United States Patent

Porter

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[54] MULTILEVEL SPRAY CONTROL

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[73] Assignee: **Amtron, Inc.**, Midlothian, Ill.

[22] Filed: **July 6, 1970**

[21] Appl. No.: **52,586**

[52] **U.S. Cl.** **340/172.5**, 118/2

[51] **Int. Cl.** **G05b 23/02**, G05b 11/26, G05b 11/32

[58] **Field of Search** 340/172.5; 118/2, 9, 11; 214/11; 239/67, 63

[56] **References Cited**

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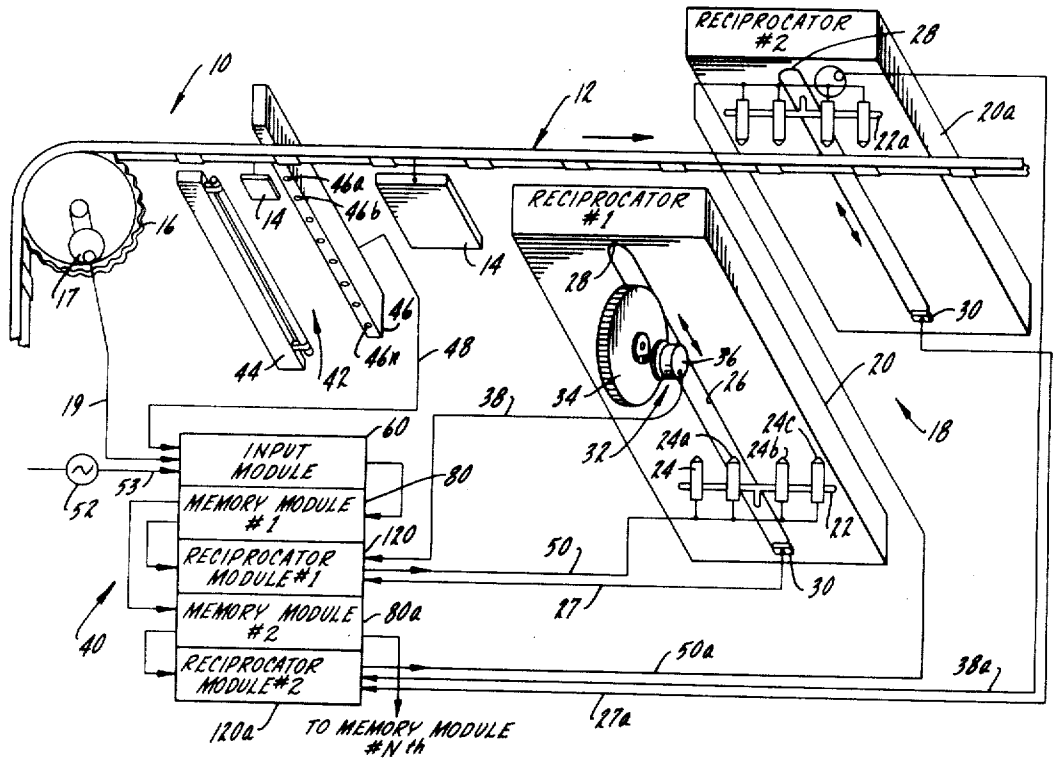
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[57] **ABSTRACT**

An electronic control circuit is disclosed for controlling the operation of a paint spray system of the type having a spray station having at least one spray gun assembly and one spray gun thereon and a conveyor means for transporting objects of diverse geometry past the spray station.

26 Claims, 7 Drawing Figures



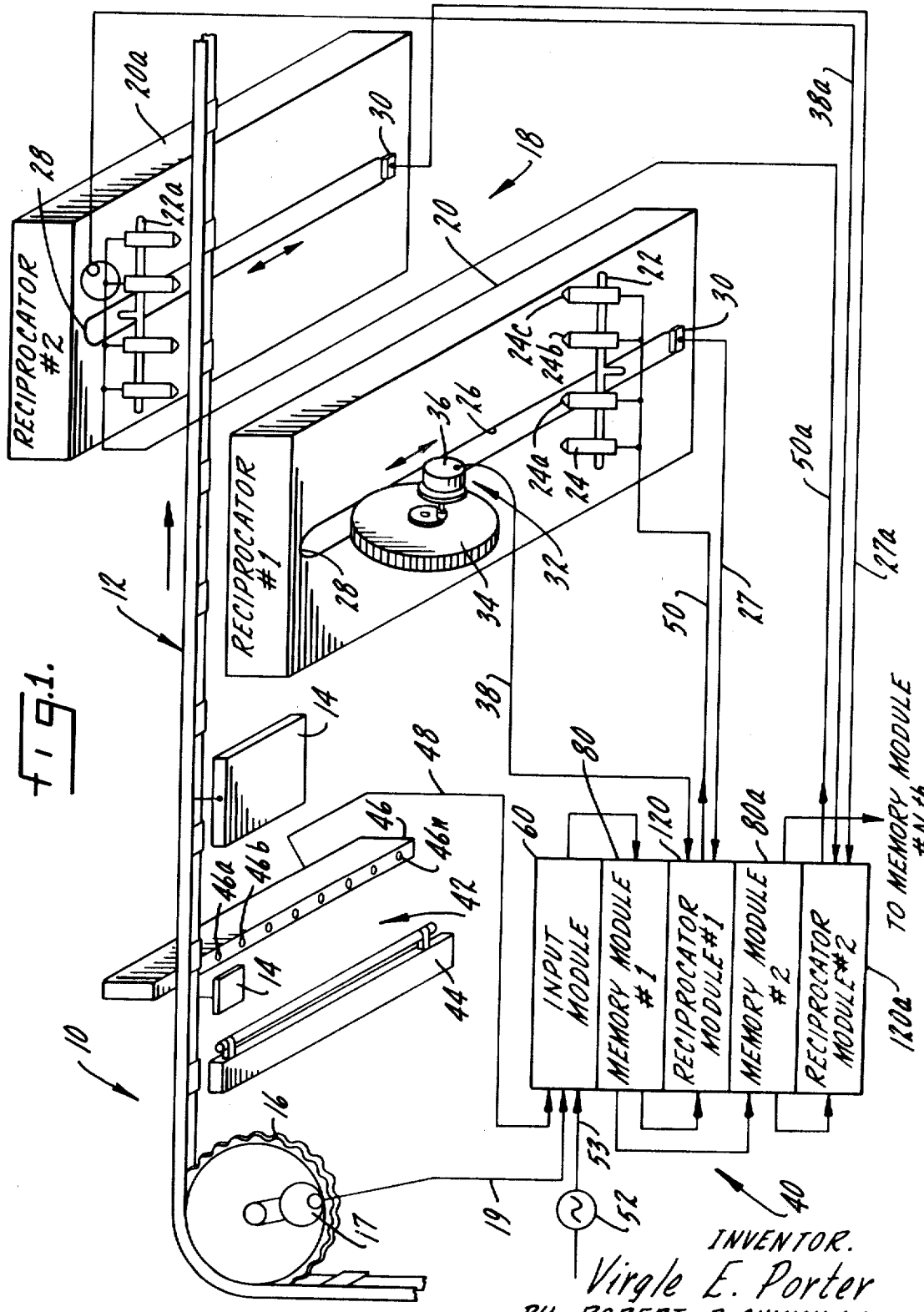


Fig. 1.

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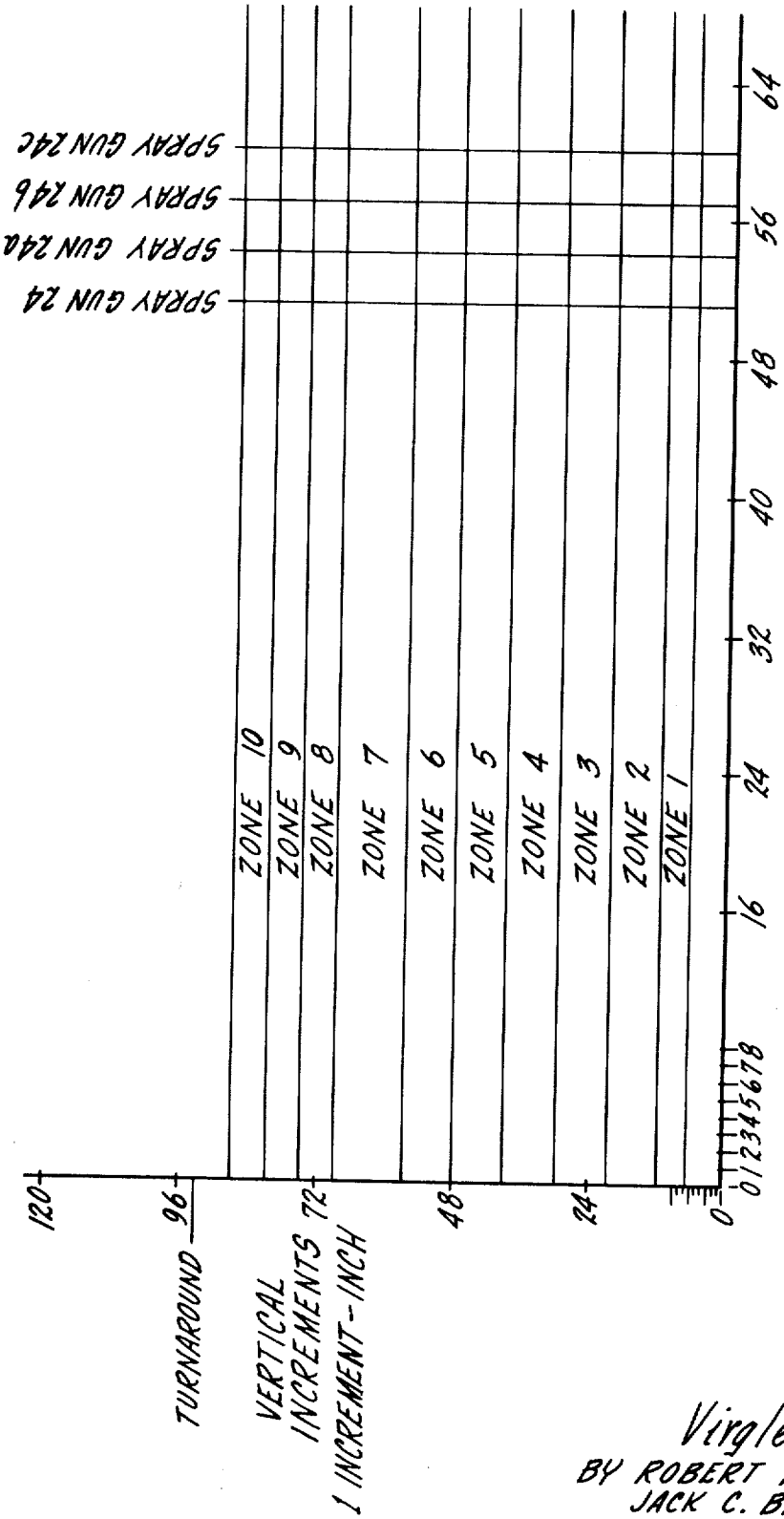


FIG. 2.

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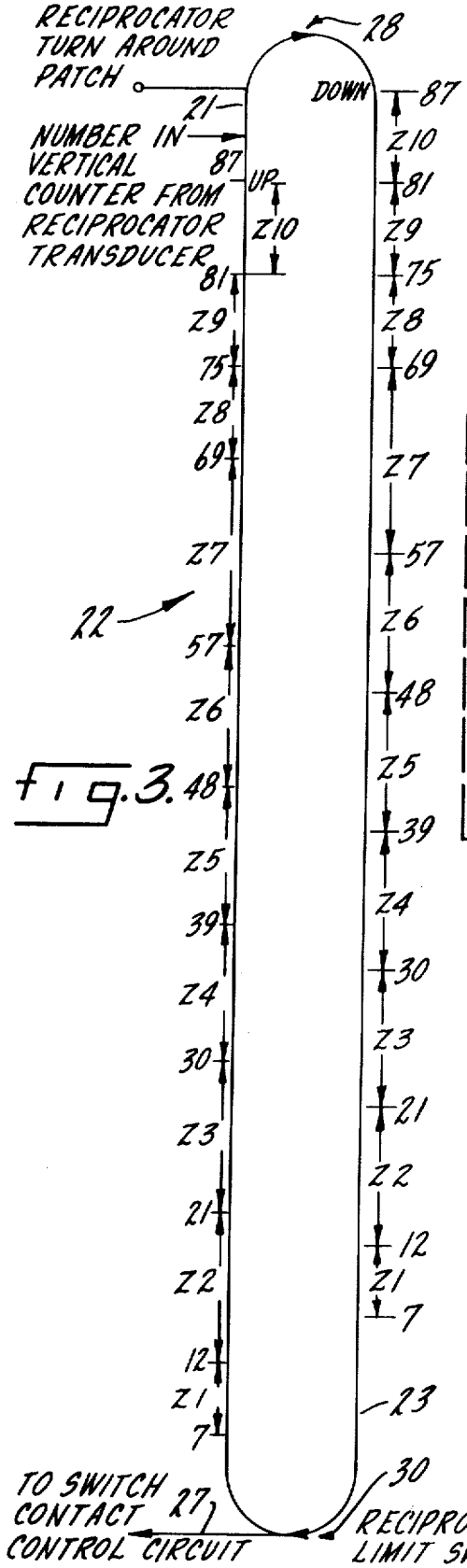


fig. 3.

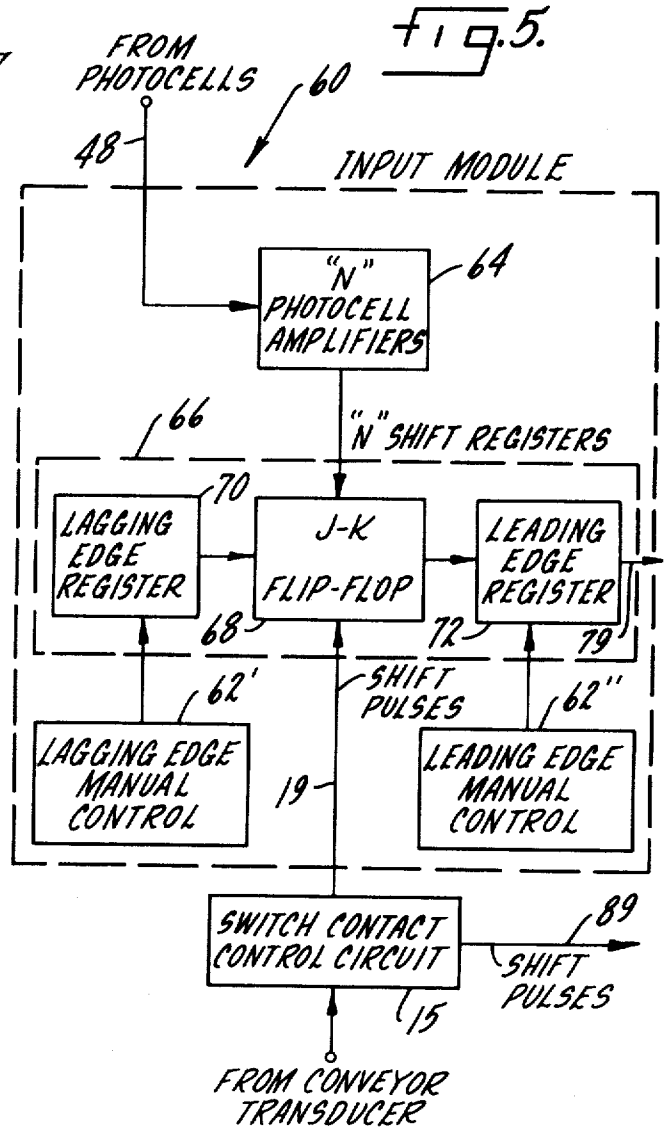


fig. 5.

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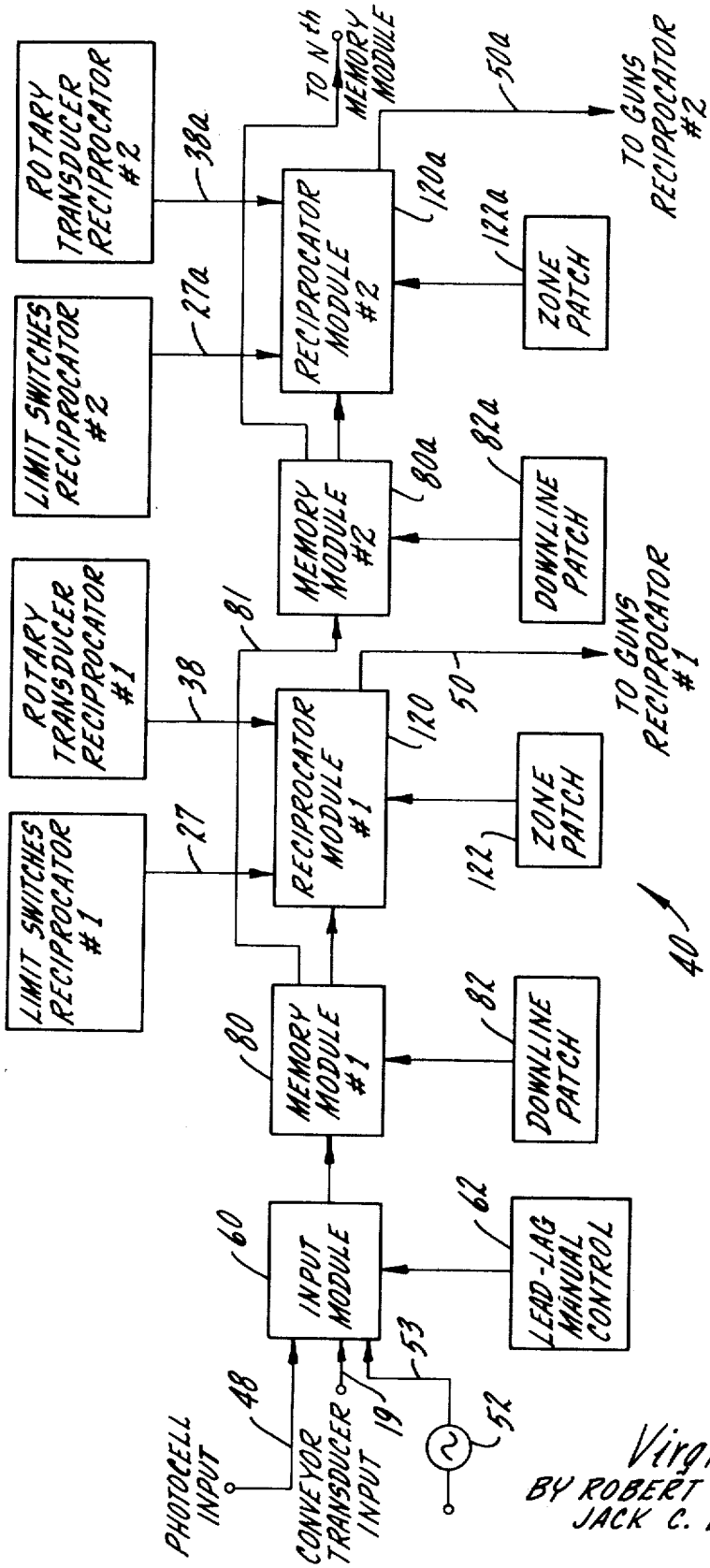


FIG. 4.

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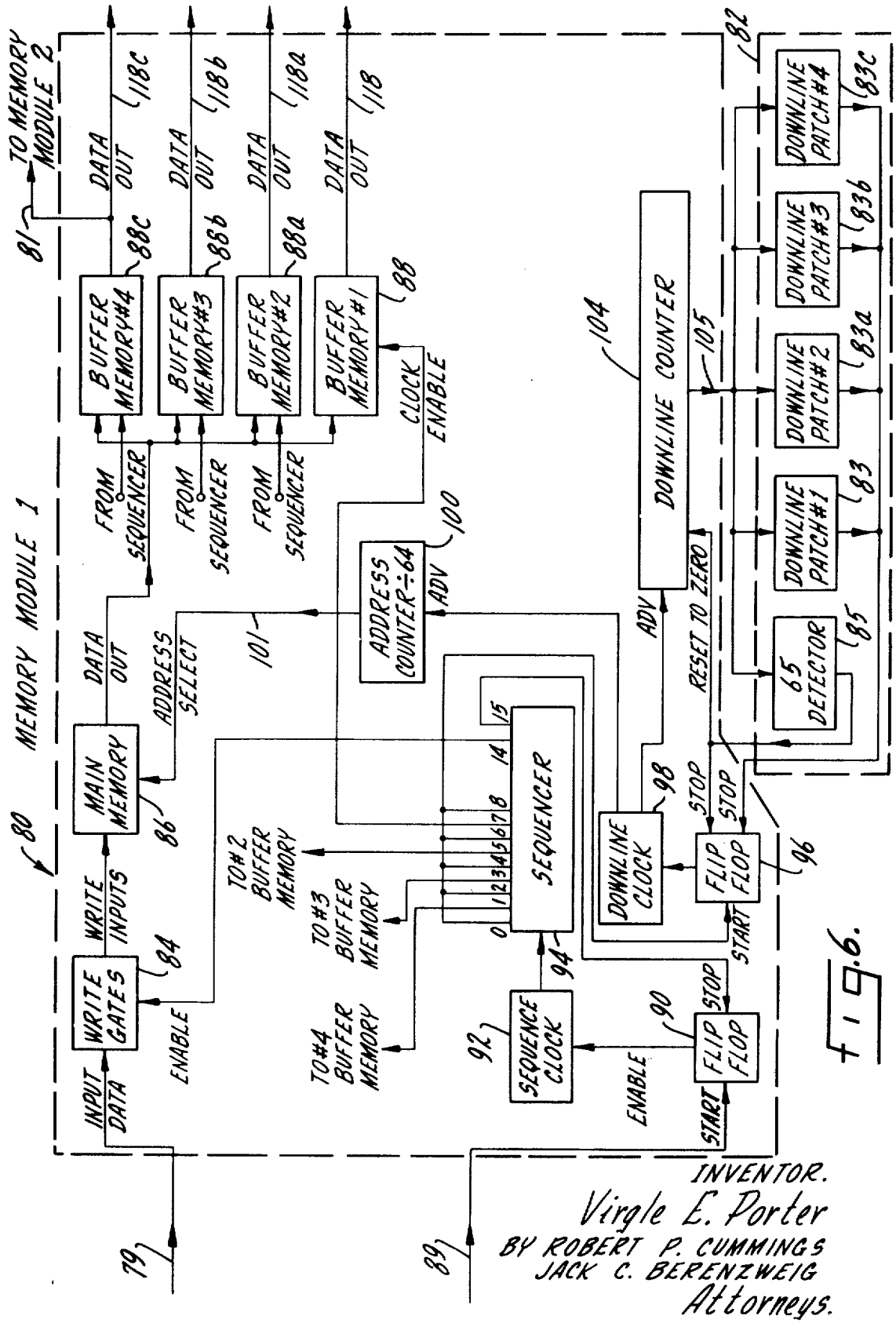


FIG. 6.

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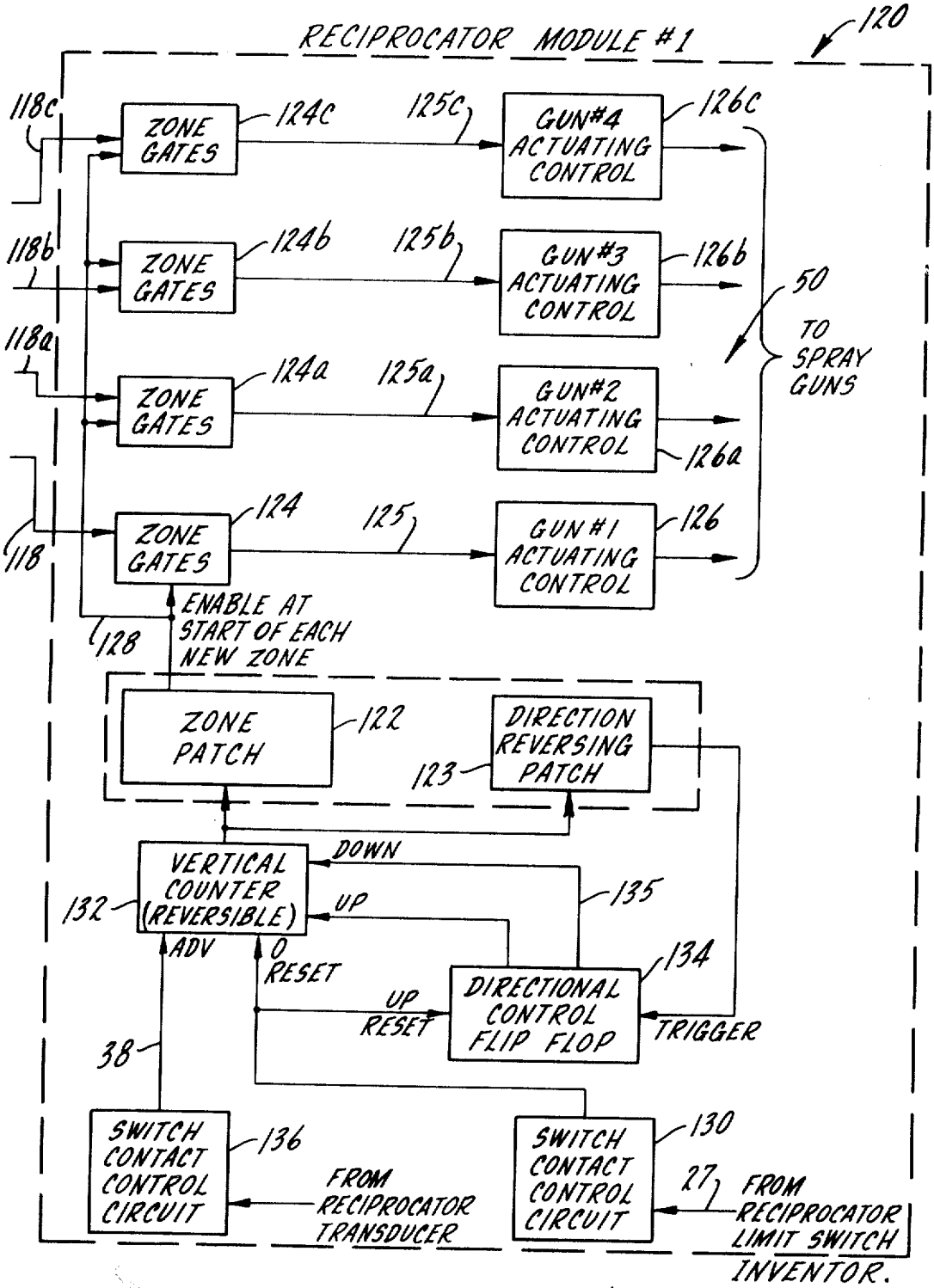


fig. 7.

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MULTILEVEL SPRAY CONTROL

BACKGROUND OF THE INVENTION

The present invention relates generally to spray coating systems of the type having a vertically reciprocating spray station and a conveyor means for transporting objects of diverse geometry past the spray station. More particularly, the invention is directed to a new and improved electronic control apparatus for automatically regulating the operation of the spray gun assembly in accordance with the sensed dimensions and the horizontal position of the various objects to be coated and in accordance with the vertical position of the spray gun assembly. Those concerned with the development of a paint spray control system have long recognized the need for developing a spray control which utilizes a horizontal and vertical recognition concept and which provides automatic operation of spray guns with a minimal waste of coating material.

Several known prior art spray gun control systems are able to sense the horizontal dimension and position of an object to be sprayed at an area remote from the spray station. In addition, one such a control system also includes means for measuring the vertical height of the part to be sprayed and is disclosed by John C. Fagan in copending United States Pat. application Ser. No. 771,865, filed Oct. 30, 1968, now U.S. Pat. No. 3,593,308 and assigned to Amtron, Inc. This spray control system includes a means for developing a digitized signal representative of the horizontal and vertical dimension of an object to be sprayed. The digitized information is then fed into a shift register and the output of the shift register actuates the spray guns on the spray gun assembly. Means are also provided for moving the spray gun assembly between two vertical limits. In order to accurately measure the vertical dimensions of the part, the above-identified application utilizes a plurality of shift registers, one shift register being associated with each incremental vertical zone. For example, if ten vertical zones are used, it is necessary to utilize 10 shift registers. Naturally, the utilization of a plurality of shift registers has proven to be expensive.

SUMMARY OF THE INVENTION

The present invention constitutes an improvement over copending United States Pat. application Ser. No. 771,865, filed Oct. 30, 1968, now Pat. No. 3,593,308 and assigned to Amtron, Inc. The present invention provides a spray control system which embraces all of the advantages of the above-identified application but which is more economical to manufacture. To attain this, the present invention utilizes a single memory storage matrix for storing a digitized information signal which is related to the dimensions of the object. The memory storage matrix replaces the need for the plurality of shift registers utilized in the copending application and furthermore, a single memory storage matrix may be utilized for sensing 16 vertical zones thereby greatly reducing the cost of the invention. In addition, other features are disclosed which constitute improvements over the copending application.

Therefore, an object of the present invention is the provision of a paint spray control system in which various objects are sensed at a position remote from the spray station and the information representative of the horizontal and vertical geometry of the part is effectively stored within a storage matrix until the object is advanced to a position adjacent to the spray control station.

Another object is to provide a control apparatus for a spray coating system which correlates the vertical position of the spray gun assembly with the dimensions of the part to be sprayed and which actuates the spray guns only when the part to be sprayed is of a proper dimension and in the proper position with respect to the spray gun assembly.

A further object is the provision of a control apparatus for a spray coating system utilizing a conventional XY memory matrix which is addressed to function in a manner similar to a shift register.

Still another object is to provide a control apparatus for a spray coating system which provides a selectively adjustable lead and lag overspray control means to assure that the spray gun assembly is operative for a sufficient duration to provide suitable coating of the initial and trailing edges of each object.

Still another object is to provide selectively adjustable underspray control means wherein a given portion of the object to be sprayed may be left uncoated.

Yet another object is the provision of a reciprocator control system for a spray gun assembly which utilizes feedback and a reversible counter.

A still further object is the provision of a spray gun coating system and a control apparatus therefor, which is capable of modular construction.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by references to the following detailed description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of a spray coating system employing a control apparatus constructed in accordance with the teachings of the present invention.

FIG. 2 is a graphical representation correlating the horizontal positions of the spray guns with the vertical sensing zones.

FIG. 3 is a schematic diagram showing the vertical zones associated with the spray gun assembly.

FIG. 4 is a block diagram of the electronic control apparatus utilized in the spray coating system shown in FIG. 1.

FIG. 5 is a block diagram of the input module shown in FIGS. 1 and 4.

FIG. 6 is a block diagram of the memory module shown in FIGS. 1 and 4.

FIG. 7 is a block diagram of the reciprocator module shown in FIGS. 1 and 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings wherein like reference numerals designate like or corresponding parts throughout the several views, there is shown in FIG. 1 a spray coating system 10 comprising a conveyor means such as a conventional overhead chain conveyor generally denoted by the reference numeral 12. Objects of diverse geometry 14 are suspended by hooks or the like from the conveyor at spaced intervals along its length. The conveyor 12 transports the objects, under the influence of a conventional drive system including a drive sprocket 16 toward a spray station generally denoted by the reference numeral 18. A transducer 17 is connected to the drive sprocket 16 and generates a signal via a lead 19 connected to an electronic control circuit 40.

The spray station 18 may generally comprise a plurality of reciprocator units 20, 20*a*, etc. It will be recognized that while FIG. 1 only shows two reciprocators 20 and 20*a*, any number of reciprocators may be utilized in accordance with the teachings of the invention. The reciprocators 20 and 20*a* may each be paired so that reciprocator 20 may coat the first side of object 14 and reciprocator 20*a* may coat the reverse side. Each reciprocator unit 20, 20*a*, etc., is conventional and may comprise a spray gun assembly or carriage 22, each having four laterally spaced spray guns 24, 24*a*, 24*b* and 24*c* as schematically represented in the drawings. The spray gun assembly 22 is adapted to be vertically reciprocated on a guide track 26 between spaced upper and lower limits 28 and 30, respectively. The spray gun assembly or carriage 22 is driven between the spaced vertical limits 28 and 30 by a conventional chain drive mechanism generally shown as numeral 32. The chain drive mechanism includes a drive sprocket 34 having attached thereto a transducer 36. The electrical output from transducer 36 is connected via lead 38 to the electronic control circuit 40.

In accordance with the present invention, the spray coating system further includes a sensor means generally designated as

numeral **42** comprising a light source **44** and a plurality of photocells **46**, **46***a*, **46***b*, *46c*, etc. The sensing means **42** is preferably positioned a predetermined distance in advance of the spray station **18**. The plurality of photocells **46***a*, **46***b*, **46***c*, etc., are vertically spaced from each other and form a plurality of sensing zones. Each sensing zone is defined as the distance between two consecutive photocell elements such as the distance between photocells **46***a* and **46***b*. An eclipse of the light source by the movement of an object **14** passing between the light source and the photocell, develops signal information on a lead **48** in a conventional manner. This signal information is coupled to the input of the electronic control circuit **40**.

The photocell arrangement or sensing means **42** in the present embodiment senses the presence or absence of an object and thereby, is able to provide information representative of the vertical dimension or height of the object **14**. An effective measure of the horizontal dimension, i.e., the width of the object **14** in the plane of the photocell, is provided by the transducer **17** attached to the drive sprocket **16**. The transducer **17** may comprise conventional reed switch plus a generator which is geared to the drive sprocket **16** of the conveyor as schematically denoted in the drawing, and is adapted to develop a reference signal pulse on its output lead **19** for each incremental unit of travel of the conveyor **12**. For example, as the conveyor **12** moves, it drives the rotary transducer **17**. The glass reed switch yields a fixed (e.g., **12**) number of closures per revolution. With suitable gearing, the closures can represent any convenient conveyor travel dimension (e.g., 3 inches). This transducer signal establishes the horizontal increments and by connecting the reed switch of the transducer **17** through a suitable contact control circuit **15** (FIG. **5**), shift pulses which are compatible with high-speed logic systems are generated along the lead **19**. A suitable switch contact control system is disclosed by Virgle E. Porter in copending United States Pat. application Ser. No. 661,894, filed Aug. 21, 1967, now U.S. Pat. No. 3,559,077 and assigned to Amtron, Inc.

The entire length of travel of the conveyor **12** may be electronically represented by the increment signals generated by the transducer **17**. Throughout the operation of the spray control system **10**, it is necessary to utilize the horizontal increments. Each spray gun **24**, **24***a*, etc., in FIG. **1** is a given horizontal distance from the sensing means **42**. This distance may be designated in increments. For example, the graph in FIG. **2** shows that spray gun **24** is 51 increments (153 inches) downline from sensing means **42** while spray gun **24***c* is 60 increments (180 inches) downline from sensing means **42**.

The electronic control circuit **40** is adapted to effectively and temporarily store signal information representative of the horizontal and vertical dimensions of the object **14** to be sprayed. In the present embodiment, this dimensional information is disclosed by the combined signal information on the input leads **48** and **19**. The electronic control circuit **40** processes the information received and compares the part dimension and horizontal position along the conveyor belt with the position of the individual gun assemblies **22**, **22***a*, etc. This latter information regarding the position of the individual gun assemblies is conveyed to the electronic control circuit **40** via the leads **38**, **38***a*, etc. This information is then compared with the information relating to the dimensions of the object **14** and its position along the conveyor **12** and when a proper relationship exists (i.e., the object **14** is horizontally positioned in front of the reciprocator units **20** and is of a dimension which coincides with the vertical position of the spray gun assembly **22**), a signal is generated on lead **50** or **50***a*, etc., which then actuates the individual spray guns **24**, **24***a*, etc., thereby spraying the object. As will be explained in greater detail below, if an object passes in front of the reciprocator unit **20** and if the vertical position of the spray gun assembly **22** is such that the spray guns are not in proper position with respect to the object, no signal would be generated on lead **50** and the guns would not spray the part. Therefore, in order to insure that the entire object **14** is sprayed, it is normally desirable to employ a plurality of reciprocator units so that the entire object will be sprayed eventually, regardless of the vertical positions of each of the spray gun assemblies **22**, **22***a*, etc.

It will be recalled that the sensing means **42** is adapted to define a plurality of sensing zones. In a like manner the vertical travel of the spray gun assembly **22**, **22***a*, etc., is also divided into spray zones so that the instantaneous position of each spray gun **24**, **24***a*, etc., may be determined. Establishment of the spray zones is based upon the height of the reciprocator unit **20** and the height of the sensing means **42**. The height of the reciprocator is divided into vertical increments in a manner similar to the horizontal increments. The height of each spray zone is equal to the height of its corresponding sensing zone. It is not necessary, however, that the zones each be the same height. For example, zone 1 may be 5 inches and zone 7 may be 12 inches. FIG. **2** shows the vertical spray zones **1** to **10** which correspond to the vertical sensing zones.

Referring to FIG. **3** in conjunction with FIGS. **1** and **2**, there is shown a schematic diagram of the vertical path of the spray gun assembly **22**. The spray gun assembly **22** is driven by the drive sprocket between upper and lower limits **28** and **30**, respectively. A limit switch (not shown) is provided at the lower limit **30** and generates a signal on a lead **27** when the spray gun assembly **22** reaches its bottom limit **30** of travel. In addition, a continuous pulse signal is generated by the transducer **36** being driven by the reciprocator drive sprocket **34** and represents the instantaneous vertical position of the spray gun assembly **22**. The pulses from the transducer **36** define vertical increments and in the preferred embodiment, each pulse or vertical increment is adapted to equal 1 inch. It will be remembered that each horizontal increment was representative of 3 inches. However, these relationships are only preferred but are not critical. FIGS. **2** and **3** show that no zones have been assigned to the turn around portions **21** nd **23** of the reciprocator unit **22**. Zone **1** has been defined as starting seven increments or 7 inches above the bottom limit of travel **30**. In the preferred embodiment, the total distance of vertical travel is 96 inches and the zones occupy 80 inches; however, this is purely arbitrary. It will also be noted in FIG. **3** that the upward zones on the left differ from the downward zones on the right. This is commonly referred to as towing and will be described in detail below.

Referring now to FIG. **4**, the electronic control circuit **40** comprises an input module **60**, a memory module **80** and a reciprocator module **120**. It will be noted that a memory module **80** is associated with each reciprocating unit. For example, memory module **80***a* is associated with reciprocator unit **20***a*. It will also be noted that reciprocator module **120** is also associated with each reciprocator unit. However, as will be explained below, only a single input module is necessary. The single input module may be used in conjunction with a plurality of memory modules and reciprocator modules. The only requirement is that the power supply **52** be powerful enough to drive the several modules.

Connected to the input of the input module **60** is a lead **48** from the sensor means **42** and a lead **19** from the conveyor transducer **17**. A source of electrical power, schematically shown as numeral **52**, is also connected via a lead **53** to the input module **60**. Also connected to the input of input module **60** is a lead-lag manual control circuit **62**. In many coating applications, it is desirable to turn the spray guns on just before the part arrives in order to coat the corners or front edges. Lead-lag manual control circuit **62** provides for this. Furthermore, it is often desired to have a similar control for use on the lagging edge of the part and the lead-lag of manual control circuit **62** provides for the enabling of the spray guns for a predetermined amount of time which is greater than that indicated by the signal information generated by the sensor means **42**. Lastly, lead-lag manual control circuit **62** also provides for an underspray characteristic. This is used when it is desired to allow a portion of the object **14** to go uncoated. In this manner, even though the sensor means **42** indicates that the spray gun should be actuated, the lead-lag manual control

circuit will prevent actuation thereby enabling the object **14** to pass uncoated for a predetermined distance.

The output from the input module **60** is fed to the input of the memory module **80**. The memory module **80** is used to store the information representative of the dimensions of the object to be sprayed as well as its horizontal position along the conveyor. The memory module **80** is always paired with a reciprocator module **120** and must be used in conjunction therewith. The data stored in the memory module **80** is received from the input module **60**. A downline patch **82** is also provided to the input of memory module **80**. The downline patch electrically represents the horizontal position in increments of each of the spray guns **24**, **24***a*, **24***b*, as will be explained in conjunction with FIG. **6**. Lastly, the output from the memory module **80** is fed to the input of the reciprocator module **120**. Also connected to the input of the reciprocator module **120** are leads **27** and **38** which provide signal information indicative of the vertical position of the spray gun assembly **22**. A zone patch **122** is provided to the input of the reciprocator module **120** in order to electrically indicate when the reciprocator passes from one vertical spray zone to the next. The data from the memory module **80** is compared with the vertical location of the spray gun assembly **22** as it moves vertically up and down between its limits **28** and **30**. When the memory module **80** and the reciprocator module **120** indicate that the object **14** is in the correct relative position with respect to the spray gun assembly **22**, a signal is generated along lead **50** which actuates a solid-state relay thereby actuating a spray gun **24**, **24***a* or **24***b*, etc.

It can also be seen from FIG. **4** that the output from memory module **80** is also transmitted via lead **81** to the input of a second memory module **80***a*. Memory module **80***a* is associated with reciprocator unit **20***a*. The output from the memory module **80***a* is transmitted to the input of a reciprocator module **120***a* which in turn controls the spray gun associated with spray gun assembly **22***a*. If it is desired to have more than two reciprocator units **20** and **20***a*, the output from the memory module **80***a* would then be connected to another memory module **80***b* (not shown) and the output from the memory module **80***b* would be fed to a reciprocator module **120***b* (not shown). From this, it can be seen that any number of reciprocator units **20** having spray gun assemblies **22** may be provided. However, it is to be remembered that each reciprocator unit has associated with it a single memory module and a single reciprocator module. As mentioned previously, only a single input module **20** (having a large enough power supply) is required regardless of the number of memory modules **80**, **80***a*, **80***b*, etc., reciprocator modules **120**, **120***a*, **120***b*, etc., and reciprocator units **22**, **22***a*, **22***b*, etc.

A more detailed understanding of the spray coating system **10** may be had by reference to the exemplary electronic control circuit **40** illustrated in FIGS. **4** through **7**. As shown, the electronic control circuit **40** comprises an input module **60**, a memory module **80**, and a reciprocator module **120**. It will be recognized that one memory module and one reciprocator module will be associated with each reciprocator unit **20** which make up the spray station **18**. For simplicity and clarity of explanation, only one memory module and one reciprocator module are shown and furthermore, the control circuit shown in FIGS. **4** through **7** is used to actuate only four guns on a single spray assembly **22**. It will be recognized that any number of spray guns and spray stations may be utilized and control circuit **40** would be enlarged to encompass these added spray guns and spray stations.

The input module **60** comprises N photocell amplifiers **64**. One photocell amplifier **64** is associated with each of the photocells **46***a*, **46***b*, etc., (FIG. **1**). The output from each photocell amplifier **64** is fed into a shift register **66**. One shift register is utilized for each photocell **46**, **46***a*, etc., in the sensor means **42**. Referring briefly to FIG. **1**, the photocells **46**, **46***a*, **46***b*, etc., are arranged so that certain of these are eclipsed as the objects to be coated **14** pass by on the conveyor **12**. The number of photocells eclipsed is a measure of the part height. As mentioned above, the distance between each cell represents a sensing zone. The cells are connected to individual photocell amplifiers **64** which then deliver information bits to the input of their respective shift registers **66**. In the preferred embodiment, each of the shift registers **66** comprise a nine-stage shift register having a single-stage J–K flip-flop **68** serially connected to two four-stage shift registers designated as a lagging edge register **70** and a leading edge register **72**. Both the lagging edge register **70** and the leading edge register **72** are four-stage conventional shift registers. The output from the photocell amplifier **64** is fed into the input of the J–K flip-flop **68**. In addition, the output from the switch contact control circuit **15** associated with the rotary transducer **17** is also fed into the J–K flip-flop **68**. As mentioned above, the switch contact control circuit **15** is fully disclosed in copending application Ser. No. 661,894, filed on Aug. 21, 1967, and assigned to Amtron, Inc.

As the conveyor **12** moves, it drives the rotary transducer **17** which consists of a glass reed switch, a permanent magnet and spoked rotating disc. This arrangement, as mentioned previously, yields a fixed number of closures per revolution and with suitable gearing, the closures may represent any convenient conveyor travel dimension such as 3 inches. This establishes horizontal increments and by connecting the reed switch through the switch contact control circuit **15**, shift pulses are fed into the J–K flip-flop. The shift pulses initiate a routine to be described later and also clock the J–K flip-flop **68**.

If the photocells **46**, **46***a*, **46***b*, etc., previously referred to, are dark thereby being eclipsed, then associated J–K flip-flops **68** are maintained in a set or "one condition." Shift pulses from the switch contact control circuit **15** then clock the J–K flip-flop **68**. Subsequent stages of the shift register **66** then respond to the serial data representing the dimension of the object **14**.

The remaining eight stages of the shift register **66** comprise a leading edge register **72** and a lagging edge register **70**. In many coating applications, it is desirable to actuate the spray guns just before the object arrives in order to coat the corners or front edges. The leading edge manual control **62''** established this adjustment and may comprise a rotary switch having several positions numbered 0, 1, 2, 3, etc. These numbers represent horizontal increments of off-spray control. Assume an object is three increments wide, if the leading edge manual control **62''** is set for **2**, spraying will persist for five increments assuming that there was "0" set on the identical lagging edge manual control **62'**. These controls **62'** and **62''** in essence supply additional "bits" of information into the shift register **66**. Thus, both the lagging edge register **70** and the leading edge register **72** supply additional bits of information to the memory module **80** in order to control the amount of spraying being done independent of the actual dimensions of the object.

Data bits from the last stage of the leading edge register **72** of the shift register **66** is made available to the input of the memory module **80**. More specifically, the bits of information which are representative of the vertical dimension of the object **14** as sensed by the photocells **46**, **46***a*, etc., and the horizontal dimension of the object and sensed by the transducer **17** and the eclipsed photocells are made available to a series of write gates **84** which are used in conjunction with an XY matrix or main memory **86**. The write gates **84** are conventional and in the preferred embodiment comprise a triple three-input NOR gate. Three triple three-input NOR gates are utilized for each sensing zone.

The main memory **86** is a conventional XY matrix and may be made up of four 16-bit scratch pad memories for each sensing zone. For ease of construction, these four 16-bit scratch pad memories associated with each zone may be packaged as a single printed circuit board, one printed circuit board being associated with each sensing zone. Connected to the output of each printed circuit board are four buffer memories **88**, **88***a*, **88***b*, **88***c*. Buffer memory **88** is associated with spray gun **24**, buffer memory **88***a* is associated with spray gun

24*a*, buffer memory 88*b* is associated with spray gun 24*b* an buffer memory 88*c* is associated with spray gun 24*c*. If there are 10 zones, there are 10 buffer memories associated with each spray gun. In the preferred embodiment, each of the buffer memories is conventional and comprises dual D flip-flop circuits.

In addition to the write gates 84, the main memory 86 comprises a flip-flop 90 which is connected to the output of switch contact control circuit 15 and a sequencer clock 92 connected to the output of the flip-flop 90. The sequencer clock 92 is used to sequence a routine sequencer or counter 94. In the preferred embodiment, the routine sequencer 94 may comprise a conventional divide by 16 counter.

As each shift pulse occurs on the lead 89 connecting the switch contact control circuit 15 to the flip-flop 90, a memory routine is initiated. This routine is set up by the routine sequencer 94 as well as the flip-flop 90 and the sequencer clock 92. When a shift pulse occurs, which signals the start of the routine, the flip-flop 90 is set. This flip-flop then enables the sequencer clock 92 which runs until the flip-flop 90 is reset. The flip-flop 90 is reset only after the routine sequencer 94 counts 16 counts after its initiation. The sequencer clock 92 is adapted to provide a clock pulse every 1 millisecond. However, this is arbitrary, and the response time of the routine sequencer 94 is the only limiting factor.

The output of time slots 0, 2, 4, 6 and 8 of the routine sequencer 94 are connected to a flip-flop 96 which in turn is connected to a 10-microsecond downline clock 98. The output from the downline clock 98 is fed to an address counter 100 and to a downline counter 104. The address counter in the preferred embodiment may comprise a conventional divide by 64 counter and decoder while the downline counter 104 may comprise a conventional divide by 100 counter and decoder. The capacity of the address counter 100 is arranged to be slightly greater than the distance in increments from spray gun 24*c*, the furthest downline from the sensing means 42. Briefly referring to FIG. 2, it can be seen that spray gun 24*c* is 62 increments downline from the sensing means 42 and therefore, the address counter 100 is a divide by 64 counter. The output lead 101 of the address counter 100 is connected to the main memory 86 and is used to address the main memory 86. A downline patch 82 is connected to the output lead 105 of the downline counter 104. As mentioned previously, downline patch 82 represents the downline location in increments of each of the spray guns 24, 24*a*, 24*b* and 24*c*. For example, the downline patch may comprise a series of leads 83, 83*a*, 83*b* and 83*c*, associated with its respective spray guns connected to the output terminals of downline counter 104 equal to increments 51, 54, 57 and 60 (see FIG. 2). In addition, an additional patch 85 is provided to detect when the downline counter has reached 65 in its count. Patch 85 in the preferred embodiment may comprise a dual four-input expandable NOR gate. When the downline counter has reached 65, the downline counter 104 is reset to zero thereby initiating a new cycle. The downline patch 82 in essence identifies when the counter has stored enough counts to represent the spray guns' downline location from the sensing means 42. In the preferred embodiment, it has been assumed that the downline end of the reciprocator unit 22 is 64 increments downline from the sensing means 42 and therefore, when the downline counter 104 reaches the number 65, it can safely be assumed that the object 14 has passed beyond the reciprocator unit 20 and thus, the downline counter can be recycled to further interrogate the main memory with regard to an additional object 14.

Briefly, before describing in detail the method in which digitized information representative of the dimensions of the object to be coated is fed into the main memory 86 and the manner in which this main memory 86 is interrogated, the physical description of the reciprocator module will be discussed. The output 118 of each of the buffer memories per zone 88, 88*a*, 88*b* and 88*c* are respectively fed into the reciprocator module 120. The output of each buffer memory 88, 88*a*, etc., is fed to the input of its respective zone gate 124, 124*a*, 124*b* and 124*c*. A zone gate is provided for each buffer memory. The output from each of the zone gates is fed to a gun-actuating control circuit 126, 126*a*, 126*b* and 126*c*. The gun-actuating control circuits 126, 126*a*, etc., are conventional power circuits which may be used to energize the solenoid of the individual spray guns whenever a signal is present on their respective input leads 125, 125*a*, 125*b*, etc. A single gun-actuating control circuit is provided for each spray gun. A signal will only be present on leads 125 when a signal is received from the output of the zone gates 124. The zone gates 124 in the preferred embodiment may comprise conventional coincidence logic gates and in order to receive an output, it is required that there be a signal from both the lead 118 as well as a signal on a lead 128. The lead 128 comes from the output of the zone patch 122. As mentioned previously, the zone patch 122 defines the vertical spray zone in which the spray assembly 22 is currently situated at a given time. If a signal is present on lead 118 indicating that photocells 46 and 46*a* (zone 1) were eclipsed by the object 14 and if a signal is present on lead 128 corresponding to zone 1, the spray gun 24 will be actuated.

It will be remembered that the reciprocator unit 20 provides two output signals to the reciprocator module 120. The first signal relates to the momentary closure of a limit switch (not shown) which represents that the spray gun assembly 22 has reached the bottom limit 30 of its travel. This provides a signal on the lead 27. This signal in the lead 27 is fed to a switch contact control circuit 130 which is fed to the reset terminal of reversible vertical counter 132. The switch contact control circuit 130 is identical to the switch contact control circuit 15 associated with the input module. The second signal received which is indicative of the position of gun assembly 22 is from the transducer 36. When the bottom limit switch is actuated, the reversible counter 132 is reset to zero and is directed to count upward. Thereafter, pulses from the rotary transducer 36 (representative of the vertical increments of travel of the gun assembly 22) sequence the vertical counter upward and through the zone patch numbers. In FIG. 3, it can be seen that a count between 7 and 12 is indicative of zone 1 while a count between 12 and 21 in the vertical counter 132 would be indicative of zone 2, etc. As the vertical counter 132 is passing through the individual sensing zones, as patched by the zone patch 122, a signal is placed on the input lead 128 corresponding to the zone represented by the count in vertical counter 132. If a signal happens to be present on any one of the leads 118, 118*a*, etc., corresponding to that same zone, the associated spray gun will be energized.

When the spray gun assembly 22 reaches the top of its stroke, an additional patch number represented by direction reversing patch 123 is encountered. This is the turnaround location above zone 10 (FIG. 3) and it directs the vertical reversible counter 132 to start counting downward. This reversal is accomplished by applying a trigger pulse to the input of a directional control flip-flop 134 which then pulses the vertical counter via the lead 135. Thus, as the reciprocator moves downward, the zones are scanned in reverse from what they would have been for the upward movement as is shown in FIG. 3.

With the basic configuration of the electronic control circuit 40 as well as the spray coating system 10, now in mind, a detailed description of the operation of the spray coating system 10 will now be described in connection with FIGS. 1 through 7. Assuming for the moment that we desire to coat a single object 14 and that this object has a vertical height such that it would eclipse four photocells and furthermore, let us assume that its horizontal width is such that it is representative of four increments of travel, i.e., a photocell will be eclipsed for the length of time necessary to move four increments, of travel, the description will then take place with this in mind. As the conveyor 12 moves, carrying the object to be coated 14, it drives the rotary transducer 17. The output from the rotary transducer 17 is fed to the switch contact control circuit

15 and provides distinct output pulses on the leads 19 and 89. These pulses are representative of the horizontal length of travel of the conveyor 12. If we assume whenever one of the photocells is eclipsed, or in a dark condition, the J–K flip-flop 68 is maintained in a set or "one condition." With regard to the four-by-four part, the first four photocells 46*a*, 46*b*, 46*c* and 46*d* will remain in a dark or eclipsed condition for four increments of travel of the conveyor or, in other words, four pulses from the rotary transducer 17. These pulses cause a shifting action in the J–K flip-flop 68 which provides a digital signal representative of the horizontal and vertical object dimensions. The shift pulses from the switch contact control circuit 15 also initiate the sequencer routine through the flip-flop 90. The digitized data information from the J–K flip-flop 68 as well as from the leading edge register 72 and the lagging edge register 70 are fed into the write gate 84 and into the main memory 86 in a conventional manner where they are stored. It will be remembered that the main memory 86, an XY memory matrix, has a portion associated with each specific zone defined by the photocells that have been eclipsed, thus, retaining a digitized signal representative of the vertical height of the part. In addition, the number of bits stored in the matrix enables the memory 86 to maintain knowledge of the length of time that the photocell has been eclipsed, i.e., the horizontal dimension of the object. Information can only be written by the write gates 84 when the sequencer 94 is set on a count of 14 as shown in FIG. 5. When the sequencer 94 is set at a count of 14, the write gates 84 are enabled and the information from the shift register 66 is written into the main memory 86.

To start a sequence, as the shift pulses from the switch contact control circuit 15 occur, the flip-flop 90 and the sequencer clock 92 set the routine sequencer 94 to zero, thereby providing a signal to flip-flop 96 and the downline counter 98. This advances the address counter 100 to the downline location (in increments) for gun number 24*c*, that is, the spray gun which is furthest away from the photocell or, in other words, is the downline gun. The decoded zero output from the routine sequencer 94 is connected to the flip-flop 96 and the downline clock 98. The flip-flop 96 enables the downline clock 98 to advance both the address counter 100 and the downline counter 104 in unison. The number of counts advanced by both counters is dependent upon the downline patching for the first or smallest number encountered in the downline counter. It will be remembered that the smallest number encountered in the downline counter 104 must correspond to the oldest information present in the main memory 86, and this information corresponds to the location of the gun 24*c*, i.e., the gun furthest from the sensor means 42. When this number is present in the downline counter 104 (represented by downline patch 83), the flip-flop 96 is reset halting both the downline counter 104 and the address counter 100. This action will occur within the one time slot (1 millisecond as determined by the sequencer clock 92) owing to the relative speed of the clocks. The address counter 100 is now at the position in the memory desired to address the information with regard to gun number 24*c*. During the second count of the routine sequencer 94 (count of one) the clock leads for the buffer memory 88*c* associated with the gun 24*c* are energized so that data bits from the present selected address (gun 24*c*) of the main memory 86 are stored in the buffer memory 88*c*. This transfer is nondestructive owing to the way in which the memory chip is designed. The information from the main memory is then temporarily stored in the buffer memory until it is ready for further use. Thus, it can be seen that there are, in essence, two memories, the main memory and the buffer memory. The information in the buffer memory is a temporary storage and is designed to deliver the information relating to dimensions of the object to the gun location at the exact correct time when the part arrives in front of the gun location. However, since the individual guns are moving up and down as determined by the reciprocator, each spray zone must be compared with the corresponding photocell sensing zone and the memory bits representative of the sensing zone in order to determine whether or not to spray paint at a given time.

After another millisecond count, the routine sequencer is advanced to a count of two, again enabling the flip-flop 90 and the sequencer clock 92 and again advancing the downline counter 104 and the address counter 100 to next highest number which corresponds to the downline patch location for gun 24*b* and the position of memory 86 associated with gun 24*b* is addressed. Thereafter, the pattern just described repeats for all the remaining guns which, in this case, is a total of four. This takes the sequencer 94 through step 7. During step 8, the downline counter 104 and the address counter 100 are again advanced for the last time during this cycle. The number sought is fixed at one count more than the total capability of the address counter. At the conclusion of this step, the address counter is always at N+1 with respect to where it was prior to the shift pulse. In the control circuit as built, the address counter has a maximum count of 64. Therefore, if this counter is advanced 65 counts during each routine, it will come to rest at N+1, where N is the count prior to the routine. When 65 is detected at the downline counter, by the patch 85, the flip-flop 96 controlling the sequencer clock 92 is again turned off. In addition, the downline counter 104 is reset to zero as can clearly be seen in FIG. 6. This is required because, in order for the sequencing to work, the downline counter must be capable of counting to a number higher than 64 (the address counter capacity) and must always be reset to zero so that the next cycle will be correct. It will be noticed, however, that the address counter 100 never has to be reset. It will also be noted that counts 9 through 13 of the sequence counter 94 are never used. However, this "dead time" or nonuse of these counts may be reduced or lengthened to accommodate the size of the system and to compensate for typical component variations in clock rates.

As described earlier, during the routine sequencer 94's count of 14, the write gates 84 are enabled so that new data may be stored at an address of N+1. This routine has the effect of converting the main memory 86 into a large shift register without the necessity of utilizing expensive shift registers and without the necessity of using a shift register for each zone which is defined. When the new data is written into the main memory 86, the old data is finally lost. When the 16th millisecond (count number 15) in the routine sequencer 94 occurs, the flip-flop 90 controlling the sequencer clock 92 is reset stopping the cock 92. This completes the routine. At this time, data for all four guns is available in the buffer memories 88 through 88*c*. Bits from the buffer memories 88 through 88*c* are presented to their respective zone gates 124 through 124*c* on a sustained basis. However, because the zone gates require two signals on the inputs, this information does not automatically actuate the respective spray guns. It is first necessary to compare the information from the buffer memories to the current position of the reciprocator 20 and thus, determine when a particular spray gun shall be energized.

Before discussing in detail the method in which the vertical position of the spray gun can be ascertained, it is helpful to reflect back and to see the function of the counters and the main memory in the overall operation of the system. Both the address counter 100 and the downline counter 104 act in cooperation to decode or interrogate the main memory 86 and pass the information which had been stored in the main memory 86 to the buffer memories 88 through 88*c*. This then completes the function of the memory module since the digitized information representative of the dimensions of the object to be sprayed has been transmitted to the reciprocator module 120.

Feedback from the reciprocator unit 20 identifies the instantaneous position of the spray gun assembly 22. As mentioned before, this is accomplished through the use of the transducer 36 and the limit switch (not shown). The signals from each of these pass through switch contact control circuits 136 and 130, respectively, which are identical to switch

contact control circuit **15**, and provide pulses to the vertical counter **132**. As the limit switch closes, the vertical counter **132** is set to zero and a directional control flip-flop **134** is reset so that the counter will subsequently count upwards. As the reciprocator moves upwards through the zones, the counter responds accordingly, keeping track of the instantaneous position. For 10 zones, as shown in FIG. **3**, 11 numbers are patched which define the limits of each zone and when a match occurs between the number in the vertical counter **132** and a patched number as represented by the zone patch **122**, the respective zone gates **124** through **124***c* which contain the information representative of the match are set and the gun-actuating control circuits **126** though **126***c* associated therewith actuates the respective spray gun. Zone gate **124** which has been set remains in that condition until a new match is encountered at the next patched number. When the top of the uppermost zone occurs, the zone flip-flops **124** through **124***c* are reset and the spraying ceases. As the reciprocator continues upward nearing the top, the turnaround patched number as represented by direction reversing patch number **123** is encountered. This reverses the direction of counting of the vertical counter **132** by triggering the directional control flip-flop **134** so that subsequently the counter **132** will count downward. It can be seen in FIG. **3** that this has the effect of actually lifting the travel zones upwardly with respect to the previous zones when the turnaround occurs ahead of dead center point **28**. This effect is known as towing and is desirable because the towing action of the reciprocator which cants the spray guns upward for up travel and downward for down travel aids in the uniform coating of the parts since the coating coming from the spray guns does not strike the parts in a horizontal plane and this aids in the angle of mist as it leaves the spray gun nozzle. Because the turnaround patching is a separate and isolated function, great variations in operation and in the angle of towing are possible and furthermore, since each spray zone dimension is in a separate patch **122**, the zones need not be alike. While the control as shown has been equipped with four spray guns **24** through **24***c*, and 10 zones, 64 horizontal increments, and 111 vertical increments, these numbers are completely arbitrary and should not be considered as limiting.

Referring to FIGS. **1**, **4**, **5**, **6** and **7**, it can be seen that the entire electronic control circuit **40** is of modular construction and is very economical to manufacture. Furthermore, since this is a digital system, it is relatively immune to variations in conveyor or reciprocator speeds. The component parts of the electronic control circuit **40** are all conventional and may be readily purchased from various manufacturers. A full description including wiring diagrams of the electronic spray control **40** may be found in an Amtron publication published on Oct. 9, 1969, entitled "Instruction Manual For Multilevel Spray System."

One embodiment of an electronic control circuit **40** which meets the above requirements contains the following exemplary components; however, it is to be recognized that these components are merely illustrative of the invention and various modifications may be made without departing from the spirit and the scope of the invention.

Element	Manufacturer's name and part number	Quantity
J-K flip-flop 68	Signetics SP 322-B, dual J-K flip-flop	1/zone.
Lagging edge register 70	Fairchild FC 9300, 4 bit shift register	1.
Leading edge register 72	Fairchild FC 9300, 4 bit shift register	1.
Write gates 84	Signetics SP 370-A, triple three input NOR gate	3/zone.
Main memory 86	Motorola MC 4005L, 16 bit scratch pad memory	4/zone.
Buffer memory 88	Signetics N 8828A, dual D flip-flop	2/zone.
Address counter 100 (÷64)	Signetics SP 322D, dual J-K flip-flop	3.
	Signetics SP 380, quad 2 input NOR gate	1.
	Signetics N 8880, quad 2 input NAND gate	2.
Route sequencer 94 (÷16)	Fairchild FC 9316, 4 bit binary up counter	1.
	Fairchild FC 9301, 1/10 decoder	1.
	Signetics N 8816, dual 6 input NAND gate	1.
Sequencer clock 92 (IMS)	Fairchild FC 9601, monostable multivibrator	1.
Downline clock 98 (10MS)	Fairchild FC 9601, monostable multivibrator	1.
Downline counter 104 (÷128 modified to count to 65)	Fairchild FC 9316, 4 bit binary up counter	1.
	Signetics SP 322B, dual J-K flip-flop	2.
	Fairchild FC 9311, 1/16 decoder	4.
	Signetics N 8880, quad 2 input NAND gate	1.
65 count detector 85	Signetics SP 317A, dual 4 input expandable NOR gate	1.
Reversible vertical counter 132 (÷111)	Sylvania SM 183, up/down 4 bit binary counter	1.
	Fairchild FC 9306, up/down BCD counter	1.
	Fairchild FC 9311, 1/16 decoder	7.
	Fairchild FC 9315, 1/10 decoder	1.
Zone gates 124	Signetics SP 380A, quad 2 input NOR gate	1/zone/gun.
Gun actuator control circuit 126	Amtron ER series relay for energizing spray gun solenoid	1/gun.
Directional control flip-flop 134	Signetics SP 322B, dual J-K binary	1.

[1] Equivalent to one buffer/gun/zone.

In summary, therefore, it can be seen that electronic control circuit **40** comprises one photocell amplifier **64** per photocell or sensing zone, one J-K flip-flop **68** per sensing zone, one lagging edge register **70** per sensing zone, one leading edge register **72** per sensing zone, one write gate **84** per sensing zone, one main memory per sensing zone, one buffer memory **88** per gun per sensing zone, one address counter **100**, one sequencer **94**, one downline counter **104**, one sequencer clock **92**, one flip-flop **90**, one downline clock **98**, one flip-flop **96**, one downline patch **83** per gun, one zone gate **124** per gun per zone, one vertical counter **132**, and one gun-actuating control circuit **126** per gun. It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

What is claimed is:

1. In a spray coating system of the type including a spray station, with at least one spray gun assembly having at least one spray gun thereon, and conveyor means for transporting objects of diverse geometry past said spray station, control apparatus comprising:

input means including a sensing device, positioned a predetermined distance in advance of said spray station, for developing predetermined signal information related to the dimensions of an object moving on said conveyor means past said sensing device;

first memory means, including a memory storage matrix for storing said signal information related to the dimensions of said object;

an actuating means associated with each of said spray guns and responsive to a predetermined input signal for operating its associated spray gun for a time interval related to the duration of said input signal;

a second memory means associated with each of said spray guns and connected between said first memory means and the actuating means associated with its respective spray gun, wherein each of said second memory means produces a signal which is introduced into the input of its associated actuating means; and

means for selectively interrogating said first memory means when said sensed object is advanced by said conveyor means to a predetermined position with respect to each of said spray guns whereby said signal information in said storage matrix is selectively transferred to said second

memory means.

2. The control apparatus of claim 1 wherein said input means comprises means for generating a sequence of digitized information signals related to the dimensions of each object.

3. The control apparatus of claim 2 further comprising:

a plurality of said sensing devices spaced vertically relative to the direction of motion of said conveyor means to thereby define a corresponding plurality of vertically spaced sensing zones;

a reciprocator carriage for continuously transporting said spray gun assembly between predetermined first and second vertical limits; and

means for developing a reciprocator signal indicative of the vertical zone location of each of said spray guns on said spray gun assembly.

4. The control apparatus of claim 3 further comprising means for comparing said vertical zone position of each of said spray guns with said dimensions of said sensed object and with said position of said sensed object and producing said predetermined input signal for said actuating means only when said sensed object and said spray gun are in a predetermined position relative to each other.

5. The control apparatus of claim 4 wherein said comparing means comprises logic means associated with each of said spray guns and connected between the output of said second memory means, the output of said reciprocator signal means and the input of said actuating means wherein said logic means provides said predetermined input signal to said actuating means only when said reciprocator signal and said signal from said second memory means indicate that said sensed object and said spray gun are in said predetermined position relative to each other.

6. The control apparatus of claim 5 wherein said means for developing said reciprocator signal comprises:

a first signal generator means for developing an output signal pulse for each incremental unit of travel of said reciprocator carriage;

zone patch means for identifying each spray zone through which said reciprocator travels; and

vertical counter means adapted to be incremented by said first signal generator means wherein said reciprocator signal is produced at the output of said vertical counter means when said number of pulses stored in said vertical counter means equals said patch means for one of said spray zones.

7. The control apparatus of claim 6 wherein said predetermined input signal for said actuating means is produced only when said signal from said second memory means corresponds to said sensed object having passed through a vertical sensing zone corresponding to said vertical spray zone represented by said reciprocator signal.

8. The control apparatus of claim 7 wherein said vertical counter is reversible and wherein said means for developing said reciprocator signal further comprises:

a second signal-generating means for resetting said vertical counter to zero when said reciprocator carriage reaches said first vertical limit; and

means for reversing said vertical counter when said reciprocator carriage reaches said second vertical limit wherein said means for developing said reciprocator signal is thereby responsive to both directions of travel of said reciprocator carriage.

9. The control apparatus of claim 2 wherein said interrogating means comprises:

address counter means adapted to select the location of said signal information in said first memory means; and

decoder means adapted to sequentially advance said address counter means to enable said address counter means to select said information location in said memory storage matrix corresponding to each of said spray guns and further adapted to enable said information located by said address counter means to be transferred to the second memory means associated with said spray gun being addressed.

10. The control apparatus of claim 9 wherein said decoder means comprises:

a downline counter means;

patch means associated with said downline counter means for identifying the downline position of each of said spray guns with respect to said sensing devices; and

a sequencing means adapted to advance said address counter and said downline counter means until the total count stored in said downline counter means corresponds to the downline position of one of said spray guns and wherein said downline counter produces a pulse stopping said address counter and thereby enabling said address counter to locate said digitized signal information corresponding to said spray gun.

11. The control apparatus of claim 10 wherein said sequencing means enables said second memory means associated with said spray gun to receive said information located by said address counter means after said address counter means has stopped.

12. The control system of claim 11 wherein said sequencing means is adapted to enable said first memory means to receive new information signals from said input means after said address counter means has located the information corresponding to each of said spray guns.

13. The control apparatus of claim 12 wherein means are provided for resetting said downline counter and said sequencing means after said second memory means has received said information corresponding to each of said spray guns.

14. The control apparatus of claim 2 wherein said means for providing said digitized information signal further comprises a shift register having a plurality of serially connected stages wherein said signal information related to the dimensions of said object is fed into one of said stages.

15. The control apparatus of claim 14 wherein said shift register is adapted to provide a leading edge spray control whereby said spray gun is operated for a preselected interval greater than or less than that established by said information signal related to the dimension of said object.

16. The control apparatus of claim 15 wherein said shift register is adapted to provide a lagging edge spray control whereby said spray gun is operated for a preselected interval greater than or less than that established by said information signal related to the dimension of said object.

17. In a spray coating system of the type including a spray station, with at least one spray gun assembly having at least one spray gun thereon, and conveyor means for transporting objects of diverse geometry past said spray station, control apparatus comprising:

a plurality of sensing devices spaced vertically relative to the direction of motion of said conveyor means thereby defining a corresponding plurality of vertically spaced sensing zones, said sensing devices being positioned a predetermined distance in advance of said spray station for developing predetermined signal information related to the dimensions of an object moving on said conveyor means past said sensing devices;

a shift register for receiving said signal information from said sensing devices and for generating a sequence of digitized information signals related to the dimensions of said object;

first memory means, including a memory storage matrix for storing said digitized signal information related to the dimensions of said object;

a reciprocator carriage for continuously transporting said spray gun assembly between predetermined first and second vertical limits;

means for developing a reciprocator signal indicative of the vertical zone location of each of said spray guns on said spray gun assembly;

an actuating means associated with each of said spray guns and responsive to a predetermined actuating input signal for operating its associated spray gun for a time interval related to the duration of said actuating input signal;

second memory means associated with each of said spray guns and connected between said first memory means and the actuating means associated with its respective spray gun, wherein each of said second memory means produces a signal indicative of the position of said sensed object and the dimensions of said sensed object;

means for selectively interrogating said first memory means when said object is advanced by said conveyor means to a predetermined position with respect to each of said spray guns whereby said digitized signal information in said storage matrix is selectively transferred to said second memory means; and

means for comparing said reciprocator signal with said signal from said second memory means wherein said comparing means provides said predetermined actuating input signal to said actuating means only when said reciprocator signal and said signal from said second memory means indicates that said sensed object and said spray gun are in said predetermined position relative to each other.

18. The control apparatus of claim **17** wherein said means for developing said reciprocator signal comprises:

a first signal generator means for developing an output signal pulse for each incremental unit of travel of said reciprocator carriage;

zone patch means for identifying each spray zone through which said reciprocator travels;

vertical counter means adapted to be incremented by said first signal generator means wherein said reciprocator signal is produced at the output of said vertical counter means when said number of pulses stored in said vertical counter means equals said patch means for one of said spray zones.

19. The control apparatus of claim **18** wherein said actuating input signal for said actuating means is produced by said comparing means only when said signal from said second memory means corresponds to said sensed object having passed through a vertical sensing zone corresponding to said vertical spray zone represented by said reciprocator signal.

20. The control apparatus of claim **19** wherein said vertical counter is reversible and wherein said means for developing said reciprocator signal further comprises:

a second signal-generating means for resetting said vertical counter to zero when said reciprocator carriage reaches said first vertical limit; and

means for reversing said vertical counter when said reciprocator carriage reaches said second vertical limit wherein said means for developing said reciprocator signal is thereby responsive to both directions of travel of said reciprocator carriage.

21. The control apparatus of claim **20** wherein said interrogating means comprises:

address counter means adapted to select said signal information in said first memory means; and

decoder means adapted to sequentially advance said address counter means to enable said address counter means to select said information location in said memory storage matrix corresponding to each of said spray guns and further adapted to enable said information located by said address counter means to be transferred to the second memory means associated with said spray gun being addressed.

22. The control apparatus of claim **21** wherein said decoder means comprises:

a downline counter means;

patch means associated with said downline counter means for identifying the downline position of each of said spray guns with respect to said sensor means; and

a sequencing means adapted to advance said address counter and said downline counter means until the total count stored in said downline counter means corresponds to the downline position of one of said spray guns and wherein said downline counter produces a pulse stopping said address counter and thereby enabling said address counter to locate said digitized signal information corresponding to said spray gun.

23. The control apparatus of claim **22** wherein said sequencing means enables said second memory means associated with said spray gun to receive said information located by said address counter means after said address counter means has stopped and enables said first memory means to receive new information signals from said shift register after said second memory means has received said information corresponding to each of said spray guns.

24. The control apparatus of claim **23** wherein means are provided for resetting said downline counter and said sequencing means after said second memory means has received the information corresponding to each of said spray guns.

25. The control apparatus of claim **24** wherein said shift register is adapted to provide a leading edge spray control whereby said spray gun is operated for a preselected interval greater than or less than that established by said information signal related to the dimension of said object.

26. The control apparatus of claim **25** wherein said shift register is adapted to provide a lagging edge spray control whereby said spray gun is operated for a preselected interval greater than or less than that established by said information signal related to the dimension of said object.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,646,521 Dated February 29, 1970

Inventor(s) Virgle E. Porter

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Columns 11 and 12, line 6 of the chart, under the heading "Quantity", the footnote "1" should be indicated.

Signed and sealed this 11th day of July 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents