June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

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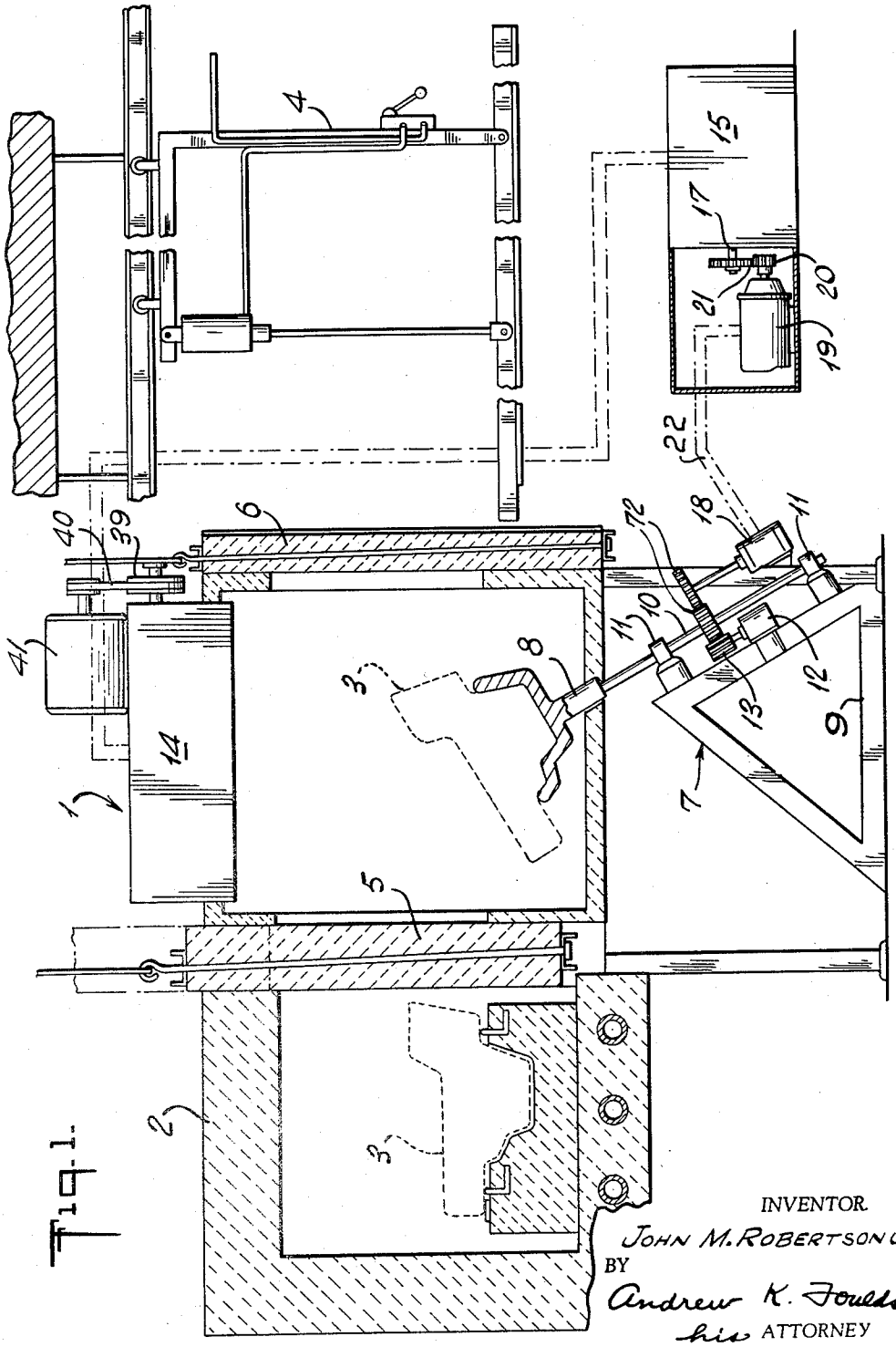

Fig. 1.

INVENTOR.
JOHN M. ROBERTSON JR
BY
Andrew K. Foulds
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

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Filed Aug. 1, 1962 8 Sheets-Sheet 2

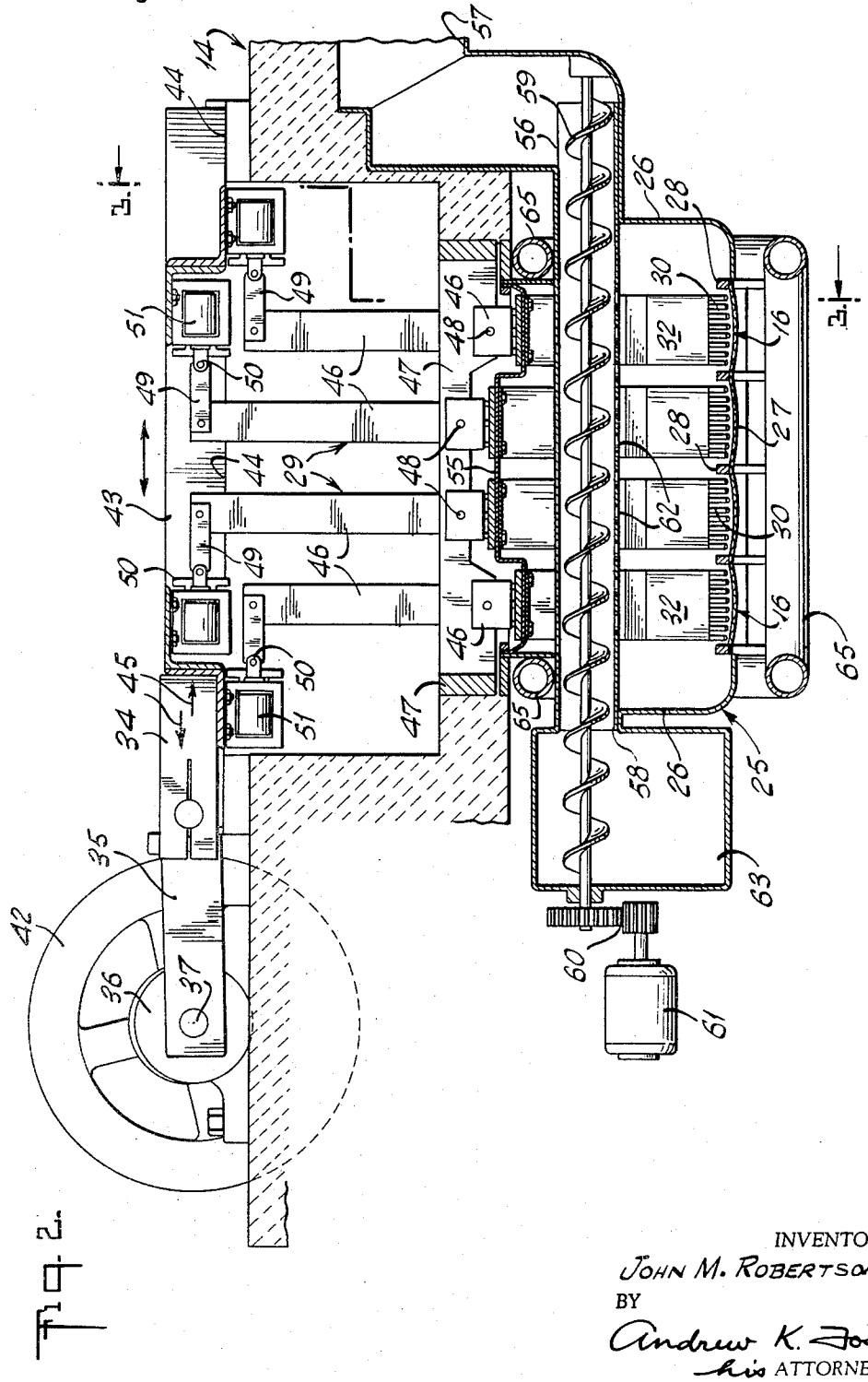


Fig. 2.

INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Foulds
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 3

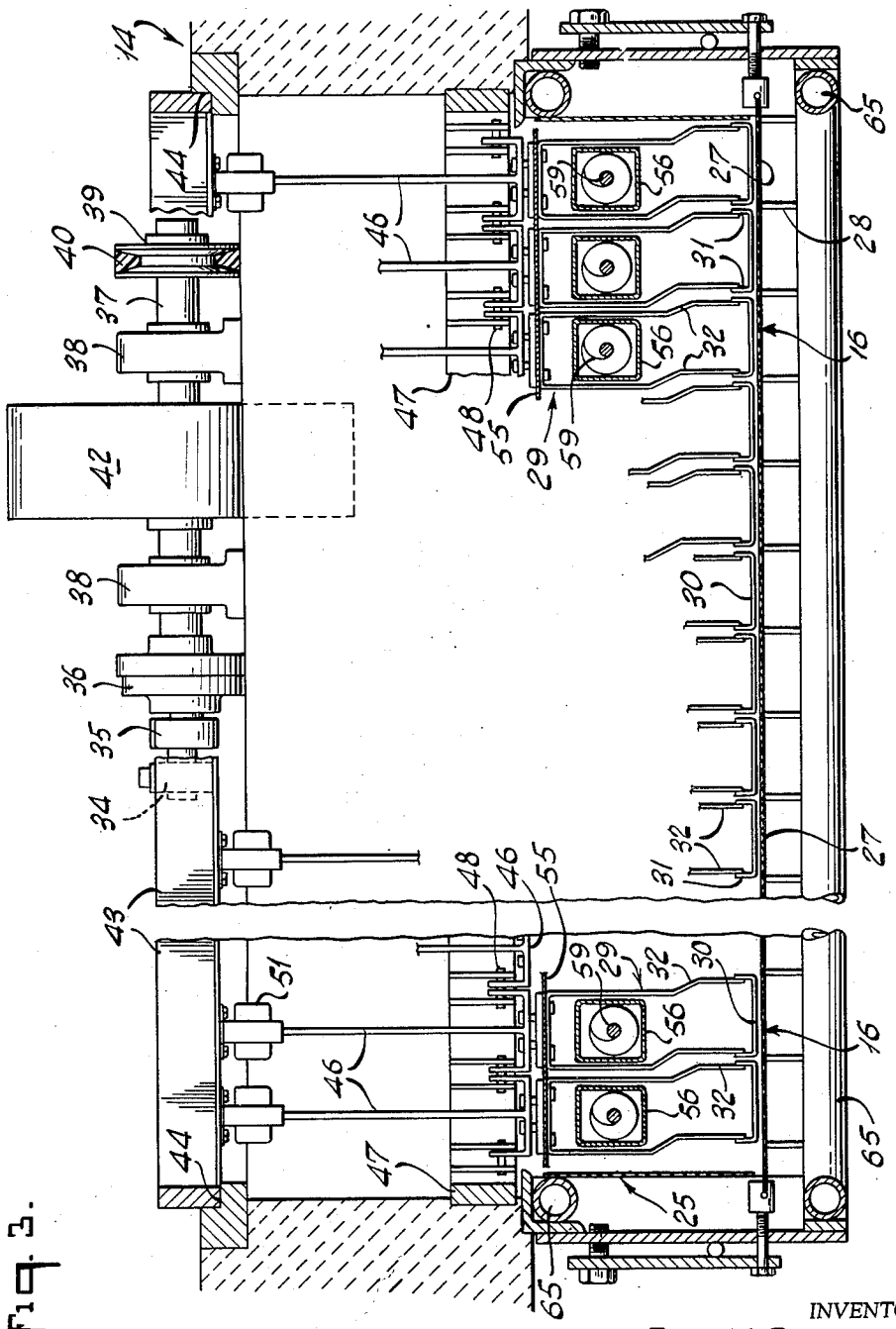


Fig. 3.

INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew H. Jones
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 4

Fig. 4.

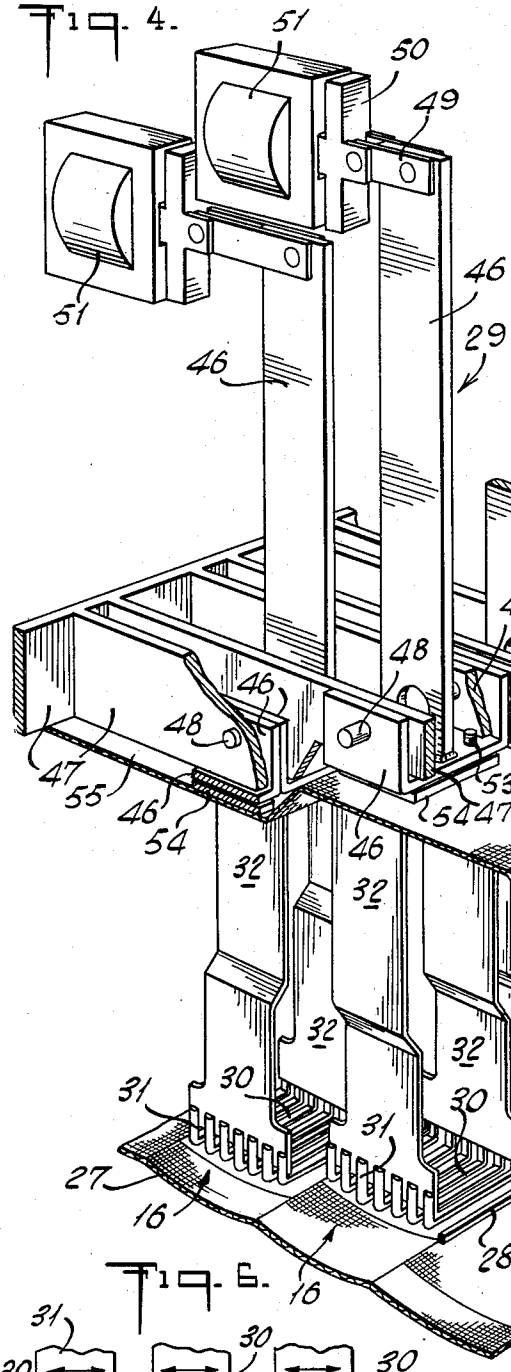


Fig. 5.

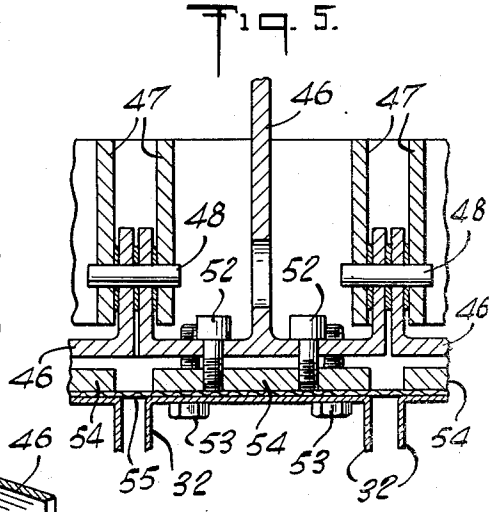
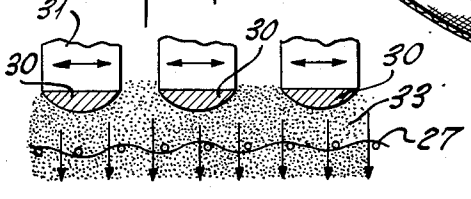


Fig. 6.



INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Jones
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 5

FIG. 15.

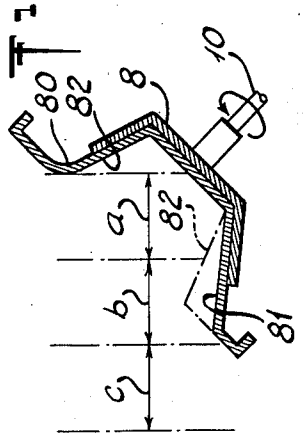


FIG. 14.

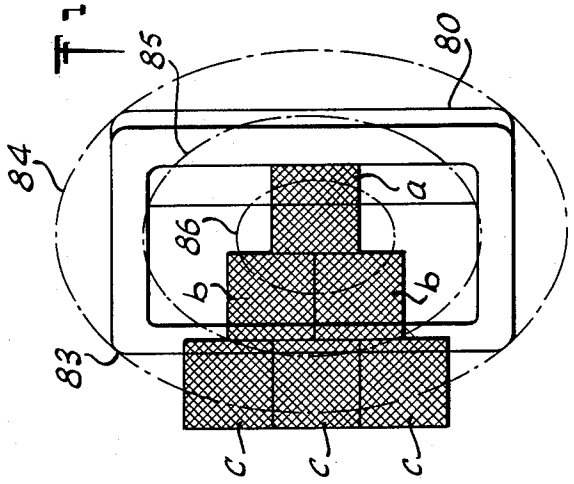


FIG. 8.

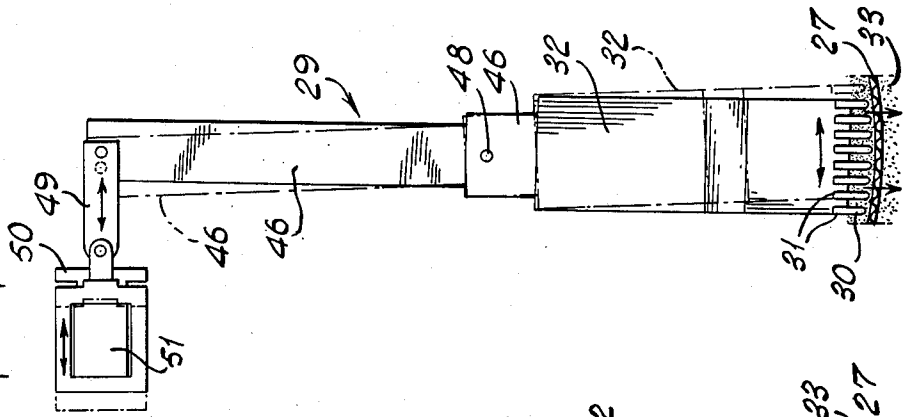
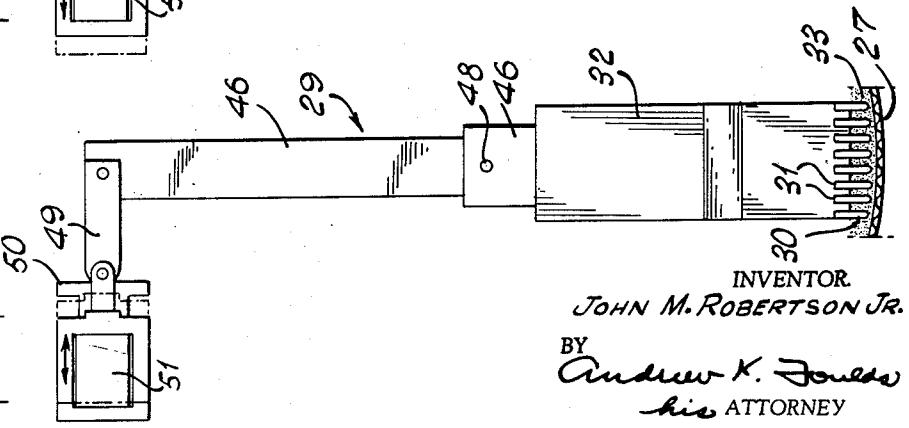


FIG. 7.



INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Jones
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 6

Fig. 9.

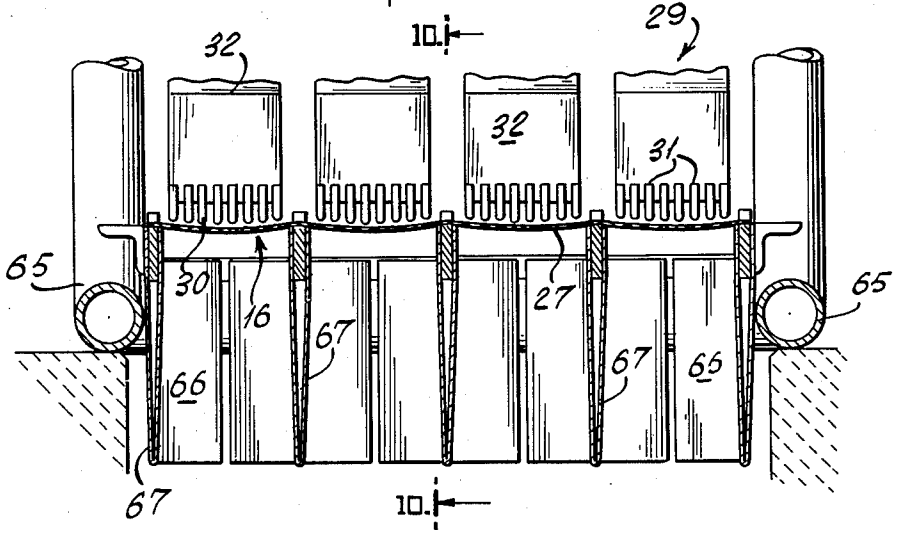
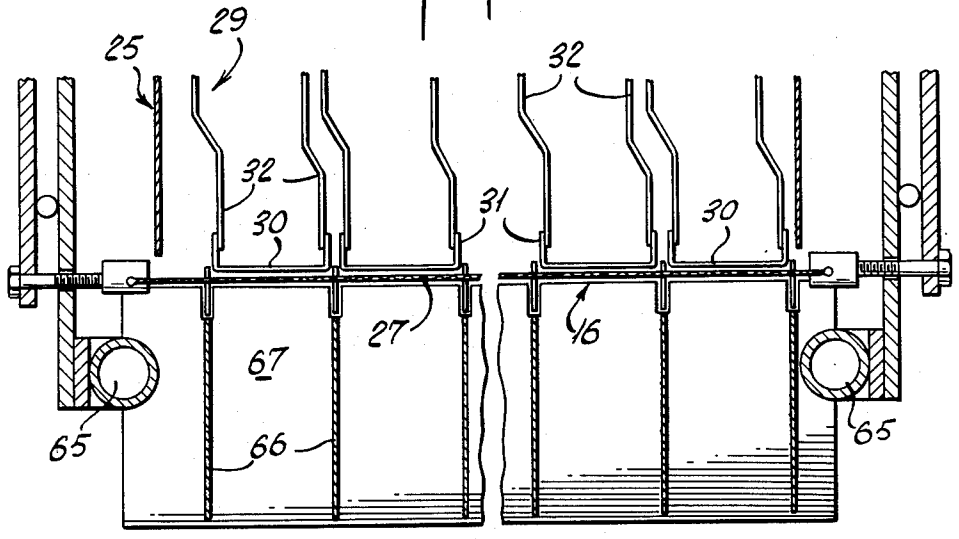


Fig. 10.



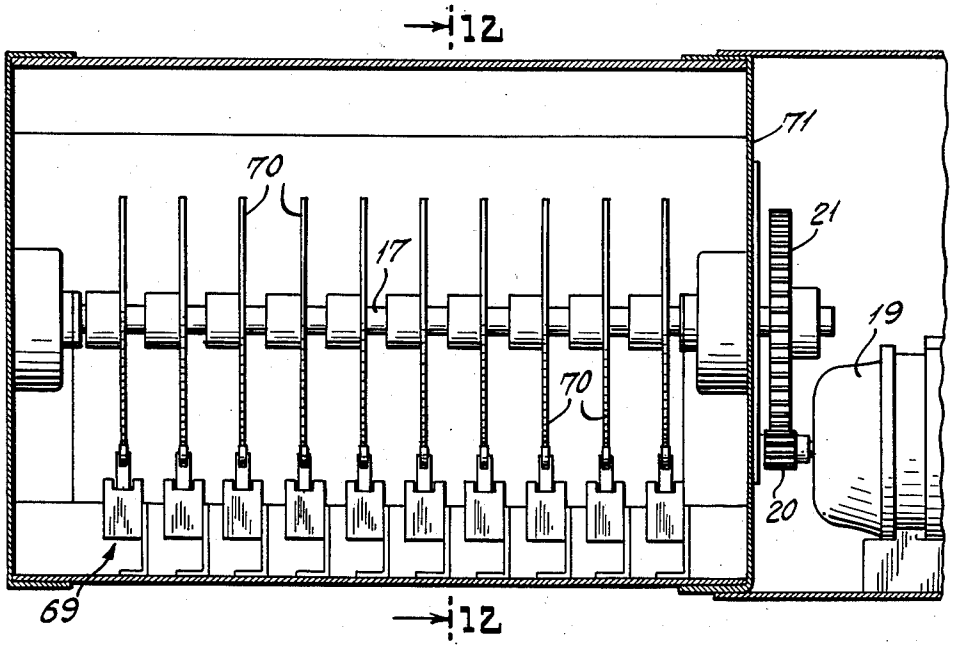
INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Foulds
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 7

Fig. 11.



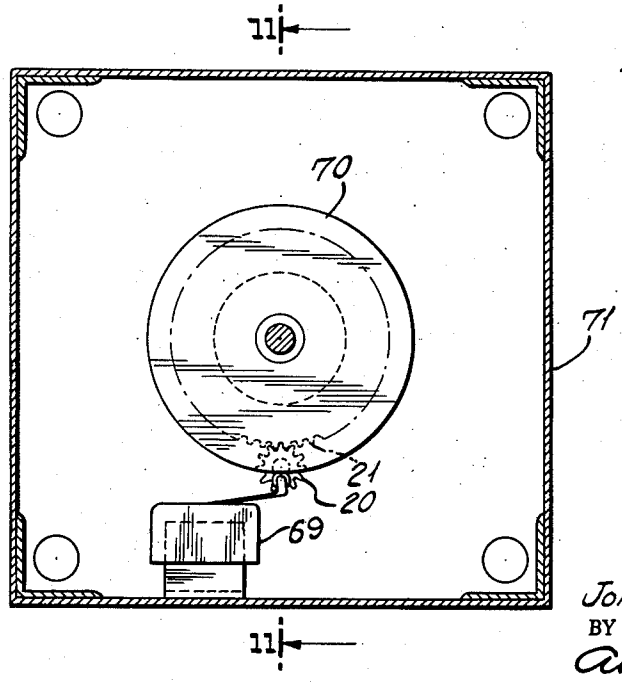


Fig. 12.

INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Fowlds
his ATTORNEY

June 29, 1965 J. M. ROBERTSON, JR 3,191,574

APPARATUS FOR DRY ENAMELING

Filed Aug. 1, 1962 8 Sheets-Sheet 8

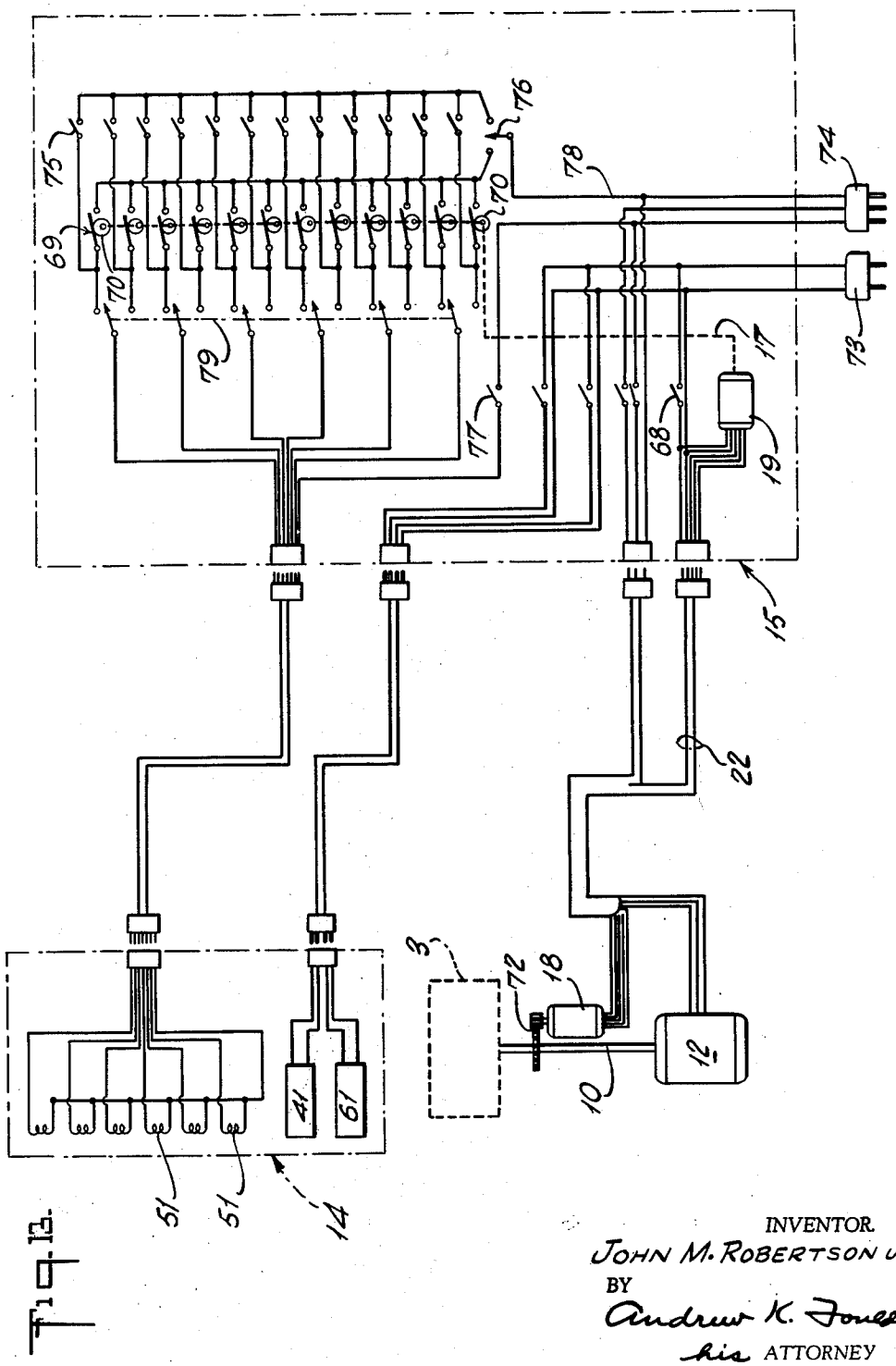


Fig. 13.

INVENTOR.
JOHN M. ROBERTSON JR.
BY
Andrew K. Jones
his ATTORNEY

United States Patent Office 3,191,574 Patented June 29, 1965

3,191,574

APPARATUS FOR DRY ENAMELING

John M. Robertson, Jr., Louisville, Ky., assignor to American Radiator & Standard Sanitary Corporation, New York, N.Y., a corporation of Delaware

Filed Aug. 1, 1962, Ser. No. 214,081
6 Claims. (Cl. 118—11)

The present invention relates to an apparatus for dry process enameling and more particularly to an improved apparatus for a programmed and automated dry process enameling.

Dry enameling is a process of applying a porcelain enamel coating to a base material such as a metal article or workpiece after the workpiece has first had a relatively thin base coating of porcelain enamel applied thereto by spraying or dipping or other means. The coated workpiece is first heated to a temperature above the fusing point of the enamel in powdered form, referred to herein as powder, and thereafter the powder is applied to the heated workpiece so that the powder fuses thereon to form the enamel coating.

In present practice the workpiece, such as a metal bathtub or sink is first placed in a furnace where its temperature is raised above the fusing point of the powder. Thereafter, the workpiece is removed from the furnace, and workmen manually apply the powder to the heated workpiece in such a manner that an even coating of powder is applied and bonded to the workpiece before it cools below the melting point of the powder. This present method has serious disadvantages, one of which is the necessity for the workmen to apply the powder in a room having a relatively high temperature and also of their working in close relation to the heated workpiece which has a very high initial temperature of the order of 1100° F. to 1600° F. This requires the workmen to wear suitable asbestos aprons, mittens and arm protectors and other protective gear which hinders their movements and which also prevents them from working for more than a few minutes at a time on the dry enameling process.

In addition, it is often necessary to return the workpiece to the furnace several times during the dry enameling process to reheat it above the melting point of the glass powder since the workpiece cools rapidly at the powder applying station even though the room may be at a temperature as high as 130° F.

The reheating slows down the enameling process and increases its cost.

An improved apparatus and method have been developed for applying the enameling powder in a heated antechamber to eliminate the necessity for reheating the workpiece in the furnace. This improved method and apparatus is described in United States Patent Application No. 5,405 filed January 29, 1960, now U.S. Patent No. 3,132,038, dated May 5, 1964, and owned by the assignee of the present application.

The present invention relates to an improved means of applying the powder in such a heated antechamber and uses a programming method and means for a fully automatic control of the enameling process.

Accordingly, an object of the present invention is to provide an improved apparatus for dry process enameling.

Another object of the present invention is to provide an apparatus for dry enameling using programmed automation.

Another object of the present invention is to provide a more rapid apparatus for dry enameling which is automatic and which employs a programmed control or automation.

Another object of the present invention is to provide a programmed apparatus for dry enameling adapted for

the automatic enameling of irregularly shaped articles.

Another object of the present invention is to provide an automatic apparatus for dry enameling operation which is easily adjusted and programmed for use in enameling a wide range of articles of different shapes and sizes.

Another object of the present invention is to provide automatic programmed control for a dry process enameling operation carried out in high temperature areas.

A further object is to provide an improved remote control operated means for selectively actuating a plurality of powder dispensing means.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

A preferred embodiment of the invention has been chosen for purposes of illustration and description and is shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. 1 is a side elevational view partially in section of the dry enameling apparatus in accordance with the present invention;

FIG. 2 is a vertical sectional view of the powder transmitter;

FIG. 3 is a vertical sectional view of the powder transmitter taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged detailed perspective view partially cut away of the powder transmitter;

FIG. 5 is an enlarged detailed sectional view of the adjustable coupling for the vibrator arms;

FIG. 6 is an enlarged detailed sectional view of the powder agitating and pressure rods;

FIG. 7 is an enlarged detailed view of the vibrating solenoid and arm for powder feed in their no-feed relationship;

FIG. 8 is an enlarged detailed view of the solenoid and arm of FIG. 7 in their powder feeding relationship;

FIG. 9 is a vertical sectional view of the lower portion of the powder transmitter showing water cooling pipes and fins;

FIG. 10 is a sectional view of the transmitter taken along line 10—10 of FIG. 9;

FIG. 11 is a vertical sectional view of the programming control cam system taken along line 11—11 of FIG. 12;

FIG. 12 is a sectional view of the cam system taken along line 12—12 of FIG. 11;

FIG. 13 is a schematic diagram illustrating the preferred embodiment of the electrical control and programming circuit for the apparatus of FIG. 1;

FIG. 14 is a diagrammatic plan view illustrating programming for automation of the enameling operation; and

FIG. 15 is a diagrammatic vertical sectional view for the programming illustrated in FIG. 14.

General description

The apparatus of the dry enameling process of the present invention will first be described generally with particular reference to FIG. 1.

As illustrated in FIG. 1, the dry enameling apparatus 1 comprises a furnace 2 in which the workpiece 3 which is to be enameled is initially heated to a temperature above the melting point of the dry powdered vitrifiable enamel. The workpiece 3 illustrated herein is a lavatory or basin but any article requiring enameling may be similarly handled. The coated workpiece 3 is initially positioned in the furnace 2 by a suitable handling means such as the rail supported lift 4. The furnace is closed by a sliding door 5 and is heated therein to a temperature

above the melting point of the powder which typically is between 1100° F. and 1600° F.

An enclosure or antechamber **6** is provided adjacent the furnace **2** in which the automatic dry enameling operation is carried out after the furnace **2** has heated the workpiece **3** to a suitable dry enameling temperature. When the temperature of the workpiece **3** has been raised to the enameling temperature, the workpiece **3** is moved from the furnace **2** into the antechamber **6**. The antechamber **6** is heated by a suitable means so that its temperature is kept well above that of the surrounding room to reduce the cooling rate of the workpiece **3** and to cause it to remain above the melting point of the enameling powder for an appreciable period during which the automatic dry enameling operation is carried out. The antechamber, for example, may be held at about 1600° F.

When the heated workpiece **3** has been moved to the heated antechamber **6**, it is mounted on the movable workpiece holder indicated generally at **7** in a suitable basket or other mounting **8** provided at the top of the workpiece holder **7** to permit the articles to be removably but firmly held in position in the workpiece holder **7** during the enameling operation. The preferred embodiment of the workpiece holder **7** comprises a rigid base **9** which mounts a rotatable support shaft **10** positioned in spaced bearings **11**. During the enameling operation the support shaft **10** is rotated at a constant speed by the drive motor **12** which is coupled to the support shaft **10** by suitable gearing **13**. The workpiece mounting **8** at the upper end of the support shaft **10** is positioned to place the workpiece **3** beneath a powder transmitter indicated generally at **14**. This powder transmitter **14** as will be described more fully below, selectively controls the application of the powder to the workpiece **3** under the control of an automatic programming device indicated generally at **15**.

The powder transmitter **14** has its lower powder transmitting surface divided into a series of adjacent but separate compartments **16** (FIG. 4) and the transmission of powder from each of these compartments is individually controlled so that the powder may be transmitted from any desired number and pattern of these compartments and for any portion of the period during which the workpiece **3** is revolving beneath the transmitter **14**. The powder transmission from the individual compartments **16** is controlled by the programming device **15**. As will be more fully described below, the program of powder transmission for a particular workpiece **3** is first determined and the program is then set-up in the programming device **15**. This permits the program to be automatically repeated each time that a new workpiece **3** is moved into the antechamber **6** for the enameling operation.

The programming device **15** includes a programming member which in the preferred embodiment comprises a rotating cam shaft **17** whose rotational position is exactly synchronized with the rotational position of the support shaft **10** through the intermediation of a servo-control including the selsyn **18** which is mechanically coupled for rotation with support shaft **10** and electrically coupled by cable **22** to selsyn **19**. Selsyn **19** is coupled to the cam shaft **17** by the gears **20** and **21**. The selsyn **19** and the cam shaft **17** when thus connected will exactly follow the rotational movement of the workpiece **3** on the support shaft **10** in the usual manner for such a servo-system. Other couplings such as a mechanical coupling may be used to synchronize the movement of the shafts **10** and **17**.

When the workpiece has completed the programmed number of revolutions on the holder **7**, it will have a uniform enamel coating. It is then removed from the antechamber to cool and the above process is repeated for the next workpiece.

Powder transmitter

As described above, the powder transmitter **14** is mounted above the moving workpiece **3** in the heated antechamber **6**. The preferred embodiment of the transmitter **14** provides a group of adjacent and separate compartments from which the powder is selectively transmitted. In the preferred embodiment, a large number of compartments **16** are provided such as about 40, although the number of compartments may be varied in accordance with the size and shape of the workpiece being enameled.

The layout of these compartments is illustrated generally in FIG. 4 wherein a powder transmitter **14** is illustrated having separate compartments arranged in rows in an offset arrangement.

The preferred embodiment of the powder transmitter **14** which will now be described with particular reference to FIGS. 2 through 10 provide a means for selectively transmitting powder downwardly from any number of the separate compartments **16** in any combination and in any controlled time sequence. The means at the transmitter **14** for this selective transmission of the powder will first be described and thereafter the means for providing the selectively automated transmission at the programming means **15** and for the set-up of the automated program will be described.

As illustrated in FIGS. 2–4, the individual compartments **16** are provided within a generally rectangular pan-like container **25** having vertical sidewalls **26** and having its bottom formed by a mesh or screen **27**. Vertical spacers **28** arranged at right angles on the screen **27** form the compartment dividers. The mesh size of the screens which form the bottom of each individual compartment is chosen so that the enamel powder being used will not pass downwardly through screen until the powder is forced therethrough by a combined vibration and pressing action. Accordingly, the passage of powder from each individual compartment **16** is controlled by providing a vibrator within the compartment **16** which may be selectively operated by the automatic control and which will be now described in detail.

The individual vibrators **29** which control the transmission of the powder from each of the compartments **16** are best illustrated in FIGS. 2–4. The powder agitating and pressing portion in the preferred embodiment comprises a series of parallel generally half-round rods **30** (FIG. 6) having their opposite ends **31** attached to a pair of spaced arms **32**. These rods **30** when activated provide a dual function of simultaneously agitating the powder **33** within each compartment **16** and also of actively forcing the powder downwardly through the openings of the screen **27** due to their half-round shape which provides a camming or squeezing action on the powder **33** which sifts downwardly between the rods **30** and the screen **27**. The pressing of the powder **33** through the screen **27** by the rods **30** tends to press the powder in a temporary lumped or pseudo-coarseness which prevents disturbance of the falling powder by air currents but which still permits the lumps to break-up readily when they strike the workpiece **3**.

The means for vibrating the rods **30** to cause the transmission of powder from the individual compartments **16** will now be described. This vibrating means provides for the selective vibration of the rods **30** in any desired number of the compartments **16** to provide for the transmission of the powder from the powder transmitter **14** in the desired pattern and for the desired periods of time as the workpiece **3** is rotated.

A single driving or power source is used for vibrating the rods **30** in the compartments **16** and this source is selectively connected to only the vibrator rods **30** in the compartments from which powder is to be transmitted. The vibrator drive comprises a reciprocating drive rod **34** slidably mounted at the top of the transmitter **14** and which is given its reciprocating motion by being coupled by crank arm **35** and eccentric coupling **36** to a drive shaft **37** supported in suitable bearings **38** at the top of the transmitter **14**. The drive shaft **37** is driven through a pulley **39** and belt **40** from a drive motor **41** (FIG. 1)

whose rotation is kept constant in speed by a fly wheel 42 positioned at the center portion of the drive shaft 37. The rotating shaft 37 thus causes a continuous oscillation or reciprocating movement of a vibrator support frame 43 which is slidably mounted on a bearing surface 44 on the upper portion of the heated antechamber 6 and which moves back and forth in the directions of the arrows 45 (FIG. 2).

Each pair of support arms 32 for a set of vibrator rods 30 is releasably coupled to this reciprocating vibrator support frame 43 through the intermediation of a support lever 46 pivotally mounted on a stationary frame 47 at 48 and having its upper end connected through a link 49 to a movable armature 50 of an electric solenoid 51. Each of the armatures 50 are slidably mounted within the solenoid 51. In the absence of an energizing current in each solenoid 51, the armature 50 and its connected support rod 46 remain stationary as the solenoid 51 is moved back and forth with a reciprocating motion corresponding to the movement of the vibrator support frame 43 on which it is mounted as illustrated in FIG. 7.

When it is desired to transmit powder from any particular compartment 16, an electric current is passed through the solenoid 51 relating to the support lever 46 for that compartment and this current locks the solenoid 51 and the armature 50 together causing them to vibrate as a unit (FIG. 8) and also causing the connected powder transmitting rods 30 within the related compartment 16 to simultaneously vibrate through the intermediation of support arms 32, support lever 46, and the link 49. A flexible shield 55 is fitted across the transmitter adjacent to frame 47 to prevent powder leakage.

FIG. 5 illustrates the adjustable connection between the support arms 32 and the support lever 46 whereby the height of the rods 30 above the screen 27 is adjusted. The arms 32 are connected by adjustable bolts 52 and 53 through adjustment plate 54. The lowering of the arms 32 toward the screen 27 increases powder flow.

In order to provide for a continuous and adequate supply of the enameling powder to each of the compartments 16 whether or not it is being used at a particular time, the preferred embodiment of the powder transmitter 14 uses an over supply system best illustrated in FIGS. 2 and 4. This system includes a series of generally horizontal powder supply tunnels 56, one of which passes over each row of powder compartments 16 as best seen in FIG. 2. Powder is continuously transported through this tunnel from an inlet 57 to an outlet 58 by means of a supply screw 59. These screws 59 are continuously driven during the operation of the powder transmitter 14 by being coupled by suitable gears 60 to a powder supply motor 61. Apertures 62 are provided in the bottom of each tunnel 56 with one aperture being positioned above each powder compartment 16 so that a continuous supply of powder drops downwardly into the compartment 16. The supply screw 59 is driven at a sufficient speed to supply powder to each compartment 16 at a greater rate than the maximum dispensing rate. This insures a constant supply of powder in each compartment 16 at all times. When a particular compartment 16 becomes full, the screw 59 will carry the extra powder being supplied to a powder take-off tunnel 63 from which it may be returned by a suitable channel to the powder inlet 57.

In order to provide for the maximum control of the powder flow as it passes downwardly from each compartment 16 to the hot workpiece 3, it is preferable that the powder transmitter 14 be located fairly close to the top of the heated workpiece 3. This means that the lower portion of the transmitter 14 will be subjected to heat being radiated by the workpiece. Accordingly, a water cooling system is preferably provided comprising a series of interconnected water cooling tubes 65 which project downwardly around the lower edge of the transmitter 14 as illustrated in FIGS. 2 and 3. A continuous supply of coolant is passed through these tubes.

Another embodiment of the cooling means is illustrated in FIGS. 9 and 10 wherein a more effective cooling is obtained by mounting a series of fins 66 on hollow tubes 67. The fins 66 and tubes 67 are positioned at right angles and are arranged to outline the rectangular zone below each compartment 16. Coolant is passed through the tubes 67 by providing connecting passageways between the tubes 67 and the coolant tubes 65. These fins 66 and tubes 67 effectively cool the hot atmosphere surrounding the lower portion of the transmitter compartments 16 to prevent melting or softening of the powdered enamel as it lies in the compartment 16.

Automatic control

In the above description of the powder transmitter 14, it was described how the powder is applied to the workpiece 3 from separate small compartments and it was indicated that the transmission of powder from each individual compartment is separately controlled so that various numbers and groupings of the compartments are selectively activated during an enameling operation to provide for a uniformly thick coating of enamel on the surface of the workpiece.

The automatic control system for selectively controlling the activation of the compartments will now be described and thereafter a typical programming operation for setting up the automatic control for automatically enameling a typical workpiece will be described.

As illustrated in the schematic diagram FIG. 13, the workpiece 3 is mounted on a rotating shaft 10 which is continuously driven by a suitable drive motor 12. During the enameling operation, the drive motor 12 will rotate the workpiece 3 continuously through one or more complete revolutions as desired. During this time, the enamel powder will be applied to the moving workpiece 3 from the powder transmitter 14 under the control of the automatic control which will now be described.

The automatic control includes the programmer 15 in which a series of switches 69 are mounted at least one of which is coupled to each of the above described solenoids 51 to control the powder transmission from the compartment 16 associated with that solenoid. In the preferred embodiment, the programmer 15 has a series of switches controlled by associated cams. As illustrated in FIGS. 11 and 12, the control cams 70 are mounted on a common drive shaft 17 housed in a suitable enclosure 71 and having one end operatively coupled to the selsyn 19 by the gears 20. The selsyn 19 is connected in the usual way as illustrated in FIG. 13 to a related selsyn 18 mounted adjacent to the workpiece supporting shaft 10 and coupled thereto by the gears 72. These cooperating selsyns 18 and 19 operate in the usual fashion so that the cam drive shaft 17 rotates in exact synchronism with the workpiece support shaft 10. In the preferred embodiment, the connection is arranged so that several rotations of the workpiece support shaft 10 will provide for a synchronized single revolution of the cam drive shaft 17. This permits the cams to be divided into sections, i.e. where the program calls for six turns of the ware, the program may be changed for successive revolutions of the ware.

The selsyns are coupled to a suitable power source indicated at 73 through switch 68 (FIG. 13). The various drive motors described above are also coupled to the power sources 73 or 74 through suitable control switches as illustrated in FIG. 13.

For clarity of illustration, the circuit illustrated in FIG. 13 shows a programmer 15 coupled to six transmitter control solenoids 51. Obviously, the number of solenoids 51 controlled by this system may be increased or decreased as desired by the addition of similar cams, switches and connections.

As described above in the description of the powder transmitter 14, each of the solenoids 51 are fixedly

mounted on a single reciprocating or vibrating solenoid support frame 43 so that when the vibrator motor 41 is energized, the solenoids 51 all vibrate continuously backwards and forwards. Each individual solenoid 51, however, is only mechanically coupled to its associated powder transmission rods 30 when a control current is passed through the solenoid to lock its armature 50 in a stationary position.

In the preferred embodiment illustrated in FIG. 13, a series of cam controlled switches 69 are illustrated for selectively energizing the solenoids under the control of the cams 70 and an alternatively operated manual control system with manually operated switches 75 is also illustrated. A switch 76 is used to switch control from the cam controlled switches 69 to the manual switches 75. The manual switches 75 are used during the initial programming to set-up and check the powder transmitting sequence during the design of the cams 70 for a particular workpiece as will be more fully described below. When the switch 76 is in the manual position, each of the solenoids 51 is selectively energized by being coupled to the power source 74 through a common line switch 77 and through a power line 78 which is removably connected to the solenoid by one of the switches 75, and a multi-gang switch 79. The multi-gang switch 79 is provided to selectively connect the six solenoids 51 to one or the other of two sets of six cam operated switches 69 or six manual switches 75. This permits the control to be switched from one program to another by the operation of the gang switch in perfecting the control pattern or in passing from one workpiece to another or in passing from one portion of a workpiece to another portion during the enameling operation.

It is now clear that each of the solenoids 51 will be electrically energized when the switch 76 is set for manual operation and whenever the related manual switch 75 is closed. During programming, the manual switches 75 will be closed whenever it is desired to transmit powder to the moving workpiece from its associated powder compartment 16. During automatic operation with the switch 76 set in the automatic position, each of the switches 69 will be controlled by its related cam 70 to energize the connected solenoids 51 and thus transmit powder from its related powder compartment 16 when the cam 70 causes the switch to close in accordance with the predetermined program for that particular cam.

Programming

The preparation for automatic operation or the programming operation will now be described with particular reference to FIGS. 14 and 15 and also the schematic FIG. 13.

FIGS. 14 and 15 illustrate a wash basin 80 which will be mounted on the workpiece support 8 in the manner described above during the enameling operation and which will be rotated through one or more complete revolutions while thus mounted. Various compartments 16 of the powder transmitter 14 will be selectively activated to apply a uniformly thick coating of enamel on the surfaces of the basin 80 during these revolutions. The basin 80 is mounted so that the axis of rotation of the support shaft 10 generally bisects the angle formed by the sides of the basin.

The plan view of the basin (FIG. 14) shows the impact area at the basin level of the powder from six selected powder compartments 16 arranged in a generally pie-shaped arrangement.

The support shaft 10 is mounted at an angle with the vertical to cause the various surfaces of the basin to be generally level as they pass through these impact areas and thus as close as possible to a plane normal to the path of the dropping powder. In the embodiment illustrated, the shaft 10 is tilted at about a 45 degree angle. As seen in FIG. 15, the front surface 81 of the basin 80 and the rear surface 82 will be relatively level as they pass through the powder impact areas *a, b* and *c*. The positioning of the rear surface 82 as it passes through the impact area is indicated by the dot-dash lines.

During the basin rotation, each point on the rotating basin 80 will describe a true circle in a plane perpendicular to the shaft 10. With respect to the plane of the impact areas which are parallel to the horizontally positioned enamel powder compartments 16, however, the path of each point on the rotating basin 80 will describe an ellipse.

Thus, as illustrated in FIG. 14, the corner 83 of the basin will describe an ellipse 84 when its path is projected onto a plane parallel to the plane of the compartments 16. The ellipses 84, 85 and 86 of FIG. 14, therefore, show the paths taken by various portions of the basin as it rotates and as these portions pass through the impact areas *a, b* and *c*.

For the basin 80 illustrated in FIGS. 14 and 15, a typical arrangement of compartments 16 is illustrated for use in programming the automatic enameling. This consists of the generally pie-shaped arrangement including one compartment for area *a*, two compartments for areas *b*, and three compartments for areas *c*. A single compartment is used for area *a* since this compartment lies above the central portion of the basin where surface speed is the least.

For the more outwardly spaced portions between the ellipses 85 and 86, two compartments are used so that more enameling powder is applied to obtain the same density on these more rapidly moving surface portions. Three compartments are used for the outermost portions whose paths during rotation are between ellipses 84 and 85 in impact areas *c*. The path of any portion of the basin as it passes through the impact areas *a, b*, and *c* is described by an ellipse drawn through that portion with its trace following the elliptical patterns of the three typical traces 84–86 illustrated in FIG. 14. When this is done for various portions of the basin 80, the path of that portion of the basin through the impact areas and the time during which powder is applied to that portion is easily determined so that the programming cams can be set to activate the appropriate compartments when the basin is beneath them.

Certain portions of the workpiece may have steeper slopes with respect to the falling powder than others as they pass through the impact areas. In order to obtain the desired thickness of enamel on these portions, an additional compartment 16 may be activated above the path of this portion for a short interval to add the necessary powder.

It is clear that the programming may be refined by having more numerous and smaller compartments 16, however, such programming follows the above described principles and relatively large compartments have been shown in FIGS. 14 and 15 so as to not unnecessarily complicate the description of the principles involved.

It will be seen that with a large number of controlled compartments 16, a wide variety of workpieces having varying slopes and shapes may be programmed and automatically enameled using the principles described above with additional compartments being activated for the portions of the workpieces which are moving at high speeds and for the portions of the workpieces which are inclined at a sharper angle to the direction of the powder fall.

Where a number of compartments 16 are continuously operated during the entire revolution of the workpiece, they may be all controlled by a single switch 69.

Once a program has been set up for a particular workpiece, this program may be preserved for future use while the apparatus is used for a different workpiece through the removal of the entire cam shaft 17 and its attached cams 70 from the enclosure 71 and by storing this particular cam shaft for later reuse. The program controlled by this particular cam shaft can be run again at any time by merely inserting this particular cam shaft 17 in the programmer 15.

The above described antechamber 6 utilizes a rotating

workpiece holder 7 since this takes advantage of the somewhat symmetrical shape of most articles which are to be enameled and since it also provides for the movement of all surfaces of the workpiece beneath the powder transmitter in a convenient path in a minimum space. It is clear that other paths may be used for the workpiece using the general principles described above. An elongated workpiece, for example, such as a bathtub might be moved along a straight path with the rotation of the cam shaft being synchronized so that one revolution corresponds to a complete passage of the tub along the straight path. In this case, the cams would be similarly activated to provide a higher density on the portions of the tub which are inclined at sharper angles to the direction of powder flow. No correction would have to be made for different rates of movement since all portions of the tub would be moving at the same speed. The support tracks for the tub would be sloped to rock the tub about both a longitudinal and a lateral axis to reduce the slope of the end and side portions to thereby present these portions on a more level plane with respect to the falling frit.

It will be seen that the apparatus of the present invention provide a significant improvement in dry process enameling wherein the enameling may be both automatically performed and also performed in a high temperature zone. This increases the speed at which the enameling may be carried out as it eliminates hand operations and the necessity for reheating the workpiece which is being enameled. It also provides for a continuous fully automatic enameling process so that there is a reduction in the number of personnel required for the operation. The apparatus is relatively simple to use both in setting up an automatic program and in performing the automated enameling of a succession of workpieces.

The new apparatus is also particularly well adapted for the automatic dry process enameling of articles having irregular shapes and for the application of an enamel coating to such objects with a uniform coating thickness. The apparatus and process are also rapidly interchanged for the automatic enameling of a variety of different shapes and once a program has been set up for a particular shape, this program may be stored and reused at any time. This makes it particularly easy to change back and forth between different articles in accordance with the demand for them.

As various changes may be made in the form, construction and arrangement of the parts herein without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. Apparatus for applying enamel powder onto a workpiece, comprising a plurality of discrete zones, a perforate member underlying said discrete zones, means maintaining said perforate member in a stationary position, supply means overlying said perforate member supplying enamel powder to said discrete zones, said perforate member having openings sized so as not to pass enamel powder therethrough when the perforate member and the enamel powder immediately above the perforate member are in a static condition, agitators positioned in each of said zones, said agitators being operable to force enamel powder through the perforated member, a drive means, release means releasably connecting each of said agitators to said drive means so that said agitators may be actuated to force powder through the portions of the perforate member associated with the actuated agitators while the portions of the perforate member underlying the remaining agitators retain the powder in its associated zone, a workpiece support underlying said perforate member, means to move said workpiece support, and control means operatively connected to said release means and said means to move said workpiece to automatically and selectively operate any one or more of said agitators in accordance with the motion of the workpiece so that the actuated agitators apply a substantially even coating of powder to said workpiece.

2. Apparatus for applying enameling powder in dry form to a heated workpiece, comprising a plurality of discrete zones arranged in juxtaposed rows, a screen underlying said discrete zones, means maintaining said screen in a stationary position, supply means overlying said screen supplying enameling powder to said discrete zones, said screen having openings sized so as not to pass enameling powder therethrough when the screen and the enameling powder immediately above the screen are in a static condition, an agitator in each of said zones, said agitators comprising movable elements overlying and closely adjacent said screen, said movable elements being operable to force enameling powder through the screen, drive means for said agitators operable to actuate any one of said agitators to force powder through the portions of the screen associated with the actuated agitators while the portions of the screen underlying the remaining agitators retain the powder in its associated zone, a workpiece support underlying said screen, means to move said workpiece, and control means operatively coupled to said drive means and said means to move said workpiece to automatically and selectively operate any one or more of said agitators in accordance with the motion of the workpiece so that the actuated agitators apply a substantially even coating of powder to said workpiece.

3. Apparatus as set forth in claim 2 wherein said agitators comprises a pair of spaced arms and said control elements comprise a plurality of generally parallel rods having their opposite ends attached to said spaced arms, said rods when actuated providing a squeezing action on the powder which sifts the powder downwardly between the rods and the screen forcing the powder through the openings of the screen.

4. Apparatus for applying enameling powder in dry form to a heated workpiece, comprising a plurality of juxtaposed discrete zones, a screen underlying said discrete zones, means maintaining said screen in a stationary position, supply means supplying powder to said discrete zones, said screen having openings sized so as not to pass enameling powder therethrough when the screen and the enameling powder immediately above the screen are in a static condition, an agitator in each of said zones, said agitators comprising movable elements overlying and closely adjacent said screen, said movable elements being operable to agitate the powder and actively force the powder through the screen by a squeezing action, a drive means for said agitators, release means releasably connecting each of said agitators to said drive means so that any one of said agitators may be selectively actuated to actively force powder through the portions of the screen associated with the actuated agitators while the portions of the screen underlying the remaining agitators retain the powder in its associated zone, a workpiece support underlying said screen, means to move said workpiece support, and control means to automatically and selectively operate any one or more of said release means in accordance with the motion of the workpiece so that the actuated agitators apply a substantially even coating of powder to said workpiece.

5. Apparatus for selectively dropping enameling powder in a predetermined pattern onto a heated workpiece, comprising a plurality of discrete zones arranged in juxtaposed rows, a screen underlying said discrete zones, means maintaining said screen in a stationary position, supply means overlying said screen supplying enameling powder to said discrete zones, said screen having openings sized so as not to pass enameling powder therethrough when the screen and the enameling powder immediately above the screen are in a static condition, vibrating means positioned in each of said zones, said vibrating means com-

prising movable elements overlying and closely adjacent said screen, said movable elements being operable to force enameling powder through the screen by a combined vibrating and pressing action, a drive member for said vibrating means, a clutch means releasably connecting each of said vibrating means to said drive members so that any one of said vibrating means may be selectively actuated to force powder through the portions of the screen associated with the actuated vibrating means while the portions of the screen underlying the remaining vibrating means retain the powder in its associated zone, a workpiece support underlying said screen, means to move said workpiece support along a predetermined path, a clutch control operatively coupled to each of said clutches and to said means to move said workpiece, and control means to automatically and selectively operate any one or more of said clutches in accordance with the motion of the workpiece so that the actuated vibrating means will apply a substantially even coating of powder to said workpiece.

6. Apparatus for selectively dropping enameling powder in a predetermined pattern onto a heated workpiece, comprising a plurality of separate and contiguous discrete zones arranged in juxtaposed rows, a screen underlying said discrete zones, means maintaining said screen in a stationary position, supply means overlying said screen continuously supplying enameling powder to said discrete zones, said screen having openings sized so as not to pass enameling powder therethrough when the screen and the enameling powder immediately above the screen are in a static condition, vibrating means overlying said screen positioned in each of said zones, said vibrating means comprising spaced arms and a plurality of rods attached to said spaced arms, said plurality of rods being disposed closely adjacent said screen, said plurality of rods being operable to force enameling powder through the screen by a combined vibrating and pressing action, a common drive member for said vibrating means, a clutch means releasably connecting each of said vibrating means to said common drive member so that any one of said vibrating means may be selectively actuated to force powder through the portions of the screen associated with the actuated vibrating means while the portions of the screen underlying the remaining vibrating means retain the powder in its associated zone, a workpiece support underlying said screen, means to move said workpiece support about a fixed axis of rotation, a clutch control operatively coupled to each of said clutches and to said means to move said workpiece, and control means to automatically and selectively operate any one or more of said clutches in accordance with the motion of the workpiece so that the actuated vibrating means will apply a substantially even coating of powder to said workpiece.

References Cited by the Examiner

UNITED STATES PATENTS

707,490	8/02	Zwermann	118—308
710,443	10/02	Dupont	118—308
1,395,798	11/21	Catlett	222—247
1,748,543	2/30	Devlin	118—308 X
2,702,655	2/55	Lopata	222—233 X
2,804,764	9/57	Runton	118—313 X
3,132,038	5/64	Ward	117—18

RICHARD D. NEVIUS, *Primary Examiner.*

JOSEPH REBOLD, *Examiner.*