

[72] Inventor Walter H. Vogelsberg
 Radnor, Pa.
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[73] Assignee General Mold and Machinery Corporation
 Millville, N.J.

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Primary Examiner—Donald D. Forrer
Assistant Examiner—David M. Carter
Attorney—Schellin and Hoffman

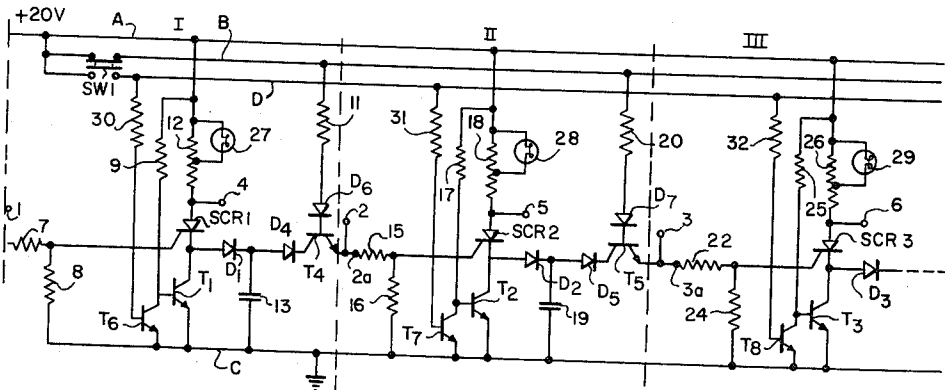
[54] **SILICON-CONTROLLED RECTIFIER SHIFT REGISTER AND RING COUNTER**
45 Claims, 8 Drawing Figs.

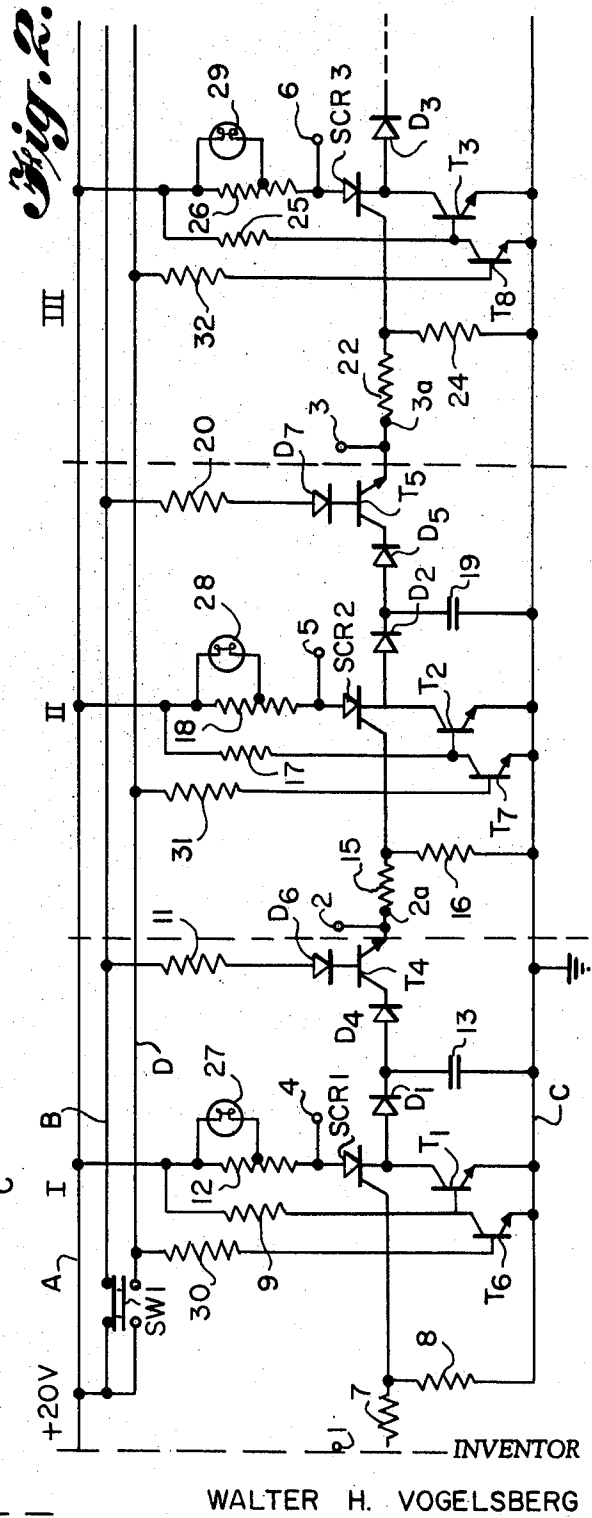
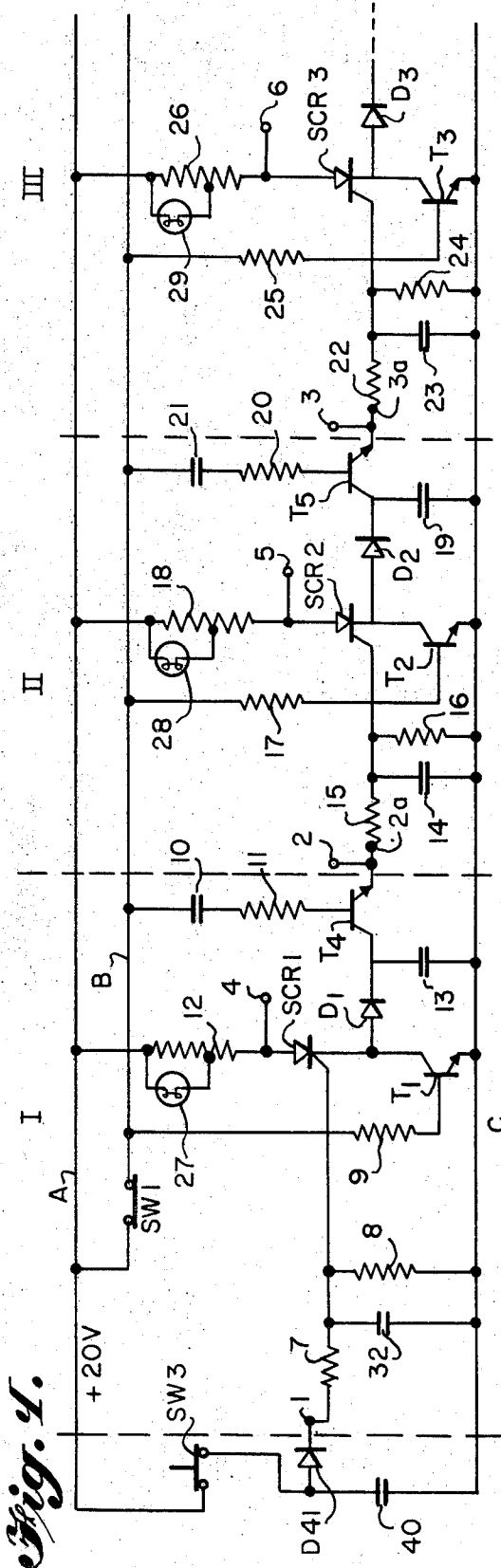
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 H01h 47/32

[50] Field of Search 307/220-
 —226, 252

ABSTRACT: A silicon-controlled shift register or ring counter using a single silicon-controlled rectifier per stage; the register can be operated as a serial register with a single input and a single output, or it can be operated as a ring counter or a plurality of inputs and outputs can be provided; also the output from any stage can be canceled; the shifting from one stage to the next is a positive shift; a special output stage to be used with the register is also disclosed; the register is particularly adaptable to machine control and to the control of industrial processes.





BY

Schellin & Hoffman
ATTORNEYS

Fig. 3.

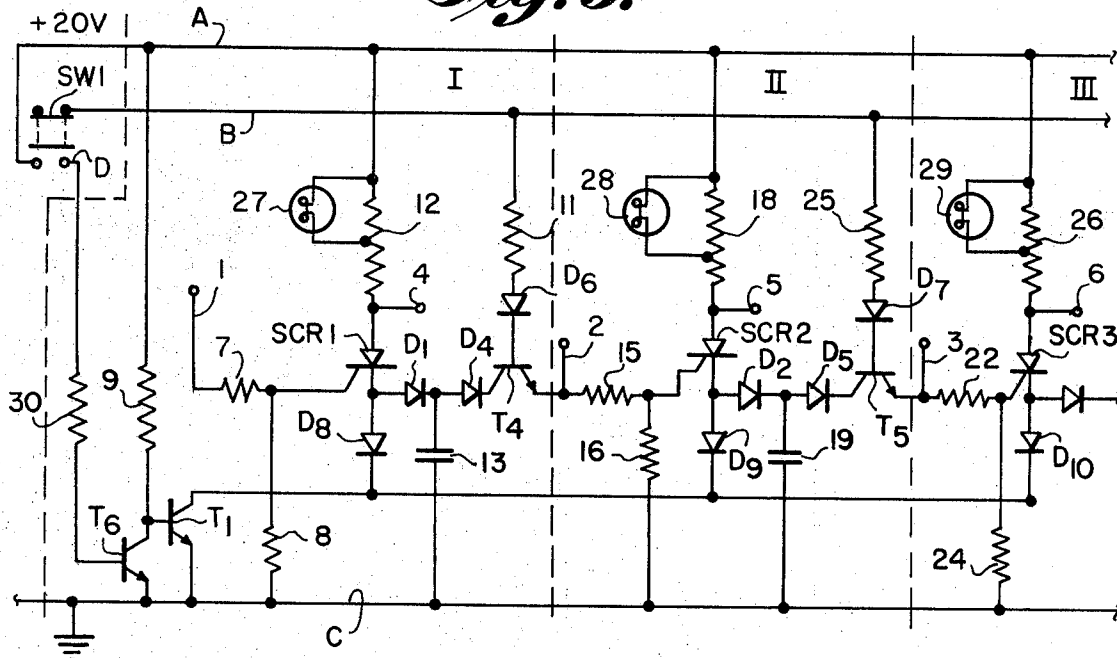
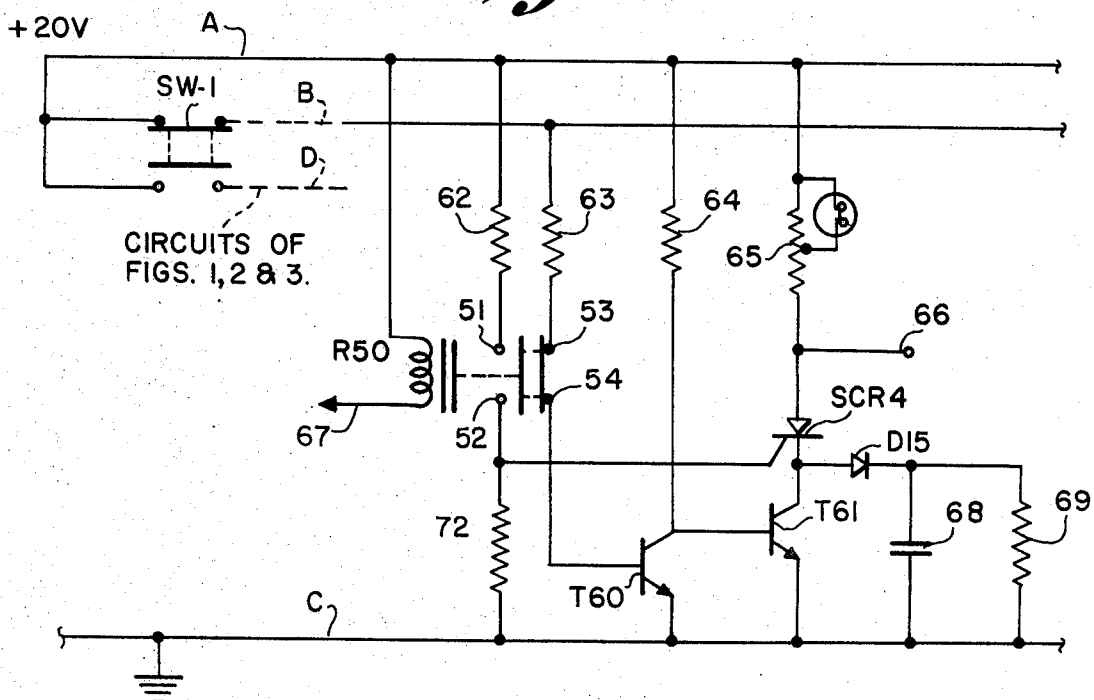


Fig. 4.



INVENTOR
WALTER H. VOGELSBERG

BY *Schellin + Hoffman*
ATTORNEYS

Fig. 5.

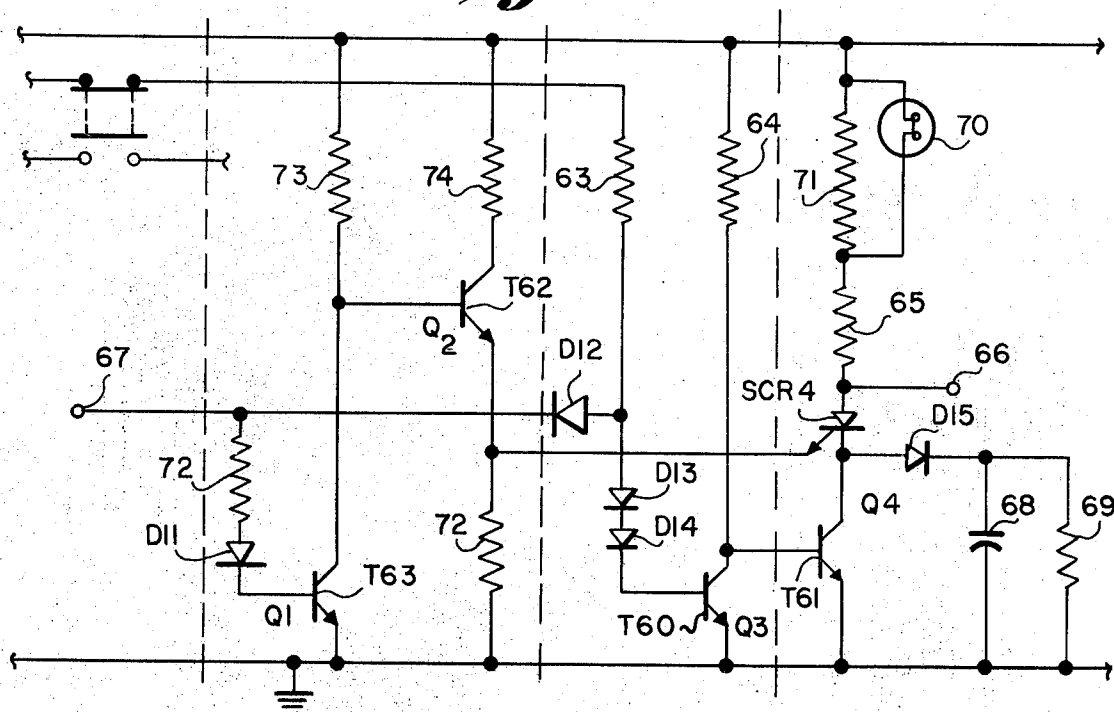


Fig. 6.

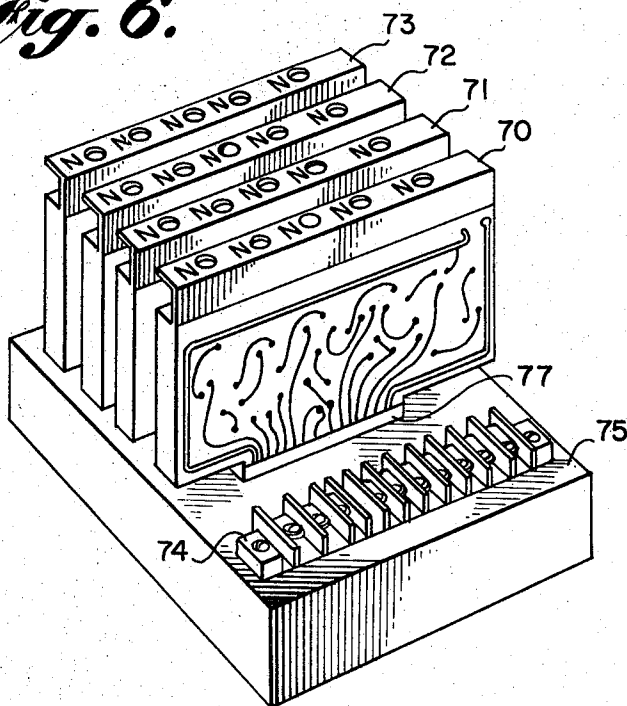
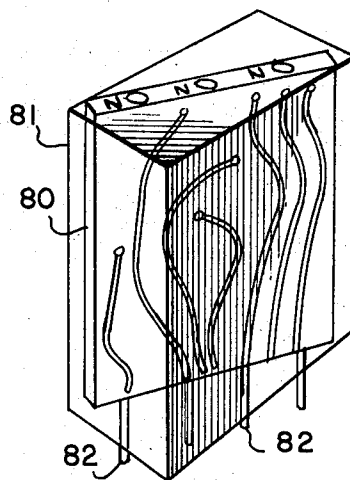


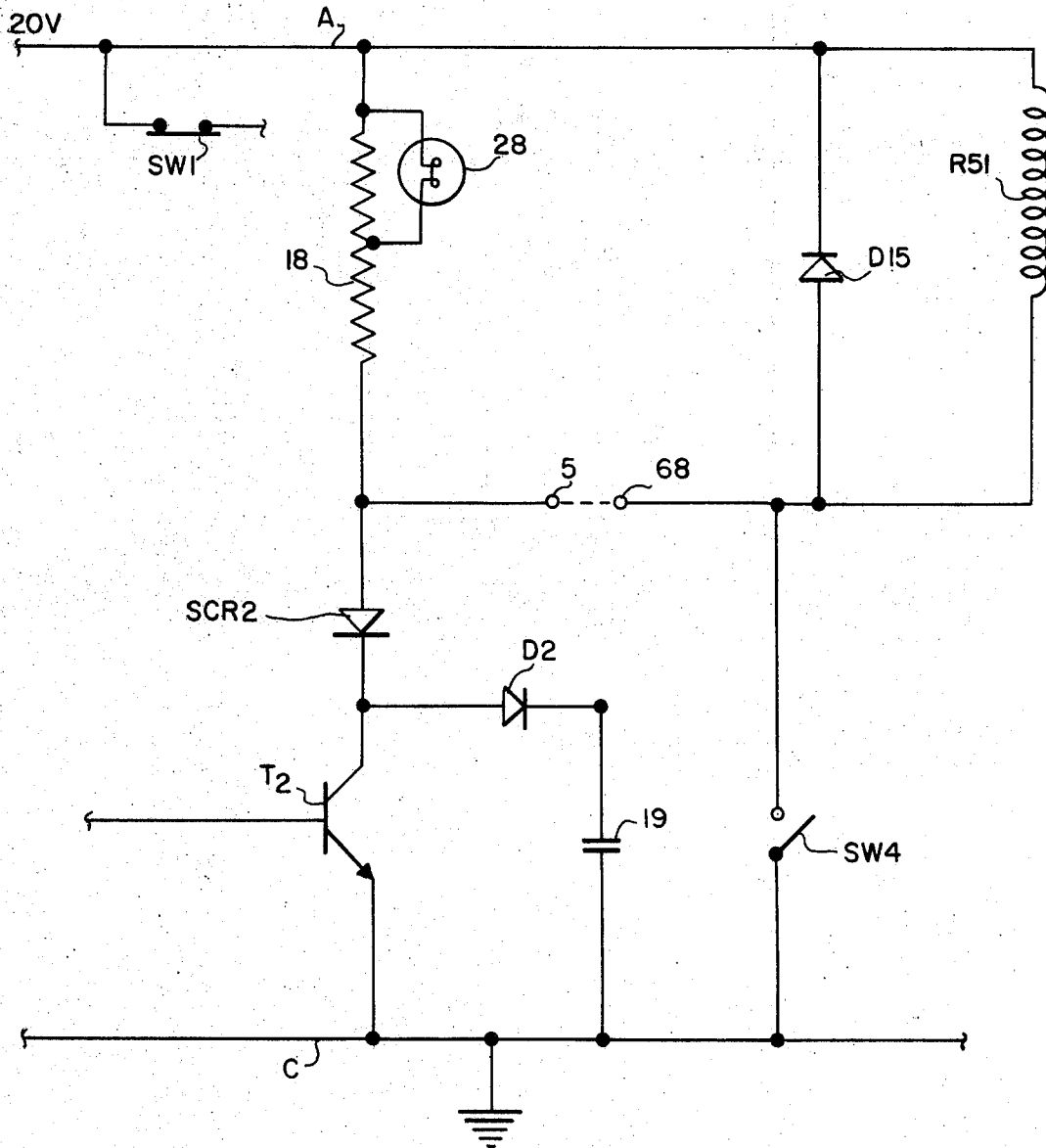
Fig. 7.



INVENTOR
WALTER H. VOGELSBERG

BY *Schellin & Hoffman*
ATTORNEYS

Fig. 8.



INVENTOR
WALTER H. VOGELSBURG

BY *Schellin & Hoffman*
ATTORNEYS

SILICON-CONTROLLED RECTIFIER SHIFT REGISTER AND RING COUNTER

BACKGROUND OF THE INVENTION

This invention relates to shift registers and ring counters and more particularly to shift registers and ring counters using silicon-controlled rectifiers.

Silicon-controlled rectifier shift registers and ring counters are known in the art. Most of these prior art devices are used in counting circuits in which the inputs to be counted are transferred through a plurality of stages only upon the occurrence of a set condition that establishes the shift. Many of these prior art shift registers and ring counters are frequently not suitable to be used as machine or assembly line control devices because they are susceptible to false shifting by extraneous signals that can be induced by the operation of the machinery. In addition the prior art shift registers and ring counters are generally designed and constructed to be used in an ideal environment. Shift registers and ring counters designed and constructed in this manner are obviously not suitable for use in a normal industrial manufacturing plant where induced electrical noise, voltage and temperature variations are a common part of the operation of the plant.

The present state of the art is such that most machine and assembly line control is achieved through the use of complex electromechanical devices utilizing relays. While these devices generally provide satisfactory control, they are normally large complex devices requiring a great amount of space and maintenance. My invention can be used to control assembly line or machine operations. Solid state construction techniques are utilized and the entire circuitry can be placed in a protected plug-in type of housing. The circuits are completely factory prewired in modular fashion and the shift register or ring counter is ready when it leaves the factory, to be connected to conventional terminal strips or plugged into adapters depending upon the final construction design. My invention is relatively immune to false triggering by extraneous signals and by the nature of its construction and operation it affords reliable maintenance-free service. In fact my invention is now being used to control a machine used in the manufacture of bottles and has been found to provide reliable trouble-free service.

In addition to the shift register or ring counter, I have invented a special output circuit that can be used with the register or counter. In some manufacturing processes, a continuous output from the control device is desired when certain conditions exist. My output circuit provides this continuous output. Also, by adding a cancel switch to a typical output circuit the output from any stage can be canceled.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide a shift to register;

Another object of this invention is to provide a ring counter;

A further object of this invention is to provide a silicon-controlled rectifier shift register;

A still further object of this invention is to provide a silicon-controlled rectifier ring counter;

A still further object of this invention is to provide a special output circuit having a continuous output under certain conditions;

A still further object of this invention is to provide a shift register or ring counter used for industrial control purposes;

A still further object of this invention is to provide a shift register or ring counter adaptable to modular construction; and

Still another object of my invention is to provide means to cancel an output from any stage of a shift register or ring counter.

BRIEF DESCRIPTION OF THE DRAWINGS

The above mentioned and other objects of my invention will be readily apparent from the following detailed description when read in conjunction with the annexed drawing in which like parts in the various FIGS. have like numbers and in which:

FIG. 1 is a schematic diagram of an embodiment of my invention;

FIG. 2 is a schematic diagram of a second embodiment of my invention;

FIG. 3 shows a variation of the circuitry shown in FIG. 2;

FIG. 4 is a schematic diagram of a special output circuit;

FIG. 5 is a schematic diagram of another embodiment of the special output circuit;

FIG. 6 is a pictorial view showing how my invention b can be constructed;

FIG. 7 is a pictorial view showing another construction of my invention; and

FIG. 8 is a schematic diagram of a typical output circuit used with the circuits of FIGS. 1-3 with a special cancel switch added to the circuit.

DESCRIPTION OF THE INVENTION

Referring now to FIG. 1 which shows in schematic form one embodiment of my shift register or ring counter. Two complete stages, the stages I and II, and part of a third stage, stage III, are shown in FIG. 1. A complete stage comprises an input circuit, one silicon-controlled rectifier, voltage storage means, signal output means, and voltage transfer means. An incandescent lamp is provided in each stage to give a visual indication of which stage is turned on. In stage I of FIG. 1, the input circuit comprises a pair of resistors 7 and 8, a capacitor 32 and an input terminal 1, the switching means comprises the transistor T₁, the voltage storage means is the capacitor 13, the output means is the output terminal 4, and the voltage transfer means comprises the transistor T₄, and the lamp 27 is the lamp used to give a visual indication that stage I is turned on. The diode D₁ is, as will be apparent later, in the charging circuit of the storage capacitor 13.

From the foregoing it is obvious that stage III would be completed by adding a storage capacitor and a transfer transistor with its associated circuitry to the cathode of diode D₃. In order to and an additional stage, stage III would have to be completed in this manner and then an additional complete stage would be connected to the emitter of the transfer transistor. Of course any number of stages can be cascaded in this manner.

Referring now in detail to FIG. 1, the anodes of each of the three silicon-controlled rectifiers, SCR 1, SCR 2, and SCR 3, is connected through a separate resistor to a positive 20 volt supply line A. Thus SCR 1, is connected to 20 volt line A through resistor 12, SCR 2 is connected to 20 volt line A through resistor 18, and SCR 3 is connected to 20 volt line A through resistor 26. The incandescent lamp 27 is shown connected across part of resistor 12 and the lamps 28 and 29 are shown connected across a part of resistors 18 and 26 respectively.

In actual construction resistor 12 consists of two separate resistors with lamp 27 connected across one of the resistors, resistor 18 similarly consists of two separate resistors with lamp 28 connected across one of the two resistors and resistor 26 consists of two separate resistors with lamp 29 connected across one of the resistors. Of course, this resistor-lamp configuration can be constructed as shown in FIG. 1, which type of construction is used is a matter of choice. However, the use of two separate resistors is desirable from a manufacturing standpoint when modular construction techniques are used. As was mentioned above, these lamps give a visual indication that the stage in which the lamp is connected is turned on. For example, when stage I is turned on, lamp 27 is ignited and remains on until stage I is turned off. The cathode of each SCR is connected to the collector electrode of a separate transistor. Thus, SCR 1 has its cathode connected to the collector of the transistor T₁, SCR 2 has its cathode connected to the collector of the transistor T₂ and the cathode of SCR 3 is connected to the collector of the transistor T₃. The emitter electrodes of all these transistors are connected to ground. The base electrodes of the transistors T₁-T₃ are connected through the resistors 9, 17 and 25 respectively to a line B. Separate input terminals 1-

—3 are provided for each stage and separate outputs 4—6 are also provided. Each stage is coupled to the next stage through the voltage storage circuit and the voltage transfer circuit. Thus, stage I is coupled to stage II through diode D, capacitor 13 and transistor T₄.

In addition to the shift register or ring counter circuitry, typical circuitry for applying an input signal to the input terminals is shown connected to input terminal 1 in FIG. 1. This circuitry which consists of a switch SW-3, a capacitor 40 and a diode D-41 is shown for purposes of describing the operation of the shift register—ring counter circuitry and is not to be considered as the only circuit that can be used to apply an input signal to anyone or all of the inputs 1-3. In fact, input signals can be applied to the input terminals from any suitable signal source through appropriate conventional coupling circuitry.

Switch SW-3 has one contact connected to 20 volt line A and the other contact connected to the anode of diode D-41. Capacitor 40 is connected between the anode of diode D-41 and ground. The cathode of diode D-41 is connected to input terminal 1. When switch SW-3 is closed an input signal is applied to terminal 1 through diode D-41.

The operation of the circuitry shown in FIG. 1 is as follows: Assume that initially all SCR's are nonconducting and the shift register is in an off state. Under these conditions, the switch SW-1 which is a normally closed switch is closed and transistors T₁, T₂ and T₃ are conducting. If SW-3 is now closed momentarily, an input pulse will be applied to the gate electrode of SCR 1, thereby gating on SCR 1. Lamp 27 will now be on indicating that SCR 1 is conducting. Conduction during this period of time is through the collector emitter electrodes of transistor T₁ because this transistor is in a conducting state as long as switch SW-1 is closed. If switch SW-1 is now opened, transistor T₁ will be cut off and capacitor 13 will be charged through diode D1. Even though there is no longer any input at terminal 1, because SW-3 was closed only momentarily, SCR 1 will remain conducting to charge capacitor 13. SCR 1 will continue to conduct until the current through the SCR is insufficient to maintain conduction. With respect to this point, I have found that the charge on capacitor 13 can be increased by connecting resistor 8 between the gate and cathode of SCR 1 rather than between gate and ground. Circuits using silicon-controlled rectifiers conventionally do have a resistor connected between the gate and cathode of the SCR. Thus the resistors 8, 16 and 24 could be connected between the gate and cathode electrodes of SCR 1, SCR 2 and SCR 14 respectively rather than between gate and ground as shown in FIG. 1. However, even though this type of connection affords for more positive shift from stage to stage because the SCR remains on longer thereby providing more time to build up a charge on the storage capacitor, I prefer to connect resistors 8, 16 and 24 as shown in FIG. 1 because I believe this connection provides for a more noise immune circuit. Lamp 27 which was turned on by the conduction of SCR 1 will of course turn off as soon as SCR 1 turns off.

During this period of time transistor T₄ is nonconducting because there is no base drive. If switch SW-1 is now closed, transistor T₄ will begin to conduct because a pulse is applied to its base and capacitor 13 will discharge through transistor T-4. Thereby, placing an input signal through resistor 15 on the gate electrode of SCR 2. Rectifier SCR 2 is now gated on and lamp 28 is turned on, indicating that this stage is now conducting.

If switch SW-1 is again opened, transistor T₂ will be rendered nonconducting, capacitor 19 will be charged through diode D2. Capacitor 19 is charged until SCR 2 turns off. If switch SW-1 is again closed, transistor T₃ will conduct, capacitor 19 will discharge and rectifier SCR 3 will be gated on. If more stages than the three shown are provided, the operation will continue sequentially in the manner described all the way down the chain.

The operation just described is the case where my register is used as a serial register. Input pulses can be applied to any

number or all of the stages simultaneously or to any particular stage individually. Also an output can be taken from any stage that is conducting. Therefore, it is obvious that parallel as well as serial operation can be obtained. In fact, numerous different sequences of operation of the stages can be obtained.

In order to operate my invention as a ring counter, the emitter of the transistor in the transfer circuit of the last stage would be connected to input terminal 1 to form a conventional ring counter. Of course, the emitter of anyone of the transfer transistors can be connected to any input terminal to form a modified ring. In fact, any stage can be coupled to any other stage to form various sequences of operation. These special sequences of operation require that the circuit be broken in places such as 2a and 3a in FIG. 1 and reconnected as required to obtain the desired sequence of operation.

Referring now to FIG. 2, the circuitry shown in FIG. 2 is similar to the circuitry shown in FIG. 1. Again, two complete stages, stages I and II and part of a third stage, stage III, are shown. In the FIG. 2 circuit, additional transistors and diodes have been added. For example, transistors T₆, T₇ and T₈ are additions to the circuitry. Also diodes D4, D5, D6 and D7 have been added and an additional line, line D, has been added. In order to switch in this additional line SW-1 in FIG. 2 is a double-throw switch rather than the single-throw switch shown in FIG. 1. Also, the resistors 12, 18 and 26 can each be replaced by two separate resistors for ease of construction and resistors 8, 16 and 24 can be connected between the gate and cathode electrodes SCR 1, SCR 2 and SCR 3 respectively in the manner described with reference to FIG. 1.

The operation of this circuit is as follows: In the off condition with switch SW-1 being closed on line B which is a normally closed line, transistors T₁, T₂ and T₃ are conducting and transistors T₆, T₇ and T₈ are nonconducting. If an input pulse is now applied to input terminal 1, SCR 1 is gated on. The circuitry shown in FIG. 1 connected to input terminal 1 can also be used to apply an input pulse to input terminal 1 of FIG. 2 or to any other or all of the input terminals in this circuit. If this circuit is used SW-3 is momentarily depressed to gate on SCR 1. SCR 1 conducts through transistor T₁. When switch SW-1 is switched such that line B is now open and line D is closed, transistor T₆ will be turned on. When transistor T₆ is on, transistor T₁ is cut off. Transistor T₁ is cut off because its base is now shunted to ground through the collector electrode of transistor T₆. Capacitor 13 will now charge through diode D1 until SCR 1 turns off as was the case in FIG. 1. If switch SW-1 is now returned to its normal position with line B closed, transistor T₄ will be turned on through diode D6 and resistor 11. Capacitor 13 will then discharge through transistor T₄ and gate on SCR 2. Switch SW-1 is again switched so that line B is open and line D is closed, transistor T₇ will now be turned on and capacitor 19 will be charged until SCR 2 turns off. As was the case in the operation of the circuit of FIG. 1, the register of FIG. 2 will continue to operate in this manner stage after stage all the way down the chain. Again lamps 27 through 29 are provided to give a visual indication of which stage is conducting and the signal at the emitter of the transfer transistor of the last stage can be fed back to input terminal 1 to obtain a ring counter or the stages can be interconnected to obtain various different sequences of operation.

Diodes D4 and D5 have been added to insure that capacitors 13 and 19 will not be charged through transistors T₄ and T₃ respectively. Diodes D6 and D7, which are also additions to the circuitry as compared to the circuit of FIG. 1 have been added to isolate line B from inputs 2 and 3 respectively.

Referring now to FIG. 3 which is a modification of FIG. 2, in this FIG. transistors T₂, T₃, T₇ and T₈ have been eliminated. Only transistors T₁ and T₆ remain. Again two complete stages, stage I and II and part of a third stage, stage III, are shown. However, now the collector electrode of transistor T₁ is connected to the cathode of all the SCR's through the separate diodes D8—D10. In all other respects the circuitry shown in FIG. 3 is the same as the circuitry shown in FIG. 2. The operation of the device is also the same. In this case transistors T₁

and T_6 operate in the same manner as they did in FIG. 2. However, now transistor T_1 and T_6 control the charging of the charge capacitors of all the stages. A pair of transistors for each stage is no longer necessary. This, of course, simplifies the circuitry considerable. The circuit of FIG. 3 is more economical and is more easily constructed in a compact manner. Again the resistors 12, 18 and 26 can each be replaced by two separate resistors with each of the lamps across one of the two resistors in each stage. Also, the stages can be interconnected in manner described with reference to FIG. 1 and 2 to obtain a ring counter or to obtain various different sequences of operations and any number of stages can be cascaded. In addition, resistors 8, 16 and 24 can be connected between the gate and cathode electrodes of SCR 1, SCR 2 and SCR 3 respectively in the manner described with reference to FIG. 1 and the circuitry shown connected to input terminal 1 of FIG. 1 for applying an input pulse to the gate of SCR 1 can be utilized with the circuit of FIG. 3 to apply an input pulse to any or all of the input terminals of this circuit.

The circuit shown in FIG. 4 is a special output circuit that can be used with the circuits of FIGS. 2 and 3. As shown in FIG. 4, the circuit comprises a first transistor T_{60} , a second transistor T_{61} , a silicon-controlled rectifier SCR 4 and a relay R 50. Relay R 50 has contacts 51-52 and 53-54 and relay contact arm 55. Transistor T_{60} has its emitter connected to ground line C and its base is connected to 20v. line A through relay contacts 53-54 and resistor 63. The collector of transistor T_{60} is connected to the base of transistor T_{61} and to the 20v. line A through resistor 64. The emitter of transistor T_{61} is also grounded and the collector of this transistor is connected to the cathode of silicon-controlled rectifier SCR 4. The anode of SCR 4 is connected to 20v. line A through resistor 65 and 71 and lamp 70 and an output is provided as at the terminal 66. Relay contact 51 is connected to 20v. line A through resistor 62 and relay contact 52 is connected to ground through resistor 72. The gate electrode of SCR 4 is connected to relay contact 52. The coil of relay R 50 has one end connected to 20v. line A and the other end of the coil, terminal 67, may be connected to output terminal 6 of either of the circuits shown in FIGS. 2 and 3 or to any one of the output terminals of these circuits. A resistor 69 and capacitor 68 are connected in parallel between ground and the cathode of a diode D15. The anode of diode D15 is connected to the cathode of SCR 4.

This special output circuit provides a continuous output under certain conditions and operates as follows: Under the conditions shown in FIG. 4 relay R 50 is not energized and relay contacts 53 and 54 are closed. When relay contacts 53 and 54 are closed transistor T_{60} is conducting and transistor T_{61} is not conducting because its base drive is shunted to ground through transistor T_{61} . During this time SCR 4 is not conducting because no input signal has been applied to its gate electrode. If it is assumed that terminal 67 of the coil of relay R 50 is connected to output terminal 6 of the circuit of FIG. 2 and SW-1 is closed, on line B, the condition just described exists when stage III of FIG. 2 is turned off.

Continuing to assume that terminal 67 of the coil of relay R 50 is connected to output terminal 6 of FIG. 2, relay R 50 will be energized when stage III is turned on. Energizing relay R 50 closes relay contacts 51 and 52 and opens relay contacts 53 and 54. When relay contacts 51 and 52 are closed, SCR 4 will be gated on because an input pulse is now applied to its gate electrode. At the same time that SCR 4 was gated on, transistor T_{60} was rendered nonconducting because its base drive had been removed by the opening of relay contacts 53 and 54. When transistor T_{60} is rendered nonconducting, transistor T_{61} will be conducting because its base drive is no longer shunted to ground. Thus SCR 4 is conducting because it has been gated on and the conduction path is through transistor T_{61} . When SCR 4 is conducting an output signal is present at terminal 66 and again an incandescent lamp, lamp 70, can be provided to indicate that SCR 4 is conducting. In FIG. 4 two resistors 65 and 71 are shown between the anode

of SCR 4 and 20 volt line A with lamp 70 connected across resistor 71. This configuration shows the two resistor circuitry that can be used for resistors 12, 18 and 26 in FIGS. 1, 2 and 3 as discussed above.

Assume now that stage III has been turned off and remains off for at least one cycle and that switch SW-1 has been switched from line B to line D. Under these conditions relay R 50 will no longer be energized and contacts 51 and 52 will be open and contacts 53 and 54 will be closed. However, SCR 4 will remain conducting because transistor T_{60} is still nonconducting and transistor T_{61} is conducting. Transistor T_{60} is not conducting because there is no base drive to this transistor when SW-1 is switched from line B to line D. Therefore an output signal remains at terminal 66 even though relay R 50 is no longer energized. If now switch SW-1 is returned to line B, transistor T_{60} will conduct cutting off transistor T_{61} and SCR 4 will turn off. SCR 4 does not turn off immediately after transistor T_{61} conducts. There is a slight delay before the current through SCR 4 has decreased to the point where SCR 4 turns off. During this time capacitor 68 is charged until SCR 4 turns off. When SCR 4 turns off capacitor 68 will discharge through resistor 69.

Assume now that stage III is again turned on, relay contacts 51 and 52 will be closed and SCR 4 will conduct as described above. At this point in time switch SW-1 is closed on line D and line B is open. Stage III will operate through its normal cycle and turn off, thereby deenergizing relay coil R 50 and opening contacts 51 and 52. However, since switch SW-1 is closed on line D, SCR 4 will remain conducting because there is no voltage present at the base of transistor T_{60} . If now switch SW-1 is closed on line B and the storage capacitor between stage II and stage III is charged, stage III will again turn on and relay coil R 50 will be energized closing contacts 51 and 52. Under these conditions SCR 4 will remain on. In other words, if stage III is turned on as soon as switch SW-1 is closed on line B, SCR 4 will continuously conduct. As will be discussed later, this type of operation is essential for the control of some types of assembly line processes.

Referring now to FIG. 5, the circuit shown in this figure is a modification of the continuous output circuit of FIG. 4. In this circuit the relay and relay contacts of FIG. 4 have been replaced with transistors and diodes. The circuit to the right of transistor T_{60} is identical to the circuitry to the right of transistor T_{60} in FIG. 4 and these components have the same reference numerals in both figures. Considering the balance of the circuit of FIG. 5, a transistor T_{63} has its base coupled to terminal 67 through a diode D11 and a resistor 71. The emitter of transistor T_{63} is connected directly to ground and the collector is connected to 20 volt line A through a resistor 73. A second transistor T_{62} has its base connected to the common point of resistor 73 and the base of transistor T_{60} is connected to 20 volt line A through a resistor 74 and its emitter is connected to ground through a resistor 72. Transistor T_{60} which is equivalent to transistor T_{60} of FIG. 4 has its base connected to line B through a pair of series connected diodes D13 and D14 and a resistor 63. A diode D12 is connected between terminal 67 and the common point of diode D13 and resistor 63. The gate electrode of SCR 4 is connected to the emitter of transistor T_{62} . As was mentioned above, the balance of the circuit is identical to the equivalent part of the circuit FIG. 4.

The circuit of FIG. 5 operates as follows: Again assume that terminal 67 is connected to terminal 6 at stage III of FIG. 2 and that SCR 3 is turned off, under these conditions T_{63} is conducting due to the base drive derived from 20 volt line A through resistor 26 of FIG. 2, resistor 72 and diode D11. When transistor T_{63} is conducting, transistor T_{62} is held nonconducting because the base of this transistor is essentially clamped to ground through transistor T_{63} . Transistor T_{60} is also conducting due to the fact that SW-1 is switched to normally closed line B thereby applying a potential to the base of this transistor through resistor 63 and diodes D13 and D14. As was the case in FIG. 4, transistor T_{61} is held nonconducting when transistor T_{60} is conducting. If now stage III of FIG. 2 is

turned on, SCR 3 will be conducting. When SCR 3 conducts the potential on the base of transistor T_{63} is decreased and transistor T_{63} is cut off. When transistor T_{63} is cut off, transistor T_{62} will conduct, its base no longer being clamped to ground. However, transistor T_{60} which has been conducting will be cut off because diode D12 which is biased off when SCR 3 is not conducting is now biased in the forward direction thereby removing the base drive from transistor T_{60} . As was the case in FIG. 4, transistor T_{61} will conduct when transistor T_{60} is cut off. The conduction of transistor T_{62} places a potential on the gate of SCR 4 thereby gating on SCR 4. As long as SCR 3 remains conducting, SCR 4 will conduct regardless of the position of switch SW-1. If stage III turns off and switch SW-1 is closed on line B, SCR 4 will turn off because transistor T_{63} and T_{60} will again be conducting, transistor T_{62} and T_{61} will be cut off and no input potential is present on the gate of SCR 4. SCR 4 will not cut off immediately. There is a slight delay before the current decreases below the current necessary to hold SCR 4 on. During this time capacitor 68 will be charged until SCR 4 turns off. When SCR 4 is turned off capacitor 68 will discharge through resistor 69.

From the foregoing description it is obvious that the circuit of FIG. 5 operates in a manner similar to the operation of the circuit shown in FIG. 4. While both circuits have been described with reference to my shift register or ring counter circuits, it is obvious that these circuits can be used as output circuits for other similar circuits to provide a continuous output instead of a pulsed output that would normally be present. As was mentioned above with reference to FIG. 4, a specific use of the continuous output circuit will be described later.

FIG. 6 is a pictorial view of one production model of my invention and FIG. 7 is a pictorial view of another production model of my invention. As is shown in FIG. 6, printed circuit boards are used to make up the shift register or ring counter circuitry. Four printed circuit boards 70-73 are shown. Each of these boards houses a five-stage register as is obvious from the five lamps N shown across the top of each of the boards 70-73. Boards 70-73 are all mounted on a prewired chassis 75. Plug-in receptacles are provided on top of chassis 75 for each of the circuit boards. Only one receptacle 77 is visible in FIG. 6. These receptacles are prewired and a circuit board can be added or taken out as needed. A terminal board 74 is provided to wire the register or ring counter to, for example, a machine the device will control. While chassis 75 provides for only four, five-stage circuit boards, it is obvious that it can be made larger so that more circuit boards could be added. Also, provisions can be made to provide for printed circuit boards having less than one or more than five stages. This type of arrangement provides for a great deal of versatility. Register or ring counter stages can be readily added or subtracted.

The model shown in FIG. 7 is a plug-in unit model. A printed circuit board 80 containing the register or ring counter circuitry is housed in a sealed glass or plastic envelope 81. The printed circuit board shown in FIG. 7 contains the three stages as is indicated by the three lamp N across the top of the board. The register circuits are brought out of envelope 81 by means of a conventional plug 82. In this model the circuitry is completely sealed from dust or corrosive material that may be present in the area where the device is being used. Any number of stages can be housed in such a sealed container. A prewired chassis similar to the chassis 75 of FIG. 6 is provided to permit easy addition or subtraction of stages. Of course, this chassis will contain a plurality of vacuum tube type receptacles rather than the type of receptacle shown in FIG. 6.

As was mentioned above, my invention is particularly adaptable to machine or assembly line control. This should be apparent now that the operation of the invention has been described. Assume that it is desired to control a machine that performs three separate functions. Assume also that these three functions are as follows: (1) The machine picks up an article being manufactured, (2) the machine applies a label to the article by a silk screen process, and (3) the machine applies a finishing process of to the article. As long as the

machine functions properly the register remains off. If the machine should fail to pick up the article, a sensing device will transmit a pulse to the shift register turning on the first stage of the register. This input to the first stage will be shifted to the second stage and the silk screen will not come down to apply a label. The register will then shift to the third stage and the machine will not perform the finishing function. The shifting of the register is in timed sequence with normal operation of the machine so that the machine will be held off at the proper time.

If it had been a long automatic assembly line process none of the assembly line functions would be performed after the first stage of the register indicates that a problem exists. Of course, an entire assembly line can be monitored by having each station of the line connected to a separate input of the register. If this type of control is utilized, then each station down line from the station indicating a problem will be held off by the shift register as it shifts from stage to stage in timed sequence with the normal operating sequence of the stations along the assembly line. No matter where the fault occurs along the line, the register will control the remainder of the line.

Under some conditions it may be necessary to also control that part of the assembly line preceeding the station indicating a problem. Under these conditions the register will be wired as a ring counter or a modified ring counter in the manner described above.

In some assembly lines provision are made to remove any rejects from the assembly line. An arm or wiper swings out and pushes the article off the line before it reaches the packaging stage of the assembly line. If the register as disclosed in FIG. 1, 2 and 3 were used, the arm pushing the product off the line would swing back and forth each time an article is pushed off the line. If several rejects are all in a row along the line, the swinging back and forth of the arm for each reject may not be desirable. Under these circumstances one would use either the output circuit shown in FIG. 4 or the output circuit shown in FIG. 5 to push the rejected articles off the line. The arm would not swing back and forth for each rejected article when the rejects follow one another on the assembly line.

In addition to the type of machine or assembly line control just described, my shift register or ring counter can be used to control an assembly line process in still another manner by using a typical output circuit that would normally be used with the circuits of FIG. 1, 2, and 3 and by adding to this typical output circuit what I call a cancel switch. This circuitry is shown in FIG. 8 of the drawing. Also, for purposes of describing the operation of this circuit a part of stage II of FIG. 1 is shown in FIG. 8.

The typical output circuit consists of an input terminal 68 a diode D15 and a relay R 51 (only the coil of relay R 51 is shown in FIG. 8). Input terminal 68 is connected to any one of the output terminals of the circuits of FIG. 1, 2, or 3. In FIG. 8 terminal 68 is shown connected by a dashed line to output terminal 5 of stage II of the FIG. 1 circuit. Of course, each stage of the shift register—ring counter circuits would normally have such an output circuit connected to its output terminal. Considering the typical output circuit only, it is obvious that relay R 51 will close every time SCR 2 is turned on and will open when SCR 4 is turned off.

To this typical output circuit, I have added a switch SW-4. I call this switch a cancel switch. If SCR 2 is turned on and SW-4 is momentarily closed, the anode of SCR 2 will be shorted to ground and SCR 2 will be cut off. Recalling the normal operation of the shift register—ring counter circuit of FIG. 1, capacitor 19 would normally be charged by SCR 2 to provide an input to the gate electrode of the SCR of the following stage. However, since SW-4 was closed momentarily thereby rendering SCR 2 nonconducting, capacitor 19 did not receive any charge. Thus, the next stage of shift register—ring counter will not be turned on when shift switch SW-1 is closed on line B to shift the register to the next stage. Of course, none of the stages following the stage in which cancel switch SW-4

is closed will turn on as is the case in the normal sequential type of operation. However, the fact that the following stages do not turn on can be used to control an assembly line process or control the operation of a particular machine.

Assume that either the circuits of FIGS. 1, 2 or 3 is used to control an assembly line in which a part is added to the article being manufactured at each station of the assembly line and that at least one stage of my shift register—ring counter is used to control each stations of the assembly line in such a manner that the part to be added will not be added unless the stage controlling that section is turned on. In other words, if the stage is turned on, the a part will be added to the article being assembled. If my shift register—ring counter is used to control an assembly line in this manner, any suitable sensing device will be used at each station to indicate that the part to be added to the article being assembled has in fact been added. If the part has not been added, the cancel switch of the stage associated with that station of the assembly line will be closed to cancel that stage. Thereafter, no other parts will be added to the article being assembled because none of the following stages will be turned on as the subassembly moves down the assembly line. Of course, what has happened before or after a stage was canceled is not affected by the canceling of a particular stage. The partially assembled article can, after it travels down the entire assembly line be returned to the proper station to complete the assembly. Cancel switch SW-4 can be manually operated it can be electronically operated using well-known electronic techniques.

This type of assembly line control is highly desirable in many assembly line operations. Without this control, parts will be added to a faulty assembly or the assembly line will have to be stopped to correct the malfunction or some other type of corrective action that may be necessary. Furthermore, if parts continue to be added to a faulty article that cannot readily or economically be disassembled to salvage the good components, an entire article that may be missing only one minor component will have to be thrown away. Thus, my invention can provide for substantial savings in an assembly-line-type operation.

As was mentioned above, the inputs and outputs of the circuits of FIGS. 1, 2 and 3 can be interconnected in any desired manner to obtain various modes of operation as the emitter of any of the transfer transistors (transistors T_4 and T_5) can be connected to the input terminal of another stage to form a modified ring counter or a conventional ring counter can be formed. Assume that a conventional ring counter is formed and that this ring counter is to be used to control a machine having three optional stages. To control such a machine the third stage of the circuit of FIGS. 1, 2 or 3 would be completed and the emitter of the transfer transistor of stage III would be connected to input terminal 1. As now connected, the shift register would shift from stage III back to stage I, then to stage II, and then to stage III and back gain to stage I and so on. If in as addition to the above mentioned connection, means are provided to automatically open and close switch SW-1, the three-step machine operation that it was assumed is being controlled by my invention will automatically be operated cycle after cycle in its three-step operation.

Of course, as has been mentioned, other combinations of interconnections can be made to obtain other sequences of operation. The circuit may have to be broken at such places as 2a and 3a in FIGS. 1 and 2 to obtain the modified operation. The necessary circuitry breaks and connections required to obtain a desired sequence of operation are obvious from the operation of the circuit.

While my invention has been described with reference to specific embodiments, it will be obvious to those skilled in the art that various changes and modifications can be made to the embodiments disclosed without departing from the spirit and scope of the invention. For example, known latching-type switching devices other than the silicon-controlled rectifiers could be used in the circuits disclosed.

I claim:

1. A control circuit comprising:

a plurality of cascaded stages, each stage including a silicon-controlled rectifier having anode, cathode and gate electrodes;

the anode electrodes of all of said silicon-controlled rectifiers being coupled to a voltage source;

the cathode electrode of each of said silicon-controlled rectifiers being coupled through a separate voltage transfer means to the gate electrode of the silicon-controlled rectifier of the subsequent stage of said stages;

separate voltage storage means coupled between a common potential point and the cathode electrode of each of said silicon-controlled rectifier means;

switching means coupled between a common potential point and the cathode electrodes of said silicon-controlled rectifiers; and

voltage switching means coupled to said voltage transfer means and said switching means.

2. A control circuit as defined in claim 1 wherein separate input signal circuit means are coupled to each of the gate electrodes of all of said silicon-controlled rectifiers and separate output signal circuit means are coupled to each anode electrode of all of said silicon-controlled rectifiers.

3. A control circuit as defined in claim 2 wherein said separate input signal means and said separate voltage transfer means are interconnected in any desired sequence.

4. A control circuit as defined in claim 1 wherein each of said separate voltage storage means comprises a capacitor.

5. A control circuit as defined in claim 1 wherein each of said separate voltage transfer means comprises a transistor having its collector coupled to the cathode electrode of the silicon-controlled rectifier of one of said stages, its emitter coupled to the gate electrode of the silicon-controlled rectifier of the subsequent stage and its base coupled to said voltage-switching means.

6. A control circuit as defined in claim 1 wherein said switching means comprises a plurality of circuits, one for each stage of said stages, each including a transistor having its emitter connected to a common potential point, its collector connected to the cathode electrode of the silicon-controlled rectifier of the associated stage of said stages and its base electrode coupled to said voltage-switching means.

7. A control circuit as defined in claim 1 wherein: said switching means comprised a plurality of circuits, one for each stage of said stages, each including a first transistor having its base coupled to said voltage-switching means, its emitter connected to ground and its collector coupled to said voltage source; and

a second transistor having its base connected to the collector of said first transistor, its emitter connected to a common potential point and its collector connected to the cathode of the silicon-controlled rectifier of the associated stage of said stages.

8. A control circuit as defined in claim 2 wherein the voltage transfer means included in the last stage of said stages is coupled back to said input circuit means connected to said first stage of said stages.

9. A control circuit as defined in claim 1 wherein:

said switching means comprises a first transistor having its emitter connected to a common potential point, its collector coupled to said voltage source and its base coupled to said voltage-switching means; and

a second transistor having its base connected to the collector of said first transistor, its emitter connected to a common potential point and its collector coupled to the cathodes of the silicon-controlled rectifiers of all of said stages.

10. A control circuit as defined in claim 2 wherein each of said separate output circuit means comprises:

a relay having first, second, third and fourth contacts and a coil, said coil being coupled between said voltage source and the anode of the silicon-controlled rectifier of the stage of said stages to which said output means is connected;

a first transistor having a base electrode coupled to said fourth relay contact, an emitter electrode coupled to a common potential point and a collector electrode coupled to said voltage source;
 a silicon-controlled rectifier having a gate electrode coupled to said second relay contact, an anode electrode coupled to said voltage source, and a cathode electrode;
 a second transistor having an emitter electrode connected to a common potential point, a base electrode coupled to said collector electrode of said first transistor, and a collector electrode coupled to said cathode electrode of said output circuit silicon-controlled rectifier; and
 output signal terminal means coupled to said anode electrode of said output circuit silicon-controlled rectifier.

11. A control circuit as defined in claim 1 wherein all of said circuits are constructed on plug-in-type printed circuit boards and a prewired chassis is provided to receive said plug-in printed circuit boards.

12. A control circuit as defined in claim 1 wherein all of said circuits are constructed on a printed circuit board and said board is placed in a sealed container having a plug to provide external circuit connections to said printed circuit board.

13. A control circuit comprising:

a plurality of stages, each stage including a silicon-controlled rectifier having cathode, anode and gate electrodes and a first transistor having emitter, collector and base electrodes;

a voltage source;

an "on"-"off" switch;

means to couple the emitter electrodes of all of said first transistors to a common potential point;

separate resistive means coupled between the base electrodes of each of said first transistors and said "on"-"off" switch;

means to couple the collector electrode of said first transistors of each stage to the cathode electrode of the silicon-controlled rectifier included in the same stage;

a plurality of signal storage means;

means to couple a different one of said plurality of signal storage means between a common potential point and the cathode electrodes of each of said silicon-controlled rectifiers;

a plurality of signal transfer means; and

means to couple a different one of said plurality of signal transfer means between the cathode electrode of each of said silicon-controlled rectifiers and the gate electrode of the silicon-controlled rectifier in the subsequent stage.

14. A control circuit as defined in claim 13 wherein separate input signal circuit means are coupled to each of the gate electrodes of all of said silicon-controlled rectifiers and separate output signal circuit means are coupled to each anode electrode of all of said silicon-controlled rectifiers.

15. A control circuit as defined in claim 14 wherein said inputs and voltage transfer means are interconnected in any desired sequence.

16. A control circuit comprising:

a plurality of stages, each stage including a silicon-controlled rectifier having anode, cathode and gate electrodes, a first transistor having emitter, collector and base electrodes and a second transistor having emitter, collector and base electrodes;

a voltage source;

a first transmission line selectively connected to said voltage source;

a second transmission line selectively connected to said voltage source;

means to couple the emitter electrode of said first transistor to a common potential point; means to couple the emitter electrode of said second transistors of all of said stages to a common potential point;

separate resistive means connected between the base electrode of each of said second transistors of all of said stages and said second transmission line;

means to couple the collector electrode of the second transistor of each of said stages to the base electrode of the first transistor in the same stage;

separate resistive means for coupling the base electrode of said first transistor and the collector electrode of the second transistor of each of said stages to said voltage source;

a plurality of signal storage means;

means to couple a different one of said plurality of signal storage means between a point of common potential and the cathode of said silicon-controlled rectifier of each of said stages;

a plurality of signal transfer means; and

means to couple a different one of said plurality of signal transfer means between the cathode electrode of said silicon-controlled rectifier of each of said stages and the gate electrode of the silicon-controlled rectifier of the subsequent stage.

17. A control circuit as defined in claim 16 wherein separate input signal circuit means are coupled to each of the gate electrodes of all of said silicon-controlled rectifiers and separate output signal circuit means are coupled to each anode electrode of all of said silicon-controlled rectifiers.

18. A control circuit as defined in claim 17 wherein said separate signal input means and said signal transfer means are interconnected in any desired sequence.

19. A control circuit comprising:

a plurality of stages, each stage including a silicon-controlled rectifier having cathode, anode and gate electrodes;

first and second transistors each having emitter, collector and base electrodes;

a voltage source;

a first transmission line selectively connected to said voltage source;

a second transmission line selectively connected to said voltage source;

means to couple the emitter electrode of said first transistor to a common potential point; means to couple the emitter electrode of said second transmitter to a common potential point;

a first resistor connected between the base electrode of said first transistor and said second transmission line;

means to couple the base electrode of said second transistor to the collector electrode of said first transistor;

a second resistor connected between the base of said second transistor and said voltage source;

means to couple the collector electrode of said second transistor to the cathode electrodes of the silicon-controlled rectifiers of all of said stages;

a plurality of signal storage means;

means to couple a different one of said plurality of signal storage means between a common potential point and the cathode electrode of said silicon-controlled rectifier of each of said stages;

a plurality of signal transfer means; and

means to couple a different one of said plurality of signal transfer means between the signal storage means of each of said stages and the gate electrode of the silicon-controlled rectifier of the subsequent stage;

20. A control circuit as defined in claim 19 wherein separate input signal circuit means are coupled to each of the gate electrodes of all of said silicon-controlled rectifiers and separate output signal means are coupled to the anode electrode of all of said silicon-controlled rectifiers.

21. A control circuit as defined in claim 20 wherein said separate signal input means and said signal transfer means are interconnected in any desired sequence.

22. A control circuit as defined in claim 13 wherein each one of said plurality of signal storage means is a capacitor.

23. A control circuit as defined in claim 16 wherein each one of said plurality of signal storage means is a capacitor.

24. A control circuit as defined in claim 19 wherein each one of said plurality of signal storage means is a capacitor.

25. A control circuit as defined in claim 13 wherein each one of said plurality of signal transfer means includes a transistor having a base electrode coupled to said "on"/"off" switch, a collector electrode coupled to the cathode electrode of the silicon-controlled rectifier of one of said stages and an emitter electrode coupled to the gate electrode of the silicon-controlled rectifier included in the subsequent stage of said stages to which its collector electrode is coupled.

26. A control circuit as defined in claim 16 wherein each one of said plurality of signal transfer means includes a transistor having a base electrode coupled to said first transmission line, a collector electrode coupled to the cathode of the silicon-controlled rectifier of one of said stages and an emitter electrode coupled to the gate electrode of the silicon-controlled rectifier included in the subsequent stage of said stages to which its collector electrode is coupled.

27. A control circuit as defined in claim 19 wherein each one of said plurality of signal transfer means includes a transistor having a base electrode coupled to said first transmission line, a collector electrode coupled to the cathode of the silicon-controlled rectifier of one of said stages and an emitter electrode coupled to the gate electrode of the silicon-controlled rectifier included in the subsequent stage of said stages to which its collector electrode is coupled.

28. A control circuit as defined in claim 17 wherein each of said separate output circuit means comprises:

a relay having first, second, third and fourth contacts and a coil, said coil being coupled between said voltage source and the anode of the silicon-controlled rectifier to which said output means is coupled;

a first transistor having a base electrode connected to said fourth relay contact, an emitter electrode connected to a common potential point and a collector electrode coupled to said voltage source;

a silicon-controlled rectifier having a gate electrode coupled to said second relay contact, an anode electrode coupled to said voltage source, and a cathode electrode;

a second transistor having an emitter electrode coupled to a common potential point, a base electrode coupled to said collector electrode of said first transistor, and a collector electrode coupled to said cathode electrode of said output circuit silicon-controlled rectifier; and

output signal terminal means coupled to said anode electrode of said output circuit silicon-controlled rectifier.

29. A control circuit as defined in claim 20 wherein each of said separate output circuit means comprises:

a relay having first, second, third and fourth contacts and a coil, said coil being coupled between said voltage source and the anode of the silicon-controlled rectifier to which said output means is coupled;

a first transistor having a base electrode coupled to said fourth relay contact, an emitter electrode coupled to a common potential point and a collector electrode coupled to said voltage source;

a silicon-controlled rectifier having a gate electrode coupled to said second relay contact, an anode electrode coupled to said voltage source, and a cathode electrode;

a second transistor having an emitter electrode coupled to a common potential point, a base electrode coupled to said collector electrode of said first transistor, and a collector electrode coupled to said cathode electrode of said output circuit silicon-controlled rectifier; and

output signal terminal means coupled to said anode electrode of said output circuit silicon-controlled rectifier.

30. An output circuit comprising:

a voltage source;

a transmission line selectively coupled to said voltage source;

a relay having first, second, third and fourth contacts and a coil, said coil having first and second terminals;

means to apply an input signal to said first terminal of said relay coil;

means to couple said second terminal of said relay coil to said voltage source;

a first transistor having a base electrode connected to said fourth relay contact, an emitter electrode coupled to a common potential point, and a collector coupled to said voltage source;

a silicon-controlled rectifier having a gate electrode coupled to said second relay contact, an anode electrode connected to said voltage source, and a cathode electrode;

a second transistor having an emitter electrode connected to a common potential point, a base electrode connected to said collector electrode of said first transistor, and a collector electrode connected to said cathode electrode of said output circuit silicon-controlled rectifier;

means to couple said first relay contact to said voltage source;

means to couple said third relay contact to said transmission line; and

output signal terminal means coupled to the anode electrode of said output circuit silicon-controlled rectifier.

31. A control circuit as defined in claim 2 wherein each of said separate output circuit means comprising:

a first, second, third and fourth transistors each having a base electrode, a collector electrode and an emitter electrode;

an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output means is coupled;

means including a first diode for coupling the base electrode of said first transistor to said input terminal;

means to connect the emitter electrode of said first, third and fourth transistors to potential point;

first resistive means for coupling the collector electrode of said first transistor and the base electrode of said second transistor to said voltage source;

second resistive means for coupling the collector electrode of said first transistor to said voltage source;

means including second and third diodes and a resistor all connected in series for coupling the base electrode of said third transistor to said voltage source;

third resistive means for coupling the collector electrode of said third transistor and the base electrode of said fourth transistor to said voltage source;

a silicon-controlled rectifier having an anode, a cathode and a gate electrode;

means to couple the anode electrode of said silicon-controlled rectifier to said voltage source;

means to connect the cathode electrode of said silicon rectifier to the collector electrode of said fourth transistor;

means to couple the gate electrode of said silicon-controlled rectifier to the emitter electrode of said second transistor; and

a fourth diode connected between said input terminal and the common point of said serially connected resistor and second diode.

32. A control circuit as defined in claim 17 wherein each of said separate output circuit means comprises:

a first, second, third and fourth transistors each having a base electrode, a collector electrode and an emitter electrode;

an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output means is connected;

means including a first diode for coupling the base electrode of said first transistor to said input terminal;

means to couple the emitter electrode of said first, third and fourth transistors to a common potential point;

first resistive means for coupling the collector electrode of said first transistor and the base electrode of said second transistor to said voltage source;

second resistive means for coupling the collector electrode of said second transistor to said voltage source;

means including second and third diodes and a resistor all connected in series for coupling the base electrode of said third transistor to said voltage source;

third resistive means for coupling the collector electrode of said third transistor and the base electrode of said fourth transistor to said voltage source;
 a silicon-controlled rectifier having an anode, a cathode and a gate electrode;
 means to couple the anode electrode of said silicon-controlled rectifier to said voltage source;
 means to couple the cathode electrode of said silicon rectifier to the collector electrode of said fourth transistor;
 means to couple the gate electrode of said silicon controlled rectifier to the emitter electrode of said second transistor; and
 a fourth diode coupled between said input terminal and the common point of said serially connected resistor and second diode.

33. A control circuit as defined in claim 20 wherein each of said separate output circuit means comprises:
 a first, second, third and fourth transistors each having a base electrode, a collector electrode and an emitter electrode;
 an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output means is coupled;
 means including a first diode for coupling the base electrode of said first transistor to said input terminal;
 means to couple the emitter electrode of said first, third and fourth transistors to a common potential point;
 first resistive means for coupling the collector electrode of said first transistor and the base electrode of said second transistor to said voltage source;
 second resistive means for coupling the collector electrode of said second transistor to said voltage source;
 means including second and third diodes and a resistor all connected in series for coupling the base electrode of said third transistor to said voltage source;
 third resistive means for coupling the collector electrode of said third transistor and the base electrode of said fourth transistor to said voltage source;
 a silicon-controlled rectifier having an anode, a cathode and a gate electrode;
 means to couple the anode electrode of said silicon-controlled rectifier to said voltage source;
 means to couple the cathode electrode of said silicon rectifier to the collector electrode of said fourth transistor;
 means to couple the gate electrode of said silicon-controlled rectifier to the emitter electrode of said second transistor; and
 a fourth diode connected between said input terminal and the common point of said serially connected resistor and second diode.

34. A control circuit as defined in claim 2 wherein each of said separate output circuit means comprises:
 an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output circuit means is coupled;
 a diode coupled between said bolt voltage source and said input terminal;
 a relay having a coil connected across said diode; and
 a normally open switch connected between said input terminal and a common potential point in such a manner that said input terminal is connected to said common potential point when said switch is closed.

35. A control circuit as defined in claim 14 wherein each of said separate output circuit means comprises:
 an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output circuit means is coupled;
 a diode coupled between said voltage source and said input terminal;
 a relay having a coil connected across said diode; and
 a normally open switch connected between said input terminal and to a common potential point in such a manner

that said input terminal is connected to said common potential point when said switch is closed.

36. A control circuit as defined in claim 17 wherein each of said separate output circuit means comprises:
 an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output circuit means is coupled;
 a diode coupled between said voltage source and said input terminal;
 a relay having a coil connected across said diode; and
 a normally open switch connected between said input terminal and a common potential point in such a manner that said input terminal is connected to said common potential point when said switch is closed.

37. A control circuit as defined in claim 20 wherein each of said separate output circuit means comprises: an input terminal coupled to the anode of the silicon-controlled rectifier of the stage of said stages to which said output circuit means is coupled;
 a diode coupled between said voltage source and said input terminal;
 a relay having a coil connected across said diode; and
 a normally open switch connected between said input terminal and a common potential point in such a manner that said input terminal is connected to said common potential point when said switch is closed.

38. An output circuit comprising:
 a voltage source;
 a first, second, third and fourth transistor each having a base electrode, emitter and collector electrode;
 an input terminal;
 a voltage source;
 means including a first diode for coupling the base electrode of said first transistor to said input terminal;
 means to connect the emitter electrode of said first, third and fourth transistor to a common potential point;
 first resistive means for coupling the collector electrode of said first transistors and the base electrode of said second transistor to said voltage source;
 second resistive means for coupling the collector electrode of said second transistor to said voltage source;
 voltage dropping means and a resistor all connected in series to the base electrode of said third transistor; means to selectively couple said base electrode of said third transistor to said voltage source;
 third resistive means for coupling the collector electrode of said third transistor and the base electrode of said fourth transistor to said voltage source;
 A silicon-controlled rectifier having an anode, a cathode and a gate electrode;
 means to couple the anode electrode of said silicon-controlled rectifier to said voltage source;
 means to connect the cathode electrode of said silicon rectifier to the collector electrode of said fourth transistor; and
 a second diode connected between said input terminal and the common point of said serially connected resistor and said voltage-dropping means.

39. A control circuit as defined in claim 2 wherein each of said separate output circuit means includes means for selectively shorting the anode of the silicon-controlled rectifier connected to said output circuit means to a common potential point

40. A control circuit as defined in claim 14 wherein each of said separate output circuit means includes means for selectively shorting the anode of the silicon-controlled rectifier connected to said output circuit means to a common potential point.

41. A control circuit as defined in claim 17 wherein each of said separate output circuit means includes means for selectively shorting the anode of the silicon-controlled rectifier connected to said output circuit means to a common potential point.

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42. A control circuit as defined in claim 20 wherein each of said separate output circuit means includes means for selectively shorting the anode of the silicon-controlled rectifier connected to said output circuit means to a common potential point.

43. A control circuit as defined in claim 14 wherein means are provided for coupling the signal transfer means of the last stage of said stages to said input signal circuit means coupled to the first stage of said stages.

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44. A control circuit as defined in claim 17 wherein means are provided for coupling the signal transfer means of the last stage of said stages to said input signal circuit means coupled to the first stage of said stages.

45. A control circuit as defined in claim 20 wherein means are provided for coupling the signal transfer means of the last stage of said stages to said input signal circuit means coupled to the first stage of said stages.

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