfer cylinder control valve **173**. This shifts the rack-transfer cylinder valve **173** so that it admits air from the source P to the rack-transfer cylinder **91** through a flow control valve **174** in the uncontrolled direction. The flow control valve **174**, and the other flow control valves, are unidirectional. They permit the unrestricted flow of air in one direction but regulate the flow in the other direction. The admission of air to the rack-transfer cylinder **91** advances its piston to the right, withdrawing one rack **37** from the canister **51** and pushing any other racks one position along the transfer table. During the initial portion of the advance, the pilot valve **99** is held closed by the speed control cam **98**, which is fixed to the piston rod of the air cylinder **91**, so that the air being exhausted from the rack-transfer cylinder **91** must pass through a "slow-advance" flow control valve **176** in the controlled direction. Further advance of the piston of the rack-transfer air cylinder **91** permits the pilot valve **99** to open. When the pilot valve **99** opens, a second exhaust path through a flow control valve **177** is provided in parallel with the flow control valve **176.** This increases the rate of exhaust and regulates the rapid advance of the piston of the transfer air cylinder **91.**

When the piston of the rack-transfer air cylinder **91** reaches its extended position to the extreme right, the racks **37—37** have been transferred one position to the right and the speed control cam **98** shifts the pilot valve **103.** This admits pilot line air simultaneously to the rack-transfer air cylinder valve **173,** an unload station air cylinder valve **178** and to a timer valve **179** through a pilot valve **187.**

First with respect to the rack-transfer air cylinder valve **173,** pilot line air admitted from the pilot valve **103** to the rack-transfer air cylinder valve **173** shifts the valve **173** back to its initial position which admits air to the right side of the transfer air cylinder **91.** This causes the piston to retract to the left and return to its starting position. The air cylinder **91** exhausts through the flow control valve **174** in the regulated direction so that the speed of the return can be controlled by this valve.

Second, with respect to the unload-station cylinder valve **178,** pilot line air from the pilot valve **103** shifts the unload-station cylinder valve **178** and admits air from the source P to the unload-station cylinder **72** through a flow control valve **181** in the unrestricted direction. This causes the piston of the cylinder **72** to rise to the top of its stroke and lift racks **37—37** off the escapement fingers **52—52.** As the piston rises, the exhaust air flows through flow control valve **183** in the controlled direction thus permitting the regulation of the speed or ascent of the piston. As the piston nears the top of its stroke, the cam **82,** which is fixed to the piston rod, shifts the valve **79.** This admits air from the source P to the escapement valve **78** and pilot line air to the valve **178** and a valve **182.** The pilot line air shifts the valve **182** and connects the escapement air cylinders **77—77** to the escapement valve **78.**

Completion of the stroke of the piston of the unload air cylinder **72** causes the cam **81** to shift the escapement valve **78** which applies air from the source P to the escapement cylinders **77—77** through the valve **182.** The air forces the pistons of the escapement air cylinders **77—77** to extend outwardly thus withdrawing the escapement fingers **71—71** so they clear the rack tie rods **41** and **42.** The application, by the valve **79,** of the pilot line air to the unload-station cylinder valve **178,** returns the valve **178** to the position shown in FIG. 22. This applies air from the source P to the upper end of the unload-station air cylinder **72** through a flow control valve **183** in the uncontrolled direction. Application of air to the upper end of the unload air cylinder **72** causes its piston to descend and its exhaust to flow through the flow control valve **181** in the regulated direction, thus providing a means of controlling the speed of descent. As the piston descends, the cam **81** allows the valve **78** to close. This traps air in the escapement cylinders **77—77** and holds the escapement fingers **71—71** open until the piston of the air cylinder **72** descends far enough for the cam **82** to allow the spring returned valve **79** to return to the exhaust position. This, in turn, allows the spring returned valve **182** to return and exhaust the escapement air cylinders **77—77.** Springs in the air cylinders **77—77** return the pistons and, therefore, the escapement fingers **71—71.** The cams **81** and **82** are fixed in relationship to each other so that the escapement fingers **52—52** are held apart just long enough for one rack **37** to pass the escapement fingers **71—71,** as the piston of the unload-station cylinder **72** descends, before the fingers are returned to support the rest of the column of racks **37—37.**

Third, with respect to the timer valve **179,** application of pilot line air by the pilot valve **103** to the pilot valve **187,** shifts the valve **187** and applies air to the timer valve **179.** The timer valve **179** shifts and also starts the timing. The shifting of the timer valve **179** applies pilot line air to the load-cylinder valve **172,** which shifts this valve, and applies air from the source P to the lower end of the load air cylinder **159** through a flow control valve **184** in the unrestricted direction. This causes the piston of the load air cylinder **159** to ascend. The upper end of the air cylinder exhausts through a flow control valve **186** in the regulated direction, thus permitting control of the speed of ascent. After an interval, as determined by the setting of the timer valve **179,** the valve **179** returns to the exhaust position and exhausts the pilot operated valve **172** which, in turn, exhausts the load air cylinder **159** through the flow control valve **184** in the regulated direction. Adjustment of the flow control valve **184** controls the speed of descent of the piston of the load air cylinder **159.**

Since the valve **103,** at the end of the stroke of transfer air cylinder **91** directs pilot line air simultaneously to the unload air cylinder valve **178,** the transfer air cylinder valve **173** and, through the valves **187** and **179,** the load air cylinder valve **172,** the pistons of both the unload and load air cylinders, **72** and **159** respectively, ascend while the piston of the transfer cylinder **91** returns to its starting position. At the top of its stroke, the piston of the unload air cylinder **72** shifts the valve **79** which causes the piston to return to the bottom of its stroke. The piston of the load air cylinder **159** is returned to its bottom position by the timer valve **179** when it shifts at the end of its time cycle.

From the foregoing, it can be seen that, when the rack-transfer solenoid **168** and its air valve **171** have been actuated, all air cylinders act cooperatively through one cycle. Further, the air cylinder actuation takes place only when the motor driven cam **149** cooperating with the limit switch **151** initiates the cycle. The speed with which the cycles are repeated is controlled by regulating the speed of the drive motor **108** by means of the speed control **188.**

From the foregoing description, it may be seen that the preferred embodiment of the invention provides a new automatic method of applying varnish simultaneously to large numbers of articles, which is improved over the older methods because it is much faster and does not contaminate or damage the articles. It is to be understood that various changes may be made from the specific details illustrated without departing from the spirit or scope of the invention.

What is claimed is:

1. The method of applying a coating of liquid to a portion of an article without contacting the article, which comprises:

engaging an applicator member with the coating liquid so as to cause a quantity of the liquid to be retained by capillary action in a concave recess formed in one surface of the member, the recess being of a size somewhat larger than the portion of the article to be coated; and

bringing the member into close, noncontacting proximity with the article so that the recess surrounds the portion of the article to be coated and the liquid flows from the applicator member onto the article to apply the coating.

2. The method as recited in claim **1,** wherein:

(a) a lower portion of the applicator member, including the recess, is dipped into and withdrawn from a bath of the coating liquid, the depth of immersion and the withdrawal rate being selected to coat the recess and surrounding portions of the application member with a predetermined quantity of the liquid, greater than the quantity required for coating; and

(b) the member is lowered into proximity with the article for a time such that a desired amount of the liquid flows onto the article from the recess and surrounding portions of the member, after which the member is withdrawn from proximity with the article.

3. The method as recited in claim **2**, for use with a viscous coating liquid, further comprising the step of holding the article down during the application of the liquid, to facilitate withdrawal of the applicator member from the article.

4. The method of applying a protective liquid coating simultaneously to the bodies of a plurality of axially leaded electrical devices comprising:

supporting said plurality of devices, by their axial leads, in an ordered array;

dipping an applicator in a solution of protective liquid and removing said applicator from said solution, the applicator having a plurality of recesses therewithin for retaining the liquid to be applied by capillary action, said recesses being oriented to cooperate with said ordered array; and

engaging said applicator with said devices, without physical contact therebetween other than the liquid to be applied, so that the bodies of said devices contact the liquid held by capillary action within the recesses, whereby the liquid flows about the bodies to provide protective coatings thereon.

5. The method of applying varnish to the two semiconductor bodies, each, of a plurality of leaded varistors, without physically contacting the semiconductor bodies with means other than the varnish to be applied, comprising:

engaging an applicating member with varnish to be applied, the member having two parallel rows of aligned recesses with an isolation between each of said recesses, each of the recesses having a dimension greater than one dimension of one of said bodies, so that varnish is retained in said recesses by capillary action, the isolation between each recess ensuring that equal quantities of varnish can be retained within said recesses without maintaining the aligned recesses precisely level; and

bringing the applicating member into proximal relation with a plurality of oriented leaded varistors so that the dual bodies of the varistors lie within corresponding recesses of the two rows of the applicating means, without physical contact therebetween, so that a portion of said bodies engage the menisci of varnish retained by capillary action within the recesses, thereby permitting varnish to flow about the peripheries of said bodies.

References Cited

UNITED STATES PATENTS

3,108,537	10/1963	Way et al.	118—243X
3,121,020	2/1964	Low	118—243X

WILLIAM L. JARVIS, Primary Examiner

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