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[21]	Appl. No	771,865
[22]	Filed	Oct. 30, 1968
[45]	Patented	July 13, 1971
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[54] PAINT SPRAY CONTROL SYSTEM
7 Claims, 4 Drawing Figs.

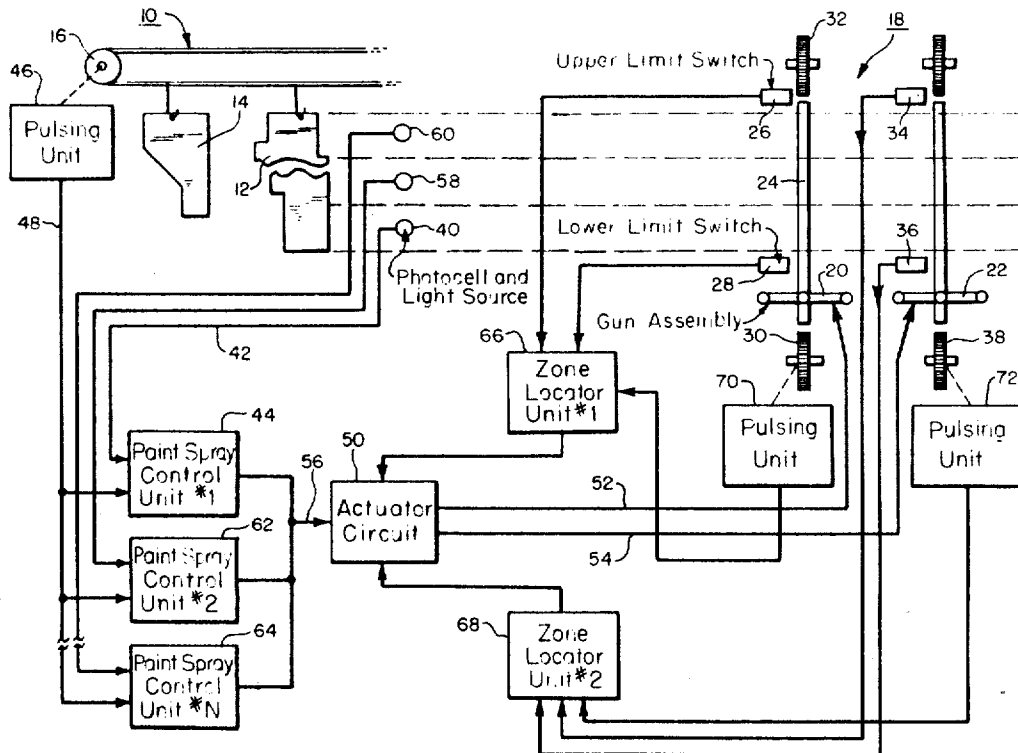
[52]	U.S. Cl.	340/172.5,
		118/2
[51]	Int. Cl.	G04b 3/06,
		G11c 19/00
[50]	Field of Search	340/172.5;
		214/11, 8; 118/2, 7

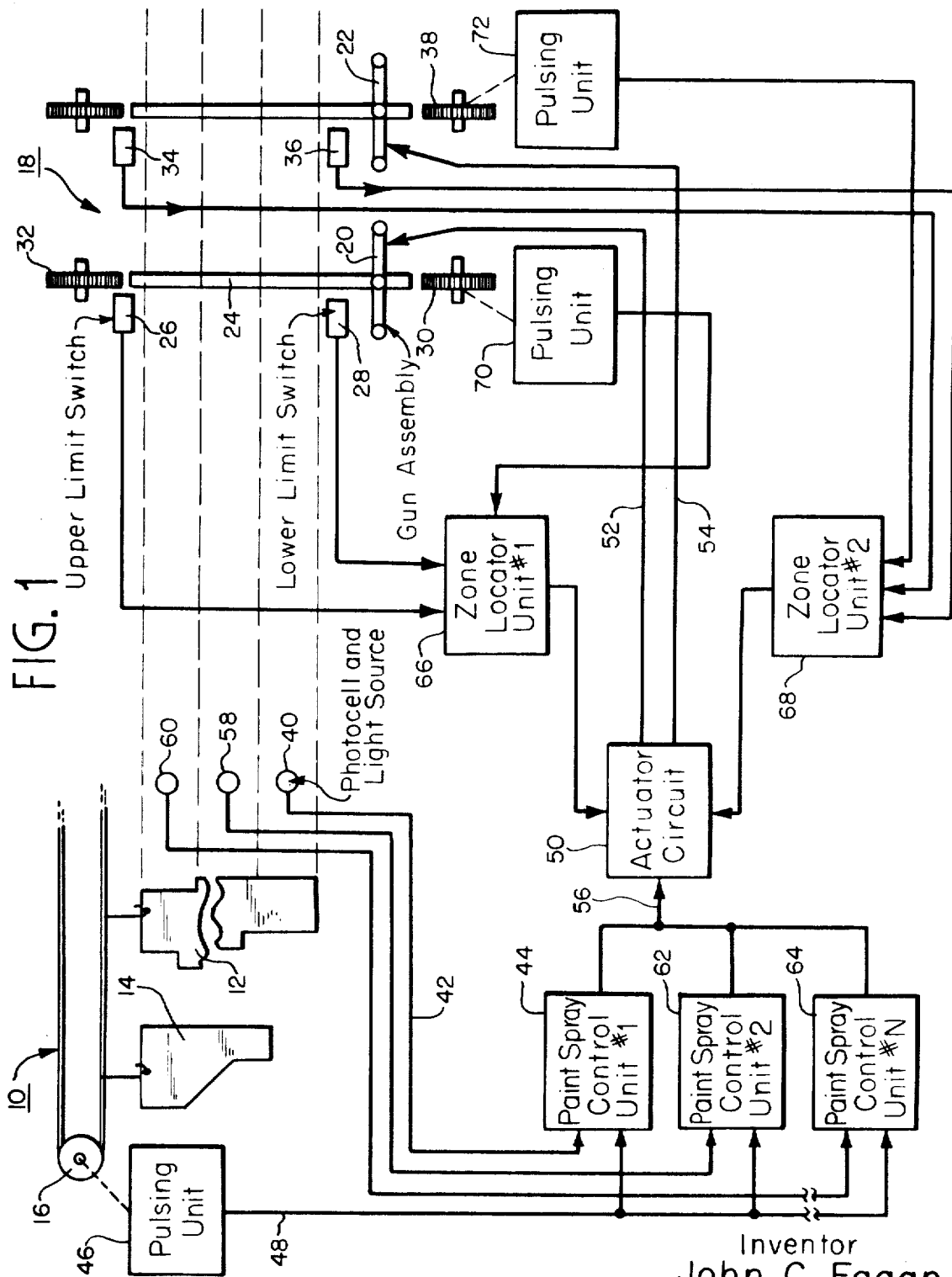
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ABSTRACT: An electronic control circuit is disclosed for regulating operation of a paint spray system of the type having a spray station with at least one spray gun assembly and a conveyor for transporting objects of diverse geometry past the spray station. A sensor is positioned in advance of the spray station to develop signal information related to the dimensions of each object. A plural stage shift register is coupled between the sensor and an actuator for the spray gun assembly. A measuring unit provides a reference pulse for each incremental unit of travel of the conveyor to periodically gate the shift register stages to the end that a unit storage signal is entered in the first stage on each coincidence of the reference and sensor signals and is advanced one stage on every successive reference pulse. The number of shift register stages is selected so that the pulse reaches the actuator coincidentally with the sensed object reaching the spray station. Other features are disclosed.

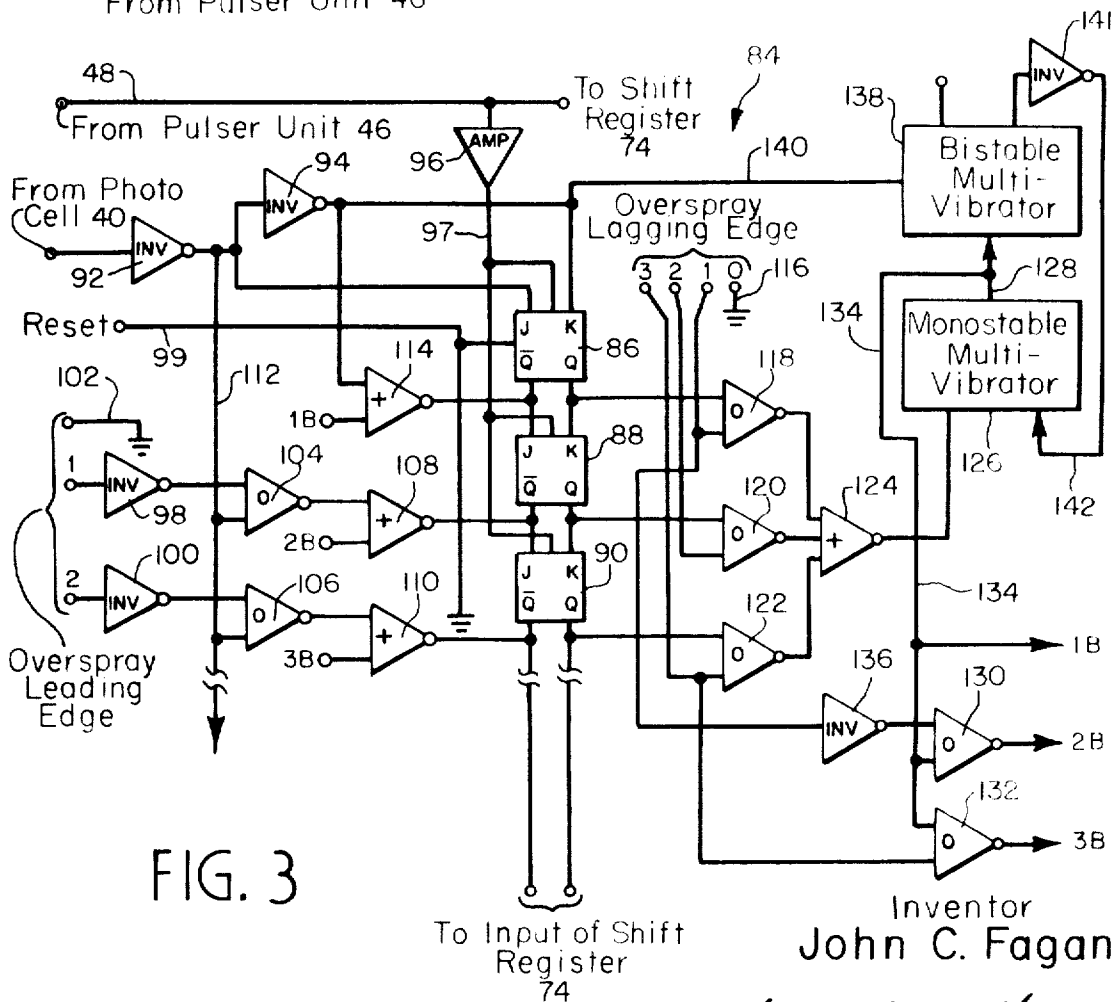
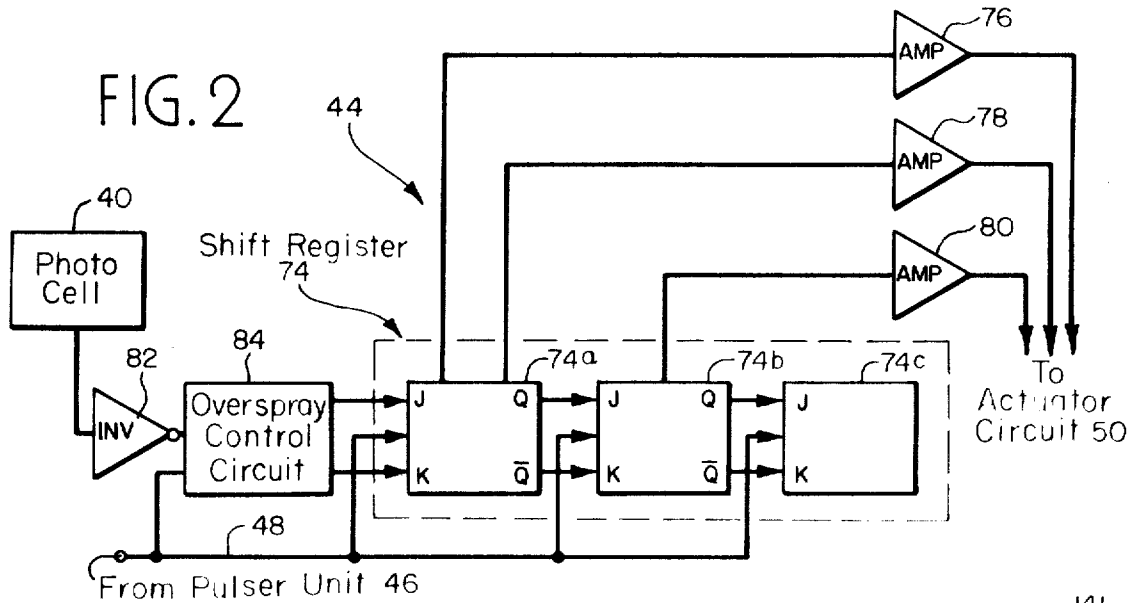




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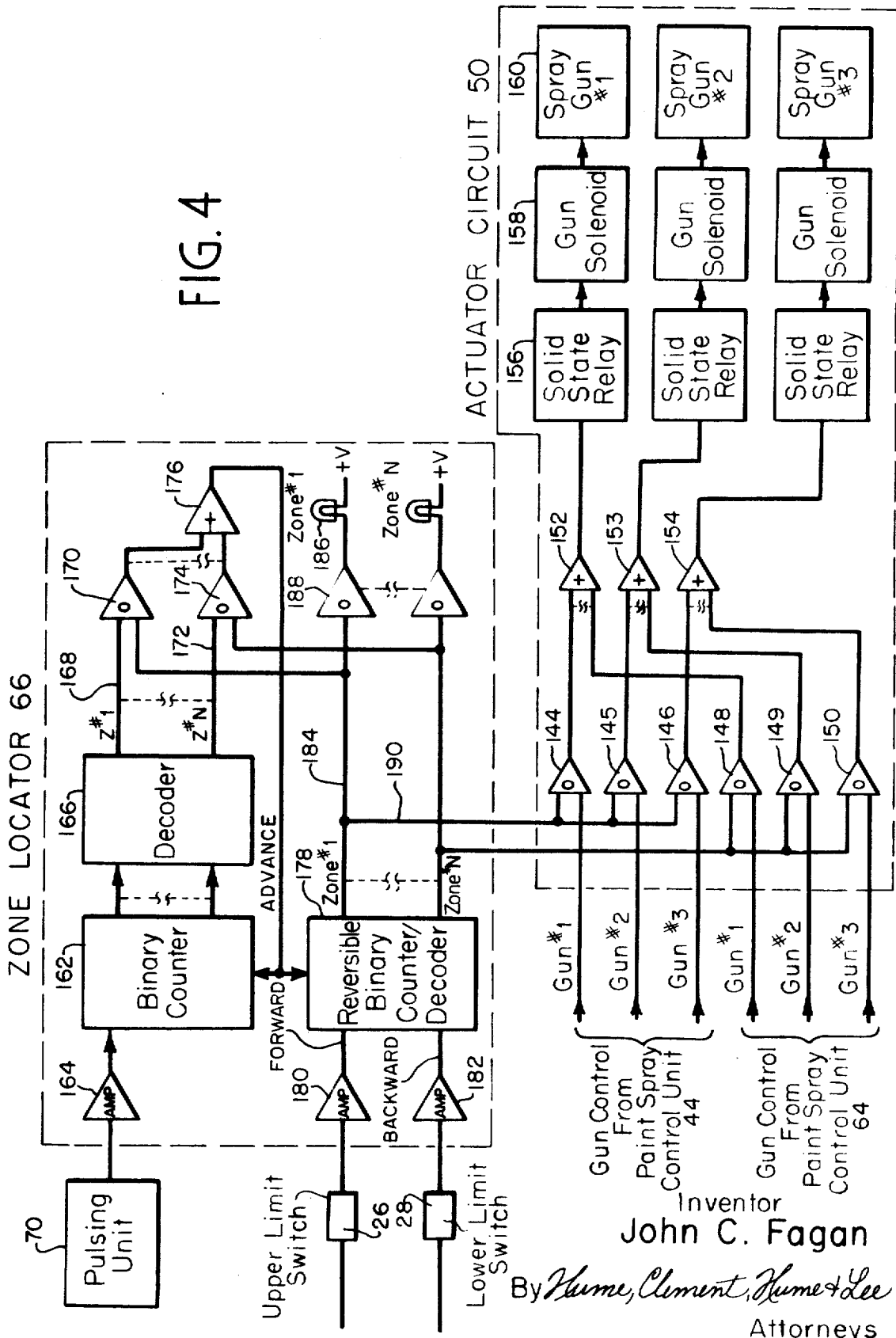
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FIG. 4



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PAINT SPRAY CONTROL SYSTEM

INTRODUCTION

The present invention relates generally to spray coating systems of the type having a spray station and a conveyor means for transporting objects of diverse geometry past the spray station. More particularly, the invention is directed to new and improved electronic control apparatus for automatically regulating the operation of the spray gun assembly in accordance with the sensed dimensions of the various objects to be coated.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a paint spray control system in which the various objects are sensed at a position remote from the spray station and the information representative of the part geometry effectively stored within the system until the object is advanced to a position adjacent to the spray station.

It is also an objective of the invention to provide 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.

It is a more specific purpose of the present invention to provide a system of the above type that develops two dimensional data on each object thereby to effect a corresponding operational control of the one or more spray gun assemblies. Hence, objects of varying geometry are fully and uniformly spray coated without an excessive or wasteful use of the coating fluid.

Accordingly, the present invention relates to a spray coating system of the type including a spray station with at least one spray gun assembly and conveyor means for transporting objects of diverse geometry past the spray station. Specifically, the invention is directed to control apparatus comprising sensor means including a sensing device positioned a predetermined distance in advance of the spray station for developing predetermined signal information related to the dimensions of an object moving on the conveyor means past the sensing device. An actuating means is responsive to predetermined input signals for operating the spray gun assembly for a duration related to that of the input signals. A control means, coupled between the sensor means and the actuating means, is provided for effectively and temporarily storing the signal information developed by the sensor means until each sensed object is advanced by the conveyor to a predetermined position adjacent the spray station. The aforesaid signal information is thereafter presented to the actuating means to operate the spray gun assembly or assemblies so as to provide a full yet efficient coating of each object.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention together with further objects and advantages thereof may best be understood by reference to the following description taken in conjunction with the accompanying drawings in the several figures of which like reference numerals identify like elements and in which:

FIG. 1 is a schematic diagram of a spray coating system embodying electronic control apparatus constructed in accordance with the teachings of the present invention;

FIG. 2 is a schematic block diagram illustrating a preferred embodiment of the similar paint spray control units of FIG. 1;

FIG. 3 is a circuit logic diagram of the overspray control circuit of FIG. 2; and

FIG. 4 illustrates in schematic form a preferred embodiment of the similar reciprocator zone locator blocks of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, the spray coating system there illustrated comprises conveyor means such as a conventional

overhead chain conveyor generally denoted by the reference numeral 10. Objects of diverse geometry as 12 and 14 are suspended by hooks or the like from the conveyor at spaced intervals along its length. The conveyor 10 transports the objects, under the influence of a conventional drive system including a chain drive sprocket 16, toward a spray station generally denoted by the reference numeral 18.

The spray station 18 likewise may be conventional and comprise, for example, a pair of spray gun assemblies or carriages 20 and 22 each having three laterally spaced spray guns as schematically represented in the drawing by the three spaced circles on each carriage. The gun assembly 20 is vertically reciprocated on a guide track 24 between spaced upper and lower limits defined respectively by the limit switches 26 and 28. The gun assembly carriage 20 is driven between the spaced vertical limits by a conventional chain drive mechanism including a lower drive sprocket 30 and an upper idler sprocket 32. The reciprocator for the gun carriage assembly 22 is identical to that of the gun assembly 20 and includes upper and lower limit switches 34 and 36 respectively and a lower drive gear 38.

In accordance with the present invention, the spray coating system further includes an electronic control circuit for regulating operation of the spray gun assemblies 20 and 22 in accordance with the sensed geometry of each object to be coated. Specifically, the electronic control system comprises sensor means having a sensing device 40, preferably a conventional photocell and light source, positioned a predetermined distance in advance of the spray station 18. An eclipse of the light source by movement of an object between the light source and photocell develops in conventional fashion signal information on a lead 42 which is coupled as an input to a first spray control means 44. The photocell arrangement in the present embodiment only senses the presence or absence of an object. An effective measure of the horizontal dimension, i.e. width, of the object in the plane of the photocell is provided by further sensor or measuring means including a pulsing unit 46. The unit 46 is a conventional reed switch pulse generator geared to the drive sprocket 16 of the conveyor, as schematically denoted in the drawing by the dashed line interconnecting these elements, and is adapted to develop a reference signal pulse on its output lead 48 for each incremental unit of travel (e.g. 3 inches) of the conveyor. As shown, the output lead 48 of the pulser 46 is connected as a second input to the spray control means 44.

The control means 44 is adapted to effectively and temporarily store signal information representative of the lateral dimension of each object as measured in the plane of the photocell 40. In the present embodiment, this dimensional information is disclosed by the combined signal information on the input leads 42 and 48 which information is converted to a data form storable within the control unit. The control means 44 retains the geometric data until the corresponding object is advanced by the conveyor 10 to a predetermined position adjacent the spray station 18 at which time the data is utilized to actuate the spray gun assemblies 20 and 22 for respective intervals related both to the sensed geometry of the object as well as other factors separately programmable into the control circuit, as will presently be explained in detail.

More particularly, the spray gun assemblies 20 and 22 are operated by an actuating means 50 that is schematically indicated in the drawing to be coupled to the gun assemblies 20 and 22 by the respective arrows 52 and 54; in a typical system, the three spray guns of each carriage may have separate electrical connections to permit their independent operation. The actuating means 50 is responsive to predetermined input signals on an input terminal, again schematically depicted by an arrow 56 leading from the spray control means 44, for operating the spray gun assemblies for a duration related to that of the input signals.

In order to accommodate nonuniformities in the lateral dimensions of each object to be sensed and to adjust the intervals of operation of the spray gun assemblies accordingly,

there is provided, in accordance with the present invention, a plurality of sensor and control means similar to that already described for dividing each object into a plurality of distinct vertically spaced zones. For simplicity and clarity of explanation, only three such zones, denoted by the parallel sets of dashed lines in the figure, are illustrated although it will be recognized by those skilled in the art that any number of zones may be employed as desired. The additional sensing zones are provided by individual sensing devices 58 and 60 coupled to associated control means 62 and 64, respectively. The control means 62 and 64 also each receive second inputs from the lead 48 of the pulsing unit 46. It will be understood that each of the additional sensing devices and control means are identical to the sensing device 40 and control means 44 earlier described herein.

The control means 62 and 64 are likewise coupled to the actuating means 50 and, for simplicity of illustration, the signal flow is schematically indicated by the common arrow 56 connecting all of the control means to the actuator circuit 50. It will, however, become apparent later herein to those skilled in the art that each control means may in fact have plural individual connections to the actuator circuit 50.

In order to selectively gate the information from the several control means 44, 62 and 64 through the actuator circuit 50 in accordance with the vertical location of the respective gun assembly carriages 20 and 22, there is provided zone spray control means including a pair of similar zone locator circuits 66 and 68. The zone locators 66 and 68 each have a pair of inputs from the upper and lower limit switches 26, 28 and 34, 36 for the gun carriages 20 and 22, respectively. A third input for each zone locator is provided by respective signal generators or pulsing units, 70 and 72. The units 70 and 72 are geared to the respective sprockets 30 and 38 of the reciprocating drive for the respective gun assemblies and operate in similar fashion to the pulsing unit 46 to provide output signal pulses for each incremental unit of travel of their associated carriages.

Briefly, the overall operation of the paint spray control system of FIG. 1 is as follows. The overhead conveyor 10 transports the hanging objects as 12 and 14 toward the spray station 18 causing the objects to eclipse the various sensing devices 40, 58 and 60 at some point remote from the spray station. Typically, the sensing devices are located thirty feet or more in advance of the spray station to preclude contact with harmful paint or other chemical sprays. An eclipsing of the individual photocell light sources by each passing object develops a continuous output signal to the corresponding control unit until the object passes. An effective measure of the object width is provided by counting within each control unit the number of reference pulses developed by the pulser 46 during the interval that the corresponding photocell light source is eclipsed. In this regard, it is preferred that the reference pulser 46 be slaved to the conveyor movement as illustrated since this provides the most reliable and absolute measure of object movement; it will be understood, however, that other types of reference signal generators such as a master clock or the like may be substituted for the arrangement illustrated.

At any rate, in the present system, the sequence of information signals representative of the object width in each zone are stored in the respective control units 44, 62 and 64 until the associated object is advanced to a position adjacent the spray station 18. Thereafter the data is presented to the actuator circuit 50 in correspondence with the movement of the object past the respective spray gun assemblies 20 and 22. As will also be explained in greater detail, the data from the control units may be coupled to the actuator 50 such that the three guns of each carriage are individually actuated in a timed sequence.

The actuator 50 includes appropriate gating circuitry enabled from the zone locators 66 and 68 such that data from the several control units 44, 62 and 64 is passed to the output leads 52 and 54 only when the gun carriages 20 and 22 are

positioned within the proper vertical zones. Specifically, the pulsing unit 70 increments a counter (not shown) within the zone locator 66 one unit for each incremental unit of movement of the carriage 20 while a decoder (also not shown) for the counter develops output signals to selectively enable the gating circuitry within the actuator 50. For example, the actuator gates are conditioned to block or inhibit the signal information from the control units 62 and 64 while passing the information from the control unit 44 when the carriage 20 is in the lowermost zone. The upper and lower limit switches 26 and 28 in addition to reversing the direction of operation of the reciprocator drive motor (not shown) also suitably condition the counter within the locator 66 for operation in a reverse counting direction. Of course, the zone locator 68 and its associated circuitry functions in like fashion to that of the zone locator 66.

A more detailed understanding of the spray control means may be had by reference to the exemplary control unit 44 illustrated in FIG. 2. As shown, the control unit 44 comprises a memory preferably in the form of a plural stage shift register 74 depicted within the dashed outline in the drawing. The shift register 74 comprises a plurality of serially connected shift register stages which in the drawing have been divided into three separate sections 74a-c each having plural bits of memory storage. Each shift register stage is of conventional construction and may, for example, be constituted of the well-known "J-K flip-flop" connected to operate as a conventional shift register stage.

Each of the memory bits of the shift register 74 is individually accessible to permit selective connection of a series of output amplifiers 76, 78 and 80 to any desired point in the memory unit. The output terminals of the amplifiers 76, 78 and 80 may individually be coupled to the actuator circuit 50 to provide sequential turnon and turnoff of the three spray guns on the gun assembly carriage 20. A second set of three output amplifiers (not shown) are connected to later stages of the shift register 74 to provide a similar control for the three guns of the assembly 22. Alternatively, the guns of each carriage may have a common input from a single amplifier stage to provide simultaneous operation.

The input information for the shift register on the object geometry is supplied from the photocell 40 through an amplifier 82 and a serially connected overspray control circuit 84, presently to be explained in detail. One unit of data is entered into the input stage of the shift register 74 for each coincidence between the photocell signal and a reference pulse on the output lead 48 of the pulser unit 46. Each such entered unit of data is advanced one stage through the shift register in conventional fashion for each succeeding pulse on the line 48.

In operation, the presence of an object adjacent the photocell 40 develops an output signal that is conveyed through the amplifier 82 and overspray control circuit 84 to the input lead pair of the shift register 74. The pulser unit 46 provides a reference signal pulse to every shift register stage for each incremental unit of travel of the conveyor thereby to momentarily and periodically gate each shift register stage to an on condition to accept the digital signal information from the preceding stage. Thus one unit of signal information, i.e. either a "zero" or a "one", is entered into the input stage of the shift register 74 on each pulse, it being a one for each coincidence between the signal inputs from the photocell 40 and the pulser 46. Since, as stated, the signal information is then advanced one shift register stage for each unit of conveyor travel (e.g. 3 inches), the leads for the respective output amplifiers 76, 78 and 80 are coupled to the outputs of shift register stages that correspond to the respective distances of their associated spray guns from the photocell 40. Accordingly, the spray guns are turned on when the first unit of data reaches the associated shift register stage and remains on until the last consecutive data unit or bit is advanced beyond that associated shift register stage.

It is necessary with objects of certain configurations and/or paints or chemicals of certain viscosity, composition, etc. to

commence operation of the spray guns at varying distances in advance of the object actually reaching a position adjacent the corresponding spray gun and to maintain such spray gun operative for a certain interval after the object has passed in order to insure a complete and uniform coating of the leading and trailing edges of the object. The overspray control circuit of the present invention for adjustably and independently defining the leading and lagging edge overspray is disclosed in detail in FIG. 3.

Specifically, the overspray control circuit 84 comprises a plurality of individual shift register stages of which the first three 86, 88 and 90 are illustrated in the drawing. The photocell 40 is coupled to one input lead of the first shift register stage 86 through an inverter 92 and to a second input lead of the shift register stage 86 through the series combination of the inverter 92 and a second inverter 94. Thus, the signals on the two input leads of the first stage 86 are of an opposite polarity with the signal on the output of the inverter 92 being of a "one" value in the presence of an object at the photocell 40 and of a "zero" value in the absence of an object.

Each of the shift register stages 86, 88 and 90 is also provided with an input from the pulser unit 46 through its output lead 48, an isolation amplifier 96 and a common input lead 97. The shift register stages may be reset or cleared by applying an input signal to a reset lead 99. The present shift register stages operate in identical fashion to those of the control unit previously described. For example, with a signal on the output lead of the amplifier 92, denoting the presence of a part adjacent the photocell 40, a first unit signal is entered into the shift register stage 86 on the first coincident pulse from pulser unit 46. Assuming on the succeeding pulse from the unit 46 that the object has moved beyond the photocell, a zero is now entered into the first stage 86 while the second shift register stage 88 is momentarily gated to an on condition to accept the unit signal formerly in the first stage. This procedure continues with ones and zeros continually being entered into the shift register and advanced therethrough according to the presence or absence of an object at the photocell 40.

The overspray circuit means of the invention permits preselected numbers of unit signals to be inserted into the shift register stages consecutively preceding or succeeding the "string" of unit signals representing the dimensions of the object. The amount of leading and lagging edge overspray is independently adjustable over a range that is adequate to assure the full and uniform coating of the leading and lagging edges of objects of diverse geometry, etc. without an excessive use of paint or chemical spray. More particularly, a first rotary selector switch or the like (not shown) is adapted for selective connection to a plurality of input amplifiers, of which only two, 98 and 100, are illustrated. The signal inputs to amplifiers 98 and 100 from their associated switch terminals represent respectively one and two units of leading edge overspray while the grounded switch terminal 102 denotes zero units of overspray.

The input amplifiers 98 and 100 are individually coupled to the output of shift register stages 88 and 90 through respective AND gates 104 and 106 and respective series connected OR gates 108 and 110. The AND gates 104 and 106 also each receive enabling inputs from the photocell 40 through the input inverter 92 and a common input lead 112. Thus, the AND gates 104 and 106 are only enabled to pass signals from the overspray selector switches in the presence of an object at the photocell 40. The gated overspray signals, if any, are coupled through the respective OR gates 108 and 110 to switch the memories of the shift register stages 88 and 90, respectively, to a unit value. It will be understood by those skilled in the art that although the presence of a momentary signal at the Q output of a shift register stage alters the memory of that stage to the input signal value, the input of the succeeding stage is unaffected in the absence of an activating signal from the reference pulsing unit 46. For example, with one unit of overspray only the memory of shift register stage 88 is altered in value and not that of the stage 90.

In addition to providing a leading edge overspray, the present circuitry also assures that extremely narrow objects which may pass the photocell 40 during an interim between reference signals from pulser 46 result in a signal of minimum term for operating the spray gun assembly. Specifically, the output of the OR gate 94 is coupled by an inverter 114 to the Q output of the first shift register stage 86. Accordingly, the first shift register stage 86 is altered to a unit value whenever an object passes the photocell 40, independently of any coincidence with the signal from the pulser unit 46.

The control circuit of the present invention also permits selective adjustment of the lagging edge overspray. Specifically, the circuit includes a second rotary selector switch or the like (not shown) that is adapted to selectively energize one of four associated input terminals labeled zero through three in the drawing. The first input terminal labeled zero is coupled to ground by a lead 116. The remaining terminals are connected as respective inputs to a series of AND gates 118, 120 and 122. The aforesaid AND gates also each receive a second input from individual sensing leads coupled to the Q outputs of shift register stages 86, 88 and 90, respectively. A predetermined one, and only one, of the AND gates 118, 120 and 122 is enabled to develop an output by connection of the selector switch to its corresponding input terminal. The AND gate so enabled provides an output signal when the last digit or unit representative of an object sensed by the photocell 40 is advanced beyond the shift register stage associated with the sensing lead of that AND gate. As will presently be explained, the foregoing information is utilized as a triggering signal to load the preselected number of units of lagging edge overspray into the shift register consecutively succeeding the one or more digits representative of the object geometry.

Specifically, in the above regard, the outputs of the AND gates 118, 120 and 122 are coupled as individual inputs to an OR gate 124 which in turn is coupled to an actuating input of a monostable multivibrator 126. An output terminal 128 of the monostable multivibrator is normally in an "off" condition thereby normally disabling a pair of AND gates 130 and 132 that are connected to the output terminal 128 through a common lead 134. The AND gate 130 is provided with a second signal input from the lagging edge selector terminal labeled "1" through an inverter 136. On the other hand, the selector terminal "3" is directly connected as a second input to the inverter 132. The outputs of the inverters 130 and 132, labeled respectively "2B" and "3B", are directly connected to the similarly labeled input terminals of the OR gates 108 and 110. The 1B input to the OR gate 114, defining one unit of lagging edge overspray, is developed directly at the output 128 of the multivibrator 126 as indicated by the arrow labeled 1B emanating from the lead 134.

In order to distinguish the unit signals representative of the trailing edge of the sensed object from the additional lagging edge overspray units inserted into the shift register, there is provided certain specialized control circuitry including a bistable multivibrator 138 having an input lead 140 from the inverter 94. An output of the multivibrator 138 is coupled through an inverter 141 to an inhibit input 142 of the monostable multivibrator which is adapted to selectively preclude operation of the multivibrator 142. The multivibrator 138 is set to an "on" condition through the input lead 140 as the leading edge of an object eclipses the light source of the photocell 40. This action removes the inhibit signal on the input lead 142 to the monostable multivibrator 126 thereby to permit the unimpeded operation of this device. Assuming that one, two or three units of lagging edge overspray have been programmed into the system through the selector switch (not shown), the monostable multivibrator 126 is momentarily triggered to its opposite state as the last unit of information representative of the object geometry is advanced beyond the appropriate one of the shift register stages 86, 88 and 90. The resultant trigger pulse on the output lead 128 of the monostable multivibrator momentarily enables the AND gates 130 and 132 while, after a predetermined time delay, set by a capacitor

discharge within the circuit, resetting the bistable multivibrator 138 thereby inhibiting a repeated firing of the monostable multivibrator 126 during passage of the added overspray units through the shift register stages. The monostable multivibrator 126 remains disabled until a second object again sets the bistable multivibrator 138.

In explaining the operation of the overspray control circuit, it will be assumed that each stage of the shift register is in a cleared condition and that the leading and lagging edge overspray selectors have been set to provide one and two units of overspray, respectively. Under these circumstances, the AND gate 104 is provided with a first enabling input through the inverter 98 while the AND gate 106 is maintained in an off condition by virtue of the absence of a signal input from the inverter 100. Assuming now that a first object eclipses the light source of the photocell 40, input signals of opposite polarity are coupled to the two input leads of the first stage register 86 through the inverters 92 and 94, respectively. This signal combination is representative of the presence of an object at the photocell 40 and is entered into the register 86 on the next succeeding reference pulse from the pulser unit 46. It will be recalled, however, that the first shift register stage 86 is preloaded to a unit value independent of operation of the pulser unit 46 through the OR gate 114 which switches the output of the first stage 86 to a unit value whenever a part is present at the photocell 40. The presence of an object at the photocell 40 also enables the AND gate 104 through the inverter 92 and the lead 112 thereby conveying a unit signal through the OR gate 108 to switch the output of the second shift register stage 88 to unit value. Accordingly, one unit is now entered into the shift register in advance of the unit representative of the leading edge of the part. Of course, had two units of overspray been desired, the leading edge selector switch would conjointly energize the selector terminals "1" and "2" to thereby enable both of the AND gates 104 and 106.

Assuming now that the object passing the photocell is of a width to cause only a single digit to be entered into the shift register, succeeding reference signals from the pulser 46 will advance the two signals stored in the shift register stages 86 and 88 into succeeding shift register stages at the rate of one shift register stage per reference pulse. Since two units of lagging edge overspray have been selected, the AND gate 120 will be energized when the last unit of object data is advanced into the shift register stage 90, i.e. beyond the stage 88. The resultant output signal from AND gate 120 passes the series OR gate 124 and triggers the monostable multivibrator 126, thereby providing momentary enabling inputs to the AND gates 130 and 132. The AND gate 132 is in an off condition since the selector is not connected to the selector terminal labeled "3" in the drawing. On the other hand, the inverter 136 provides an on input to the AND gate 130 whenever the selector switch is not at the "1" position. Since both inputs to the AND gate 130 are energized, the output of the shift register stage 88 is converted to a unit value by the signal conveyed on the 2B lead through the OR gate 108.

The second digit of lagging edge overspray is entered into the shift register stage 86 through the 1B input of the OR gate 114. Specifically, the 1B terminal is momentarily energized whenever the monostable multivibrator 126 is triggered to an on condition by a signal input from the OR gate 124 which in turn is actuated by the output of one of the AND gates 118, 120 and 122 according to the setting of the overspray selector switch, all as previously discussed. Of course, triggering of the monostable multivibrator 126 occurs only after the digits representative of the object geometry have been advanced to a point within the register to permit insertion of the total lagging edge overspray units into the succeeding register stages.

Similar operation is experienced when the lagging edge overspray selector is on one of the other lagging edge overspray terminals. On the other hand, if the selector is on the zero terminal 116, all of the AND gates 118, 120 and 122 remain disabled thereby precluding operation of the OR gate

124 and triggering of the monostable multivibrator 126. The bistable multivibrator 138 is, accordingly, not reset and the monostable multivibrator 142 is not inhibited. It is, of course, not necessary to inhibit the monostable multivibrator 126 under these circumstances since no overspray units have been entered into the shift register.

Referring now to FIG. 4, the actuator circuit 50 and the exemplary zone locator 66 are illustrated in further detail. The actuator circuit 50 comprises a first series of AND gates 144—146 to which are coupled the control inputs for the three guns of the spray carriage assembly 20 in FIG. 1, these inputs being derived from the respective outputs of the amplifiers 76, 78 and 80 shown in FIG. 2.

For simplicity, the control inputs from unit 44 for the guns of carriage 22 as well as the associated logic circuitry of the actuator 50 has been omitted from the drawing. It will be recognized that the control information from the control unit 44 constitutes the total information for a first zone level and that the information from unit 44 is only coupled to the guns when the carriage is within the confines of that zone.

Control signals for the individual guns of the carriage 20 are also provided in correspondence with each of the other spaced vertical sensing zones as exemplified by the control unit 64 which couples individual inputs to a second set of AND gates 148—150, representative of the Nth zone gun control information. Each of the two series of AND gates 144—146 and 148—150 as well as the other gates not shown is provided with respective enabling input leads from the zone locator 66 as will presently be described.

The control signals for the several zone levels of a particular spray gun, as derived from the plurality of control units, are coupled to a common OR gate, as exemplified by the connection of the gun 01 leads of control units 44 and 64 through their respective AND gates to the OR gate 152. The corresponding leads for the guns 2 and 3 of the control units 44 and 64 are coupled to similar OR gates 153 and 154. The OR gate 152 is coupled to a solid state relay 156 for energizing a series connected gun solenoid 158 to initiate operation of the spray gun 160. The outputs of the OR gates 153 and 154 are coupled to operate their associated spray guns in similar fashion.

The zone locator 66 is adapted to selectively couple the control signals from the respective control units to the actuating circuits for the spray guns only when the gun carriages are within the zone corresponding to the sensing latitude of the respective control unit. To this end, the zone locator 66 comprises a conventional binary counter 162 that is incremented by the pulsing unit 70 through an input amplifier 164. The output of the binary counter 162 is coupled to a conventional decoder circuit 166 having a plurality of output leads which are sequentially energized in accordance with each incremental unit of travel as the associated gun carriage moves between its spaced limits.

The first output lead 168 of the decoder 166 is coupled as an input to an AND gate 170 while the Nth output lead denoted as 172 in the drawing is coupled to a similar AND gate 174. The AND gates 170 through 174 representing increments of gun carriage travel 1 through N are coupled to a common OR gate 176, the output of which is coupled to a second binary counter and decoder circuit 178 and a reset lead for the counter 162. Each output signal of the OR gate 176 is adapted to increment the counter of the block 178 by one unit and also to clear the binary counter 162. Since the gun carriages are reversible, it is necessary that the counter 178 be adapted to count in a forward direction as the gun carriage moves upwardly and then in a reverse direction as the carriage returns to its original position. To this end, the counter 178 is provided with inputs from the upper and lower limit switches 26 and 28 through respective input amplifiers 180 and 182.

The output leads of the reversible binary counter 178 correspond in number to the number of sensing zones and only a predetermined one of these leads is energized at any one time

corresponding to the zone location of the gun carriage. Assuming, for example, that the zone 1 output lead 184 of the counter/decoder 178 is energized, the input to the AND gate 170 is enabled. Thus, when the decoder output lead 168 is likewise energized as will occur when the gun carriage has traveled a preselected increments of travel, an advance signal is coupled through the OR gate 176 to increment the reversible binary counter 178 to a zone 2 output lead (not shown) and to reset the binary counter 162 to zero.

The lead 184 is also coupled to a zone indicator lamp 186 through an amplifier 188 to visually denote the zone location of the gun carriage. The zone output lead 184 is further connected by a common lead 190 to respective enabling inputs of the actuator and gates 144—146. Thus, when the carriage 20 in FIG. 1 is within the zone 1 as denoted by the energized output lead 184 of the counter/decoder 178, the zone indicator lamp 186 is lit and the control information from the control unit 44 is gated to the respective gun actuating circuitry. Of course, the remaining gating circuitry of the actuator 50 operates in similar fashion to couple the control information from the control units to the gun actuating circuits according to the latitude of the carriage. Each zone width is adjustable to any number of increments of counter 162 by selection of the output lead of the decoder 166 that is connected to the following AND gates.

While particular embodiments of the present invention have been shown and described, it is apparent that various changes and modifications may be made, and it is therefore intended in the following claims to cover all such modifications and changes as may fall within the true spirit and scope of this invention.

I claim:

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

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

control means, coupled to said sensor means for developing digitized signals from the signal information developed by said sensor means and for storing said digitized signals until said object is advanced by said conveyor means to a predetermined position adjacent said spray station and for thereafter presenting said digitized output signals to said actuating means in correspondence with the movement of said object by said spray station;

actuating means responsive to said digitized signals from said control means for operating said spray gun assembly; and overspray control means for introducing respective preselected numbers of digitized signals into said control means consecutively preceding and succeeding the digitized signals developed for said object by said sensor means to establish respective predetermined numbers of dimensional units of leading and lagging edge overspray for said object.

2. The control apparatus of claim 1 in which said control means comprises a plurality of serially coupled shift register stages, each stage for storing a digitized signal and for advancing said digitized signal to the succeeding stage with each incremental unit of travel of said conveyor means.

3. The control apparatus of claim 2 in which said overspray control means includes a plurality of shift register stages serially coupled between said sensor means and said shift register stages of said control means and in which said overspray control means further includes leading edge overspray control apparatus responsive to the initial presence of said object at said sensor means for introducing a first preselected number of digitized signals into a corresponding number of said shift register stages of said overspray control means consecutively following the first of said shift register stages to establish a

number of dimensional units of leading edge overspray corresponding to said first preselected number.

4. The control apparatus of claim 3 in which said overspray control means further includes a lagging edge overspray control means responsive to the presence of the last of said consecutive sequence of said digitized signals at a predetermined shift register stage of said overspray control means for introducing a second preselected number of digitized signals into a corresponding number of said shift register stages of said overspray control means consecutively preceding said predetermined shift register stage to establish a number of dimensional units of lagging edge overspray corresponding to said second preselected number.

5. The control apparatus of claim 1 further comprising a plurality of said sensor means having their respective sensing devices spaced vertically relative to the direction of motion of said conveyor means to define a plurality of vertically spaced sensing zones; a plurality of said control means; each associated with a respective one of said sensor means; and zone spray control means, coupled to said actuating means, including a reciprocator carriage for continuously transporting said spray gun assembly between predetermined upper and lower vertical limits, and discriminator apparatus for selectively coupling each of said plurality of control means to said actuating means according to the zone in which said spray gun is located.

6. In a spray coating system of the type including a spray station having a spray gun assembly and conveyor means for transporting object of diverse geometry past said spray station, control apparatus comprising:

sensor means including a plurality of individual sensing devices positioned a predetermined distance in advance of said spray station and spaced laterally relative to one another to define a plurality of laterally spaced sensing zones for developing signal information indicating the horizontal and vertical dimensions of an object within an associated one of said sensing zones, moving on said conveyor means past said sensing device;

actuating means responsive to said signal information from said control means for operating said spray gun assembly for the duration of time that said signal information is provided;

control means coupled to said plurality of sensing devices for storing said signal information developed for each sensing zone by said sensing devices of said sensor means until said object is advanced by said conveyor means to a predetermined position adjacent said spray station and for thereafter presenting said signal information to said actuating means in correspondence with the movement of said object by said spray station;

and zone spray control means, coupled to said actuating means, including a reciprocator carriage for continuously transporting said spray gun assembly between predetermined upper and lower vertical limits, and further including discriminator apparatus for developing an output signal responsive to the position of said reciprocator carriage and for a selectively coupling each of said control means to said actuating means according to the zone location in which said spray gun assembly.

7. The control apparatus of claim 6 wherein said control means comprises a plurality of individual control units; and wherein said zone spray control means includes a signal generator for developing a signal for each incremental unit of travel of said reciprocator carriage, and a binary counter incremented by said signal generator; and wherein said discriminator apparatus of said spray control means comprises a programmable decoder, coupled to said binary counter, developing a plurality of distinct enabling output signals in response to a predetermined signal input combination from said binary counter for selectively and individually coupling said control units of said control means to said actuating means.