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RECIPROCATING SPRAYING APPARATUS

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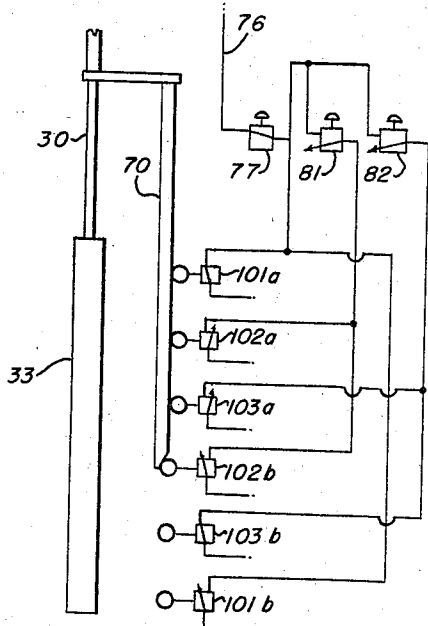


Fig. 2

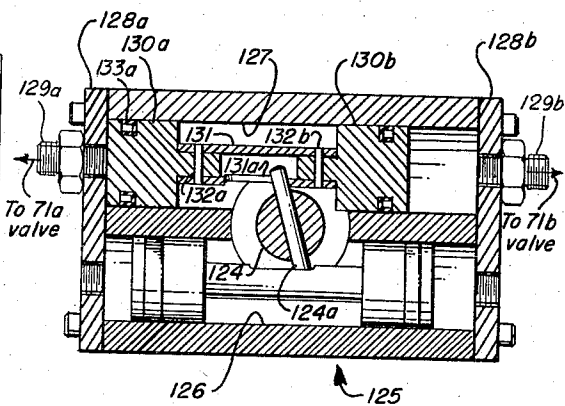


Fig. 3

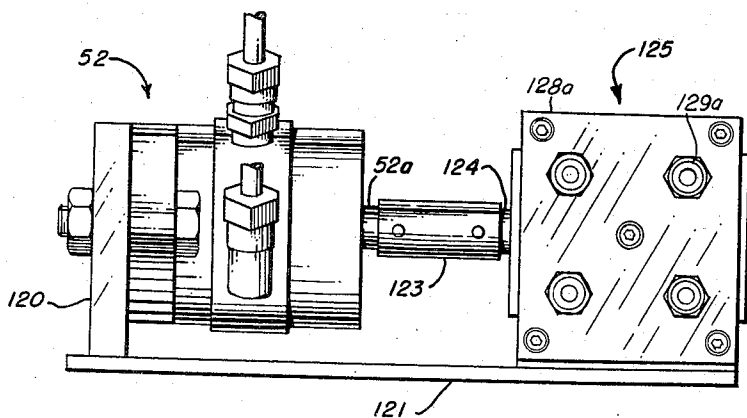


Fig. 4

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RECIPROCATING SPRAYING APPARATUS

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7 Claims. (Cl. 299—1)

This invention relates to apparatus for controlled movement of a spray coating device or the like, and particularly for reciprocating an electrostatic coating device.

Industrial spray coating of articles is well-known. During recent years electrostatic forces have been utilized in spray coating systems to more efficiently effect deposition of spray particles on the articles. Electrostatic coating systems are now in use in which a charged spray of coating material particles are projected from an atomizing device through a quiescent atmosphere to be electrostatically deposited on an article of manufacture moving on a conveyor past the atomizing device to form a coating thereon. Where the articles to be spray coated are of such length that the entire article cannot be properly coated with a stationary atomizing device the effective width of the spray can be increased by repetitive or reciprocatory movement of the atomizing device transverse to the conveyORIZED path of the article in order to coat the entire length of the article.

It has been found that reciprocation of the atomizing device a number of times as the article moves past possesses advantages in addition to permitting the coating of larger articles. Such reciprocation permits the coating material to be applied to the article in a large number of light "passes" or applications which in turn permits a build-up of unusually heavy films of coating material without a tendency to sag or run. In some cases it is possible with a reciprocating atomizing device to apply the equivalent of two normal thicknesses of coating material with a single atomizing device. Moreover, the feature of permitting a slight interval of air drying intermittently with a number of light passes is particularly desirable when using certain coating materials such as hammertones and metallic paints where too rapid an application of such coating materials results in an unsatisfactory finished appearance. Coating by a number of light passes has the additional advantage that any overcoating or other irregularities occurring during any one pass tend to be covered up or "corrected" by the other passes.

When a reciprocating atomizing device for the spray coating of articles is to be used, it has been found desirable to be able to change the length of stroke and/or rate of movement of the atomizing device without having to first stop the coating operation. For example, it may be necessary to rapidly change the length of stroke of the reciprocating atomizing device from 70" to 50" and vice versa in order to properly coat intermittent batches of 70" and 50" articles moving along the conveyor into coating relation with the atomizing device without interrupting the coating operation or shutting down the conveyor line. Likewise, in order to accommodate different shapes and types of articles on the conveyor line it is desirable to permit selective control of the speed of movement of the spraying device within each stroke without otherwise interrupting its cycle of operation.

Due to the use of electrical potentials in the order of

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100,000 volts or more in electrostatic coating systems, safety requires that any manually operable controls for the system must be mounted a considerable distance away from the coating zone and adjacent area wherein portions of the apparatus are at high voltage. Therefore, such controls for a reciprocating electrostatic coating device must inherently be remotely operable in order to protect the operator.

This invention provides means for changing the length of stroke and/or speed of a reciprocable spraying device between predetermined limits during operation of the coating system. One type of apparatus which embodies our invention includes a reversible fluid operated motor for reciprocating movement of the atomizing device, a pump for supplying fluid under pressure to the motor and a reversible two-position valve controlling the flow of fluid from the pump to the motor having one position permitting fluid flow to cause movement of the atomizing device in one direction and another position permitting fluid flow to cause movement of the atomizing device in the other direction. Means are provided for reversing the two-position valve from one to the other of its positions by a cam mounted for movement with the atomizing device and at least three cam-operatable control devices each of which is connected for operating the valve reversing means only when the control device itself is activated. The control devices are arranged for cam operation in accordance with predetermined stroke limits for the atomizing device and means are provided for selective activation of one or more of the control devices.

The use of an annular-edged atomizing device in an electrostatic coating system with a generally circular or "loop" conveyor for moving the articles to be coated along a curved path to take advantage of the natural spray pattern of the annular-edged atomizing device is shown and described in the copending application of C. C. Simmons, Serial No. 274,909, filed March 5, 1952, now Patent No. 2,808,343. While our invention is in no way limited to such a system, it is admirably adapted for use with an electrostatic coating system as disclosed in the aforesaid patent application. The invention may assume many different forms but for convenience of illustration there are shown in the drawings and will now be fully described several specific embodiments of our invention in an electrostatic coating system which are illustrative of the principles of the invention. However, it will be understood that no limitations are to be implied from the specific description now provided.

Fig. 1 of the accompanying drawings is a diagrammatic showing of a reciprocable atomizing device utilizing one form of the invention;

Fig. 2 is a further diagrammatic showing of another embodiment of the invention;

Fig. 3 is a front cross-sectional view of a piston block assembly which may be embodied in our invention; and

Fig. 4 is a side elevational view of the piston block assembly shown in Fig. 3 connected to a pilot valve.

Referring first to Fig. 1, there is diagrammatically shown an elongated article 10 to be coated supported by a support 11 from a conveyor track 12. The supported article 10 moves along the conveyor track into coating relation with an atomizing device shown generally as 15 which includes a rotatable annular-edged atomizing disc 16 which is rotated about its axis by motor 17 and to which liquid coating material is fed through a central passageway in the motor and shaft from liquid supply tube 18. Normally the spacing between article 10 and disc 16 is in the order of from 8 to 12 inches. Article 10 shown is one of an annular series moving around atomizing device 15 on circular track 12 in the manner described in the aforesaid co-

pending patent application. The liquid coating material fed at a controlled rate through tube 18 will spread into an outwardly moving annular film on the upper surface of rotating disc 16 to be atomized therefrom as a spray of finely divided particles of liquid coating material. An electrostatic field is established between the liquid spray particles and the spaced articles 10 to be coated by means of a high voltage source 19 which is connected to the atomizing device while the articles are grounded through conveyor 12 as shown. For the 8 to 12 inch spacing above mentioned, the potential of the source 19 may be in the neighborhood of 100,000 volts. Thus, the spray is electrostatically deposited on the article.

In order to reciprocate atomizing device 15 transverse to the path of article 10, the atomizing device is mounted directly or indirectly by column 20 on one end of a piston rod 30. To the other end of piston rod 30 is affixed piston 31 which is slidably mounted within a cylinder 32. Piston rod 30, piston 31 and cylinder 32 together with their feed lines constitute a fluid motor designated as 33.

Fluid motor 33 is operated by a hydraulic fluid and flow of the fluid is controlled to effect reciprocation of piston 31 by a compressed air system. It is to be understood, however, that other fluids may be used to operate motor 33 and that the control system by appropriate modification may be electrical, magnetic, mechanical or hydraulic. In the system shown in Fig. 1 motor 33 is operated by hydraulic oil which is fed from a reservoir 40. Pump 41 supplies oil under pressure past pressure relief valve 42 and through volume control valve 43 so that a controlled quantity of oil is fed through feed lines 44 and 45 to the upper end of cylinder 32. Oil is supplied to the opposite end of cylinder 32 from feed line 46 after passing through a two position pilot-operated flow control valve 47 and a variable check or counterbalance valve 48 located between line 44 and line 46. When flow control valve 47 is in position so that liquid is delivered from feed line 44 to both lines 45 and 46 and thus to both the upper and lower ends of cylinder 32, the difference in areas between the upper and lower faces of piston 31 exposed to the pressure of the hydraulic oil (which difference is equal to the cross-sectional area of the piston rod) will result in upward movement of piston 31 and piston rod 30. This in turn will of course move atomizing device 15 in an upwardly direction. The rod, of course, is of a thickness adequate to support the elements carried by it.

When valve 47 is in the other of its two positions, liquid flow to line 46 will be cut off. Oil under pressure will, however, continue to be supplied at the normal rate through line 45 to the upper end of cylinder 32 causing the downward movement of piston 31 and piston rod 30 as oil is expelled from the lower portion of cylinder 32 and flows out through line 46, counterbalance valve 48, valve 47 and drain lines 50 and 51 for return to reservoir 40. A vent line 50a provides atmospheric pressure at the rear of the piston in counterbalance valve 48 and serves as a path for any leakage of oil from the counterbalance valve into drain line 51.

Valve 47 is moved from one of its positions to the other hydraulically by oil under pressure through a four-way rotary pilot valve 52. Oil under pressure is supplied to the pilot valve 52 through a line 54 from line 44 and the same pump 41 and flow control valves as used to supply fluid motor 33. Oil is supplied through line 54 to pilot valve 52 and with the valve in one of its positions the liquid is fed from pilot valve 52 through line 55 to valve 47 so as to move valve 47 from one of its positions to the other. When liquid is thus supplied to valve 47 through line 55, a parallel line 56 between pilot valve 52 and valve 47 is connected through the pilot valve to a vent line 57 and drain line 51 to provide atmospheric pressure in the line and permit any excess oil to drain back to reservoir 40. When pilot valve 52 is

operated or moved into its other position, liquid under pressure from line 54 is supplied through line 56 to move valve 47 to its opposite position, in which case line 55 is vented through pilot valve 52 to vent line 57 and drain line 51.

The rate of liquid flow to fluid motor 33 through lines 45 and 46 may be varied to change the rate of movement, i. e. the speed, of piston 31 and piston rod 30 in order to vary the rate of reciprocation of atomizing device 15 during a predetermined portion of each stroke. This may be accomplished by providing an additional path of flow for oil from pump 41 past pressure relief valve 42 to feed line 44. A line 60 feeds a four-way spring-return valve 61 which in turn feeds liquid to line 44 through volume control valve 43a and check valve 63. Volume control valve 43a can be fed selectively through either of two parallel lines 64a and 64b containing respectively cut-off valves 65a and 65b. These speed control lines may be used in many different ways. For example, liquid can be normally fed to line 44 through volume control valve 43 along, that is, normally without any liquid at all flowing through the volume control valve 43a. In such case, cut-off valve 65a could be closed, valve 65b open, and valve 61 normally positioned to feed liquid to closed line 64a so that no liquid would flow through valve 61. Then if it is desired, for example, to increase the speed of fluid motor 33, valve 61 would be moved by pressure against its spring into its other position so that liquid would flow from line 60 through valve 61 to the open line 64b, and thence through open cut-off valve 65a, volume control valve 43a and check valve 63 to line 44 to increase the oil flow in line 44 to the fluid motor.

Pilot valve 52 is actuated, i. e. moved from one of its operative positions to the other, by means of reversing mechanism which can be selectively changed by remote control from one set of limits to another without interrupting the coating operation. Means jointly operable with the reciprocable member, which in the embodiment shown is a cam bar 70 affixed to piston rod 30, operates the plungers of a plurality of spring-return air control valves 71a, 71b, 72a, 72b, 73a and 73b. In order to activate these air control valves compressed air from a source 75 is supplied through line 76 to an air supply valve 77. With valve 77 open, air flows through lines 78 and 79 to both air control valves 71a and 71b, which operate as a pair. The opening of air supply valve 77 also supplies air to line 80 which feeds air supply valves 81 and 82. With valve 81 open air flows through lines 83 and 84 to both air control valve 72a and 72b which also operate as a pair; likewise, with valve 82 open air flows through lines 85 and 86 to activate the pair of valves 73a and 73b.

A separate air line runs from each one of air control valves 71a, 71b, 72a, 72b, 73a, and 73b to air cylinders 91a, 91b, 92a, 92b, 93a and 93b respectively. Each of these six air cylinders is arranged to move pilot valve 52 from one of its operative positions to the other. The air cylinders operate in pairs corresponding to the pairs of air control valves as shown. One effective arrangement of the air cylinders in a block assembly for operating pilot valve 52 is shown in Figs. 3 and 4 and will be described in detail hereafter. It has been found that using air cylinders to operate a pilot valve which in turn hydraulically operates the means for reversing a hydraulic motor such as the flow control valve 47, is much superior to using a plurality of compressed air lines directly connected to a flow-reversing means such as valve 47.

When air supply valve 77 is open and valves 81 and 82 remain closed it is apparent that only the pair of air control valves 71a and 71b are activated, i. e. are able to effect a change in the direction of movement of piston rod 30, and that air control valves 72a, 72b, 73a and 73b remain inactive. Thus no change is produced as the piston rod and cam bar 70 move upwardly and the end of the cam bar passes over and releases the spring-loaded plung-

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ers of inactive air control valves 72b, 73b, 73a and 72a in turn, but when the spring-loaded plunger of air control valve 71a moves outwardly as the end of the cam bar moves upward past this valve air will flow from valve 71a through the connecting line to move the plunger of air cylinder 91a. The moving plunger of cylinder 91a will "trip" pilot valve 52 to its other position causing a reversal of oil pressures as between lines 55 and 56 to reverse the position of valve 47 and thereby cause the downward movement of piston rod 30. During downward movement, cam bar 70 will depress the plungers of the inactive air control valves without effect until reaching activated air control valve 71b. Depressing the plunger of this valve causes air to flow through the valve to air cylinder 91b in turn causing reversal of pilot valve 52, valve 47 and fluid motor 33.

The stroke of the piston, and thereby the stroke of atomizing device 15, is under the control of air supply valve 81 or 82. The opening of valve 81 will, of course, confine the stroke of the device within limits determined by the pair of air control valves 72a and 72b, while opening of valve 82 will activate air control valves 73a and 73b to confine the reciprocation of the atomizing device to limits determined by the positions of this latter pair of air control valves. It is apparent that changes in the limits of reciprocation can be easily made by adjusting the positions of the air control valves in relation to cam bar 70.

One such other arrangement of air control valves is shown in Fig. 2. In this embodiment all of the pairs of air control valves, and hence the stroke limits, do not lie one within the other as in the embodiment shown in Fig. 1. The coating apparatus, fluid motor, and hydraulic reversing means are all similar to those shown in Fig. 1 and only the necessary changes in the air control valves will be described. In the embodiment in Fig. 2 compressed air is supplied through line 76 to an air supply valve 77 which when open supplies air to activate air control valves 101a and 101b. With only these air control valves activated the atomizing device will reciprocate between limits represented by valves 101a and 101b which, regardless of the other changes in the system, remain as the outer limits of reciprocation.

Air can also be supplied through manually operable air supply valve 81 to activate control valves 102a and 102b; likewise, air can be supplied through valve 82 to activate control valves 103a and 103b. Appropriate separate air lines connect each of the air control valves to one of the air cylinders which operate rotary pilot valve 52. Thus when supply valves 77 and 81 are open but valve 82 is closed, the atomizing device will reciprocate between limits represented by the pair of control valves 102a and 102b. When supply valves 77 and 82 are open and valve 81 closed the device will reciprocate between limits determined by control valves 103a and 103b. When all of supply valves 77, 81 and 82 are open the device will reciprocate between limits determined by control valves 103a and 102b. Various other arrangements of supply and control valves will be apparent to those skilled in the art without departing from the scope of our invention.

While the supply valves 77, 81 and 82 in both Figs. 1 and 2 are shown as manually operable, it should be understood that automatic means may be employed to selectively activate the desired control valves. Photoelectric or other means responsive, either immediately or with a time delay, to differences in the size or shape of the articles to be coated moving along the conveyor towards the atomizing device 15 can be connected to operate one or more of the supply valves and hence the appropriate control valves. In this manner the stroke of the atomizing device can be automatically adjusted to permit proper coating of various sizes and shapes of articles without manual control.

Another feature of the invention provides for selectively changing the speed cycle of an atomizing device or the

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like during a given stroke of its operation without shutting down the system. It may be desired to coat intermittent batches of two different types of articles, for example, one type of article may require reciprocation of the atomizing device at a constant speed while the other type of article requires a faster speed of the atomizing device through the middle of its stroke and a slower speed near the ends of its stroke. In such a case the hydraulic speed control mechanism may be used with cut-off valve 65a closed and cut-off valve 65b open as previously described. Thus normally oil under pressure would flow only through volume control valve 43 to line 44 and such flow, controlled by appropriate setting of volume control valve 43, to fluid motor 33 would move the atomizing device at the constant rate required for coating articles of the first type just described. Volume control valve 43a would be set to such position that when it received oil through line 64b that the combined flow of oil through volume control valves 43 and 43a would result in the faster speed of reciprocation required for the center of the stroke in coating articles of the second type described.

To effect such control a manually operable air supply valve 90 is connected to supply line 80 to supply air to an additional pair of air control valves 95a and 95b connected in series with valve 90 as shown. Valve 95a is normally closed and depression of its plunger opens the valve to permit air to flow to valve 95b which is normally open. Depression of the plunger of valve 95b prevents air flow beyond this valve to air line 96 and at the same time bleeds line 96 to the atmosphere. Air line 96 supplies air to an air cylinder 97 which operates the four-way spring-return valve 61. Thus when air supply valve 90 is opened to activate control valves 95a and 95b and when the air circuits in valves 95a and 95b are both open, air will be supplied through line 96 to air cylinder 97 for operating against the spring of valve 61 to reverse the position of valve 61 and change the flow of liquid from closed line 64a to open line 64b.

When air supply valve 90 is closed so that valves 95a and 95b are inactive, the movement of the plungers of these control valves by cam bar 70 will produce no changes in the speed of fluid motor 33. However, the opening of air supply valve 90 will render the speed control mechanism operable. Then as cam bar 70 moves downwardly to depress the plunger of valve 95a air will be fed through normally open valve 95b and line 96 to air cylinder 97, operating its plunger and thereby permitting oil from line 60 to flow through line 64b, open cut-off valve 65b, flow control valve 43a and check valve 63 to line 44. This will increase the speed of downward movement of the fluid motor. Then as the end of cam bar 70 depresses the plunger of control valve 95b which is normally open it will close the valve and release the air pressure in line 96 operating the plunger of air cylinder 97. This loss of air pressure permits the spring operated return of valve 61 to its normal position to shut off the flow of oil to volume control valve 43a. This will accordingly reduce the speed of piston 31 during the remainder of its downward stroke. Therefore, by selective opening or closing of air supply valve 90 the rate of movement of atomizing device 15 can be changed to accommodate batches of different types of articles moving along the conveyor into coating relation with the atomizing device.

Our invention is not, of course, limited to speed control within the stroke between only two predetermined points as shown in Fig. 1. Only one (or several) of control valves 95a and 95b might be used to make a two-stage (or a many stage) speed cycle rather than the three-stage cycle above described. Likewise, appropriate camming mechanism can be used in conjunction with the speed control valve or valves to obtain an entire stroke or portion of a stroke with an infinitely or gradually varying speed, if such gradual variation in the speed of the atom-

izing device is desired to properly coat a particular type of article.

Figs. 3 and 4 illustrate a further feature of our invention which provides a novel arrangement for a plurality of air cylinders to operate a hydraulic pilot valve. As shown rotary pilot valve 52 is mounted on a flange 120 of a base plate 121. The rotatable operating shaft 52a of the pilot valve is connected by coupling 123 to a rotatable shaft 124. Shaft 124 is journaled within a piston block assembly 125 which is securely mounted on base plate 121. In this embodiment piston block assembly 125 incorporates four air cylinders and double-ended piston assemblies which permits its use with as many as eight separate or four pairs of cam operated air control valves for reversing the flow of oil to fluid motor 33. It is apparent that more or less cylinders and piston assemblies may be incorporated in the piston block depending upon the particular needs of the system.

The axes of the cylinders of piston block assembly 125 are arranged generally perpendicular to the extent of shaft 124 and either above or below it. Two of these cylinders 126 and 127 lie one above the other as shown in Fig. 3. The cylinders and their associated piston assemblies are similar and hence only the assembly associated with cylinder 127 is described. The opposite ends of cylinder 127 are closed by a pair of similar end plates 128a and 128b. Threaded holes and appropriate connections, such as, for example, connections 129a and 129b in end plates 128a and 128b respectively, provide air tight connections to air lines from appropriate air control valves, for example, the pair of air valves 71a and 71b. Slidably mounted within cylinder 127 are a pair of similar pistons 130a and 130b. These pistons are connected by an axially positioned hollow shaft 131 by means of pins 132a and 132b. The hollow shaft 131 has a longitudinal slot 131a which accommodates the end of a pin 124a rigidly mounted on rotatable shaft 124. Appropriate flexible rings such as ring 133a may be mounted on the pistons to provide effective sealing between the pistons and cylinder walls.

In the operation of this apparatus, air pressure applied to the face of piston 130b through the line from air control valve 71b will force the piston assembly to the left. This will move pin 124a and shaft 124 in a counter-clockwise manner to reverse pilot valve 52 and change the direction of flow of oil to fluid motor 33 as previously described. Then as control valve 71b is closed by the return stroke of the cam bar, the pressure against the face of piston 130b will be released. Although this release of pressure will not move the piston assembly, it will leave the assembly free to be moved by the application of air pressure in the opposite direction against the face of piston 130a through the air line connected to air control valve 71a as this valve is opened. Such movement to the right of the piston assembly will move pin 124a and shaft 124 in a clockwise direction to cause the reversal of the rotary pilot valve and accordingly of the flow of fluid to motor 33.

We claim:

1. In an electrostatic spray coating system, a hydraulic reciprocator for reciprocating a spraying device comprising a cylinder; a piston slidably mounted within said cylinder; a piston rod connected to said piston and extending axially beyond the confines of said cylinder; said cylinder, piston and piston rod forming two separate enclosed chambers within said cylinder on opposite sides of said piston; two separate lines to said chambers, each line adapted to supply liquid under pressure to one of said chambers; a hydraulically operated reversible two-position flow control valve in one of said lines, said flow control valve having one position permitting flow of liquid under pressure to said cylinder to cause movement of said piston in one direction and the other position permitting release of liquid from said cylinder to cause movement of said piston in the other direction; means

including a pilot valve for hydraulically reversing said flow control valve from one of its positions to the other; a cam bar connected to said piston rod for movement therewith; at least three air control valves each connected to operate said pilot valve and thereby to reverse said flow control valve only when said air control valve is activated by air under pressure supplied thereto, said air control valves being arranged in a series to be operated in succession by movement of said cam bar; a source of air under pressure; a manually operable on-off air supply valve; three parallel lines from said air source for supplying air under pressure to the two outer air control valves in said series and to said manually operable air supply valve; and a line from said air supply valve for selectively supplying air under pressure to the intermediate air control valve in said series.

2. Means for changing the length of the stroke of a piston rod of a reciprocable hydraulic motor between two distinct sets of predetermined limits, comprising a reversible two-position flow control valve associated with said motor having one position permitting flow of liquid under pressure to cause movement of said piston in one direction and the other position permitting flow of liquid under pressure to cause movement of said piston in the other direction; a two-position pilot valve connected to said flow control valve for hydraulically reversing the position of said flow control valve; a cam bar connected with said piston rod for movement therewith; two pairs of air control valves operated by said cam bar and spaced one from another along the path of movement of said cam bar according to the predetermined limits of the stroke of said piston rod, each of said air control valves being connected to be individually capable of causing the operation of said pilot valve to reverse the position of said flow control valve only when air under pressure is supplied to said air control valve; a source of air under pressure; two manually operable on-off air supply valves each of which is independently supplied with air under pressure from said source; and two parallel lines from each of said air supply valves for supplying air under pressure simultaneously to one of the pair of said air control valves.

3. Means for changing the length of stroke of a piston in a reciprocable fluid-operated motor between two sets of predetermined limits, comprising means for supplying fluid to said fluid motor to move said piston, a reversible flow control valve connected to said fluid supply means and having one position permitting flow of fluid to cause movement of said piston in one direction and the other position permitting flow of fluid to cause movement of said piston in the other direction, means for reversing the position of said flow control valve, moving means associated with said piston and mounted for movement proportional to the movement of said piston, two pairs of individually operable control devices operated by said moving means, each of said control devices being capable of operating said flow control valve to reverse the fluid flow only when said control device itself is activated, said control devices being spaced one from another for operation by said moving means according to the predetermined limits of the stroke of said piston, and means for selectively activating each of said control devices.

4. In a spray coating system having a reciprocating spraying device, means for changing the length of stroke of the spraying device between predetermined limits during operation of the coating system comprising a reversible fluid operated motor for reciprocating said spraying device, a pump for supplying fluid under pressure to said motor, a reversible two-position valve controlling fluid flow from said pump to said motor having one position permitting fluid flow to cause movement of said spraying device in one direction and the other position permitting fluid flow to cause movement of said spraying device in the other direction, means for reversing said two-position

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valve from one of its positions to the other, moving means mounted for movement proportional to the movement of said spraying device, at least three control devices individually operable by said moving means, each of said control devices being connected for operating said valve reversing means only when said control device itself is activated, said control devices being arranged for operation by said moving means in accordance with the predetermined stroke limits of the spraying device, and means for selectively activating each one of said control devices.

5. Means for operating the rotatable shaft of a rotary pilot valve comprising a pin extending substantially radially from the rotatable shaft, an enclosed cylinder lying with its axis offset from said shaft and substantially perpendicular thereto, a pair of pistons slidably mounted within said cylinder, a piston rod connecting said pistons, said pin engaging said rod whereby movement of said rod and pistons within said cylinder will rotate the shaft of said pilot valve from one of its positions to the other, air lines connected to the opposite ends of said cylinder, and means for selectively applying air under pressure through one of said lines to said cylinder for moving said pistons and piston rod to operate the rotatable shaft of said pilot valve.

6. In an electrostatic spray coating system having a hydraulically actuated reciprocator for reciprocating a spraying means, an arrangement for controlling the stroke of said spraying means comprising a two-position flow control valve having a first passageway connected to said reciprocator, a supply passageway, a vent passageway, and hydraulically operated movable means for connecting said first passageway alternatively to one or the other of said supply passageway and said vent passageway; means for supplying liquid under pressure through said supply passageway to said flow control valve; a two-position pilot valve; two liquid lines connected between the hydraulically operated movable means of said flow control valve and said pilot valve whereby movement of said pilot valve from one of its positions to the other will hydraulically operate the movable means of said flow control valve to connect the first passageway of said control valve from one to the other of said supply pas-

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sageway and said vent passageway; a plurality of control devices each in operative relationship with said pilot valve for moving said pilot valve from one of its positions to the other and each of said control devices being operated by the movement of said spraying means; and means remote from said spraying means for selectively rendering said pilot valve control devices operable.

7. In an electrostatic spray coating system having a hydraulically actuated reciprocator including a piston and cylinder device having a rod connected to the piston for reciprocating an electrically charged spraying device, means for changing the length of the stroke of the piston rod of said reciprocator during the reciprocation of said spraying device comprising a two-position flow control valve connected to said reciprocator and movable from a first position permitting flow of liquid under pressure to cause movement of said piston in one direction to a second position permitting flow of liquid under pressure to cause movement of said piston in the other direction; a two-position pilot valve connected to said flow control valve for hydraulically moving said flow control valve; a cam bar connected to said piston rod for movement proportional to the movement of said piston rod; a plurality of control means operable by said cam bar and spaced one from another along the path of movement of said cam bar according to predesired limits of the stroke of said piston rod; a plurality of pilot valve moving devices each operable by one of said cam-operated control means, and each in operative relationship with said pilot valve for moving said pilot valve from one of its positions to another; and means for rendering each of said control means operable.

References Cited in the file of this patent

UNITED STATES PATENTS

2,051,052	Morgan	Aug. 18, 1936
2,113,161	Osborne	Apr. 5, 1938
2,222,630	Pickford et al.	Nov. 26, 1940
2,383,023	Sykes et al.	Aug. 21, 1945
2,658,472	Ransburg	Nov. 10, 1953
2,660,978	Dyne et al.	Dec. 1, 1953