

United States Patent

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[56]

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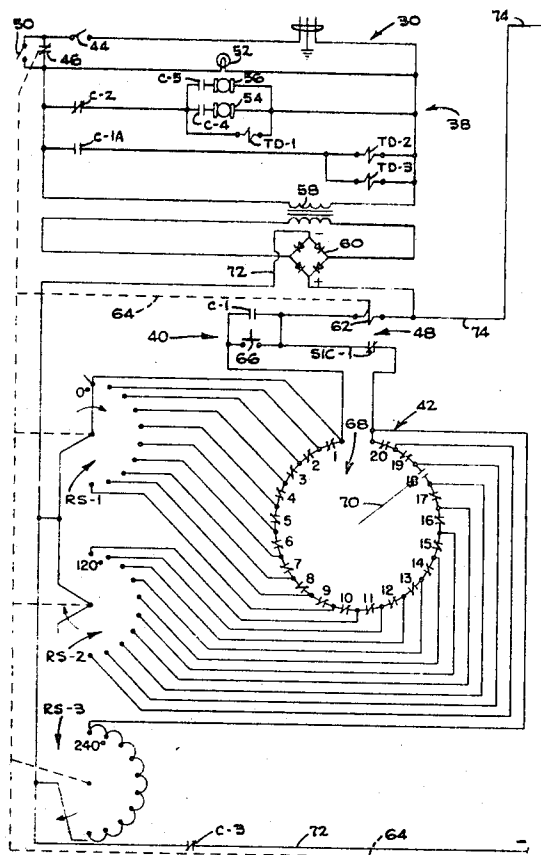
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[54] IRRIGATION CONTROL SYSTEM 4 Claims, 7 Drawing Figs.

[52] U.S. Cl. 307/141
[51] Int. Cl. H01h 7/00
[50] Field of Search 239/69, 70;
307/47, 141, 141.4, 141.8, 127

ABSTRACT: A control system for opening and closing multiple irrigation valves. At desired time intervals a repeating timer actuates a stepping relay which drives pairs of rotary switches that sequentially energize independent pairs of conductors in a five-conductor control cable assembly. Voltage and polarity discriminating control plugs are employed to tap the control cable at each valve to be actuated.



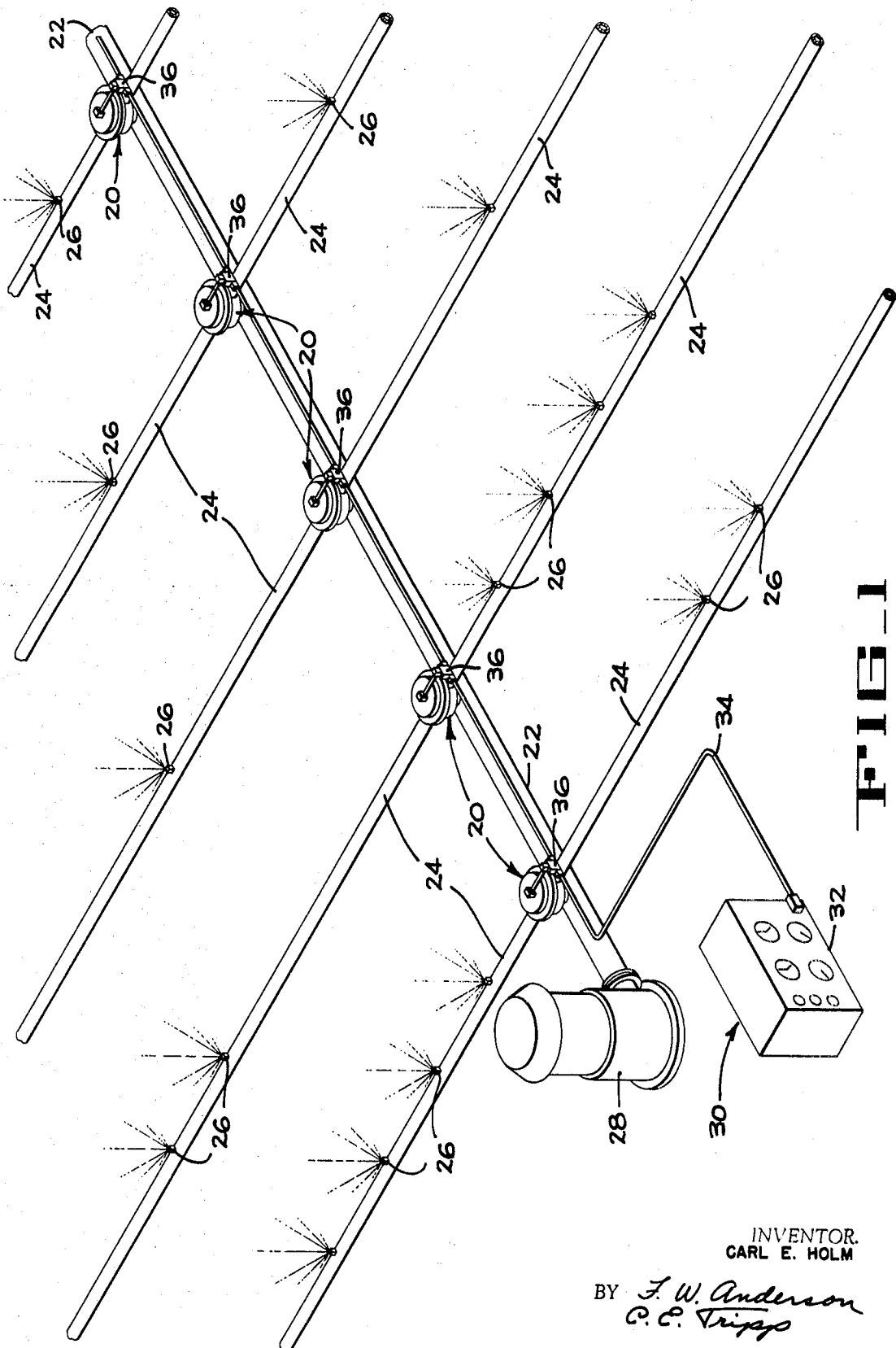


FIG. 1

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FIG. 3

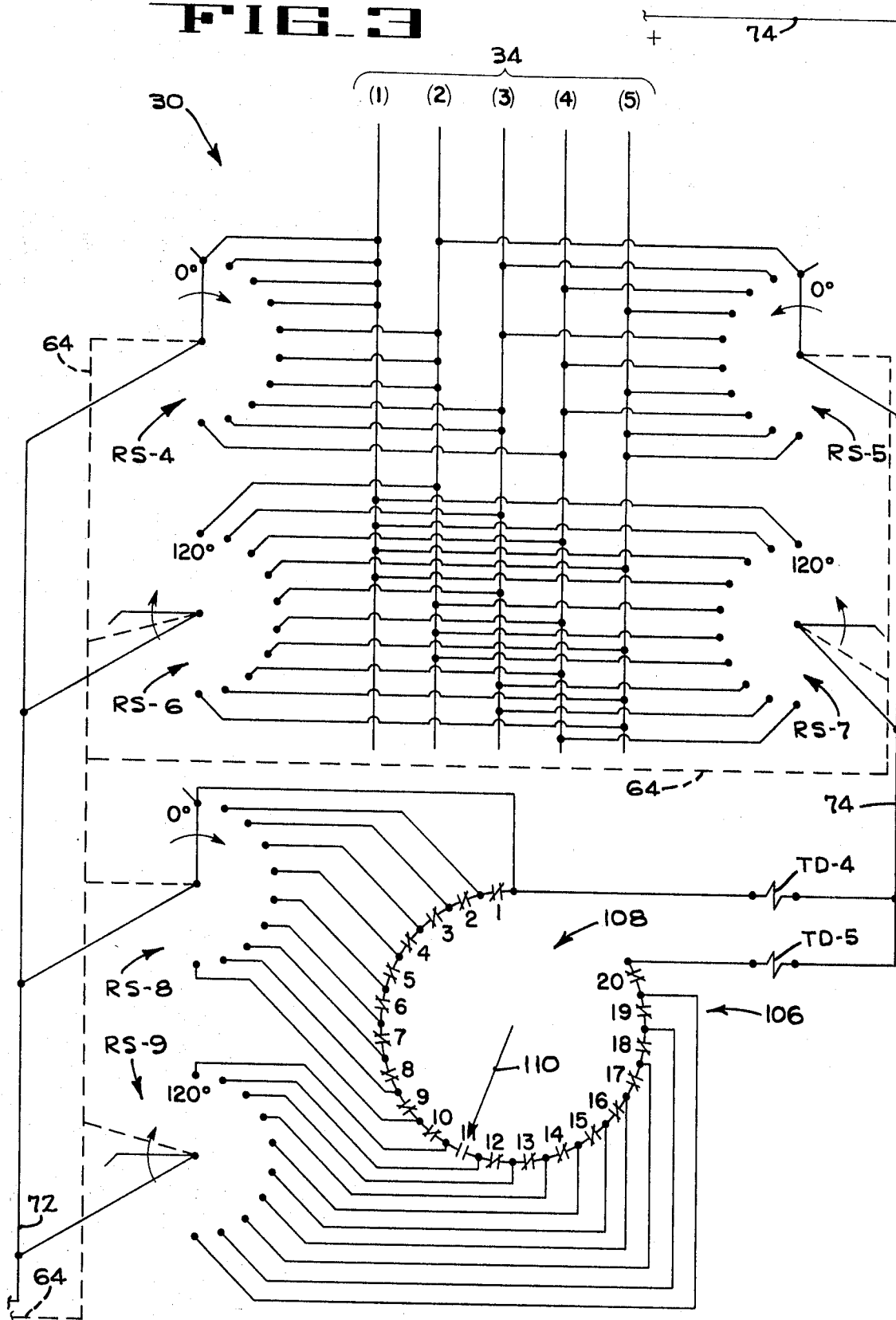


FIG. 4

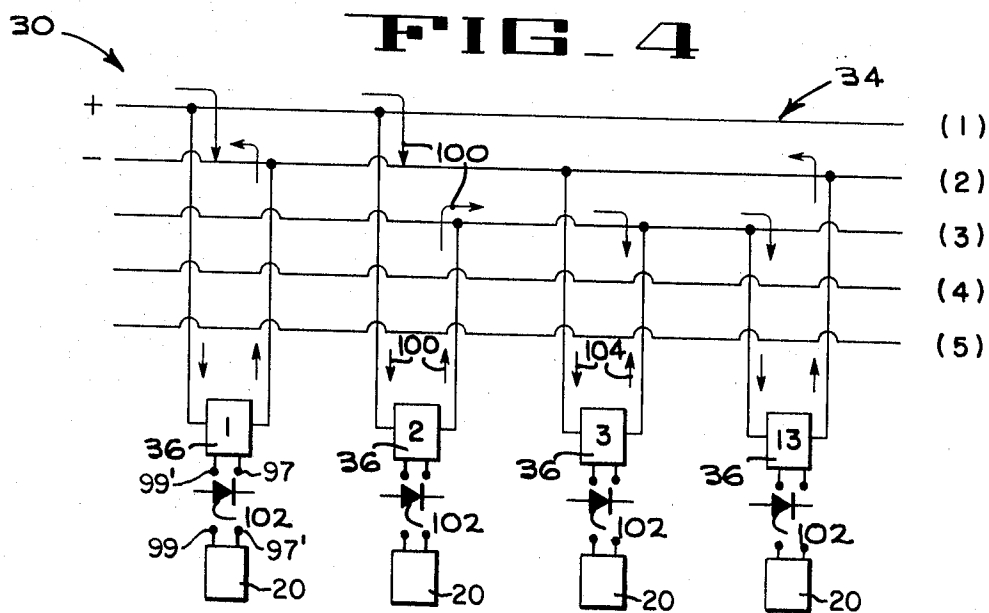


FIG. 5

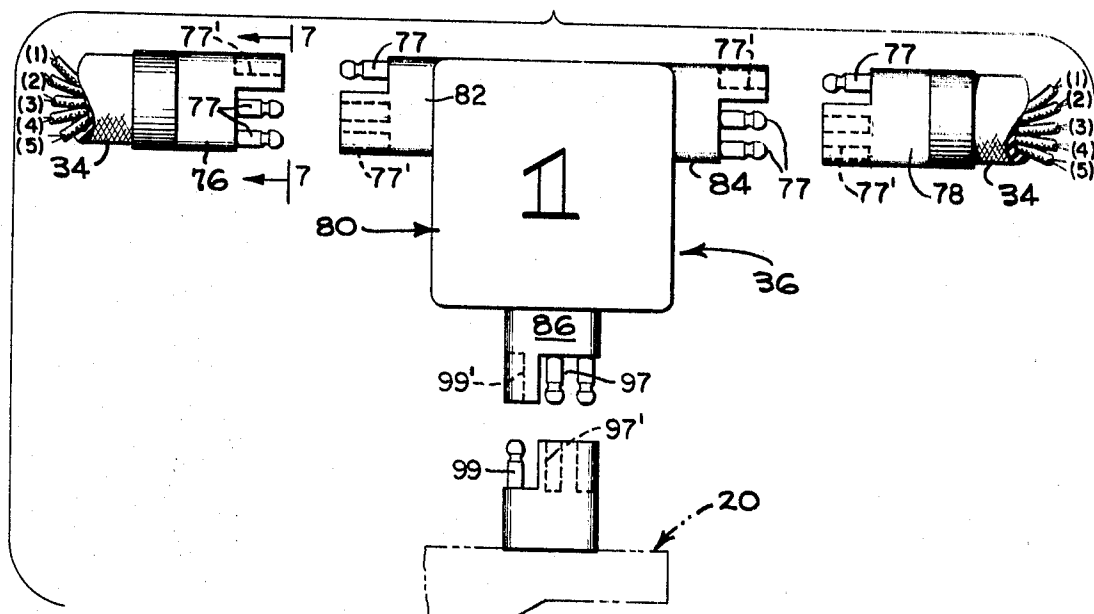


FIG. 7

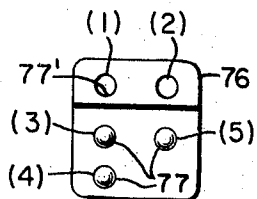
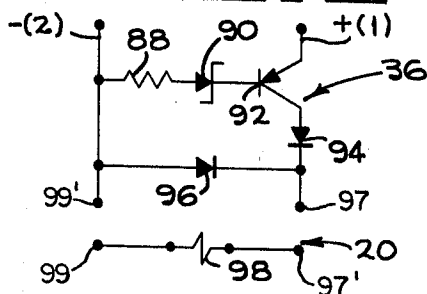


FIG. 6



IRRIGATION CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns a system for controlling irrigation sprinkler operation and in particular to a system which enables the irrigation period to be varied, the number and pattern of irrigation sprinklers to be varied, and permits actuation of a maximum number of irrigation valves through a minimum number of electrical conductors.

2. Description of the Prior Art

Arbogast 2,185,394 describes a timing circuit for operating solenoid actuated sprinkler valves. A cam operated switch driven by a master clock activates a timing clock that in turn drives a set of cams which sequentially close sets of contacts thereby completing circuits to the valve solenoids.

Alston et al. 3,309,543 discloses an extensive timing control system in which a motor drives a set of rotary switches that initiate the sprinkling cycle at any time period preset on a pair of switch blocks. The period of actuation of each sprinkler is set by adjusting individual potentiometers. As the sprinkling cycle is initiated a motor steps the rotary switches to the first set of contacts, opening the first sprinkler. Another motor then drives a potentiometer until a bridge formed with the first sprinkler potentiometer is balanced and the circuit is broken and the process repeats for the next sprinkler.

SUMMARY OF THE INVENTION

The present invention relates to an automatic irrigation control system whereby the irrigation time for a particular crop or multiple crops may be set and the crops are then watered in specified sequential manner. This permits the maximum pump capacity to be employed continuously while the area under irrigation is changed automatically, thereby reducing the manpower requirement to manually open and close the irrigation valves on a 24 hour basis. Water costs are significantly reduced by preventing excess irrigation, facilitating growing of superior crops by uniform irrigation. It is not uncommon to experience a 5 percent water waste due to tardiness or unavailability of personnel for manual switching.

Another object of the invention is to permit more efficient use of pumping and well capacity. In the irrigation of large fields, most pump and well capacities will not permit the entire field to be irrigated simultaneously. By properly programming the irrigation pattern so that a relatively constant quantity of water is used, the supply pump can be operated at its most efficient range, reducing pumping costs. Additionally, water canal supply sources can be employed where a constant rate of water is delivered and cannot be refused for short intervals or varied according to irrigation system demands.

Another object of the invention is to decrease the costs of installation and reduce the danger to personnel by the employment of a low voltage valve actuating circuit. The invention permits up to twenty individual valve-actuating solenoids and/or groups of solenoids to be controlled through a single five-conductor cable thereby reducing the number of conductors resulting in a reduction in cost in long distance field installations. This object is accomplished by employing switching means which individually and sequentially connect line pairs of the conductor cable, producing 10 mutually exclusive line pairs. The number of independent signals carried is doubled by employing polarity discriminating plugs. Actuation of more than one control plug due to the series-parallel connections formed is prevented by including a voltage discriminating circuit in each plug.

A further object of the invention is to make possible variation of the irrigation pattern by merely changing the control plug located at the valve.

Another object of the invention is to permit the controlling of any one of the irrigation valves for a predetermined time period of 1 to 12 hours. A selector switch is provided so that the irrigation cycle can be limited to a lesser number of valves

or groups of valves. The control system also contains a timer which may be either run continuously or on a manual reset basis to control the period of irrigation for each valve.

Another object of the invention is to enable two different irrigation times to be set simultaneously and programmed in a specific order to employing multiple timing clocks.

DESCRIPTION OF THE Drawings

FIG. 1 is a diagrammatic view of an irrigation system employing one form of the control system of the present invention.

FIG. 2 is a partial electrical schematic of the control system showing the timing circuit.

FIG. 3 is a partial electrical schematic showing the switching circuit and the remainder of the control system.

FIG. 4 is a partial diagrammatic view showing the manner in which the control plugs tap the control cable assembly.

FIG. 5 is a view of the control plugs showing the manner of connection to the control cable assembly and valve tee.

FIG. 6 is an electrical schematic of the control plug.

FIG. 7 is an end view of a one-way connector looking in the direction of arrows 7-7 in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention can be employed in a irrigation system such as seen in FIG. 1. Valve tees 20 are located at approximately 40-60 foot intervals along a supply line 22 and lateral irrigation lines 24, having multiple sprinklers 26, are attached to the outlets of each tee and extend across the field on either side of the supply line 22. A pump 28 or other supply sources such as water canals may be employed to deliver water to the supply line.

In order to control the opening and closing of the valve tees 20, an irrigation control system 30 is employed and generally comprises timing and switching circuitry located at the control panel 32, a control cable assembly 34, and a number of voltage and polarity discriminating control plugs 36.

Timing and Switching Circuit

The timing and switching circuit is schematically illustrated in FIGS. 2 and 3 as generally comprising a clock circuit 38, a stepping relay solenoid circuit 40 which drives the shaft and the wipers of a stacked set of rotary switches, and a switch 42 to indicate and limit the number valves in use and determine which timing clock controls the duration of irrigation.

Referring to FIG. 2, the timing circuit 38 receives power from a normal 120 v. alternating current source and includes a system on-off switch 44 and a contact 46. The contact 46, which is normally closed, is mechanically opened upon one complete revolution of a stepping relay 48 by a cam on its shaft. A cycle switch 50 determines whether the system will run continuously or only through one complete cycle. When switch 50 is open the entire system is shut off when the contact 46 is mechanically opened by the stepping relay 48. If switch 50 is closed, contact 46 is bypassed and the system operates continuously. A lamp 52 is provided to indicate when the system is in operation.

The period of irrigation of the individual valve tees 20 in the irrigation system is controlled by either a single or a pair of repeating timers 54 and 56. Each of the timers is to the type that is set at any point between 0 and 12 hours and runs backward toward 0, winding against a spring so that when a normally engaged motor clutch relay TD-1 is released, the timer resets itself by means of the spring. When the clock shaft (not shown) reaches the 0 position, a cam thereon closes relay contacts C-1 and C-1A. Upon closing of contact C-1A, relays TD-2 and TD-3 are energized and actuate contacts C-2 and C-3 respectively. When contact C-2 (normally closed) is opened by the time delay relay TD-2, it remains open for approximately 5 seconds turning off power to the timers 54, 56 and the timer clutch relay TD-1, thereby permitting the timer to reset itself. During the 5 seconds in which the timer motor is

off, the clutch and timer shaft are released so that the aforementioned spring resets the timer and reopens contacts C-1 and C-1A. After 5 seconds, contact C-2 closes, the timer motor is energized and relay TD-1 causes the clutch to engage driving the timer for another cycle.

Concurrent with the reset cycle of the timer, time delay relay TD-3 opens contact C-3 for 2 seconds to prevent arcing of the rotary switches (to be described later) during actuation of the stepping relay 48.

Continuing through the circuit, the alternating current passes through a step down transformer 58. After passing through a full wave rectifier 60, the resulting 24-volt direct current drives the remaining circuitry. By employing a low voltage, danger to personnel handling the irrigation and control equipment in a wet or damp environment is reduced.

The stepping relay 48 as seen in FIG. 2 of the electrical schematic includes a ratcheting mechanism that produces rotary motion of a shaft upon actuation of the stepping relay solenoid 62. The shaft, diagrammatically indicated by the dashed lines 64, passes through the center of a series of nine stacked rotary switches RS-1 through RS-9 whose contacts are normally open as seen in FIGS. 2 and 3. The wiper of each rotary switch is mounted on the shaft and as the stepping relay 48 is actuated in response to the momentary closing of contact C-1 the relay solenoid 62 advances the shaft one increment of the ratcheting mechanism.

The stepping relay 48 can also be operated through a manual push button switch 66. The switch bypasses the contact C-1 and is effective to engage the stepping relay solenoid 62 when actuated so that the relay can be indexed or manually advanced at any time.

Returning to the rotary switches RS-1 through RS-9, each switch has ten sets of contacts radially spaced through 120 degrees. The wipers are oriented on the shaft so that the wipers for switches RS-1, RS-4, RS-5 and RS-8 sweep their contacts in the first 120 degrees of shaft rotation. The wipers for switches RS-2, RS-6, RS-7 and RS-9 are thereafter effective from 120 to 240 degrees of shaft rotation and the wiper of switch RS-3 is effective from 240-360° of rotation.

Since the control system is specifically designed to actuate up to 20 individual control plugs, only 20 contacts or 240 degrees of rotation of the stepping relay is employed in the switching operation. The remaining 120 degrees or 10 contacts are employed with rotary switch RS-3 to effect a homing operation to return the stepping relay 48 back to the 0 or starting position.

Selector Switch

In connection with the stepping relay homing operation, a selector switch 68 is employed to enable the operator to limit the number of valve tees actuated to any number less than 20. The selector switch 68 is of a rotary type having normally closed contacts. When the selector switch is set to limit the number of valves actuated to 18, for example, a wiper 70 interrupts the contact No. 18 as seen in FIG. 2. The selector switch 68 is connected to the rotary switches RS-1 through RS-3 as shown and is also connected to a normally closed self-interrupting relay contact SIC-1 that is mechanically interconnected with the stepping relay solenoid 62. It will be apparent that upon completion of the 18th irrigation period, the wiper of rotary switch RS-2 is moved into contact with connection on the other side of the open contact 18 of the selector switch 68, completing a circuit with the self-interrupting contact SIC-1. When this circuit is complete, the stepping relay 48 is advanced to the 20th step and immediately the self-interrupting relay SIC-1 is mechanically opened and then closed so that solenoid 62 automatically steps the relay to the next position. The wiper of switch RS-3 is now effective and since all the terminals are connected together maintaining a completed circuit with relay SIC-1, the stepping relay continues to step until it reaches the 0 or starting position without actuation of contact C-1 from the timing circuit 38 or the manual switch 66.

Switching Circuit

The switching circuit, which includes rotary switches RS-4 through RS-7 and the manner in which they are connected to the five-conductor control cable assembly 34, is illustrated in FIG. 3. As previously described, switches RS-4 and RS-5 operate in unison during the first 120° of rotation or the first 10 steps of the stepping relay 48. Thereafter, switches RS-6 and RS-7 similarly operate in unison during the next 120° of the stepping relay rotation. As seen in FIGS. 2 and 3, the wipers of switches RS-4 and RS-6 are connected to the negative pole of the rectifier 60 by a line 72 and switches RS-5 and RS-7 are similarly connected to the positive side by a line 74.

In order to obtain 20 independent circuits with a single five-conductor cable, the following method of connecting the cable 34 is employed as shown in FIG. 3. It will be apparent that 10 independent pairs of line combinations can be established by attaching each of the five conductors to the several terminals of switches RS-4 and RS-5. As the switches are stepped in unison, alternating pairs of conductors are connected to the negative and positive lines 72 and 74, for example 1-2, 1-3, 1-4, 1-5, 2-3, 2-4, etc. The terminals of switches RS-6 and RS-7 are similarly connected to the five-conductor control cable assembly 34; however, the connections are made so that the polarity of the resulting 10 line combinations is opposite that produced by switches RS-4 and RS-5.

Control Plugs

Multiple control plugs 36 are employed to connect the actuating mechanisms, such as solenoids, of the valve tees 20 to the control cable assembly 34. Referring to FIG. 4, each control plug 36 is effective to complete a circuit across one pair of conductors of the cable assembly. The control plugs are inserted between one-way mating connectors 76 and 78 of FIG. 5, which are located at each valve tee as seen in FIG. 1. The control cable assembly 34 consists of multiple sections that are plugged together forming a cable long enough to extend the entire length of the supply line 22. A body portion 80 of the control plug 36 (FIG. 5) includes one-way plugs 82, 84 and 86 that prevent improper connection of the control plug 36.

In order to double the number of independent pairs of line combinations, the control plugs must be voltage limiting as well as polarity discriminating. As previously described, the second set of 10 line combinations produced by switches RS-6 and RS-7 are identical but reversed in polarity to the line combinations produced by switches RS-4 and RS-5. The manner in which the control plugs 36 tap the five-conductor control cable assembly 34 is schematically indicated in FIG. 4. Control plug No. 1 is connected across lines (1) and (2), while the remaining lines (3), (4) and (5) are continuous between plugs 76 and 78. Referring now to FIGS. 5 and 7, the multiple conductors (1)-(5) of cable 34 are connected to the pins 77 and receptacles 77' of the one-way connector 76 as illustrated in FIG. 7. In the case of control plug number one, the pins 77 and receptacles 77' corresponding to conductors (1) through (5) of the one-way plugs 82 and 84 are directly interconnected to provide a through connection for these lines between plugs 76 and 78 while connector (1) and (2) are tapped and connected to the voltages limiting and polarity discriminating circuit shown in FIG. 6. Connector 86 contains a pin 97 and a receptacle 99' that mate with a corresponding pin 99 and receptacle 97' on the irrigation valve T 20 (FIGS. 4 and 5) and serve to connect the valve operating solenoid 98 as shown in FIG. 6.

The voltage limiting and polarity discriminating circuit is seen in FIG. 6 and comprises a resistor 88, a zener diode 90, a PNP transistor 92 and blocking diodes 94 and 96. When lines (1) and (2) are energized by the switching circuit as indicated in FIG. 4 and the control plug circuit of FIG. 6 is subjected to the indicated polarity, it can be seen that the current will flow from the positive connection of line (1) to the emitter side of the PNP transistor 92. The base of the transistor is connected

to the zener diode 90 and the negative line (2) through resistor 88. The zener diode is of the type that will block all current until a potential of greater than 18 volts exists across lines (1) and (2). Assuming for the moment that the potential across lines (1) and (2) is 24 volts, neglecting any voltage drop in the line prior to the control plug, the zener diode 90 will cascade and the negative pole of the transistor 92 will be subjected to a current flow, thereby permitting current to flow across the PNP transistor toward diode 94. Since the diode 94 is positioned to permit current flow toward solenoid 98, a circuit is completed and actuates one of the valve T's 20. As the switching circuit breaks the contact with lines (1) and (2), solenoid 98 is disengaged and the inductance built up therein causes a continuing current flow. The location of diode 96 across the connection to the solenoid 98 short circuits this current and prevents any interference in the operation of the system due to the induced voltage caused by the decaying field around the solenoid coil as it is switched off.

Assume for the moment that the switching circuit has been stepped so that the first contacts of switches RS-6 and RS-7 are closed. Lines (1) and (2) are again energized; however, in this case it is to be noted that the polarity is reversed from the initial connection shown in FIGS. 4 and 6. In this case of reverse polarity, a small current is allowed to pass across the zener diode 90 and transistor 92; however, the large resistance of 1000 ohms of resistor 88, associated with the zener prevents damage to the transistor 92. The current is prevented from flowing through the solenoid 98 by means of transistor 92 which acts as a diode in this case, preventing any appreciable current flow between its collector and emitter portions. In addition, diode 94 is positioned to block the flow across the transistor 92 in this direction, thereby providing additional protection.

Thus it can be seen from the foregoing description when line (1) is positively polarized, line (2) is negatively polarized and a sufficient potential exists across the lines, i.e., in excess of 18 volts, the control plug 36 actuates solenoid 98. However, when the polarity is reversed, irrespective of the potential across lines (1) and (2), the diode 94 and the PNP transistors 92 effectively block the current flow across control plug No. 1 and the valve T 20 is not actuated. It is to be noted that another control plug No. 11 of similar construction, except that lines (1) and (2) are oppositely connected, is actuated for the reverse polarity discussed in connection with plug No. 11 and not the normal polarity associated therewith.

The necessity for the voltage limiting characteristics of the control plug circuit just described may not be readily apparent from the preceding discussion. Referring to FIG. 4, it can be seen that control plug No. 1 is subject to a 24 v. potential across its connections to lines (1) and (2). However, it is to be noted that additional connections are formed across lines (1) and (2) by control plugs No. 2, 3 and plug Nos. 2 and 13. The connection of control plug No. 2 between lines (1) and (3) and control plug No. 3 between lines (2) and (3) establish an indirect connection between lines (1) and (4). The direction of current flow is indicated by arrows 100 while the direction of current flow which is permitted across the control plugs 36 by their internal circuitry is shown by diode symbols 102. The polarity of plug No. 3, as indicated by arrows 104, opposes the current flow indicated by arrows 100; hence, no circuit is completed. However, control plug No. 13 has an opposite polarity to plug No. 3 so that an indirect connection is formed by plug Nos. 2 and 13. The resulting voltage drop across these plugs is 12 v., since they are in series. Since most solenoids have a wide range of actuation voltage, 12 v. potential across the solenoids associated with control plugs 2 and 13 would be sufficient to cause the undesired actuation of additional valve T's 20. The zener diode 90 in conjunction with the transistor 92 provides a voltage limiting function so that only the desired control plugs are actuated.

It is possible to employ a number of identical control plugs at one time in the irrigation system. If number 14 wire is used in the control cable, approximately 4 plugs of each type may

be employed thereby increasing the number of valve T's controlled to 80. The valve T's themselves can be employed to hydraulically slave additional valves as is well known in the art.

TIMER SELECTOR

When multiple timers 54 and 56 are employed to provide two different irrigation periods, a timer selector circuit 106 is included to determine which of the timers is effective to actuate the stepping relay 48. Referring to FIG. 3, the selector circuit 106 includes a selector switch 108, rotary switches RS-8 and RS-9 and a pair of relays TD-4 and TD-5. The selector switch 108 is of the type having normally closed contacts and a manually adjustable wiper 110 that is effective to open a pair of contacts at which the switch is set, as seen at contact 11 in FIG. 3. The contacts of switch 108 are connected to switches RS-8 and RS-9 which are driven by the stepping relay 48 in the same manner as switches RS-1 and RS-2. The relays TD-4 and TD-5 connect the switch to the positive line 74 of the control system. When actuated, relays TD-4 and TD-5 are effective to close contacts C-4 and C-5 seen in FIG. 2. When the wiper 110 is at position 11 on switch 108, relay TD-4 is actuated closing contact C-4 and consequently timer 54 controls the first 11 steps of stepping relay 48 while timer 56 is effective for the remainder of the irrigation cycle.

If only one timer is employed, the timer selector circuit 106 and contacts C-4 and C-5 as well as switches RD-8 and RD-9 may be eliminated from the irrigation control circuit.

OPERATION

In the employment of the irrigation control system, assume that it is desired to control 18 valve T's. Eighteen control plugs 36 are inserted in the control cable assembly 34 at each side of the valve T's 20. It is to be noted that the control plugs 36 may be installed in any order to provide the desired irrigation pattern and sequence. The selector switch 68 is set at 18 so that the stepping relay 48 is returned to the starting position upon completion of the irrigation cycle. If two different periods of irrigation are desired in the cycle, the desired time intervals are set on timers 54 and 56 and the timer selector switch 108 is set for example at 11. The time set on timer 54 is then effective to control the length of the irrigation period for the first 11 control plugs and the remainder are controlled by timer 56.

After the desired mode of operation of the irrigation control system has been set, operation is initiated by closing switch 44. The timer 54 actuates the stepping relay contact C-1 at the preset time intervals causing actuation of the stepping relay 48 which in turn sequentially switches independent line pairs of the control cable assembly 34 and operates the valve T's 20 through control plugs 36. The timer also actuates contact C-1A thereby activating relays TD-2 and TD-3. Relay TD-2 opens contact C-2 allowing the timers 54 or 56 to reset while relay TD-3 opens contact C-3 which deenergizes the switching circuit during the period in which the stepping relay 48 drives switches RD-1 through RS-9, thereby preventing arcing across the switch contacts and increasing their service life.

The operation continues until all 20 of the control plugs have been actuated or the number set on selector switch 48 has been reached. In either case the stepping relay is then returned to the start position by the homing operation of the stepping relay 48, completing 1 irrigation cycle. If the continuous cycle switch 50 is closed, the system continues to repeat the complete irrigation cycle until interrupted by the on-off switch 44.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention.

What I claim is:

1. A sequential irrigation system comprising a plurality of solenoid operated irrigation valves, direct current source and

return lines, a control cable having at least three conductors, multipole switches for selectively connecting said source and return lines to various individual pairs of conductors for converting the selected conductors into current source and return lines, valve operating circuits respectively connecting individual valve solenoids across various pairs of said cable conductors, voltage limiters in said valve operating circuits for preventing those valve solenoids which have thus become series-connected from operating their valves, polarity discriminators in said valve operating circuits for increasing the selectivity of the circuit, and timer means for indexing said multipole switches.

2. The system of claim 1, wherein the voltage limiters and polarity discriminators of the valve operating circuits are contained in control plugs, a pair of mating one-way connectors in said control cable at each irrigation valve, each of said control plugs having a pair of one-way connectors insertable between said control cable connectors, a single connector between the control plug and the valve solenoid, said one-way connectors on the control plug being effective to connect two conductors of said control cable to the valve operating circuit and provide a through connection for the remaining conductors.

3. A method for independently controlling multiple solenoid operated irrigation valves comprising the step of activating

ing a relay at predetermined time intervals, incrementally advancing multipole switches, selectively and sequentially connecting current source and return lines to individual pairs of conductors in a multiple conductor cable to which valve solenoid operating circuits are connected, blocking current of one polarity in said solenoid operating circuits while permitting current of opposite polarity to pass, and blocking said latter current if the potential is less than a predetermined minimum.

4. A control system for sequentially actuating multiple irrigation valves having relay means actuated at predetermined intervals by a timer, said relay means being effective to cause incremental rotation of multiple rotary switch means, said switch means including pairs of switches operating in unison, a multiple conductor control cable connected to said pairs of switches so that a maximum number of independent pairs of conductors are formed as said switch pairs of incrementally rotated, multiple control plug means for tapping the control cable to connect the irrigation valve, said control plug further comprises a body portion having three one-way plugs, two of said plugs being insertable between similar opposed plugs in said control cable, and said third plug to a connector on the irrigation valve, said one-way plugs preventing improper insertion of the control plug in the control cable.

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