United States Patent [19]

Algeri et al.

[11] **3,775,624**

[45] **Nov. 27, 1973**

[54] **CONTROL CIRCUIT FOR GENERATING OUTPUT SIGNAL OF SPECIFIED DURATION AT SPECIFIED DELAY AFTER RECEIVING INPUT SIGNAL**

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[22] Filed: **Apr. 5, 1972**

[21] Appl. No.: **241,455**

Related U.S. Application Data

[62] Division of Ser. No. 108,082, Jan. 20, 1971, Pat. No. 3,682,131.

[52] **U.S. Cl.** **307/293**, 307/265, 307/283, 307/284, 307/288, 328/130

[51] **Int. Cl.** **H03k 17/26**

[58] **Field of Search** 307/265, 293, 288, 307/283, 284; 328/72–75, 129–131

[56] **References Cited**

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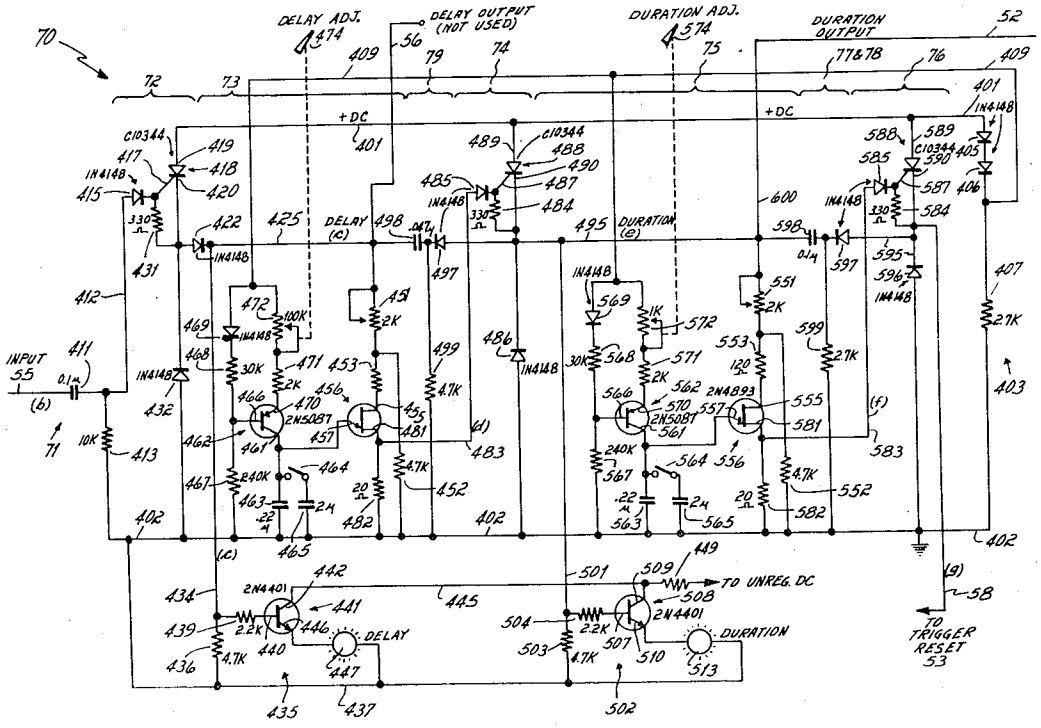
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Primary Examiner—Stanley D. Miller, Jr.
Attorney—Wood, Herron & Evans

[57] **ABSTRACT**

A control system for turning on and off an apparatus which discharges a coating liquid onto objects at a coating station. A sensor positioned adjacent the path of the objects upstream of the coating station initiates an interval timer as an object passes. After a predetermined time delay, the timer turns on a discharge gun positioned at the coating station, to begin to deposit the liquid upon the object. The timer maintains the discharge gun in an actuated condition for a predetermined time duration, and then turns the gun off. The control provides rapid and reliable turn on and turn off of the coating apparatus without false triggering, and provides precise time intervals which are continuously settable over an exceptionally wide range. The control utilizes a rapid reset hold and lock out circuit, SCR switches, unijunction relaxation oscillators having constant current charging circuits, an over voltage output circuit with short circuit protection, and means for programming the operation of plural discharge devices over different time periods.

12 Claims, 6 Drawing Figures



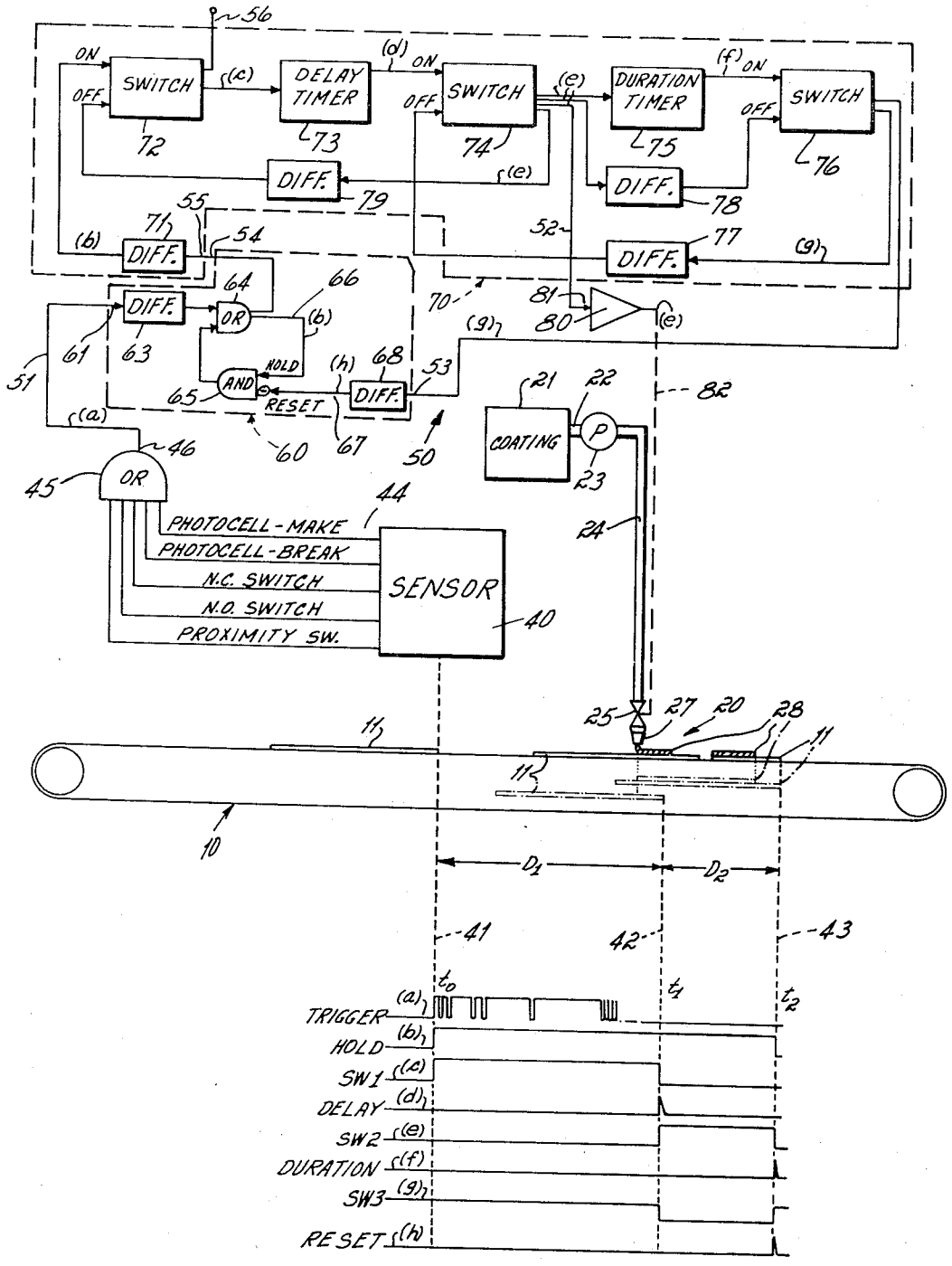

56
ON
OFF
SWITCH
72
(c)
DELAY TIMER
73
(d)
ON
OFF
SWITCH
74
(e)
DURATION TIMER
75
(f)
ON
OFF
SWITCH
76
DIFF.
79
(e)
DIFF.
78
DIFF.
77
(g)
55
71
(b)
DIFF.
54
52
64
66
DIFF.
OR
(b)
70
81
80
(e)
61
63
51
(g)
HOLD
(h)
68
53
AND
65
RESET
DIFF.
67
60
50
21
22
82
(a)
46
COATING
P
23
45
OR
44
24
PHOTOCELL - MAKE
PHOTOCELL - BREAK
N.C. SWITCH
N.O. SWITCH
PROXIMITY SW.
SENSOR
40
25
27
20
28
11
11
11
10
D1
D2
41
42
43
t0
t1
t2
(a)
TRIGGER
(b)
HOLD
SW1
(c)
(d)
DELAY
SW2
(e)
(f)
DURATION
SW3
(g)
RESET
(h)

Fig. 1

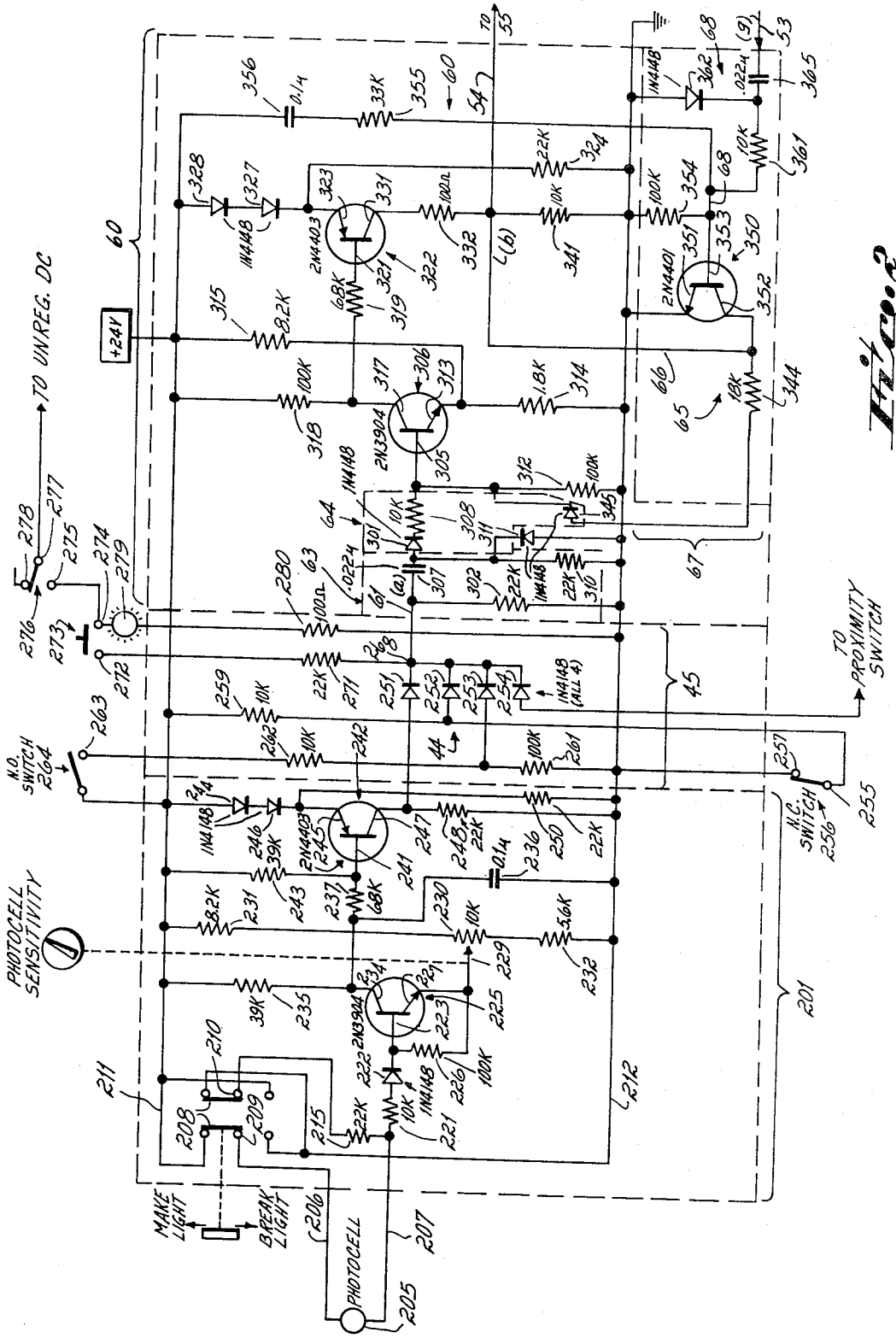

TO UNREG. DC
+24V
PHOTOCELL SENSITIVITY
N.O. SWITCH 264
MAKE LIGHT
BREAK LIGHT
PHOTOCELL
TO PROXIMITY SWITCH
N.C. SWITCH 256
2N4403
2N3904
2N4401
IN4148
IN4148 (ALL 4)

Fig. 2

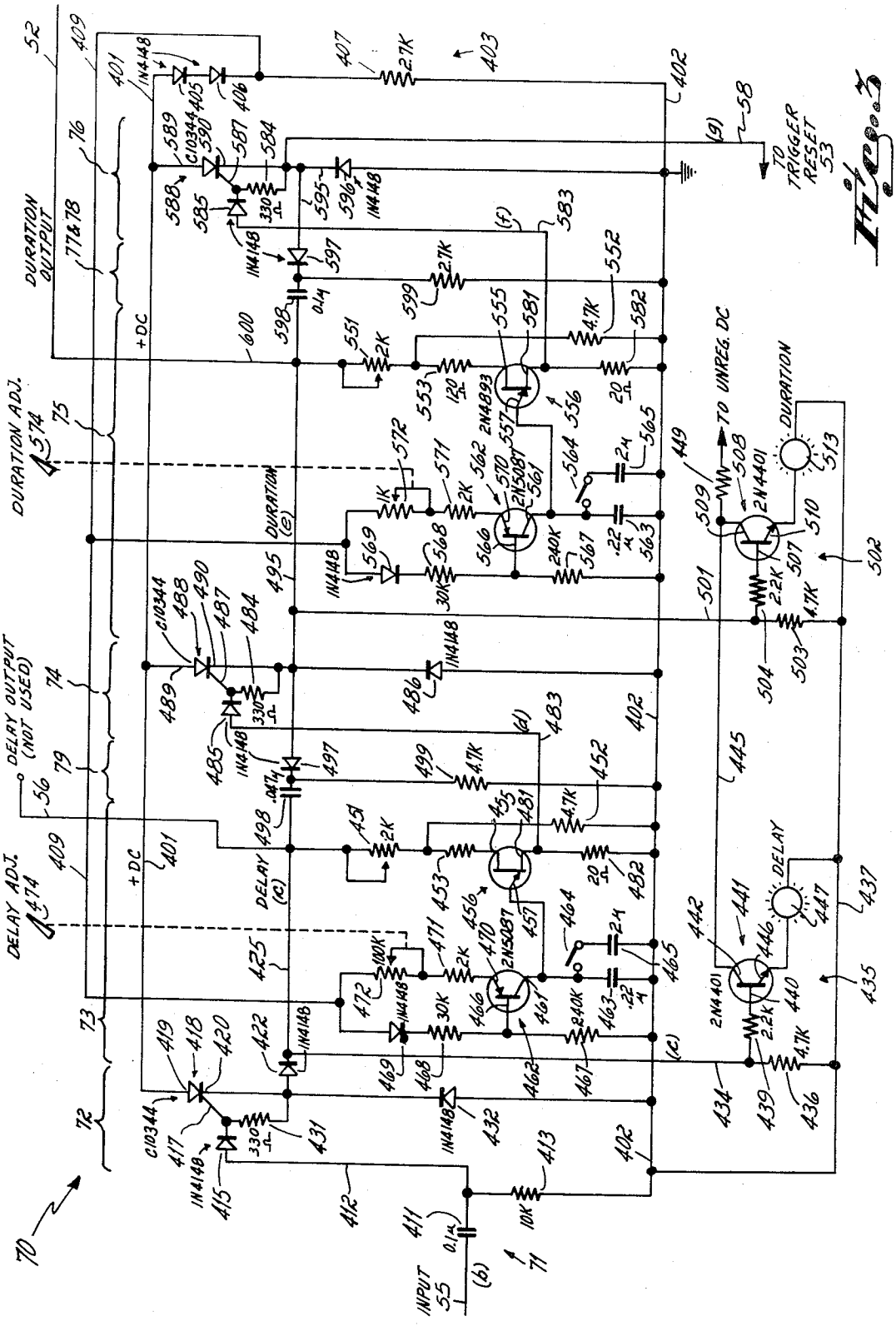
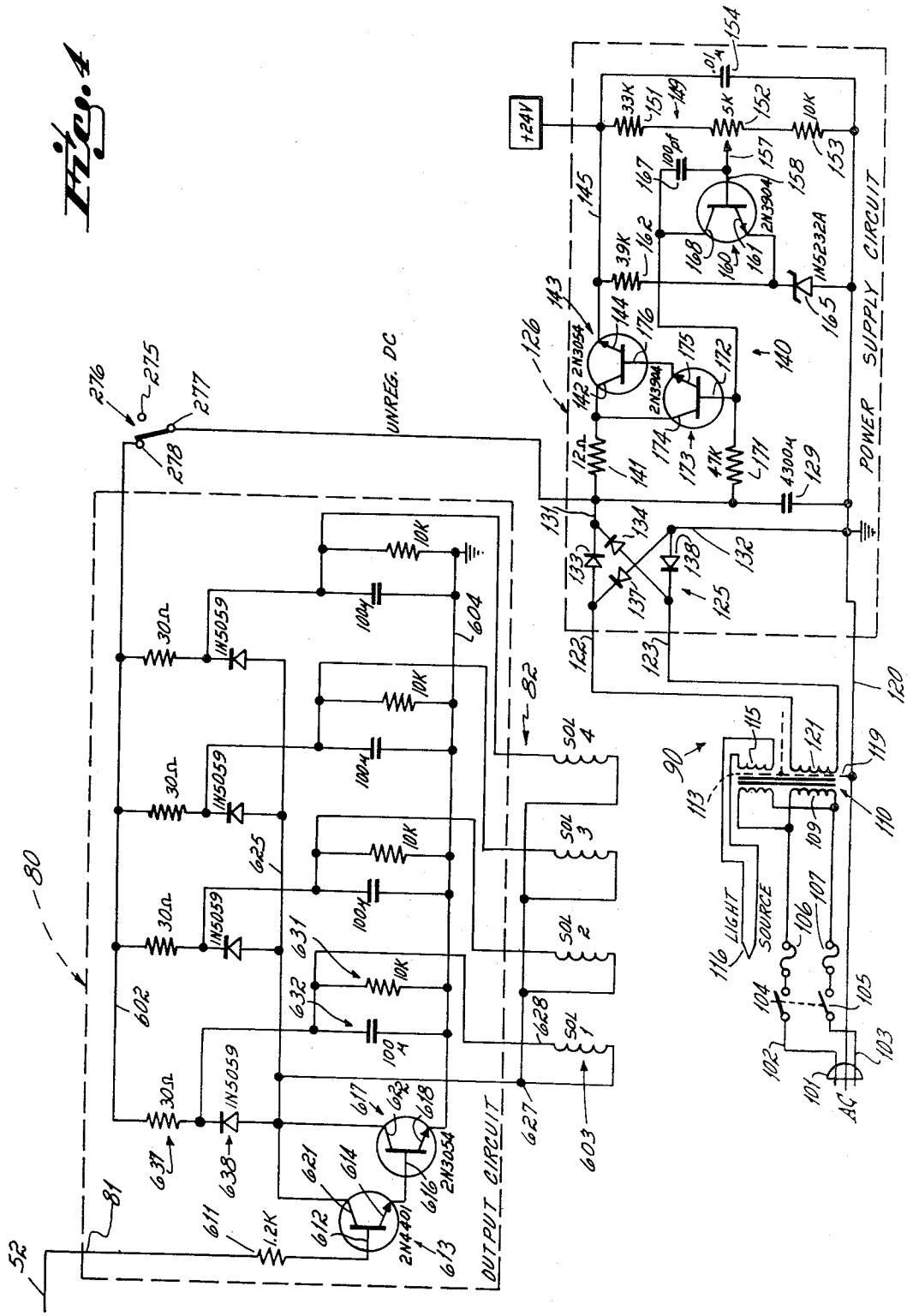

DURATION OUTPUT
DURATION ADJ.
DELAY OUTPUT (NOT USED)
DELAY ADJ.
+DC
TO UNREG. DC
TO TRIGGER RESET 53
DURATION
DELAY
INPUT 55
2N4893
2N5087
2N4401
IN4148
C10344
330Ω
27K
4.7K
2K
1K
100K
30K
240K
20Ω
140Ω
2.2K
10K
.047
.22
.24
.1μ

Fig. 4


+24V
UNREG. DC
OUTPUT CIRCUIT
POWER SUPPLY CIRCUIT
LIGHT SOURCE
AC
SOL 1
SOL 2
SOL 3
SOL 4
2N3054
2N4401
2N3904
IN5059
IN5232A

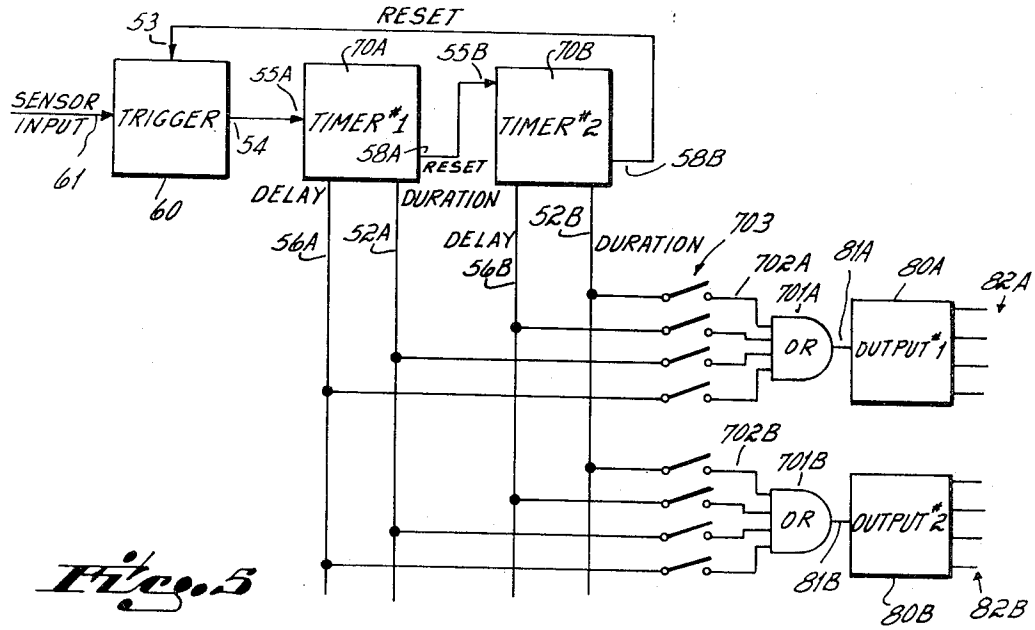

RESET
53
70A
55B
70B
55A
SENSOR INPUT
TRIGGER
TIMER #1
TIMER #2
54
58A
RESET
58B
61
60
DELAY
DURATION
DELAY
DURATION
56A
52A
56B
52B
703
702A
81A
80A
82A
701A
OR
OUTPUT #1
702B
701B
OR
OUTPUT #2
81B
80B
82B

Fig. 5

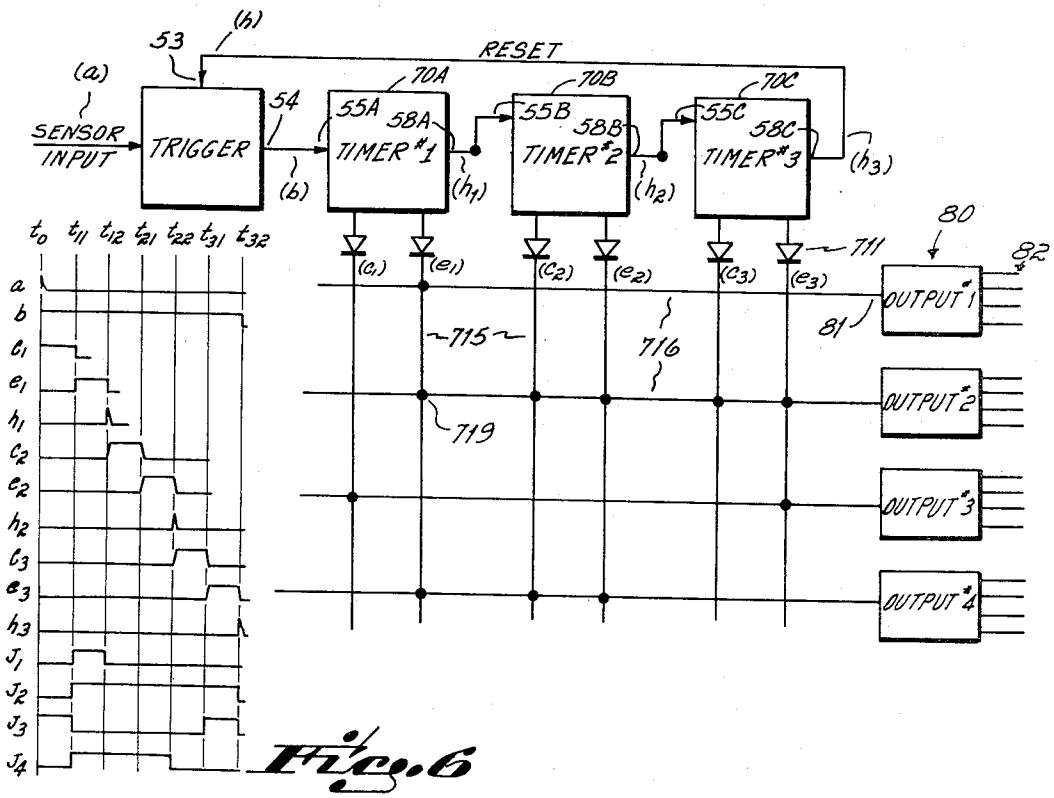

(h)
53
RESET
(a)
70A
70B
70C
SENSOR INPUT
TRIGGER
54
55A
58A
TIMER #1
55B
58B
TIMER #2
55C
58C
TIMER #3
(h3)
(b)
(h1)
(h2)
80
82
711
(c1)
(e1)
(c2)
(e2)
(c3)
(e3)
OUTPUT #1
81
715
716
719
OUTPUT #2
OUTPUT #3
OUTPUT #4
t0 t11 t12 t21 t22 t31 t32
a
b
c1
e1
h1
c2
e2
h2
c3
e3
h3
J1
J2
J3
J4

Fig. 6

CONTROL CIRCUIT FOR GENERATING OUTPUT SIGNAL OF SPECIFIED DURATION AT SPECIFIED DELAY AFTER RECEIVING INPUT SIGNAL

This is a division of application Ser. No. 108,082, filed Jan. 20, 1971, now U.S. Pat. No. 3,682,131, issued Aug. 8, 1972.

The present invention relates to coating apparatus controls and, more particularly, to automatic controls for timing the operation of the discharge of coating liquid upon objects as they are moved in relation to the discharge nozzle of the coating apparatus.

In coating systems of many types, series of objects are moved sequentially in relation to a coating station from which a coating liquid is discharged from one or several discharge nozzles and deposited upon the objects as they move past the station. In paint spray systems, for example, series of objects are carried past a paint spray station upon a moving conveyer. At the station, decorative and protective coating liquids such as paints, varnishes, waxes, etc. are sprayed upon the objects.

Another type of coating system is one in which adhesive, such as hot melt adhesive, is discharged upon objects as they are sequentially fed past the discharge apparatus. One typical application of the hot melt adhesive system is one in which the adhesive is deposited upon pre-cut paper carton blanks, as they are advanced toward a folding apparatus wherein they are to be folded and glued into the shapes of cartons. Another typical use of hot melt adhesive systems of this type lies in systems in which the adhesive is applied to a base object as it is being fed to an apparatus which positions another object such as a liner against the adhesive coated portion of the base object, as, for example, in the application of disc linings to bottle caps.

Another important application of such coating systems is in the spraying of protective coatings upon cans which are to be used as beverage containers or the like. In such applications, partially formed cans are guided along a predetermined path into a position at a coating station adjacent a coating apparatus. At the coating station a discharge apparatus is actuated to deposit the coating, usually in the form of a spray, upon the inside or the outside or both inside and outside, of the can.

In such coating systems, controls are employed to intermittently actuate the discharge apparatus so that the coating liquid is deposited only upon a specified portion of the objects when the objects are at some predetermined position in relation to the discharge station. Typically, such controls are synchronized to the relative position of the moving objects to be coated in relation to the discharge station. This synchronization usually is achieved by providing a sensor which senses the presence of an object in relation to the discharge station, either directly or indirectly, directly by sensing the presence of the object itself, and indirectly by sensing the presence of the conveyer means or machine element which moves in accordance with the motion of the object. This sensor is most conveniently positioned upstream of the coating station and is connected through a time delay device to control the operation of the discharge device. The time delay device accounts for the time lag between the sensing of the object and the positioning of the object at the coating station. In many cases, an additional timing function is provided to control the duration of the discharging operation.

Varying conditions, such as varying shapes and sizes of the objects to be coated, varying response times of the discharge apparatus due to differing types of coatings of varying viscosities, and a wide range of system operating speeds, make it desirable that the delay and duration time intervals be variable to accommodate these changing conditions. Furthermore, in order that the coating be deposited on precisely the desired portion of the object, high precision and accuracy in the settings of these time intervals is important to provide a proper coating and to prevent waste of the coating liquid.

Such control systems, for example, must incorporate timers which operate in a time range which is relatively long in terms of electronic circuit time constants, but which is relatively short in terms of the operating and switching times of the coating apparatus operated. Such time ranges lie within the range of from one millisecond to several seconds, for example. The control system must provide a rapid and positive turning on and turning off of the coating discharge apparatus while providing accurate control of the time intervals between operations of the spray system. In addition, the control system must be insensitive to signals from the sensor which represent anything other than a specific point on the workpiece moving relative to the coating station. Usually, this point which the sensor is to respond to is the leading edge of the object or workpiece on a conveyer, or to some specific point on the mechanism which moves with the object. However, due to irregularities in the workpieces themselves and to environmental noise sources, several signals can be generated by a sensor in addition to the signal responsive to the desired point to be sensed. This is especially true of photocells, limit switches and proximity switches which make up the most convenient types of sensors. Such erroneous signals, unless discriminated from the desired signal from the sensor, can result in costly and wasteful operation of the coating apparatus.

These features are particularly important in such high speed systems as hot melt systems and can coating systems.

In the hot melt systems, for example, blank cartons may be fed past a discharge station at speeds of 200 feet per minute or higher. The hot melt discharge apparatus operates to deposit adhesive in narrow strips from a fraction of an inch to several inches in length upon the carton blanks as they are fed past the station. In these systems, it is extremely important that the discharge nozzle open and close at precisely the beginning and end of the region which is desired to be coated, not only so that the product has the proper adhesive applied to it, but so that excessive application of adhesive is avoided. Improper application of adhesive can result in defective cartons, while excessive adhesive results in undue cost of the cartons.

In can coating systems, for example, cans are coated in various ways on machines which operate sequentially upon several hundred cans per minute. In some applications, the cans are traversed linearly past stationary spray devices which might apply coating, for example, to the welded seams of the cans. In other applications, the cans are moved into position adjacent the spray devices where they are stopped and then rotated while the coating is sprayed on the inside through the open ends of the cans. In the latter application, for example, the can is sensed as it is fed into position adjacent the discharge device, sometimes indirectly by a sensing of the motion of the feed device. A time delay

is required in order to allow the can to be stopped in its proper position and then rotatably accelerated to a uniform velocity before the coating can be applied. The duration of the application of the coating must be precisely controlled in order to insure that the coating is applied to the interior of the can uniformly by operating the discharge gun for an integral number of revolutions of the can, with allowance for only a very slight overlap. In this way, the minimum coating thickness can be precisely maintained while wasted coating material due to excessive overlap is eliminated.

In the high speed hot melt systems, one application in which the timing is highly critical is that of applying hot melt to the inside of bottle caps, so that linings or gaskets can be secured inside them. In this application, only a very small amount of glue is deposited and the duration of the discharge operation might be in the area of 3–4 milliseconds or less. In such cases, it is essential that the drop of hot melt be deposited precisely at the right instant as the caps are positioned adjacent the nozzle. Typically, this accuracy must be within plus or minus one millisecond, while the delay time from the instant the cap is sensed may be from 15–20 milliseconds or longer.

For these high speed applications, the timers provided by the prior art systems for this purpose have not provided precision and reliability with continuous time interval settings over a sufficiently wide range of settings. Furthermore, many prior art coating system timers have not been completely insensitive to erroneous trigger signals, or have not reset quickly enough to respond to the sensing of the next successive object.

Accordingly, the present invention is predicated in part upon the concept of providing a bi-stable trigger circuit which will rapidly respond to the first signal from the sensor generated by the detection of an object moving relative to the coating station, to lock out further input signals until completion of the coating operation, at which time the trigger circuit is rapidly reset so that the next object will be detected. The present invention is further predicated in part upon the concept of providing a delay-duration interval timer which operates in conjunction with the trigger circuit to rapidly and positively switch between ready, delay and duration conditions. Furthermore, the timers which provide these features must also have the capability of varying the time intervals to any length within an exceptionally wide range of time intervals.

The timer incorporates unijunction relaxation oscillators, with constant current charging circuits, operating in a one-shot capacity in combination with bi-stable SCR switches. In addition, the present invention is predicated in part upon providing a solenoid driver circuit which operates to rapidly energize, hold and de-energize the solenoids of the coating apparatus control system, but which does not delay the operation and resetting of the control circuit which operates more rapidly than the solenoids can respond, and which further provides output short circuit protection.

Another aspect of the present invention is a provision for the combining of general timing controls to operate plural discharge devices, and in the further provision for programming the timer outputs to operate the different discharge devices over different periods of time during the coating cycles.

One basic advantage of the present invention is that it provides a higher reliability and more rapid operation of a coating apparatus, in intermittently coating workpieces moving relative to the coating station, than do the systems of the prior art, and overcomes the disadvantages of prior art systems set forth above.

These and other objects and advantages of the present invention will be more readily apparent from the following detailed description of the drawings illustrating one preferred form of a control for a coating apparatus according to principles of the present invention, wherein:

FIG. 1 is a diagrammatic view partially in perspective of a hot melt coating system embodying principles of the present invention;

FIG. 2 is a schematic diagram of a portion of the control circuit of the system of FIG. 1 illustrating particularly the trigger circuit;

FIG. 3 is a schematic diagram of a portion of the control circuit of the system of FIG. 1 illustrating particularly the timing circuit;

FIG. 4 is a schematic diagram of a further portion of the control circuit of the system of FIG. 1 illustrating particularly the output circuit and the power supply circuit; and

FIGS. 5 and 6 are partial block and partial schematic diagrams illustrating plural timer controls for the system of FIG. 1, and including means for programming the outputs.

SYSTEM DESCRIPTION AND OPERATION

Referring to FIG. 1, a coating system illustrated is of the type in which hot melt adhesive is deposited upon paperboard carton blanks which are to be folded into cartons. In such a system, a conveyer 10 represents the means by which a plurality of cartons or workpieces 11 are sequentially fed and carried in a prescribed path past a coating station 20. The conveyer 10 moves at some predetermined speed. In high speed hot melt systems, the conveyer travels at a speed of two hundered feet per minute or higher. At the coating station 20, a discharge apparatus such as a hot melt gun operates to discharge a coating of liquid adhesive upon the workpieces 11 as they move successively past the coating station 20. The coating apparatus at the station 20 includes a hot melt source 21 having an output port 22 connected to a pump 23 which advances the melt to a delivery line 24. Connected to the delivery line 24 are one or more remotely controllable check valves 25 which, in the embodiment shown, are solenoid controlled check valves. Each of the check valves 25 connects the line 24 to a discharge nozzle 27. The nozzles 27 are directed toward the conveyer 10 and operate to discharge a strip of hot melt 28 upon the workpieces 11 as they are advanced past the station 20. At the station 20, the check valves 25 open intermittently so that the hot melt is only discharged on the desired portions of the workpieces 11 when they are adjacent the coating station 20. The time period for which the valves 25 remain open constitues the duration of the coating interval. During this interval, the leading edge of the workpiece 11 travels through a distance D_2 with the conveyer 10. In many paint-spraying and can coating applications, the check valves 25 are opened to start the spray just before the leading edge of the workpiece 11 enters the station 20, and remains opened until the trailing edge of the workpiece 11 passes the station 20. In such applications, the distance D_2 is as long as the objects 11. In the hot melt application illustrated, the

adhesive is applied only to a portion of the length of the objects **11** and the distance D_2 is in this case less than the length of the object.

To provide control for timing the coating interval, the illustrated embodiment of the present invention provides a sensor unit **40** positioned adjacent the conveyer **10** upstream of the coating station **20.** The sensor unit **40** has provision for mounting various types of sensors which are responsive in various ways to the presence of a workpiece **11** at a position **41** along the conveyer **10** adjacent the sensor **40.** In the preferred embodiment the sensor **40** is a photocell adapted to generate a signal in response to the leading edge of the workpiece **11** as it moves past the sensor **40.** The outputs **44** of the sensor **40** are connected to the inputs of an OR-gate **45** which has its output **46** connected to the input **51** of a control circuit **50.** The output **52** of the control circuit **50** is connected in turn to the input **81** of a solenoid driver amplifier **80** which has its output **82** connected to the windings of the solenoid controlled check valves **25** to energize the solenoids and thereby turn on the gun for the duration of the coating interval. Because the sensor **40** is positioned upstream of the station **20,** the coating interval must be delayed for the amount of time required for the leading edge of the workpiece **11** to move from the sensor **40** to a position **42** adjacent the coating station **20.** During this delay, the leading edge of the object **11** moves through a distance D_1.

The control circuit **50** provides this timing operation through a trigger circuit **60** and a delay-duration timer circuit **70.** The trigger circuit **60** has an input **61** connected to the control circuit input **51** and operates to develop a trigger signal from the sensor **40** and apply it at its output **54** to the input **55** to the timing circuit **70,** while locking out erroneous signals from the sensor. The timing circuit **70** is energized by the trigger signal to activate the amplifier **80** after a delay interval, then to de-activate the amplifier **80** after a further duration interval, and to reset the trigger lock out circuit at the end of the duration interval.

The sensor **40** may be any one of a number of devices, and the specific embodiment of the present invention is designed to provide a selection of general sensor devices. Preferred for many applications is a photocell sensor which is connected so that it may develop a sensor signal either upon the making or upon the breaking of a light beam. Other sensors provided include limit switches positioned along the conveyer to be tripped by the workpiece **11,** for example by the leading edge of the workpiece **11,** as it passes upon the conveyer. The switches provided include both normally opened or normally closed switches. Provision for another sensor, such as a proximity switch sensor or some other type of sensor adapted to generate a positive going electrical signal, can also be used with the present invention. The present invention provides an input selector gate **45** having a plurality of inputs connected to the outputs **44** of the different types of sensors. The selector gate **45** has its output **46** connected to the input line **51** of the control circuit **50.** This input **51** connects to the input **61** of the trigger circuit **60.**

The trigger circuit input **61** connects through a differentiator **63** to one input of an OR-gate **64.** Another input of the OR-gate **64** is connected to the output of an AND-gate **65** which has another one of its two inputs connected to output of the OR-gate **64.** This provides a feedback circuit **66** which operates as a holding circuit to lock the OR-gate **64** to the ON condition when a sensor pulse is received from the sensor **40.** To turn the holding circuit **66** off, a reset circuit **67** is provided connected between the output of a differentiator **68** and a negative input of the AND-gate **65.** The input of the differentiator **68** is connected to the reset input **53** of the trigger circuit **60.** When a positive going electrical signal appears at the input **53** to the differentiator **68,** a reset pulse appears at the output of a differentiator **68** and the output of the AND-gate **65** will go to zero, turning off the OR-gate **64,** breaking the holding circuit **66.** When the holding circuit is ON, additional signals from the sensor **40,** such as may be generated by detection of irregularities in the workpiece shape, or from switch or photocell static, will be locked out.

The trigger signal is developed at the output of the OR-gate **64** and appears at the output **54** of the trigger circuit **60** and proceeds to the input **55** of the timer circuit **70** connected to the input of a differentiator **71.** The output of the differentiator **71** connects to the "turn-ON" input of a bi-stable switch **72** which has an output connected to the input of a delay timer **73.** The delay timer **73** has an output connected to the turn-ON" input of a second bi-stable switch **74** which has one of its outputs connected to the input of a duration timer **75.** The output of the duration timer **75** is connected to the "turn-ON" input of a third bi-stable switch **76** which has its output connected in a feedback path through a differentiator **77** to the "turn-OFF" input of the second bi-stable switch **74.**

Another output of the second bi-stable switch **74** is connected to the output **52** of the timing circuit **70** which connects to the input of the output amplifier **80.** The other outputs of the second switch **74** are connected through a differentiator **79** to the "turn-OFF" input of the first switch **72,** and through a differentiator **78** to the "turn-OFF" input of the third switch **76.** A delay output **56** is provided and connects to the output of the switch **72** but is not used in the illustrated embodiment.

In operation, a workpiece **11** moves along the conveyer **10** until some predetermined portion of the workpiece **11** energizes the sensor **40.** Typically, this predetermined portion of the workpiece **11** will be the leading edge of workpiece **11.** When the sensor **40** is energzied, a trigger signal passes through the selector gate **45** and on to the control circuit input **51** and to the trigger input **61.** This trigger signal will take a form similar to that illustrated as curve (a) at time t_0 in the timing diagram at the bottom of FIG. **1.** This is because the sensor **40** may respond to many points along the length of the workpiece **11** causing the sensor signal to fluctuate on and off several times before the workpiece has passed. In many cases, a burst of pulses is emitted by the sensor **40** as it is triggered on or off. This signal, curve (a), proceeds through the differentiator **63** where sharp pulses, corresponding to the leading edges of the sensor signal, are passed to the input of the OR-gate **64.** The first pulse through the OR-gate **64** passes through the circuit **66** to energize the AND-gate **65.** The negative input of the AND-gate **65** from the reset circuit **67** is normally in an ON state. As this first pulse through the OR-gate **64** energizes the AND-gate **65,** an "ON" signal is fed back through the AND-gate **65** and applied to the other input of the OR-gate **64** and a closed loop is completed which holds the OR-gate **64**

in the ON condition. This hold signal is illustrated by curve (b) in the timing diagram. This hold signal constitutes a trigger signal which is differentiated at the differentiator **71** to form a single pulse which proceeds to the "turn-ON" input of the switch **72** to turn it on. This causes the switch **72** to develop an output signal as illustrated by curve (c) of the timing diagram. This signal energizes the delay timer **73.** The timer **73** is adjustable and is preset to develop an output signal marking the end of a delay time period. This time delay corresponds to the time it takes a point on the workpiece **11** to move on the conveyer **10** a distance D_1 from the position **41** adjacent the sensor **40** to a position **42.** This signal, represented by curve (d) advances to the "turn-ON" input of the switch **74,** which energizes the solenoid driver amplifier **80** to open the check valves **25** in accordance with curve (e) of the timing diagram.

This signal, curve (e), is also differentiated by the differentiator **79** to generate a pulse which turns off the switch **72** as curve (c) illustrates, at time t_1 in the timing diagram. The signal of curve (e) is also differentiated by the differentiator **78** to generate a pulse which turns off the switch **76.** The switch **76** is defined in the ON state, relative to the sense of the other signals of the circuit **70,** prior to the circuit **70** being triggered. The signal, curve (e), also proceeds directly to energize the duration timer **75.** The duration timer **75** is, like the delay timer **73,** settable to generate a pulse at some predetermined time after it has been energized. The time interval of the timer **75** corresponds to the time it takes a workpiece **11** to move from point **42** to point **43.** After the elapsing of the duration interval of the timer **75,** a pulse is generated at the output of the timer **75** as illustrated by curve (f) at time t_2. The pulse of curve (f) proceeds to the "turn-ON" input of the switch **76,** turning the switch **76** to the ON state at time t_2, as illustrated by curve (g) of the timing diagram. The output of the switch **76** develops a reset signal which resets the timer circuit **70** and the trigger circuit **60.** The signal, curve (g), proceeds through the differentiator **77** to the "turn-OFF" input of the switch **74** to turn it off, as curve (e) illustrates. The turning off of switch **74** turns off the discharge device at time t_2 when the leading edge of the workpiece is adjacent the point **43** on the conveyer **10.** The signal, curve (g) also proceeds through the differentiator **68** of the trigger circuit **60** to generate a reset pulse, illustrated by curve (h) which becomes inverted at the negative input of the AND-gate **65** to cause the AND-gate **65** to break the hold circuit through the OR-gate **64.** This is represented by curve (b) in the timer diagram at time t_2.

The circuit details of a control circuit **50,** which performs the functions described in connection with the block diagram of FIG. **1** above, are illustrated in FIGS. **2, 3** and **4.**

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The control circuit **50** as stated above includes four basic subcircuits: the trigger circuit **60,** which is illustrated in detail in FIG. **2;** the timer circuit **70,** which is illustrated in detail in FIG. **3;** the output or solenoid driver circuit **80,** and a power supply circuit **90,** which are both illustrated in detail in FIG. **4.**

Referring first to FIG. **4,** the power supply circuit **90** includes a power line **101** connectable externally to a conventional AC power line having a pair of leads **102** and **103,** each connected internal of the circuit **90** through an on-off switch **104** and **105,** respectively, and a fuse **106** and **107,** respoectively, to opposite terminals of a primary winding **109** of a transformer **110.** The transformer **110** has a secondary winding **115** connected across light source **116** for a photocell. The respectively, **110** has a core **119,** which is connected to a ground line **120,** and another secondary winding **121** which is isolated from the winding **115** by an electrostatic shield **113** grounded to the core **119.** The secondary winding **121** is connected across the input termianls **122** and **123** of a bridge rectifier **125** of the power supply rectifier and regulator circuit **126.** The bridge rectifier **125** has a pair of output terminals which includes a positive output terminal **131** which provides a source of unregulated DC power, and a negative output terminal **132** which is connected to ground line **120.** The output **132** is connected through a filter capacitor **129** to ground line **120.** The rectifier **125** includes a first pair of diodes **133** and **134** which both have their cathodes connected to the positive output terminal **131** and each has its anodes connected to the rectifier input terminals **122** and **123,** respectively. The rectifier **125** also includes a pair of diodes **137** and **138** which both have their anodes connected to the negative or ground terminal **132** and each has its cathodes connected to the input terminals **122** and **123,** respectively.

A voltage regulator circuit **140** includes a resistor **141** connected in series between the rectifier output **131** and the collector **142** of an NPN transistor **143.** The emitter **144** of the transistor **143** is connected to the power supply output line **145.** The transistor **143** operates as a series variable impedance device which regulates the DC voltage on the output line **145.** Connected between the output line **145** and the ground line **120** is a voltage divider circuit **149** which includes a fixed resistor **151,** a potentiometer **152,** and a fixed resistor **153** connected in series. Connected across the voltage divider **149** is a filter capacitor **154.** The potentiometer **152** has a wiper contact **157** connected to the base **158** of an NPN transistor **160.** The transistor **160** has its emitter **161** connected through a resistor **162** to the output line **145.** The emitter **161** is also connected to the cathode of a zener diode **165** which has its anode connected to the ground line **120.** A capacitor **167** is connected between the base **158** and the collector **168** of the transistor **160.** The collector **168** of the transistor **160** is connected through a resistor **171** to the unregulated DC output **131,** and to the base **172** of a transistor **173.** The transistor **173** has its collector **174** connected to the collector **142** of the transistor **143,** and its emitter **175** connected to the base **176** of the transistor **143.**

Referring to FIG. **2,** a photocell circuit **201,** the sensor selector gate **45,** a trigger circuit **60,** and a trigger reset circuit **67** are illustrated.

The photocell circuit **201** includes an externally located photocell **205** having a pair of leads **206** and **207.** The photocell **205,** together with the light source **116** (FIG. **4**) constitutes the sensor **40.** A light beam make and a light beam break selector switch **208** is provided which conditions the trigger circuit to generate a trigger pulse upon either the making or breaking of the light beam to the photocell. The switch **208** is a double-pole, double-throw slide action switch having a pair of common terminals **209** and **210** which are alternatively connectable to either the regulated positive voltage line **211** as illustrated or the ground line **212.** The terminal

210 connects through a resistor 215 to the photocell lead line 207. The common terminal 209 of the switch 208 is connected to the photocell lead line 206. The line 207 is connected also through a resistor 221 to the anode of a diode 222. The diode 222 has its cathode connected to the base 223 of an NPN transistor 225. A resistor 226 is connected between the base 223 of the transistor 225 and the emitter 227 of the transistor 225. The emitter 227 of the transistor 225 is connected to the wiper contact 229 of a photocell sensitivity potentiometer which forms part of a voltage divider which also includes a resistor 231 connected between one end of the potentiometer 230 and the regulated positive DC supply line 211, and a resistor 232 connected in series between the opposite end of the potentiometer 230 and the ground line 212. The collector 234 of the transistor 225 is connected through a resistor 235 to the positive line 211. The collector 234 is also connected through a filter capacitor 236 to the ground line 212 and through a resistor 237 to the base 241 of a PNP transistor 242. Base 241 of the transistor 242 is also connected to a resistor 243 to the positive line 211. The emitter 245 of the transistor 242 is connected to the cathode of a diode 246 which has its anode connected to the cathode of a diode 244. The diode 244 has its anode connected to the positive line 211. The collector 247 of the transistor 242 is connected through a resistor 248 to the common line 212. A resistor 250 is connected between the emitter 245 of transistor 242 and the ground line 212.

The input gate 45 is provided with four inputs 44 consisting of the anodes of diodes 251 through 254, respectively. The anode of diode 251 is the photocell input and is connected to collector 247 of the transistor 242. The anode of diode 252 is the normally closed switch input and is connected to the common contact 255 of the normally closed switch 256 which has its normally closed contact 257 connected to the ground line 212. The anode of diode 252 is also connected through a resistor 259 to the positive DC line 211. The anode of diode 253 provides the normally open switch input and is connected through a resistor 261 to the ground 212 and through a resistor 262 to a normally opened contact 263 of the normally opened switch 264. The common terminal of the switch 264 is connected to the positive voltage line 211. The anode of diode 254 is connectable to a proximity switch (not shown). The cathodes of diodes 251–254 are connected together at the gate output terminal 268. A fifth test input is provided which includes a resistor 271 connected between the gate output 268 and one contact 272 of a momentary push button test switch 273. The other contact 274 of the switch 273 is connected to one contact 275 of a test operate switch 276. The common terminal of 277 of the switch 276 is connected to the unregulated DC power line. The other contact 278 is connected to the output of circuit 80 (FIG. 4). Connected between the terminal 275 of the switch 276 and the ground line 212 is a test indicator lamp 279 connected in series with a resistor 280.

The gate output 268 is connected to the input 61 of the trigger circuit 60 and the differentiator 63. The input 61 is connected through a resistor 302 to the ground 212, and through a capacitor 307 to the anode of a diode 301. Connected in series between the cathode of the diode 301 and the base 305 of an NPN transistor 306, is a resistor 308. The anode of diode 301 is connected through a resistor 310 to ground line 212 and to the cathode of a diode 311 which has its anode connected to ground line 212. The base 305 of the transistor 306 is connected through a resistor 312 to a ground line 212.

The emitter 313 of the transistor 306 is connected through a resistor 314 to the ground line 212 and through a resistor 315 to the positive voltage line 211. The collector 317 of the transistor 306 is connected through a resistor 318 to the positive line 211 and through a resistor 319 to the base 321 of a PNP transistor 322. The emitter 323 of the transistor 322 is connected through a resistor 324 to the ground line 212 and to the cathode of a diode 327, which in turn has its anode connected to the cathode of a diode 328, which has its anode connected to the positive voltage line 211. The collector 331 of the transistor 322 is connected to a resistor 332 to the trigger circuit output line 54. The output line 54 is connected through a resistor 341 to the ground line 212. The circuits of the transistors 306 and 322 generally make up the OR-gate 64.

The trigger output line 54 is also connected through the holding circuit 66, which is connected through a resistor 344 to the anode of a diode 345. The diode 345 has its cathode connected to the base 305 of the transistor 306.

A trigger reset circuit includes an NPN transistor 350 having its emitter 351 connected to the ground line 212 and its collector 352 connected to the trigger circuit output line 54. The base 353 of the transistor 350 is connected to a resistor 354 to the ground line 212 and through a series circuit consisting of a resistor 355 and a capacitor 356 to the positive voltage line 211. The base 353 of the transistor 350 is also connected through a resistor 361 to the cathode of a diode 362 which has its anode connected to the ground line 212. A capacitor 365 is connected between the cathode or diode 362 and the reset input line 53. The capacitor 365, the resistors 354 and 361, and the diode 362 make up the differentiator 68.

Referring now to FIG. 3, the timing circuit 70 has a positive regulated voltage line 401 and a ground line 402. A diode-resistor voltage divider 402 having a first diode 405 connected at its anode to the positive voltage line 401 and its cathode to the anode of a diode 406 which in turn has its cathode connected through resistor 407 to the common ground line 402. At the juncture of the diode 406 and the resistor 407 is connected a charging voltage line 409.

The input 55 of the timing circuit 70 is connected to the output 54 of the trigger circuit 60 of FIG. 2. The input 55 is connected through the differentiator 71, which includes a capacitor 411 connected to the "turn-ON" input 412 of the switch 72, which is connected through a resistor 413 to the ground line 402, and to the anode of a diode 415.

The cathode of the diode 415 is connected to the gate 417 of an SCR 418. The SCR has its anode 419 connected to the positive voltage line 401 and its cathode 420 connected through diode 422 to the delayed signal line 425, which is the output of the switch circuit 72. The cathode 420 of the SCR 418 is connected through a resistor 431 to the SCR gate 417. The cathode 420 is also connected to the cathode of a diode 432 which has its anode connected to the ground line 402.

The delay signal line 425 is connected to the input 434 of a delay signal lamp illuminating circuit 435. The

lamp illuminating circuit 435 includes a resistor 436 connected between the input 434 and a ground line 437, which is in turn connected to the ground line 402. The input 434 is also connected through a resistor 439 to the base 440 of an NPN transistor 441 which has its collector 442 connected to an unregulated positive DC voltage line 445, and its emitter 446 connected through a delay indicator lamp 447 to the ground line 437. The voltage line 445 is connected through a resistor 449 to the unregulated positive voltage line 131 of the power supply 126 (FIG. 4).

The delay signal, curve (c) of FIG. 1 table, on line 425 is also connected to the input of the delay timer circuit 73 through a variable resistor 451 and a fixed resistor 452 to ground. The variable resistor 451 provides a means to adjust the "turn-ON" threshold of the timer 73 and to calibrate the timer dial set forth below. The timer circuit 73 is a unijunction relaxation oscillator circuit. The junction of the resistors 451 and 452 is connected through a resistor 453 to the base-two terminal 455 of a unijunction transistor 456. The emitter 457 of the unijunction transistor 456 is connected to the collector 461 of a PNP transistor 462, and through a capacitor 463 to the ground line 402. Connected across the capacitor 463 through a switch 464 is a capacitor 465. This provides a means for selecting the range of time delays which the timer 73 can produce. With the switch 464 closed, longer delays are possible.

The circuitry associated with the transistor 462 provides a constant current charging circuit for the capacitors 463 and 464. The transistor 462 has its base 466 connected through a resistor 467 to ground line 402, and through a resistor 468 to the cathode of a diode 469. The anode of the diode 469 is connected to the charging circuit voltage line 409. Connected between the voltage line 409 and the emitter 470 of the transistor 462 is a fixed resistor 471 and a variable resistor 472. The variable resistor 472 is provided with an externally accessible dial 474 which permits adjustment of the delay of the output signal of the timer circuit 73. By use of this constant current charging circuit, an exceptionally wide range of settings is possible by continuous adjustment of the single variable resistor 472. The delay interval is measured from the time at which the timer 73 is energized through its input at the resistor 451. A delay signal output 56, unused in the present embodiment, is provided and connects with the line 425.

Between the base-one terminal 481 of the unijunction transistor 456 and the ground line 402 is connected a resistor 482. The delay signal output, curve (d), is developed at the base-one termianl 481 of the unijunction transistor 456 which is connected to the end-delay output line 483. The line 483 is connected to the anode of the diode 485 which has its cathode connected to the gate 487 of an SCR 488. The diode 485 is the "turn-ON" input of the SCR switch 74. The SCR gate 487 is connected through resistor 484 to the SCR cathode 490. The SCR 488 has its anode 489 connected to the positive voltage line 401 and its cathode 490 connected to the duration signal line 495 which is the output of the switch circuit 74. The signal on line 495 is illustrated by curve (e) of the table of FIG. 1. The cathode 490 of SCR 488 is also connected to the cathode of a diode 486 which has its anode connected to the ground line 402.

The line 495 is also connected through the differentiator circuit 79 to the delay signal line 425, which serves as the "turn-OFF" input of the switch circuit 72. The differentiator circuit 79 includes a diode 497 having its anode connected to the cathode 490 of the SCR 488 and its cathode connected through a capacitor 498 to the delay signal line 425, and through a resistor 499 to the ground line 402.

The duration line 495 is also connected to the input 501 of a lamp driver circuit 502. The input 501 of the circuit 502 is connected through a resistor 503 to the ground line 437, and through a resistor 504 to the base 507 of an NPN transistor 508. The collector 509 of the transistor 508 is connected to the unregulated DC line 445, and the emitter 510 of the transistor 508 is connected through the duration indicator light 513 to the ground line 437.

The duration signal, curve (e) of FIG. 1, on line 495 is also connected to the input of the duration timer circuit 75 through a variable resistor 551 and a fixed resistor 552 to ground. The variable resistor 551 provides a means to adjust the "turn-ON" threshold of the timer 75 and to calibrate the timer dial set forth below. The timer circuit 75 is a unijunction relaxation oscillator circuit similar to the delay timer circuit 73. The junction of the resistors 551 and 552 is connected through a resistor 553 to the base-two terminal 555 of a unijunction transistor 556. The emitter 557 of the unijunction transistor 556 is connected to the collector 561 of a PNP transistor 562 and through a capacitor 563 to the ground line 402. Connected across the capacitor 563 through a switch 564 is a capacitor 565. This provides a means for selecting the range of time delays which the timer 75 can produce.

A constant current charging circuit for the capacitors 564 and 565 includes the transistor 562 which has its base 566 connected through a resistor 567 to ground line 402 and through a resistor 568 to the cathode of a diode 569. The anode of the diode 569 is connected to the charging circuit voltage line 409. Connected between the voltage line 409 and the emitter 570 of the transistor 562 is a fixed resistor 571 ana variable resistor 572. The variable resistor 572 is provided with an externally accessible dial 574 which permits adjustment of the delay of the output signal of the timer circuit 75. This delay is measured from the time at which the timer 75 is energized through its input at the resistor 551. Between the base-one terminal 581 of the unijunction transistor 556 and the ground line 402 is connected a resistor 582. The duration signal output, curve (f) is developed at the base-one terminal 581 of the unijunction transistor 556 which is connected to the end-duration output signal line 583. The line 583 is connected to the anode of the diode 585 which has its cathode connected to the gate 587 of an SCR 588. The diode 585 is the "turn-ON" input of the SCR switch 76. The gate 587 of SCR 588 is connected through resistor 584 to the SCR cathode 590. The SCR 588 has its anode 589 connected to the positive voltage line 401 and its cathode 590 connected to the reset output line 58 which connects to the reset input 53 of the trigger circuit 60. The signal on line 58 is illustrated by curve (g) of the table of FIG. 1. The cathode 590 of SCR 588 is also connected to the cathode of a diode 596, in line 595, which has its anode connected to the ground line 402.

The line 595 is also connected through the differentiator circuit 77 to the duration signal line 495, which serves as the "turn-OFF" input of the switch circuit 74. The differentiator circuit 77 includes a diode 597 having its anode connected to the cathode 590 of the SCR 588 and its cathode connected through a capacitor 598 to the duration signal line 495 and through a resistor 599 to the ground line 402. The differentiator circuit 77 also forms the differentiator 78 when operating in the reverse direction to transmit a pulse from line 495 to the cathode 590 of SCR 588 to turn it off.

Referring again to FIG. 4, the output or solenoid driver circuit 80 has an input 81 which is connected to the output 52 of the timing circuit 70. The driver circuit 80 has a positive DC line 602 which is connected to the operate contact 278 of the test-operate switch 276 which has its common terminal 277 connected to the unregulated DC output 131 of the power supply 90. The switch 276 is also illustrated in the circuit of FIG. 2. The output circuit 80 is also provided with a ground line 604. The outputs of the output circuit are the windings 603 of the solenoid valves 25.

The input 581 of the output circuit 80 is connected through a resistor 611 to the base 612 of an NPN transistor 613, which has its emitter 614 connected to the base 616 of an NPN transistor 617, which in turn has its emitter 618 connected to the ground line 604. The collector 621 of the transistor 613, and the collector 622 of the transistor 617, are connected to a bus line 625. The bus line 625 is connected to one terminal 627 of each of the windings 603 of the solenoid valves 25. The other terminal 628 of each of the windings 603 of the solenoid valves 25 is connected through a different one of the resistors 631 to the ground line 604. Across each of the resistors 631 is a capacitor 632. The terminals 628 of the windings 603 are each connected through one of a set of resistors 637 to the positive unregulated line 602. The terminals 628 fo windings 603 are also each connected to the cathodes of one of diodes 638. Each of the diodes 638 has its anodes connected to the bus line 625. The terminals 627 and 628 of the solenoid windings 603 constitute the outputs 82 of the driver circuit 80.

The output circuit 80 combines two important features. The first is a rapid solenoid pull-in feature provided by the capacitors 632 which charge to a higher voltage than is required to pull-in the solenoids 603, when the output circuit is off, and provide additional overvoltage current to accelerate the initial pull-in of the solenoids 603 at the instant the transistor 617 is actuated. The second feature is that of short circuit protection provided by the resistors 637.

CIRCUIT OPERATION

The specific operation of the timer circuit 50 will be better understood by tracing a signal through the circuit of FIGS. 2–4, for the case where the sensor signal is generated by the making of a light beam.

As illustrated in the drawing of FIG. 2, the photocell 205 will generate a signal upon the making of a light beam. This signal will be reflected in the circuit by a decrease of impedance of the photocell 205. With the switch 208 set as shown in FIG. 2, the signal on the base 223 of transistor 225 is normally below the level of the emitter 227 as determined by the setting of the sensitivity potentiometer 229, rendering the transistor 225 non-conductive. The signal from the photocell causes the base 223 of the transistor 225 to go positive, relative to the emitter 227, switching the transistor 225 ON, causing a decreasing voltage to appear at the collector 234 of the transistor 225. The capacitor 236 filters out high frequency noise from this collector signal. The switching ON of the transistor 225 also switches ON the transistor 242 to cause a positive going voltage to be applied through the diode 251 to the differentiator 63. The differentiator 63 transmits a positive pulse, corresponding to the leading edge of this positive going voltage, to the base 305 of the transistor 306, causing it to switch ON. This applies a negative voltage to the base 321 of transistor 322 which in turn applies a positive voltage to line 55. This positive voltage on line 55 is the trigger signal. This positive voltage is fed back from the line 55 through the hold circuit 66 to the base of the transistor 305. Thus, once the transistor 305 is turned ON, it latches itself in the ON state until the hold circuit 66 is broken, thus holding the trigger signal on line 55 in the ON state.

The signal on the line 55 is differentiated by the differentiator 71 to transmit a single positive pulse, corresponding to the leading edge of the trigger signal, to the "turn-ON" input of the first SCR switch 72 at the gate 417 of the SCR 418. This causes the SCR to switch ON and to continuously conduct to energize the line 425 during the delay interval.

Normally, when SCR 418 is OFF, the line 425 and consequently the base-two terminal 455 of the UJT 456 is at a low voltage state, which allows the constant current output from the collector 461 of transistor 462 to be grounded through the emitter base-one of the UJT 456 and resistor 482, discharging capacitor 463 (and capacitor 465). This develops some initial low voltage on the capacitors 463 and 465 as determined by the setting of the resistor 451.

The voltage on line 425 energizes the timer circuit 73 through the resistor 451. This allows the capacitor 463 to begin to charge at a predetermined rate by a constant current controlled by the setting of the delay interval control resistor 472. (If the switch 464 is closed to connect the capacitor 465 across the capacitor 463, much longer charging times will be selected). When the capacitor has charged to the point determined by the combined settings of resistors 451 and 472, where the voltage at the emitter 457 of the unijunction 456 reaches the break-over voltage of the unijunction transistor, the unijunction transistor 456 will conduct, causing a momentary positive voltage to appear across the resistor 483. This momentary voltage or pulse marks the end of the delay interval and the beginning of the duration interval in which the spray apparatus is to be operating. This momentary voltage appears as a positive pulse at the gate of the SCR 488 and causes the SCR 488 to conduct. This applies a positive voltage to the line 495 which, differentiated through the capacitor 498, applies a positive pulse to the base of SCR 418, reverse biasing SCR 418 and turning it off. This disables the timer 73. It is noted that the trigger signal on line 55 is still in the ON condition.

The signal on line 495 is conducted through the output line 52 to the input line 81 of the output circuit 80. This applies a positive signal to the base of the transistors 613 and in turn to the base of transistor 617, causing the transistor 617 to ground the line 625 to line 604. This causes the capacitors 632, which are normally maintained in a charged state, to discharge

through the solenoid windings **603**. The capacitors **632** are normally charged with a higher voltage than is necessary to energize the windings **603** and one of large enough capacity to supply ample current to very rapidly energize the windings **603**. The windings **603** remain energized through the resistors **637** until the signal at the input line **81** is removed, de-energizing the transistors **613** and **617**. The resistors **637** limit the output current to the windings **603** in the event that their terminals become shorted, thus protecting the output transistor **617**.

The positive signal on line **495** is transmitted through the differentiator **78** to backward bias the SCR **588** to turn it off. The SCR **588** will have remained on from the previous trigger signal.

The positive voltage on line **495** further energizes the timer **75**, which causes the capacitor **563** to charge at a rate controlled by the setting of the variable resistor **572**. After a period of time representative of the duration time interval, the unijunction transistor **556** conducts, discharging the capacitor **563** through the resistor **582**, causing a momentary positive pulse to appear on line **583**. This pulse is applied to the gate **587** of the SCR **588** to turn on the SCR switch **76**. The turning on of the SCR switch **76** generates a positive going signal which is differentiated at the differentiator **77** to apply a positive pulse to line **495** which backward biases the SCR **488**, turning it off. This removes the voltage from output line **52**, turning off transistors **613** and **617** and de-energizing the windings **603**.

Also, the turning ON of the SCR **588** generates a positive going signal on line **58** which is differentiated by the differentiator **68** in FIG. **2** to apply a positive going pulse to the base **353** of the transistor **350**, causing it to conduct, shunting the holding circuit **66** to ground. If the sensor signal has returned to normal, this reset signal removes the base current from the transistor **306**, turning OFF the trigger signal output until the next signal is received from the sensor.

PLURAL TIMER EMBODIMENTS

FIGS. **5** and **6** illustrate control systems in which a plurality of timers **70** are connected sequentially to provide multiple time intervals. In this way, different coating devices can be made to operate at different times during a coating cycle. The diagrams of FIGS. **5** and **6** illustrate two alternative means for programming plural outputs differently in accordance with different combinations of outputs from the timers **70**.

Referring specifically to FIG. **5**, the input **61** of the trigger circuit **60** connects from the output **46** of the sensor selector gate **45**. The output **54** of the trigger circuit **60** connects to the input **55A** of the first timer circuit **70A**. The reset output **58A** from the timer **70A** connects to the input **55B** of the timer **70B**. The reset output **58B** of the timer **70B** connects to the reset input **53** of the trigger circuit **60**. The timer **70A** and **70B** are identical to the circuit of the timer **70**, illustrated in FIG. **3**. Each has a delay output line **56A** and **56B**, respectively, and a duration output line **52A** and **52B**, respectively. A pair of output circuits **80A** and **80B** are provided, each having sets of outputs **82A** and **82B**, respectively, connecting to different solenoid valves, which control different discharge devices. The output circuits **80A** and **80B** are as illustrated in FIG. **4**. Each of the outputs **80** has a respective input **81A** and **81B** which is connected to the output of an OR-gate **701A** and **701B**. Each of the OR-gates has a plurality of inputs **702A** and **702B**, respectively. Each of the inputs is connected through a different one of a plurality of switches **703** to one of the outputs **56A**, **56B**, **52A**, and **52B** of the timers. By selectively closing the various ones of the switches **703**, the output circuit **80** can be actuated during any of four time intervals during each of the cycles.

Similarly, a circuit of FIG. **6** illustrates a control system in which three timers **70A**, **70B**, and **70C** are connected sequentially. In a similar manner, the reset outputs **58A** and **58B** of each of the circuits connects to the input **55B** and **55C** of the next succeeding timer circuit, with the reset output **58C** of the timer **70C** being connected to the reset input **53** of the trigger board **60**. The delay and duration outputs **56** and **52** are each connected to the anodes of different ones of the diodes **711**, which have cathodes connected to a different one of the conductors of a first set of conductors **715**. A second set of conductors **716** is provided which connects to an input of a different one of a plurality of output circuits **80**. The conductors **715** and **716** in the embodiment illustrated are in matrix form. In this combination, six output intervals can be programmed for each cycle, and any number of output units **80** can be selectively programmed to be actuated during any one of the six output intervals. To program the outputs **80**, the corresponding conductors of the set **716** are electrically connected by the use of connectors, switches, or other means to the conductors of the set **715** which correspond to the desired interval output from the timer **70**, during which it is desired to actuate the outputs **80**.

In addition to the combinations of timers **70** illustrated in FIGS. **5** and **6**, it will be apparent from the present specification that various other combinations can be employed.

As an example of the operation of the combination of timers, the circuit illustrated in FIG. **6**, when programmed, is illustrated in that figure with each of the dots **719** representing the contact points between the respective conductors **715** and **716**. The operation can be readily understood from the timing diagram at the left of FIG. **6**, in which the curves (j_1) through (j_4) represent the outputs of the respective output circuits **80A** through **80D**, while the curves (a) through (h_8) represent signals corresponding in operational detail to those illustrated in the timing diagram of FIG. **1** in connection with the single timer control system, and correspond to the respective timers **1** through **3**.

EMBODIMENT FOR CLOSED WORKPIECE SPACING

When the objects to be coated are fed with exceptionally close spacing, it may be desireable to overlap the delay and duration intervals for the purpose of speeding up the coating operation. When this is desired, the holding circuit **66** (FIGS. **1** and **2**), or perhaps even the entire trigger circuit **60** may be eliminated. In this case, the first solid state switch **72** will perform the trigger signal lock-out function during the delay interval and will be reset at the end of the delay interval. In such a way, the timer circuit **70** is in a condition to accept the next succeeding sensor signal while the duration interval is proceeding. In such cases some minor circuit modification may be necessary within the timer circuit **70** (FIG. **3**). For example, it has been

found that additional isolation means are desirable to be connected in series with the capacitor **498** to prevent effecting the duration interval when SCR **488** is turned ON by, for example, premature turn-OFF of SCR **488.** For such a purpose, an additional SCR has been incorporated successfully into the differentiator **79,** with its cathode to the junction of capacitor **498** and resistor **499,** and its anode connected to line **401.** Diode **497** was disconnected and re-connected with its cathode connected to the gate of this additional SCR and its anode connected to the base-one terminal **481** of UJT **456.**

We claim:

1. A control circuit for generating an output signal of a specified duration at a specified delay after receiving an input signal, said circuit comprising:

a bi-stable trigger circuit having a "set" input for receiving said input signal, a "reset" input for receiving a reset signal, and an output;

a delay-duration interval timer circuit having an input connected to the output of said trigger circuit, a delay output for presenting an output signal only during the delay interval, and a duration output for producing an output signal only during the duration interval;

said trigger circuit comprising:

a. first and second DC power leads, including a positive and a negative lead;

b. a first and a second transistor, including a PNP and an NPN transistor;

c. said first transistor having its base connected to said "set" input and its emitter to said first lead;

d. a first resistor connected between the collector of said first transistor and said second lead;

e. said second transistor having its base connected to the collector of said first transistor, and its collector connected to said trigger output;

f. a second resistor connected between the collector of said second transistor and said first lead;

g. a diode connected between the emitter of said second transistor and said second lead; and

h. a third transistor having its base connected to said "reset" input, and having its collector and emitter connected between the base of said first transistor and said first lead.

2. A control circuit for generating an output signal of a specified duration at a specified delay after receiving an input signal, said circuit comprising:

a bi-stable trigger circuit having a "set" input for receiving said input signal, a "reset" input for receiving a reset signal, and an output;

a delay-duration interval timer circuit having an input connected to the output of said trigger circuit, a delay output for presenting an output signal only during the delay interval, and a duration output for producing an output signal only during the duration interval;

said timer circuit comprising:

a. positive and negative DC power leads;

b. a third lead including means for connecting said third lead to said positive lead;

c. first, second and third SCRs;

d. first and second UJTs;

e. first and second PNP transistors;

f. said first SCR having its gate connected to said timer input, its anode connected to said positive lead and its cathode connected to said delay output;

g. a first resistor connected between the base-one termianl of said first UJT and said negative lead;

h. a first variable resistor connected between the base-two termianl of said first UJT and said delay output;

i. a first capacitor connected between the emitter of said first UJT and said negative lead;

j. a second variable resistor connected between the emitter of said first transistor and said third lead;

k. the collector of said first transistor being connected to the emitter of said first UJT;

l. a voltage divider connected between said third lead and said negative lead, and having an intermediate point connected to the base of said first transistor;

m. said second SCR having its gate connected to the base-one terminal of said first UJT, its anode connected to said positive lead and its cathode connected to said duration output;

n. a second resistor connected between the base-one terminal of said second UJT and said negative lead;

o. a third variable resistor connected between the base-two terminal of said second UJT and said duration output;

p. a second capacitor connected between the emitter of said second UJT and said negative lead;

q. a fourth variable resistor connected between the emitter of said second transistor and said third lead;

r. the collector of said second transistor being connected to the emitter of said second UJT;

s. a voltage divider connected between said third lead and said negative lead, and having an intermediate point connected to the base of said second transistor; and

t. said third SCR having its gate connected to the base-one terminal of said second UJT and its anode connected to said positive lead.

3. A control circuit according to claim **2** further comprising:

a third capacitor connected between the cathodes of said first and second SCRs; and

a fourth capacitor connected between the cathodes of said second and thirds SCRs.

4. A control circuit according to claim **3** further comprising:

a fifth capacitor connected between said timer input and the gate of said first SCR; and

a sixth capacitor connected between the cathode of said third SCR and the "reset" input of said trigger circuit.

5. A control circuit according to claim **2** further comprising:

a first diode connected in said voltage divider between said third lead and said intermediate point; and

said third lead connecting means including a second diode connected between said positive lead and said third lead.

6. A control circuit according to claim **2** wherein said trigger circuit comprises:

a'. first and second DC power leads, including a positive and a negative lead;

b'. a first and a second transistor, including a PNP and an NPN transistor;
c'. said first transistor having its base connected to said "set" input and its emitter to said first lead;
d'. a first resistor connected between the collector of said first transistor and said second lead;
e'. said second transistor having its base connected to the collector of said first transistor and its collector connected to said trigger output;
f'. a second resistor connected between the collector of said second transistor and said first lead;
g'. a diode connected between the emitter of said second transistor and said second lead; and
h'. a third transistor having its base connected to said "reset" input, and having its collector and emitter connected between the base of said first transistor and said first lead.

7. A control circuit according to claim **2** further comprising:
a power output circuit having
a''. a pair of output leads;
b''. a pair of DC power leads;
c''. a capacitor connected between one of said output leads and one of said power leads;
d''. a resistor connected between said one of said output leads and the other of said power leads;
e''. a power transistor having its collector and emitter terminals connected between the other of said output leads and said one of said power leads; and
f''. said power transistor having its base connected to an output of said timer circuit.

8. A timer circuit according to claim **7** further comprising:
a second transistor having its collector connected to the collector of said power transistor, its emitter connected to the base of said power transistor, and its base connected to said output of said timer circuit.

9. A control circuit for generating an output signal of a specified duration at a specified delay after receiving an input signal, said circuit comprising:
a bi-stable trigger circuit having a "set" input for receiving said input signal, a "reset" input for receiving a reset signal, and an output;
a delay-duration interval timer circuit having an input connected to the output of said trigger circuit, a delay output for presenting an output signal only during the delay interval, and a duration output for producing an output signal only during the duration interval; and
a power output circuit having
a''. a pair of output leads;
b''. a pair of DC power leads;
c''. a capacitor connected between one of said output leads and one of said power leads;
d''. a resistor connected between said one of said output leads and the other of said power leads;
e''. a power transistor having its collector and emitter terminals connected between the other of said output leads and said one of said power leads; and
f''. said power transistor having its base connected to an output of said timer circuit.

10. A timer circuit according to claim **9** further comprising:
a second transistor having its collector connected to the collector of said power transistor, its emitter connected to the base of said power transistor, and its base connected to said output of said timer circuit.

11. A control circuit for generating an output signal of a specified duration at a specified delay after receiving an input signal, said circuit comprising:
a delay-duration interval timer circuit having an input connected for receiving said input signal, a delay output for presenting an output signal only during the delay interval, and a duration output for producing an output signal only during the duration interval;
said timer circuit comprising:
a. positive and negative DC power leads;
b. a third lead including means for connecting said third lead to said positive lead;
c. first, second and third SCRs;
d. first and second UJTs;
e. first and second PNP transistors;
f. said first SCR having its gate connected to said timer input, its anode connected to said positive lead and its cathode connected to said delay output;
g. a first resistor connected between the base-one terminal of said first UJT and said negative lead;
h. a first variable resistor connected between the base-two terminal of said first UJT and said delay output;
i. a first capacitor connected between the emitter of said first UJT and said negative lead;
j. a second variable resistor connected between the emitter of said first transistor and said third lead;
k. the collector of said first transistor being connected to the emitter of said first UJT;
l. a voltage divider connected between said third lead and said negative lead, and having an intermediate point connected to the base of said first transistor;
m. said second SCR having its gate connected to the base-one terminal of said first UJT, its anode connected to said positive lead and its cathode connected to said duration output;
n. a second resistor connected between the base-one terminal of said second UJT and said negative lead;
o. a third variable resistor connected between the base-two terminal of said second UJT and said duration output;
p. a second capacitor connected between the emitter of said second UJT and said negative lead;
q. a fourth variable resistor connected between the emitter of said second transistor and said third lead;
r. the collector of said second transistor being connected to the emitter of said second UJT;
s. a voltage divider connected between said third lead and said negative lead, and having an intermediate point connected to the base of said second transistor; and
t. said third SCR having its gate connected to the base-one terminal of said second UJT and its anode connected to said positive lead.

12. A control circuit for generating an output signal of a specified duration at a specified delay after receiving an input signal, said circuit comprising:

a delay-duration interval timer circuit having an input connected for receiving said input signal, a delay output for presenting an output signal only during the delay interval, and a duration output for producing an output signal only during the duration interval; and

a power output circuit having

a''. a pair of output leads;

b''. a pair of DC power leads;

c''. a capacitor connected between one of said output leads and one of said power leads;

d''. a resistor connected between said one of said output leads and the other of said power leads;

e''. a power transistor having its collector and emitter terminals connected between the other of said output leads and said one of said power leads; and

f''. said power transistor having its base connected to an output of said timer circuit.

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