March 3, 1959 L. M. OBERLIN 2,876,434

INDICATING AND CONTROL SYSTEM

Filed Oct. 1, 1951 4 Sheets-Sheet 1

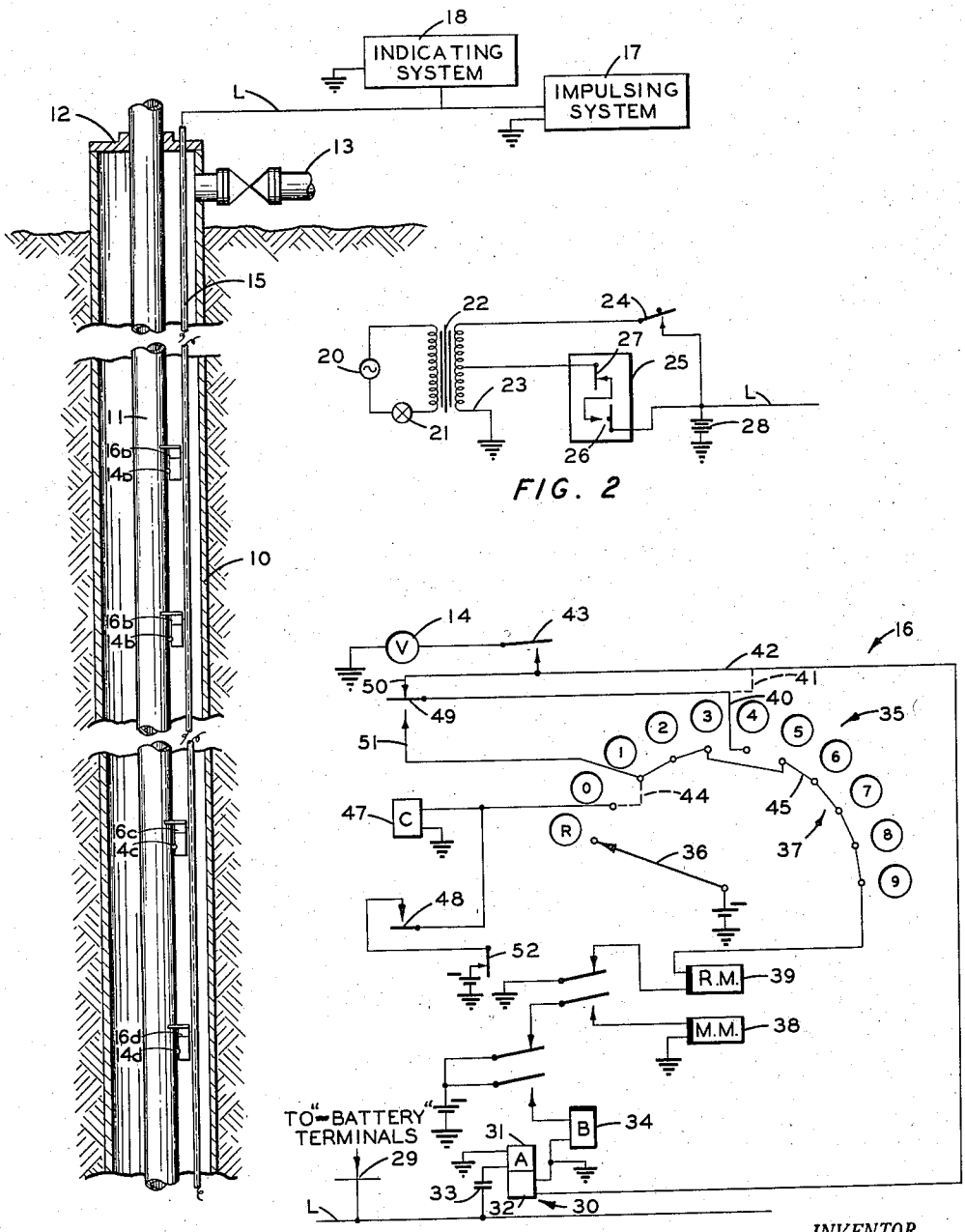

FIG. 1

FIG. 2

FIG. 3

INVENTOR.
L. M. OBERLIN

BY

Hudson & Young

ATTORNEYS

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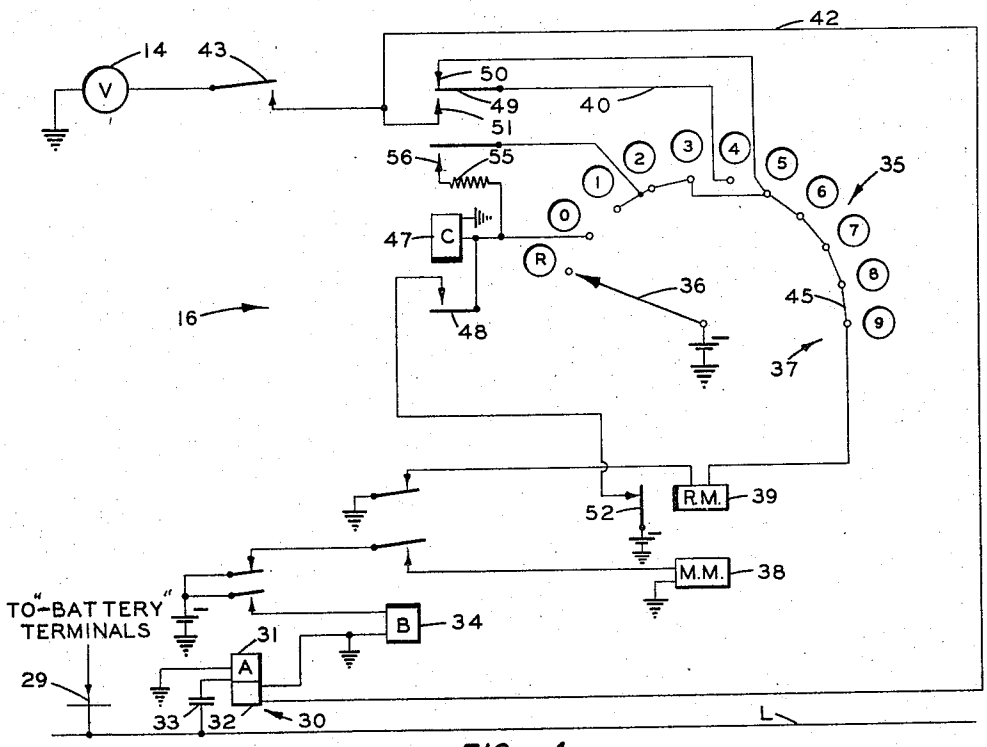

FIG. 4

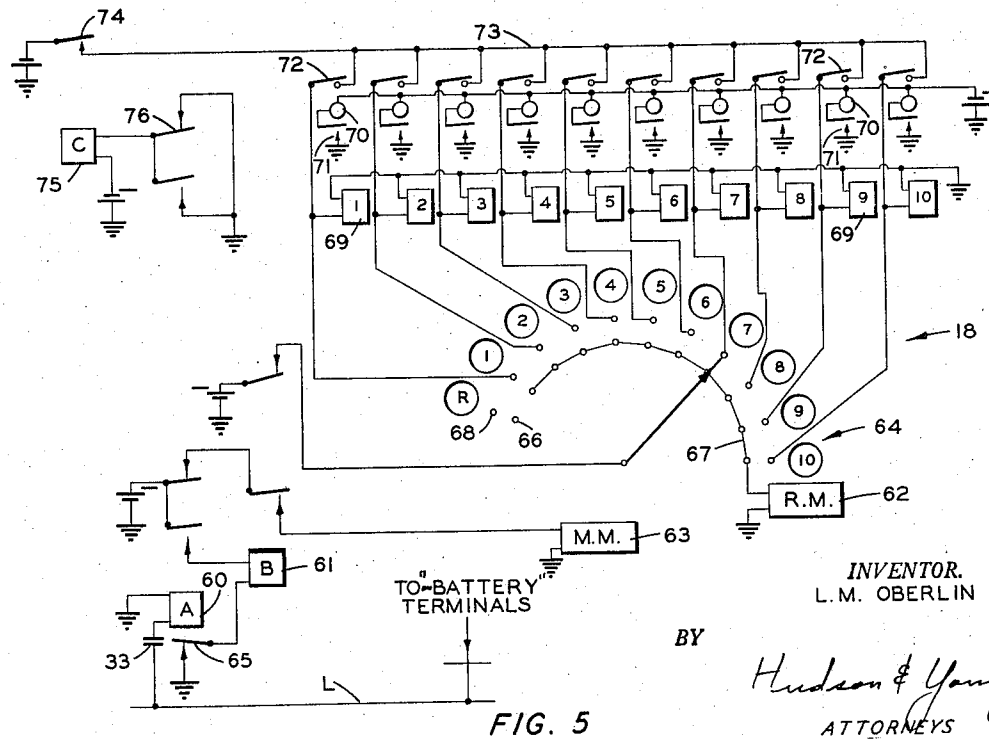

FIG. 5

INVENTOR.
L. M. OBERLIN

BY

Hudson & Young

ATTORNEYS

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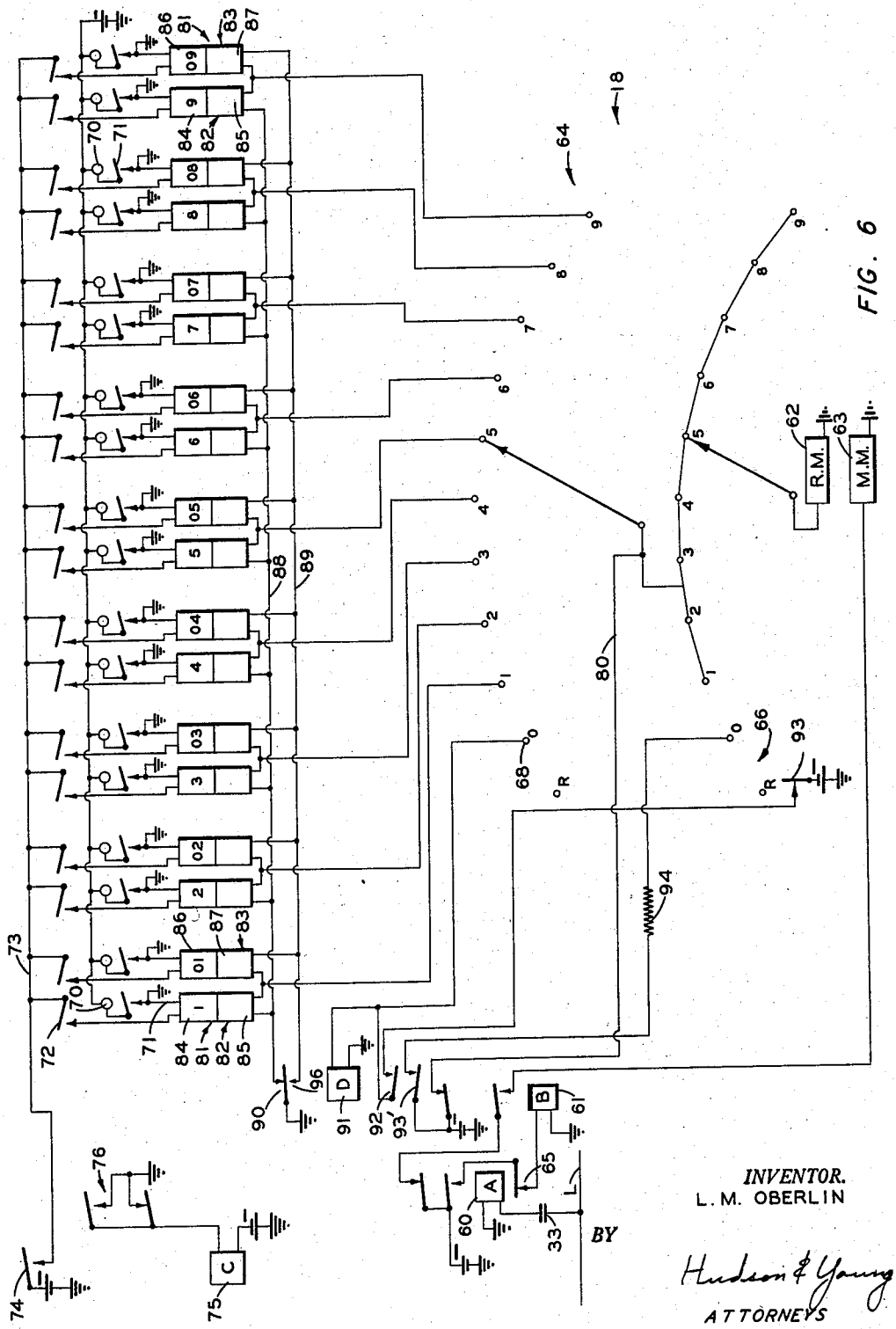

FIG. 6

INVENTOR.
L. M. OBERLIN

Hudson & Young
ATTORNEYS

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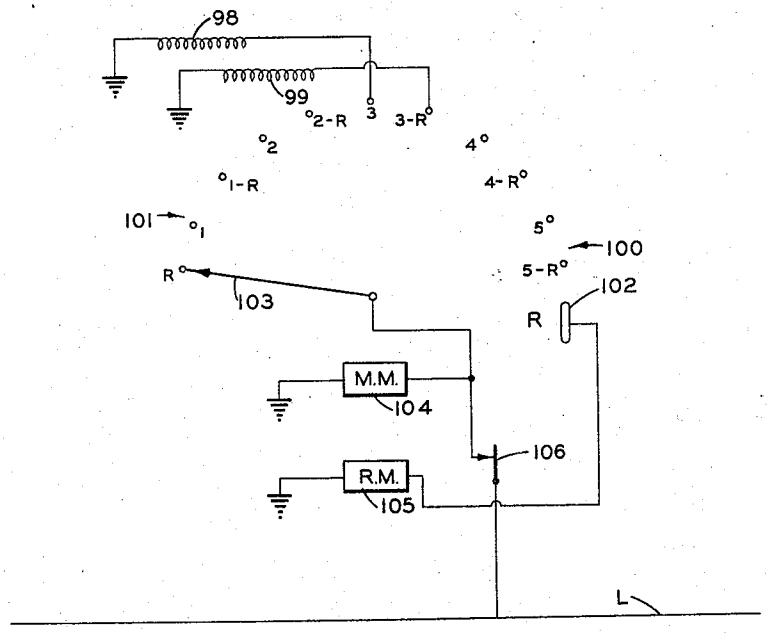

FIG. 7

INVENTOR.
L. M. OBERLIN

BY

Hudson & Young

ATTORNEYS

United States Patent Office 2,876,434 Patented Mar. 3, 1959

2,876,434

INDICATING AND CONTROL SYSTEM

Lyman M. Oberlin, Dewey, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Application October 1, 1951, Serial No. 249,103

14 Claims. (Cl. 340—164)

This invention relates to a system for selecting and operating gas lift valves. In another aspect, it relates to an electrical selector circuit. In still another aspect, it relates to an electrical indicating device. In still another aspect, it relates to a combined selecting and indicating device.

It has been previously proposed to mount a string of gas lift valves within the interspace between the tubing and casing of a well, a selected valve or valves being opened at different times to produce aeration of the fluid within the tubing by a gas which is injected under pressure into the interspace between the tubing and casing. In this manner, the liquid within the tubing is aerated and rises to the surface of the well.

In previous systems for controlling such gas lift valves, difficulties have arisen in permitting a flexible selection of any desired one or more valves for operation. Further, difficulties have arisen in indicating which of the valves is selected for operation.

In accordance with this invention, I provide a completely flexible system of selecting and operating any desired valve or combination of valves from the surface. I have also provided an indicating device to identify the valve or combination of valves selected. The selector and indicating circuits incorporated in this control system have independent utility in other applications and for controlling devices other than gas lift valves.

It is an object of the invention to provide an improved control and indicating system for gas lift valves.

It is a further object to provide an electrical selector unit of novel construction.

It is a still further object to provide an electrical indicating system of improved construction.

It is a still further object to provide a system for controlling gas lift valves wherein only two conductors extend from the surface to the gas lift valves.

It is a still further object to provide an improved combination selecting and indicating circuit.

Various other objects, advantages and features of the invention will become apparent from the following detailed describtion taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic view of the control and indicating system of this invention, as applied to a gas lift system;

Figure 2 is a schematic circuit diagram of the impulsing system of Figure 1;

Figure 3 is a schematic circuit diagram of a gas lift valve and associated selector circuit;

Figure 4 is a schematic diagram of a modified selector circuit for use in conjunction with a large number of valves;

Figure 5 is a schematic circuit diagram of the indicating system of Figure 1;

Figure 6 is a schematic circuit diagram of a modified indicating system; and

Figure 7 is a schematic circuit diagram of another modification of the selector circuit.

Referring now to Figure 1, the system will be generally described in connection with indicating and control apparatus for a plurality of gas lift valves, although it will be understood that the circuits and system also have utility in other fields. In this figure, I have shown a well within which is disposed a casing 10 and a concentric string 11 of tubing. At the top of the well is a casing head 12 and a conduit 13 for admitting gas under pressure to the interspace between the tubing and casing. Spaced vertically along the tubing are a plurality of electrically actuated gas lift valves 14*a* to 14*d*, inclusive. Although I have shown only four valves, it will be understood that any desired number can be employed without departing from the spirit and scope of the invention, as will become apparent from the following description.

Each valve, when opened, establishes communication between the tubing and the interspace between the casing and tubing. It is preferable that any selected valve or combination of valves be operated as desired so that gas under pressure from conduit 13 can be introduced into the tubing through such valve or valves to aerate the liquid therein at any desired point or points.

To this end, each valve 14 has associated therewith a pulse-controlled selector unit which, in turn, is responsive to and controlled by pulses fed down a line L from the surface of the well. After selection, the desired valve or valves are maintained in open position by a pulse of relatively high voltage. It will be noted that the line L is a single continuous conductor extending from the surface of the well to the lowermost gas lift valve. This conductor and a ground return constitute the only connection between the surface of the well and the individual gas lift valves. If desired, the line conductor can be incorporated in an insulated cable 15. The individual selector units in the example shown are identified by reference numerals 16*a* to 16*d*, inclusive.

At the surface, an impulsing system 17 and an indicating system 18 are connected between the line L and ground. Impulsing system 17 is adapted to send a series of coded low voltage alternating current pulses down the line to effect selection of any desired one or more of the units 16, each individual series of pulses selecting a different one of the valves 14 for operation. When the desired valve or valves has been selected, a high voltage alternating current pulse is sent down the line and transmitted by the selected units 16 to the valves associated therewith, thereby causing such valves to open and remain so throughout the duration of the high voltage pulse. At the end of the high voltage pulse, all valves are closed, and all selector units are cleared so that the system is in readiness for a new selection of valves by a subsequent series of coded low voltage pulses. Impulsing system 17 also provides direct current for the operation of auxiliary apparatus, such as relays and magnets, incorporated in the selector units.

Indicating system 18 is responsive to the coded series of low voltage pulses passed down the line and provides an individual indication for each such series of pulses. This system is likewise cleared by the termination of the high voltage pulse by which the selected valve or valves are operated, so that it is ready to provide a new indication when a subsequent series of coded low voltage pulses is fed to the line. Indicating system 18 also receives direct current from the line for operating the indicating device, relays, and magnets contained therein.

The impulsing system is shown in more detail by Figure 2 in which it will be noted that an alternating current source 20 is connected in circuit with a switch 21 and the primary winding of a transformer 22. One terminal

of the secondary winding of transformer 22 is grounded at 23, and this terminal is tapped to provide a high voltage terminal which is connected to line L through a push button 24 and a low voltage terminal connected to line L through an impulsing switch 25, which may be similar to a telephone dial. Impulsing switch 25 includes a set of off normal contacts 26 which are closed when the switch is moved from its normal or rest position. Switch 25 is further provided with a set 27 of break springs which produce momentary interruptions in the current, the number of such interruptions corresponding to the extent of displacement of the control arm or dial of the switch. If the number 1, for example, is dialed, contacts 26 are closed when the dial is moved to an off normal position and these contacts are opened when it returns to a normal position. In this case, break springs 27 do not operate so that the signal produced consists of a single period during which low voltage alternating current is transmitted down the line. If the number 2, or a higher number is dialed, the same action occurs except that the current is interrupted one or more times by the break springs 27, depending upon the number dialed. If, for example, the number 5 is dialed, low voltage current is supplied to the line as the springs 26 are moved to an off normal position, after which break springs 27 produce four interruptions of this current which is then permanently interrupted when the dial returns to its normal position. The current pattern provided by each dialing step is referred to herein as a coded series of low voltage pulses.

After the desired series of low voltage pulses has been dialed, push button 24 is actuated to supply high voltage alternating current to the line throughout the period during which the valve is to be operated. The current supplied during this period is referred to herein as a high voltage pulse.

A battery 28, or other source of direct current, is connected between line L and ground to provide a steady flow of direct current through the magnets, indicating device and relay windings hereinafter described.

In Figure 3, I have shown the circuit of one of the selector units 16. Assuming that there are ten or less valves to be operated, certain elements of this circuit will be eliminated in the manner hereinafter described. It will be noted that the selector unit is provided with a rectifier 29 through which direct current is fed to each terminal to which a negative battery connection is indicated, the battery being shown in the diagram purely for purposes of convenience. In this manner, direct current is supplied to the relay windings and magnets to be hereinafter described.

Each selector unit includes a quick acting relay 30 hving two operating windings 31 and 32 together with a set of normally open contacts and a set of normally closed contacts. Operating winding 31 is connected to ground and to line L through a condenser 33 so that this relay is energized by each alternating current pulse passed down the line but, due to condenser 33, it is not actuated by the direct current potential on this line. A slow to release relay 34 is provided with an operating winding, a set of normally open contacts, and a set of normally closed contacts. This relay is operated each time that relay 30 is actuated, and its operating circuit can be traced from ground, through the relay operating winding, and the normally open contacts of relay 30 to negative battery.

Each unit further includes a selector switch 35 having a rotary contact arm 36, a bank 37 of contact points, which are numbered 0 through 9, inclusive, and rest or normal, a motor magnet 38, and a release magnet 39. When the motor magnet 38 is energized, contact arm 36 is moved in a stepwise manner into successive engagement with the contact points of bank 37. If desired, motor magnet 38 may have an auxiliary or "tag" magnet associated therewith in a manner well understood by those skilled in the art. When release magnet 39 is energized, contact arm 36 is moved in a counterclockwise direction to its rest or normal position.

Where ten or less valves are to be controlled, one selected bank contact point of each selector unit (point 4, in Figure 3) is connected by leads 40, 41 and 42 to a branch circuit, one branch including a normally open contact set 43 of relay 30 and the energizing winding of the associated valve 14, the other branch including the winding 32 of relay 30. Contact set 43 is closed only when a high voltage pulse is fed to winding 31 and not when low voltage pulses are fed thereto. Further, when ten or less valves are to be controlled, all of the non-selected bank contact points (all points except point 4 in Figure 3) are connected in circuit by conductors 44 and 45 with release magnet 39, the normally closed contacts of relay 34, ground, negative battery, and contact arm 36. Further, motor magnet 38 is connected in an operating circuit which extends through the normally open contacts of relay 34, and the normally closed contacts of relay 30 to negative battery.

It is assumed that the unit shown in Figure 3 controls the operation of valve number 4, it being understood that each of the other valves is provided with a selector unit having a different selected bank contact point connected to the leads 41 and 42.

The operation of the circuit as thus far described is as follows. If the number 1 is dialed, a low voltage operating current pulse is supplied to winding 31, thereby energizing relay 30. As a result, an incomplete circuit to motor magnet 38 is broken and the operating circuit of relay 34 is closed, thereby energizing this relay. As a result, the release magnet circuit is further opened and an incomplete circuit is closed to motor magnet 38. At the end of the low voltage pulse, relay 30 restores, thereby closing the circuit to the motor magnet 38 and opening the circuit to relay 34. This latter relay, being slow to release, remains closed while the motor magnet is energized to move contact arm 36 one step to position "0." Thereupon, relay 34 restores with resultant opening of the motor magnet circuit and closure of the release magnet circuit through bank contact point. This operates the release magnet, restoring the selector switch 35 to its rest position.

If the number 2, or any higher number other than 4 is dialed, the same action occurs except that the circuit to relay 30 is momentarily interrupted one or more times depending upon the number dialed. Relay 34 remains closed during these interruptions since it is slow to release. Each such restoration of relay 30 momentarily closes the motor magnet circuit and advances the rotary switch one step.

If the number 4 is dialed, the arm 36 comes to rest at contact point 4, but the release magnet is not energized since its circuit is not connected to contact point 4. Rather, a circuit is closed through the winding 32 which opposes subsequent low voltage pulses fed to winding 31 and prevents them from operating relay 30. Thus, once the number assigned to a particular selector unit is dialed, the unit becomes insensitive to subsequent low voltage pulses. Further, the engagement of contact arm 36 with bank contact 4 prepares the operating circuit of valve 14. When a subsequent high voltage pulse is sent down the line, the voltage impressed upon winding 31 is substantially greater then the opposing voltage fed to winding 32 with the result that relay 30 is completely operated, thereby closing contacts 43 and operating the valve 14. The valve remains open until the high voltage pulse is terminated, at which time its circuit is opened at contacts 43. It will be noted that, during the high voltage pulse, relay 34 was energized. Accordingly, when relay 30 is deenergized at the end of the high voltage pulse, the motor magnet is energized to move con-

tact arm 36 from point 4 to point 5. Thus, when relay 34 opens a short interval after the end of the high voltage pulse, the release magnet circuit is closed through bank contact point 5 and the circuit restores to its normal condition.

In summary, it will be noted that each selector unit is responsive only to one individual series of low voltage pulses. When any other series, other than the one to which a given selector is responsive is fed thereto, the selector switch is restored to normal at the end of such series. Further, when the proper series of low voltage pulses is fed to the selector, the operating circuit of the valve controlled thereby is prepared for operation and the selector is rendered insensitive to further series of low voltage pulses. Finally, a high voltage pulse causes operation of the valves whose selectors have been sensitized, and these selectors are cleared for a subsequent operation at the termination of the high voltage valve-operating impulses.

The "0" contact point on each switch is in all cases connected to lead 45. That is, there is no selector unit wherein conductor 41 is connected to the "0" contact point, and there is no dial position corresponding thereto. Thus, after each high voltage pulse, the contactor 36 steps to contact point "0" and the release magnet is operated when relay 34 is restored.

Where the number of valves to be controlled is greater than ten, but less than 18, the first group of nine selector units is so adjusted that it responds only to the numbers 1 through 9. If the number zero is dialed, the next succeeding number does not affect such unit and the unit is cleared at the end of such next succeeding number. In the second group of nine units, the selector switches are not responsive to the numbers 1 to 9, but only to the dialing of zero and thereafter the dialing of one of the digits 1 to 9.

In Figure 3, I have illustrated one of the units of the first group of 9. In this particular example, if the number 4 is dialed, the valve operating circuit is prepared and no further low voltage pulses affect the selector unit. If the number zero is dialed followed by any other number, the second number does not affect the unit and it is cleared after the second number is dialed. To this end, conductors 41, 44 are omitted and the zero contact point is connected to ground through the operating winding of a relay 47 having a set of normally open contacts 48, and a contact spring 49 cooperating with a normally closed contact 50 and a normally open contact 51. If any number in the group 1 to 9, inclusive, is dialed, the unit is operated in the manner already described, the release magnet 39 being actuated if any number other than 4 is dialed, and the valve operating circuit, together with the disabling circuit through the winding 32 of relay 30, being prepared if the number 4 is dialed. This results from the connection of conductor 40 to conductor 42 through contact spring 49 and normally closed contact 50.

If the number zero is dialed, contact arm 36 moves into engagement with the zero contact point, thus closing the operating circuit of relay 47. As a result, relay 47 closes a holding circuit through its operating winding, normally open contacts 48, and a set 52 of break springs which are opened upon operation of release magnet 39 to negative battery. Operation of relay 47 also transfers the connection of bank contact point 4 and conductor 40 from conductor 42 to normally open contact 51 and conductor 45. When the next number is dialed, the contact arm 36 is stepped to a subsequent bank contact point and the release magnet circuit is operated when relay 34 is restored at the end of the dialing period. This clears the selector switch, and relay 47 is restored due to the breaking of its holding circuit by momentary opening of break springs 52.

The circuit of the second group of nine selector units is shown in Figure 4, in which parts and operations similar to those of Figure 3 will not be further described. In this circuit, dialing of any number from 1 to 9, inclusive, causes the selector unit to return to normal at the end of the dialing period. If the number zero is followed by any number other than 4, a similar clearing action occurs whereas, if the number zero is followed by the number 4, the valve operating circuit is prepared and relay 30 is disabled insofar as subsequent low voltage pulses are concerned.

It will be noted that normally closed contact 50 is connected to conductor 45 while normally open contact 51 is connected to conductor 42. That is, the connections of these contacts are reversed with respect to the connections shown in Figure 3. Accordingly, bank contact 4 is normally connected to conductor 45 so that the selector unit is cleared and switch 35 restored to normal if any digit from 1 to 9, inclusive, including 4, is dialed. Associated with bank contact point zero is an auxiliary release circuit which can be traced through a resistance 55, a normally open contact set 56 of relay 47, conductor 45, the release magnet, normally closed contacts of relay 34, negative battery, and contact arm 36. When the number zero is dialed, and contact arm 36 moves into engagement with bank contact zero, relay 47 is energized and its holding circuit is completed through contacts 48 and 52. This completes the auxiliary release circuit and actuates release magnet 39 to restore switch 35 to its normal position. However, due to the presence of resistance 55, the field established by the release magnet is not sufficiently strong as to interrupt the break springs 52 so that relay 47 remains energized.

Further responsive to the energization of relay 47, the circuit of bank contact 4 and conductor 40 is transferred from conductor 45 and contact 50 to contact 51 and conductor 42. If the number 4 is now dialed, the valve operating circuit is prepared and relay 30 is disabled insofar as subsequent low voltage pulses are concerned, the valve being operating and the system cleared in the manner already described when a high voltage pulse is fed down the line. If the dialing of the number zero is followed by the dialing of any digit other than 4, the release magnet is, of course, energized and rotary switch 35 is restored to normal. Further, this actuation does not take place through resistance 55 so that the full field strength of the release magnet 39 is utilized. As a result, break springs 52 are momentarily opened, thereby breaking the holding circuit of relay 47 and causing this relay to restore. Similar connections are made in each of the other selector units of the second group of nine so that each such unit is responsive only to the dialing of digit zero followed by a subsequent one of the digits 1 to 9, inclusive.

The indicating system 18 of Figure 1, as shown in Figure 5, is for use where ten or less gas lift valves or other controlled devices are to be controlled. This circuit includes a relay 60 having a set of normally open and a set of normally closed contacts corresponding to those of relay 30 in Figures 3 and 4. The circuit also incorporates a slow to release relay 61 having a set of normally open and normally closed contacts similar to those of relay 34 in Figures 3 and 4. These relays cooperate with a release magnet 62 and a motor magnet 63 of a rotary switch 64 in the same manner as indicated in Figures 3 and 4 to advance the switch in a stepwise manner responsive to low voltage alternating current pulses fed to line L. The operating circuit of relay 61, however, includes a set 65 of normally closed contacts associated with relay 60, these contacts being opened only when a high voltage pulse is fed to relay 60 through condenser 63. Rotary switch 64 has a bank 66 of contact points which are all connected in circuit with release magnet 62 by a conductor 67. As a result, the rotary switch is restored after each series of low voltage impulses fed down the line L to the indicating system.

Rotary switch 64 is also provided with a second bank 68 of contact points which are connected respectively to a series of pilot relays 69 which are numbered 1 to 10, inclusive, to correspond with the bank contact points. Relays 69 are sufficiently slow to operate that the momentary contact of the switch arm in passing over them to reach a subsequent contact does not cause actuation thereof. However, when the contact arm dwells upon a point of bank 68 at the end of a pulse series and before the operation of release magnet 62, the corresponding pilot relay is energized.

Associated with each pilot relay is an individual indicating device 70, such as a pilot light, which is connected to negative battery through a common conductor and to ground through a normally open contact set 71 of the associated pilot relay. Further, each pilot relay 69 has a holding circuit which extends through a normally open set 72 of pilot relay contacts, a common conductor 73, a set 74 of normally open contacts of a relay 75, negative battery, ground, and the winding of the associated pilot relay. Relay 75 has an operating circuit which extends through a set 76 of make before break contacts associated with relay 60, and operable only upon application of a high voltage pulse to said relay 60.

In operation, as numbers are dialed corresponding to the valves to be selected for operation, selector switch 64 moves into engagement with the corresponding points of contact bank 68. Each time the contact arm dwells upon one of these contacts, the corresponding pilot relay is energized, illuminating the associated pilot light and completing the holding circuit through contacts 74, it being understood that relay 75 is energized due to engagement of the break contacts of set 76.

When a high voltage pulse is fed to the line, contacts 76 are actuated but their circuit is not interrupted since they are make before break contacts. Accordingly, while the high voltage pulse persists the selected pilot relays remain energized and their corresponding pilot lamps remain illuminated. The described high voltage pulse also opens contacts 65 and disables relay 61 so that there is no actuation of motor magnet 63 responsive to the high voltage pulse. When the high voltage pulse is terminated, there is a momentary interruption of current to relay 75 at the make before break contacts 76 with the result that contacts set 74 is momentarily opened, thereby breaking all the holding circuits of the pilot relays. The system is then cleared for another cycle of operation.

Where more than nine but less than eighteen valves are to be controlled, the indicating system of Figure 6 is used in connection with the selector units of Figures 3 and 4. In this figure, parts similar to those described in connection with Figure 5 will not be set forth in detail, either as to circuit or operation.

In Figure 6, all contact points of bank 66 except the zero contact point are connected in circuit with release magnet 62, a conductor 80 and the normally closed contact set of relay 61. Accordingly, if any number from 1 to 9, inclusive, is dialed, the arm of the switch 64 moves to the proper contact point and the release magnet then operates to restore the selector switch to its normal position. The points of contact bank 68, except the zero contact point, are each connected to a dual pilot relay unit 81 instead of to a single pilot relay, as in Figure 5. Each dual pilot relay includes sections 82 and 83, each section 82 having two windings 84, 85 and each section 83 having two windings 86 and 87. One terminal of each winding 85 and 87 is connected to the associated bank contact point, the other terminals of each winding 85 being connected to a common conductor 88 and the other terminals of each winding 87 being connected to a common conductor 89. Each section 82 or 83 has an individual pilot light or indicating device 70 connected in circuit with a normally open contact set 71, together with a holding circuit extending through a normally open contact 72, the common conductor 73, and contact 74 in the same manner as described in connection with Figure 5. Conductor 88 is grounded through a normally closed contact set 90 of an auxiliary relay 91.

Consequently, when any number from 1 to 9, inclusive, is dialed, the associated relay section 84, 85 is energized when the contact arm dwells upon the corresponding bank contact point. The energized relay section thereupon illuminates the pilot lamp and closes its holding circuit in the manner previously described.

When the number zero is dialed followed by one of the numbers 1 to 9, inclusive, the contact arm of the rotary switch moves to the zero contact point in response to dialing of the first digit. This closes the operating circuit of relay 91 through the normally closed contact set of relay 61, conductor 80, the upper switch arm, and the zero contact point of bank 68. Thereupon, relay 91 establishes a holding circuit for itself through a normally open contact set 92, normally closed contact springs 93, negative battery and ground, it being understood that contact springs 93 are momentarily opened when release magnet 62 is actuated. The energization of relay 91 also closes an auxiliary release circuit extending from a negative battery through a normally open contact set 93' of relay 91, a resistance 94, the zero contact point of bank 66 and release magnet 62. Accordingly, release magnet 62 operates and restores the rotary switch to its normal position. Due to resistance 94, the field established by release magnet 62 is not sufficient to open contact springs 93 so that the holding circuit of relay 91 remains closed.

Further responsive to the energization of relay 91, the ground impressed upon conductor 88 through contact set 90 is transferred to conductor 89 through contact set 96. Accordingly, when the next number is dialed and the arm of the selector switch moves to the corresponding point of contact bank 68, one of the relay sections 83 is actuated, with result illumination of its pilot lamp and closure of its holding circuit. After dialing of this second digit, the release magnet is actuated directly without passage of the current through resistance 94. As a result, the rotary switch 64 is restored to normal, and contacts 93 are momentarily opened, thereby breaking the holding circuit of relay 91 and permitting said relay to restore. The system is then ready for a subsequent series of pulses.

The circuit operates in the manner described in connection wtih Figure 5 when a high voltage pulse is passed down the line. Such high voltage pulse causes contacts 65 to open thereby disabling relay 61 and, when the high voltage pulse is terminated, the circuit to relay 75 is momentarily interrupted, thereby breaking the holding circuit of all the pilot relays. This clears the system and prepares it for a new cycle of operations.

Referring now to Figure 7, I have shown a modified type of selector wherein each valve in the gas lift system has a winding 98 for energizing it, and a winding 99 for releasing it. In such a valve, the actuation and release are each accomplished by a single relatively short pulse so that it is not necessary to supply a high voltage pulse during the entire period of valve operation. This circuit includes a selector switch 100 having a contact bank 101 provided with a release contact point 102 beyond the tenth bank contact point. The switch also incorporates a rotary contact arm 103, a motor magnet 104, and a release magnet 105. Each valve has its windings connected, respectively, to two adjacent bank contact points so that five such valves can be controlled by a single selector switch.

In operation, a selected number of low voltage pulses is sent down the line to move the selector switches of each valve control unit to a position corresponding to the

number of pulses. For example, if it is desired to operate valve number 3, five pulses are sent down the line so that the rotary switch arm **103** rests on bank contact point 3. Thereupon, a high voltage impulse is sent down the line to effect operation of winding **98** and open the valve which remains open until its release winding is energized. Thereafter, a large number, and at least ten, low voltage pulses are sent down the line so that each selector arm **103** is moved into contact with release bank point **102**. Upon such contact, the release magnet is operated, thereby restoring all the selector switches to normal. Operation of the release magnet breaks the circuit to the motor magnet **104** at a set of break springs **106**, this circuit being broken for a sufficiently long period as to allow the completion of the second series of low voltage pulses without further actuation of the motor magnet. If it is desired to release valve number 3, six pulses are sent down the line so that the contact arm **103** engages bank contact point 3R. Thereupon, a high voltage pulse is passed down the line to operate release winding **99** and close the valve. The system is cleared by application of a subsequent series of low voltage pulses in the manner hereinbefore described. It will be understood that motor magnet **104** operates upon interruption of the current at the end of each pulse. Accordingly, when a high voltage pulse is sent down the line, it causes operation of the selected valve winding, the switch stepping to its next position at the end of such high voltage pulse.

In this manner, no current is supplied into the valve during its period of operation, and the auxiliary equipment associated with the selector switch can be eliminated.

It will be apparent that I have achieved the objects of my invention in providing a system wherein any one or combination of gas lift valves can be selected for operation, these valves then being operated as long as desired by passing a high voltage pulse down the line L. Further, only two conductors are required for complete control of the system and the indicating device **18** provides a reliable indication of the valve or valves selected for operation or in operation, the indicating system being cleared by the high voltage operating pulse. Finally, it will be apparent that the described circuits of the selector units, indicating system, and their combination have independent utility for purposes other than the control of gas lift systems.

While the invention has been described in connection with a present, preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

I claim:

1. A selector comprising, in combination, a line; means for impressing low voltage and high voltage pulses upon said line; a selector switch having a plurality of contacts, and an arm movable along said contacts from a rest position; means responsive to each low voltage pulse to move the arm of said switch in a stepwise manner; means for returning said arm to said rest position at the end of each pulse series when said arm is engaged with a non-selected contact; means for disabling said stepping means when said arm rests upon a selected contact at the end of a pulse series; whereby the stepping means is not responsive to subsequent low voltage pulses, means responsive to the engagement of said contact arm with said selected contact to transmit a subsequent high voltage pulse from said line to a device to be controlled; and means responsive to the termination of said high voltage pulse to return said arm to its rest position.

2. The selector of claim 1 wherein said means for returning comprises means connected to one non-selected contact for disabling said means for disabling responsive to the last event in a cycle of events that includes stepping said arm to said one non-selected contact, returning said arm to said rest position, then stepping said arm to said selected contact, said cycle being effected by operating the second said means, the third said means, then the second said means again, respectively to accomplish each cycle event.

3. The selector of claim 1 wherein said means for disabling comprises means connected to one non-selected contact for enabling said means for disabling responsive to the last event in a cycle of events that includes stepping said arm to said one non-selected contact, returning said arm to said rest position, then stepping said arm to said selected contact, said cycle being effected by operating the second said means, the third said means, then the second said means again, respectively, to accomplish each cycle event.

4. A selector comprising, in combination, a line, means for impressing low voltage and high voltage pulses upon said line, a plurality of selector units, each including a quick acting relay having two opposing windings, together with a normally open and a normally closed contact set, and a third contact set which is closed only upon application of a high voltage pulse to one of said windings, means for feeding low voltage pulses from said line to said one winding, a slow to release relay having a normally open and a normally closed contact set together with an operating winding connected in circuit with a current source and the normally open contact set of said quick acting relay, a selector switch having a motor mag net, a release magnet, a rotary switch arm, and a plurality of contact points cooperating therewith, an operating circuit for said motor magnet including the normally open contact set of said slow to release relay, the normally closed contact set of said quick acting relay, and a current source, leads connecting non-selected contact points of said selector switch in circuit with said release magnet, the normally closed contact set of said slow to release relay, said contact arm, and a current source, leads connecting a selected contact point in circuit with said contact arm, a current source, a device to be controlled, and the third contact set of said quick acting relay, and leads connecting said selected contact point in circuit with said contact arm, a current source and the other winding of said quick acting relay, the circuit defined by the last-mentioned leads desensitizing the quick acting relay to low voltage pulses when the switch arm dwells on said selected contact point.

5. A selector unit comprising, in combination, a quick acting relay having two opposing windings; a normally open and a normally closed contact set; a slow to release relay having a normally open and a normally closed contact set together with an operating winding, the latter being connected in circuit with a current source and the normally open contact set of said quick acting relay; a selector switch having a motor magnet, a release magnet, a rotary switch arm, and a plurality of contact points cooperating therewith; an operating circuit for said motor magnet including the normally open contact set of said slow to release relay, the normally closed contact set of said quick acting relay, and a current source; leads connecting non-selected contact points of said selector switch in circuit with said release magnet, the normally closed contact set of said slow to release relay, said contact arm, and a current source; and leads connecting a selected contact point in circuit with said contact arm, a current source and the other winding of said quick acting relay, the circuit defined by the last-mentioned leads desensitizing the quick acting relay to subsequent pulses when the switch arm dwells on said selected contact point.

6. A selector unit comprising, in combination, a line; means for impressing low voltage and high voltage pulses upon said line; a quick acting relay having two opposing windings, a normally open and a normally closed contact set, and a third contact set which is closed only upon application of a high voltage pulse to one of said windings; means for feeding pulses from said line to said one winding; a slow to release relay having a normally open and a normally closed contact set together with

an operating winding connected in circuit with a current source and the normally open contact set of said quick acting relay; a selector switch having a motor magnet, a release magnet, a rotary switch arm, and a plurality of contact points cooperating therewith; an operating circuit for said motor magnet including the normally open contact set of said slow to release relay, the normally closed contact set of said quick acting relay, and a current source; leads connecting non-selected contact points of said selector switch in circuit with said release magnet, the normally closed contact set of said slow to release relay, said contact arm, and a current source; leads connecting a selected contact point in circuit with said contact arm, a current source, a device to be controlled, and the third contact set of said quick acting relay; and leads connecting said selected contact point in circuit with said contact arm, a current source and the other winding of said quick acting relay, the circuit defined by the last-mentioned leads desensitizing the quick acting relay to low voltage pulses when the switch arm dwells on said selected contact point.

7. An indicating device comprising, in combination, a line, means for impressing low voltage and high voltage pulses upon said line, a quick acting relay having an operating winding, a set of make before break and a set of normally closed contacts which are actuated only when a high voltage pulse is applied to said winding, a normally open and a normally closed set of contact springs which are actuated when each pulse, whether high voltage or low voltage, is applied to said winding, means for feeding pulses from said line to said winding, a slow to release relay having a normally closed and two normally open contact sets together with an operating winding connected in circuit with a current source, the normally open contact set and the normally closed contact springs of said quick acting relay, a selector switch having a motor magnet, a release magnet, a rotary switch arm, and two decks of contact points cooperating therewith, an operating circuit for said motor magnet including one normally open contact set of said slow to release relay, the normally closed contact set of said quick acting relay, and a current source, leads connecting all contact points except one selected point of one deck of said selector switch in circuit with said release magnet, the normally closed contact set of said slow to release relay, said contact arm, and a current source, leads connecting each contact point of the second deck in circuit with its contact arm, a current source, said normally closed contact set of said slow to release relay and the operating winding of a dual pilot relay, a pilot lamp energized by the closure of each section of each pilot relay, a selector relay having an operating winding, two normally open contact sets, a contact spring, a first contact normally engaging said spring, and a second contact normally spaced from said spring, an operating circuit for said selector relay including its operating winding, the second deck contact point corresponding to said selected point of the first deck, the associated contact arm, the normally closed contact set of said slow to release relay, and a current source, a holding circuit for said selector relay including its operating winding, one normally open contact set thereof, a set of normally closed contact springs actuated by said release magnet, and a current source, an auxiliary release circuit including the second set of normally open contacts of said selector relay, a resistor, said selected contact point of the first deck, its associated contact arm, the release magnet, and a current source, an operating circuit for one group of pilot relays including their operating windings, a current source, said first contact and its associated contact spring, an operating circuit for the second group of pilot relays including their operating windings, said second contact, the contact spring associated therewith, and a current source, a holding circuit for each pilot relay including a normally open set of pilot relay contacts, an auxiliary winding of such pilot relay, a current source, and a common normally open contact of an auxiliary relay, said auxiliary relay having an operating circuit including its operating winding, a current source, and the make before break contacts of said quick acting relay.

8. An indicating device comprising, in combination, a line, means for impressing low voltage and high voltage pulses upon said line, a quick acting relay, means for feeding pulses from said line to the operating winding of said relay, a slow to release relay, means for operating said slow to release relay each time said quick acting relay is actuated, a selector switch having a motor magnet, a release magnet, a rotary switch arm, and contact points cooperating therewith, means for operating said motor magnet when said slow to release relay is energized and said quick acting relay is deenergized, means for operating said release magnet when said contact arm dwells upon a non-selected contact point, leads connecting each contact point in circuit with its contact arm, a current source, a normally closed contact set of said slow to release relay and the operating winding of a dual pilot relay, an indicating device energized by the closure of each section of each pilot relay, a selector relay having an operating winding, two normally open contact sets, a contact spring, a first contact normally engaging said spring and a second contact normally spaced from said spring, an operating circuit for said selector relay including its operating winding, a selected contact point, the associated contact arm, said normally closed contact set of said slow to release relay, and a current source, a holding circuit for said selector relay including its operating winding, one normally open contact set thereof, a set of normally closed contact springs actuated by said release magnet, and a current source, an auxiliary release circuit including the second set of normally open contacts of said selector relay, a resistor, a selected contact point, its associated contact arm, the release magnet, and a current source, an operating circuit for one group of pilot relays including their operating windings, a current source, said first contact and its associated contact spring, an operating circuit for the second group of pilot relays including their operating windings, said second contact, the contact spring associated therewith, and a current source, a common holding circuit for all of said pilot relays, and means responsive to a high voltage pulse for breaking said holding circuit.

9. A selector unit comprising, in combination, a quick acting relay having two opposing windings; a normally open and a normally closed contact set; a slow to release relay having a normally open and a normally closed contact set together with an operating winding, the latter being connected in circuit with a current source and the normally open contact set of said quick acting relay; a selector switch having a motor magnet, a release magnet, a rotary switch arm, and a plurality of contact points cooperating therewith; an operating circuit for said motor magnet including the normally open contact set of said slow to release relay, the normally closed contact set of said quick acting relay, and a current source; means for connecting non-selected contact points of said selector switch in circuit with said release magnet, the normally closed contact set of said slow to release relay, said contact arm, and a current source; and means for connecting a selected contact point in circuit with said contact arm, a current source and the other winding of said quick acting relay, the circuit defined by the last-mentioned means desensitizing the quick acting relay to subsequent pulses when the switch arm dwells on a selected contact point.

10. The selector unit of claim 9 wherein said release magnet further comprises a normally closed set of contact springs and wherein the last mentioned means for connecting comprises an auxiliary relay connected to one of said non-selected contact points and having a contact

set in circuit between the selected contact point in the other winding of said quick-acting relay and another contact set; and a holding circuit for said auxiliary relay including a current source, said relay magnet normally closed contact springs, and said another contact set of said auxiliary relay.

11. The selector unit of claim 10 wherein said auxiliary relay contact set in circuit comprises a normally closed switch that is opened responsive to said arm dwelling on said one non-selected contact point.

12. The selector unit of claim 10 wherein said auxiliary relay contacts set in circuit comprises a normally open set that is closed responsive to said arm dwelling on said one non-selected contact point.

13. The selector unit of claim 11 further comprising means responsive to the opening of said normally closed switch for connecting the selected contact point to said means for connecting non-selected contact points.

14. The selector unit of claim 12 further comprising a

resistor connected in series between said relay and said means for connecting non-selected contact points.

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