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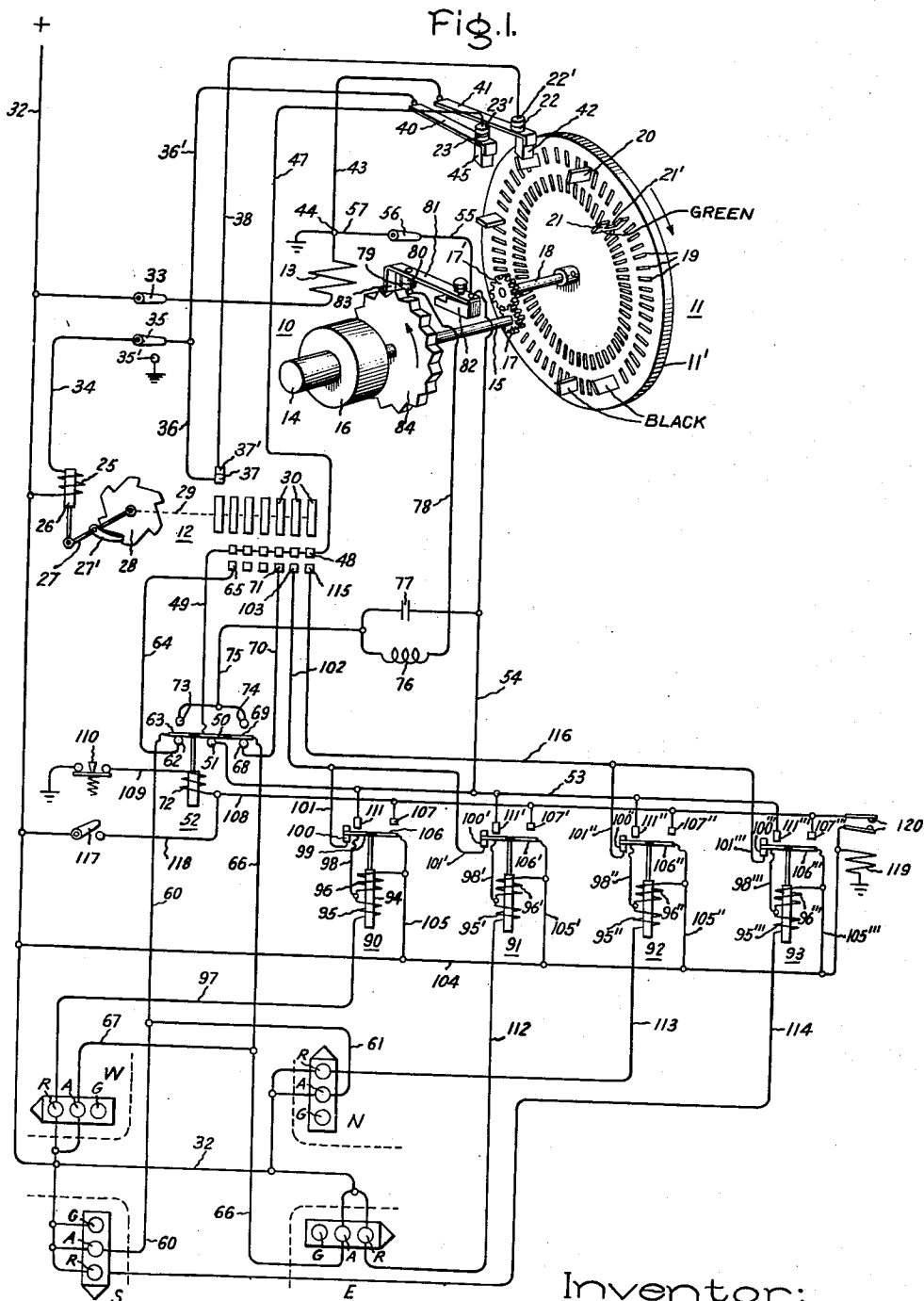
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2,249,481

TRAFFIC SIGNAL CONTROLLER

Filed Oct. 3, 1939

2 Sheets-Sheet 1



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Fig. 2.

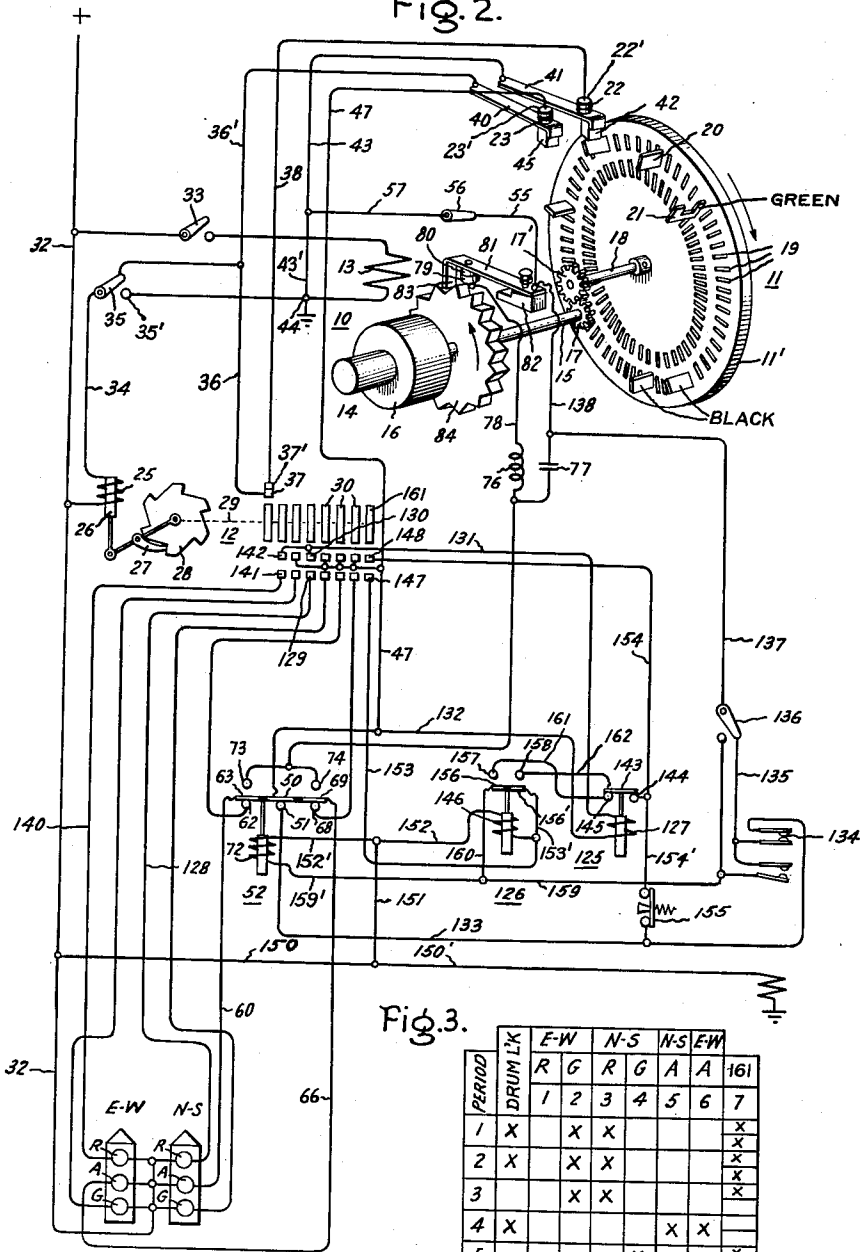


Fig.3.

PERIOD	DRUM \ X	E-W		N-S		N-S E-W		161
		R	G	R	G	A	A	
		1	2	3	4	5	6	7
1	X		X	X				X
2	X		X	X				X
3			X	X				X
4	X					X	X	
5	X	X			X			X
6	X					X	X	

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UNITED STATES PATENT OFFICE

2,249,481

TRAFFIC SIGNAL CONTROLLER

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5 Claims. (Cl. 177—337)

My invention relates to traffic signal controllers, and more particularly to an improved apparatus for indicating the failure of a signal lamp.

One object of my invention is to provide an indicating means which is automatically energized when a signal lamp becomes inoperative.

Another object of my invention is to provide a lamp failure or outage indicating means which will become effective upon the failure of any one of several signaling lamps and will become ineffective as soon as such lamp is replaced by an operative lamp.

For a better understanding of my invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings, Fig. 1 illustrates, diagrammatically, one type of traffic signal controller provided with a lamp failure indicating means built in accordance with my invention; Fig. 2 is a diagrammatic illustration of the same controller provided with a modification of my invention; and Fig. 3 is a chart indicating one schedule of signal operations.

Referring to the drawings in detail, Fig. 1 discloses a traffic signal controller comprising essentially a driving motor 10, a timing dial 11 driven by the motor, and a rotary switch preferably in the form of a drum controller 12 which operates suitable contacts connected into the circuits of groups of traffic signals N, S, E, and W. The drum controller 12 is operated by a suitable mechanism controlled by the dial through contacts actuated by keys mounted in the dial and through circuits connecting said contacts to said mechanism.

The motor 10 is preferably a self-starting synchronous motor of the type disclosed in U. S. Patent No. 1,430,867 Warren. It is diagrammatically illustrated as having a field 13, an armature enclosed in a casing 14, and a shaft 15 driven by the armature through a speed reducing gearing which is enclosed in an enlarged casing 16 attached to and made a part of the casing 14. The motor drives the timing dial 11 through a pair of pinions 17, 17' and a shaft 15. The shaft 15 also carries the actuating wheel 34 for a signal flashing mechanism.

The timing dial 11 comprises a disc 11' mounted directly on the shaft 15 and driven thereby in the direction indicated by the arrow. The disc is provided with equally spaced radial slots 19, near its periphery, arranged to receive keys 20

and 21; there being, in the present instance, five keys 20 and one key 21, the key 21 being longer than key 20 and being provided with a notch 21'.

Adjacent to dial 11 is a resilient contact arm 41 fixed at its one end on a suitable support (not shown) and at its free end provided with a contact 22 and a block 42. The contact 22 is attached to the upper side of the contact arm and the block 42 is attached to the lower side of this arm and has a beveled lower end which projects into the path of movement of and is adapted to be engaged by the keys 20. When a key 20 moves under block 42 during rotation of dial 11', it momentarily raises the free end of arm 41 to bring the contact 22 into engagement with a fixed contact 22'.

Also, adjacent to dial 11' is a second resilient arm 40 fixed at its outer end on a suitable support (not shown). At its free end it is provided with a contact 23 and a block 45 having a beveled lower end which projects into the path of, and is adapted to be engaged by, the key 21. When key 21 is moved under block 45 during rotation of dial 11', it momentarily raises the free end of arm 40 to bring the contact 23 into engagement with a fixed contact 23'. The notch 21' in key 21 is in line with block 42; therefore, when key 21 is in position to operate block 45, the block 42 passes through this notch 21' and is not lifted to close the contacts 22—22'.

The drum controller 12 comprises a series of seven cams 30 mounted on shaft 29 which are adapted to operate contacts mounted adjacent to the cam surfaces respectively. The cam surfaces are so arranged that when the cams are rotated in a step-by-step manner through a fixed number of positions in each revolution, by a suitable operating mechanism, the contacts are moved to open or close circuits with cooperating contacts in accordance with a predetermined schedule. In the present instance the cams are successively moved to six positions, in each revolution, which comprises one cycle of signal operations. The first cam on the left-hand end of the drum operates a contact 37, and the other cams each operate a contact and thereby respectively control circuits of the several signal lamps.

The mechanism for advancing the drum comprises an electromagnetically operated ratchet mechanism including a magnet coil 25 provided with an armature 26. The armature is connected to the free end of an arm 27 which is pivoted at its other end on the shaft 29 and carries a pawl 27'. The free end of the pawl co-operates with a ratchet wheel 28 which is rigidly

attached to the end of the shaft 29. This pawl slides over the surface of the ratchet wheel when the coil 25 is energized to lift its armature. When the coil 25 is deenergized, the armature drops and moves the pawl counterclockwise. During this movement, the free end of the pawl engages a tooth face on the ratchet wheel, and thereby moves the ratchet wheel with it. The length of this movement is proportioned to move the drum to its next position. In the present instance the movement of the pawl and the teeth on the ratchet wheel are arranged to rotate the wheel through one revolution in six operations. The drum cams are correspondingly arranged for six-position operation.

The manner of timing the movement of the drum 12 and the manner in which it is maintained in a definite relationship with the continuously rotating dial, may be understood from a consideration of the circuits interconnecting the dial operated contacts and the magnet of the advancing mechanism. The electric current needed for this operation is received through a conductor 32 indicated on the left-hand side of the drawing. The motor 10 is started by the closure of a switch 33 which closes a circuit between the conductor 32 and one end of the motor field winding 13. The other end of this field winding is connected to a grounded terminal 44. The motor then rotates the dial 11, causing keys 20 to intermittently close a circuit by raising the contact 22. This circuit may be traced from the conductor 32 through the magnet coil 25 of the drum advance mechanism, conductor 34, a switch 35, conductor 36, contacts 37—37', conductor 38, contacts 22'—22, arm 41, conductor 43, to the grounded terminal 44. At each closure of this circuit, the drum mechanism advances the drum to a succeeding position. The time interval between movements of the drum is proportional to the spacing of the keys in the slots of the dial as long as a uniform speed is maintained by the motor.

It may be pointed out that since both dial and drum are rotated by separate mechanisms, there is a possibility of starting them off in any desired relationship which would obtain as long as the drum is advanced at each closure of the circuit through contacts 22—22'. The spacing between the keys 20 is not uniform, however, and it is therefore necessary, for proper operation, to maintain a definite relationship between the drum and the dial so that each position of the drum is maintained for the desired time period. For this purpose the drum is caused to open the circuit of the drum-advance coil in one of its six positions. This is effected by the contacts 37 and 37'. When the contacts 37—37' are separated, the circuit to the magnet coil 25 through contacts 22—22' is opened, and keys 20 are unable to effect an advancement of the drum. For the purpose of advancing the drum beyond this position a shunt circuit is established by the closure of contacts 22—22' effected by the key 21 at the instant that the dial is in the proper relation to the drum.

The key 21 is preferably placed in the dial in a position which marks the end of the time interval allotted to the main street right of way. The contacts 37—37' are opened when the drum is moved to its main street right-of-way position and remain open in this position of the drum. When the dial reaches its proper position in relation to the drum, the key 21 closes the circuit by raising contact 23. The established circuit

may be traced from conductor 32 through the coil 25, conductor 34, switch 35, conductor 36', contact arm 40, contacts 23—23', conductor 47, interconnected contacts 48, conductor 49, contacts 50—51 of a relay 52, conductors 53, 54, 55, switch 56, conductor 57, to grounded terminal 44. That instant at which the dial 11 reaches the position at which it closes contacts 23—23' marks the end of the time interval for the drum position in which contacts 37—37' are separated. At the succeeding position of the drum, contacts 37—37' are closed and keys 20 again effect an advancement of the drum. The relationship of the drum and dial is therefore checked at each revolution, the drum being held stationary until the dial moves to the proper position relatively to the drum.

The drum may also be advanced by a manual manipulation of the switch 35. The switch is provided with a cooperating grounded contact 35'. When the switch arm engages this contact a circuit is established through the coil 25. By intermittently moving the switch to engage this contact, the drum 12 may be advanced at will, the circuits through the dial-operated contacts being simultaneously inoperative since they are opened at the contact 35.

Further details of this controller may be found by reference to copending application Serial No. 203,888, filed April 23, 1938, by R. A. Reid, and assigned to the assignee of the present application.

The traffic signal groups are designated as N, S, E, and W, are energized through circuits controlled by the above described mechanism. They are placed at the four corners of a street intersection to regulate traffic moving in four directions along two intersecting streets, the directions chosen for purpose of illustration being the four cardinal points of the compass. Each of the groups is provided with a red, amber, and green lamp designated respectively by the letters R, A, and G. The signals for each street are connected in pairs since traffic moving in opposite directions in one street is signalled simultaneously; i. e., the N—S signals are connected in pairs and the E—W signals are connected in pairs.

In Fig. 1, my invention is applied to indicate the failure of the red lamp in each signal group, although my invention may be applied also to indicate the failure or outage of the green lamp in each group. Briefly, the mechanism for producing such indication includes an electro-magnetic switch or relay connected into the circuit of each red lamp. This switch remains in one position as long as the respective red lamp circuit carries current during the signal period, and moves to a second position when the current is interrupted during such signal period. When this switch moves to its second position, it energizes an electromagnetic relay which in turn interrupts the circuits to all the signal lamps and establishes a new circuit for an indicating device. In the present instance, the amber lamps of all the groups are energized simultaneously through a flashing device for the purpose of indicating the failure of the red lamp.

The signal lamps are all energized from the common source conductor 32 and the respective circuits are completed through the drum operated contact 48 which are connected to the ground terminal 44. For the purpose of describing my invention, the circuits for the amber and red lamps only are necessary. The conductors

leading from the proper drum controller contacts to the green lamps are not shown, so that the red and amber lamp circuits may be more readily traced. These conductors are merely continuous conductors of sufficient capacity to carry the current of the green lamps and are indicated in Fig. 2. Two cams and cooperating contacts are provided, one for the E-W green lamps, and one for the N-S green lamps.

The amber lamp circuits for the two intersecting highways may be traced from the source conductor 32 to the respective drum operated contacts in two groups; i. e. N and S and E, W. The circuits for the N, S amber lamps may be traced from conductor 32 through the amber lamp in the S group to a conductor 60, and from conductor 32 through the amber lamp in the N group to a conductor 61 which also joins the conductor 60. The common circuit for these two amber lamps continues through the conductor 60 to a movable contact 63 on a relay 52, a stationary contact 62 of the relay, conductor 64, to a contact 65 of the drum controller. In predetermined positions of the drum, the cam 30 aligned with this contact 65 and with a cooperating contact 48, will effect an engagement of the two contacts and thereby close a circuit which may be traced to grounded terminal 44 through conductor 49, relay contacts 50-51, conductors 53, 54, 55, switch 56, conductor 57, and ground terminal 44. The circuit for the E and W amber lamps may be traced from conductor 32 through the amber lamp in the E group, to a conductor 66, and from conductor 32 through the amber lamp in the W group to a conductor 67 which is in turn connected to the conductor 66. The common circuit for these two amber lamps continues through the conductor 66, through movable contact 69 and stationary contact 68 of the relay 52, through a conductor 70 to a contact 71 on the drum controller. Here again, a circuit is closed during predetermined positions of the drum by a cam 30, which is in line with the contact 71 and a cooperating contact 48, and the circuit continues to grounded terminal 44.

It may be here noted that relay 52 controls the circuits of the amber lamps through two pairs of contacts 63-62 and 69-68, and controls the circuit for all the lamps through the third pair of contacts 50-51 which are in the common grounded return conductor of the lamp circuits. In the position illustrated, the three pairs of contacts are in engaged relation and the circuits therethrough have been traced. For actuating the movable contacts the relay is provided with a coil 72 which when energized raises the movable contacts 63, 50, and 69 to break the circuits therethrough and to establish a new common circuit for the four amber lamps. To establish this new common circuit, the contacts 63 and 69, which are terminals respectively for the N-S and E-W amber lamps, respectively are raised to engage stationary contacts 73 and 74 which are connected to a single conductor 75. When so raised, these contacts establish the new circuit, through the amber lamps, which continues through conductor 75, a filter choke coil 76, a conductor 78 to a stationary contact 79, a movable contact 80, a contact arm 81, conductor 55, switch 56, conductor 57 to grounded terminal 44. The contact arm 81 which supports the contact 80 is pivotally mounted on a stationary block 82 and the free end thereof is provided with a nose 83 which rides on the star wheel 84 mount-

ed on the motor shaft 15. The circuit for the amber lamps is thereby intermittently closed and opened at contacts 79-80 to effect a flashing of all the amber lamps. The filter choke coil 76 cooperates with a condenser 77 connected between conductor 54 and conductor 75 for the purpose of suppressing the high frequency magnetic waves emanating from the arc at the contacts 79 and 80, thereby preventing interference with radio reception in the vicinity of the controller.

The relay 52 which effects the circuits of all the signal lamps is operated in response to the outage of any one of the red lamps. This operation is obtained by providing a switch in each red (R) lamp circuit which operates to energize the operating coil 72 of the relay 52 when a red lamp burns out. Referring to Fig. 1, the switches in the red lamp circuits are illustrated as electromagnetic relays 90, 91, 92 and 93. The relay 90 is connected into the circuit of the red lamp in the W group of signals, the relay 91 is in the circuit of the red lamp in the E group; relay 92 is in the red lamp circuit of the N group, and relay 93 is in the red lamp circuit of the S group of signals.

Relay 90, the first of the above-mentioned relays, is provided with an armature 94 controlled by a series coil 95 connected in series with the W-red lamp and by a coil 96 connected in shunt to the same lamp. This latter coil may be called, for the sake of convenience, a potential coil. The circuit for the W-red lamp may be traced from the positive conductor 32 through the lamp to a conductor 97, series coil 95, conductor 98, to a movable contact 99 on the relay. The relay is shown in its deenergized position, and in this position, contact 99 is in engagement with a stationary contact 100. The circuit for the lamp continues through conductors 101 and 102 to a contact 103 on the rotary drum switch 12. A cam 30 on this drum moves the contact 103 into engagement with a contact 48 at predetermined positions of the drum to complete the circuit to the grounded terminal 44 through the contact 48, conductor 49, contacts 50-51, conductors 53, 54, 55, switch 56 and conductor 57, as already traced for the amber lamps. The circuit for coil 96 may be traced from conductor 32 to conductors 104 and 105 through the coil 96 and from the coil through conductor 98, relay contacts 99, 100, conductors 101 and 102 to drum contact 103. During the signal period for this lamp the circuit continues through contacts 48 to grounded terminal 44 as traced for the lamp circuit. As long as current flows to the lamp, the two coils 95 and 96 are both energized and act, upon the armature 94, in opposite directions; the potential coil tending to lift the armature and the series coil tending to hold it in its normal position. The power of the coils is such that no movement of the armature takes place. When the series coil becomes deenergized, however, during a signal period when the potential coil is normally energized, the potential coil raises the relay contacts and effects an operation of the amber lamp relay 52.

The operation of relay 90 breaks the normal red lamp circuit and establishes two circuits, one of these two being a locking circuit for the potential coil; and the other a circuit for the operating coil 72 of the amber lamp relay. The circuit to the operating coil 72 of the amber lamp relay 52 may be traced from the positive conductor 32 to conductors 104, 105, and movable

contact 106 on the relay 90. When the relay armature is raised, the movable contact 106 engages a stationary contact 107 and the circuit continues through a conductor 108 through coil 72, conductor 109, a normally closed push button switch 110 to ground. The second circuit established by the relay in its raised position, is a locking circuit established for its potential coil 96. This circuit may be traced from positive conductor 32 to conductors 104, 105, through coil 96, conductor 98, to movable contact 99, stationary contact 111, conductors 53, 54, 55, switch 56, conductor 57 to grounded terminal 44. The stationary contacts 100 and 111 are so arranged that the moving contact 99 does not leave contact 100 before it engages 111. In this manner it maintains a continuous energization of the coil 96 during the change of connections. The circuit through the coil is then maintained, independently of the drum contacts, through the conductor 53 to which the contact 111 is connected, and through conductors 54, 55, switch 56, conductor 57 to the grounded terminal 44.

The operation of the amber relay effects an interruption of the normal operation of the signals and of the drum switch 12. The separation of the relay contacts 50—51 effects both of these conditions. The signal circuits are interrupted instantly upon the separation of the contacts 50—51 because these contacts break the common return circuit for all the lamps. The drum switch is advanced by the actuation of switch 22—22' by the keys 20, until the drum reaches the position at which the interlock contacts 37—37', in this operating circuit, are opened and the keys 20 become ineffective. The key 21 cannot advance the drum, through the circuit of contacts 23—23', because the return circuit for these contacts operated by 21, is also broken at the contacts 50—51.

When it is desired to renew the burned out lamp, the controller is placed into operation for one cycle to enable an operator to detect the inoperative lamp and place a new one in its socket. A push button switch 110, in the operating circuit of the amber lamp relay, is provided for this purpose. As long as this switch is held in its circuit interrupting position, the circuit for coil 72 is broken and the relay 52 will drop its contacts. The controller will then operate the signals normally. When the broken lamp has been detected, this switch is allowed to close.

When a new lamp is placed in this socket, the circuit to series coil 95 is established through the relay contacts 99—111. This circuit may be traced from conductor 32 through the W-red lamp and conductor 97, coil 95, conductor 98, contacts 99—111, conductors 53, 54, 55, switch 56, conductor 57 to ground terminal 44. The series coil 95 of the relay 90 will then be energized and the relay contacts will be moved to their lower position, the series coil being made powerful enough to overcome the pull of the potential coil. The amber lamp relay coil circuit is thereby opened at the contacts 106—107 of this relay. The relay 52 will, accordingly, drop to its first position and the controller will continue its normal sequence operation.

The same operation occurs when any one of the other three red lamps becomes inoperative. The relays in the red lamp circuits are exactly alike and are arranged to operate relay 52 in the same manner. The E-red lamp is connected in series with the relay 91 through conductor 112. This lamp is energized simultaneously with the

W-red lamp through the conductor 102 by the rotating drum switch 12. The relay elements and contacts correspond to the elements of the relay 90, and are accordingly worked, a single accent mark being used to distinguish them from the elements of the relay 90. The coils 95' and 96' are energized simultaneously with the coils of relay 90. The contacts 107' and 111' are also connected to conductors 108 and 53, respectively, so that in response to an outage of the E-red lamp, the relay 52 is operated as in response to an outage of the W-red lamp.

The elements of the relays 92 and 93 correspond to the elements of the relays 90 and 91. They are marked with double and triple accent marks to distinguish them from the same elements of the other relays. The series relays 92 and 93 are connected at one end to the N-red and S-red lamps respectively through conductors 113 and 114. The common circuit for the series coils of these relays is closed by the drum switch 12 through contacts 48—115 and a conductor 116. The circuit closed by these relays in response to an outage of either lamp N-red or S-red is that for coil 72 and is the same as for relays 90 and 91.

The controller may be shifted to flashing amber operation by a hand operated switch 117. This switch 117 energizes the amber lamp relay coil 72 by closing a circuit from the positive conductor 32 through a conductor 118, and through the coil to ground through the normally closed push button switch 110. A time controlled switch indicated diagrammatically by a coil 119 and a pair of contacts 120 may also be used to initiate flashing amber light operation by closing the circuit between conductor 104 and 108. The coil 72 is then energized through a circuit from conductor 32 through conductors 104, 108, coil 72, conductor 109, switch 110, to ground.

In Fig. 2, I have illustrated a modification of my invention. In this figure, the invention is applied to the same traffic signal controller that is illustrated in Fig. 1, corresponding elements being designated by the same numerals. The relay 52, which is the relay used in Fig. 1 to operate the outage indication, is in this modification controlled by an arrangement of one relay, connected in series with the red lamps during their respective operating periods, and an auxiliary relay. This arrangement is more economical in that less relays are used than in the arrangement of Fig. 1.

Referring to this figure in detail, the controller includes the motor 10, dial 11 and controller 12, as in Fig. 1. The signals are arranged in two groups E—W and N—S having red (R), amber (A) and green (G) lamps respectively. They are permanently connected to the feed conductor 32 and are respectively connected to contacts on the drum controller by individual conductors. The relay 52 is provided, as in the arrangement of Fig. 1, to change the circuits of the lamps for flashing amber operation. The operating coil 72 thereof is controlled, however, by a series relay 125 and an auxiliary relay 126, instead of four separate relays as in Fig. 1. The operation of this arrangement will be understood from an examination of the circuits interconnecting the controller and the relays above mentioned.

The circuit for the operating coil, 127, of the series relay 125 may be traced from the positive conductor 32 through the red lamp of the N—S group, conductor 128, controller contacts 129—130, conductor 131, coil 127, conductor 132, contacts 50—51 of the amber lamp relay, con-

ductor 133, normally closed time-clock contacts 134, conductor 135, switch 136, conductors 137, 138 and 55, switch 56, conductors 57 and 43' to ground terminal 44. A circuit of this same relay coil may also be traced through the E-W red lamp. This latter circuit continues from the positive conductor 32 through the E-W red lamp to conductor 140, controller contacts 141—142 to conductor 131 and to the relay coil 127. The remainder of the circuit from the relay coil to ground is the same as for the N-S red lamp. The series coil is, therefore, energized during the red lamp period for N-S and also during the red lamp period for the E-W signal groups, and consequently, is continuously energized during the normal operation of the red lamps. This relay 125 is provided with a single moving contact 143 which is raised when the relay coil is energized and which drops to engage stationary contacts 144—145 when the relay coil is deenergized.

The intermediate relay 126 is provided so as to prevent the application of an electric impulse to the amber lamp relay, through the contacts of the series relay, when power is first applied to the control apparatus. The contacts of the intermediate relay are closed whenever any one of the red lamps is energized and are open when the lamps are deenergized. The contacts of the series relay are open when the red lamps are energized, and are closed when the red lamps are deenergized. The contacts of these two relays are, placed in series, in the operating coil circuit of the amber lamp relay, so that when the intermediate relay is energized and the series relay becomes deenergized, the amber lamp relay circuit is closed and the controller operation is changed to flashing amber. When the signals are turned off, the intermediate relay opens its contacts and the series relay closes its contacts. Therefore, when the current is turned on, the circuit to the relay coil 72 remains open.

The intermediate relay 126 is provided with a coil 146 which is energized through a pair of contacts 147—148 on the signal operating drum 12, a cam 161 being arranged to hold these contacts in closed or open position in accordance with a predetermined chart of operations. An example of such a chart is illustrated in Fig. 3 and will be explained in connection with the operation of this controller.

The circuit for the intermediate-relay coil 146 may be traced from the source conductor 32 through conductors 150, 151, 152 to the coil 146, conductor 153, controller contacts 147—148 conductor 154, normally closed push button switch 155, conductor 133, time switch contacts 134, conductor 135, switch 136, conductors 137, 138, 55, switch 56, conductors 57, 43' to grounded terminal 44.

This relay 126 is provided with a pair of movable contacts 156—156' and a pair of stationary contacts 157—158. When the coil 146 is energized the contacts of the relay establish a locking circuit and partly establish a circuit that is completed only when the contacts of the series relay are closed. The amber relay coil circuit may be traced from conductor 32 through conductors 150, 151, 152' to relay coil 72 and through conductors 159' and 160 to contacts 156—157. The contact 157 is connected to the stationary contact 145 of the series relay by a conductor 157'. When the series relay is closed, the circuit continues from contact 145 through bridging contact 143, contact 144 to conductor 154. The

circuit then continues through conductor 154' switch 155, to conductor 133 and time switch contacts 134 to grounded terminal 44 as previously traced for the intermediate relay coil circuit.

At the time that the intermediate relay establishes the amber relay circuit, it also establishes a locking circuit for its own coil 146. This circuit is established by the closure of contacts 156'—158. The moving contact 156' is connected to conductor 153' to which one end of the coil 146 is also connected. When the relay operates, the current from conductor 32 is carried by conductors 150, 151, and 152 to the coil 146 and the circuit continues through the conductor 153' to contacts 156'—158, through a conductor 162 to the moving contact 143 of the series relay. This relay now being closed, the circuit continues to the grounded terminal 44 over the conductor 154', switch 155, etc. in common with the intermediate relay coil circuit. The result of current flowing through the circuits just traced is that the amber lamp relay is energized as soon as the series relay drops, due to a lack of current in its coil, and the intermediate relay establishes a circuit for itself through its own contacts and thereby becomes independent of the drum contacts 147—148. The intermediate relay contacts are placed in series with the series relay contacts so as to prevent an operation of the amber lamp at times when switching operations other than the normal signal sequence operations are performed. Thus, for instance when current is first turned on, the series relay is deenergized and has closed the circuit to the amber lamp relay. The intermediate relay is also deenergized and its contacts are open and the amber lamp relay coil remains deenergized.

If it were not for the intermediate relay, which is also deenergized at this time, the amber relay would snap into flashing amber position before the series relay had an opportunity to open its contacts in this amber relay coil circuit. This same condition holds when, under the influence of the time-switch contacts 134, the controller is set to operate on sequence operation. The contacts of the time switch operate with a snap-action so that the normal sequence operation circuits are established before the amber relay drops into deenergized position or, alternately, before the series relay breaks the circuit to the amber relay coil. In either case, the amber lamp relay would remain closed if the intermediate relay did not prevent this operation by interposing a break in the amber relay coil circuit.

When a red lamp burns out, the series relay drops to close its contacts and, the intermediate relay being closed, establishes the circuit to the amber relay 52 as above traced. When a new lamp is substituted for the burned out lamp, the circuit to the new lamp is not automatically reestablished in this modification, because the circuit for the coil 127 of the relay 125 is broken by the center contacts 50—51 of the relay 52. In the circuit of Fig. 1, a bypass circuit is established under these circumstances by the relay contacts 111 and 99. The series coil is thereby automatically reenergized when a new lamp is placed in the socket of the burned out lamp, and the relay 52 is thereby deenergized to establish its normal circuits. In the arrangement of Fig. 2, it is necessary to momentarily break the circuit of the coil 72 by pressing the push button switch 155. In that instant, at which the push button is pressed, the relay 52 drops its contacts to establish normal connections, and thereby estab-

lishes a circuit for the series coil 127 through the replaced lamp. This circuit may be traced from positive conductor 32 through either of the red lamps and its controller contacts to conductor 131, through coil 127, conductor 132, contacts 50—51, conductor 133, contacts 134, conductor 135, switch 136, conductors 137—138, 55, switch 56, conductors 57 and 43' to ground contact 44.

In Fig. 3 I have illustrated a chart of operations for the controller above described. The chart indicates that the controller 12 has six positions or periods, numbered vertically 1 to 6. There are eight cams on the controller drum. The first cam (left to right) operates the drum-lock contacts 37—37'. The closed position of the contacts is indicated by crosses in the rectangular spaces of the chart. Reading the chart, under this interlock cam it is indicated that the contacts are open in the third period. The six rows indicate the closed and open positions for the red, green, and amber signals respectively.

The last cam marked 161 operates the contacts 147—148 which are in the intermediate relay coil circuit. This cam is divided into twelve positions so that the operation of the contacts 147—148 may be offset in relation to the operation of the red lamp contacts. It is indicated in this chart that in periods 4 and 6 both red lamps are out.

In order that the amber relay circuit may not be operated under these circumstances, the intermediate relay contacts are opened by the cam 161 during the movement of the drum from period 3 to 4. The cam surface is, therefore, so arranged that the contacts 147—148 are opened one-half step before the red lamp contacts are opened. The contacts remain open during the fourth period and are closed during the fifth period. It is indicated, however, that the contacts are closed during the first of the two half periods into which this cam is divided. This simply means that while the drum is in its fifth position the contacts are closed. When the drum is being moved to its sixth position, the cam permits the contacts to open when it has traveled only one half the distance to this next position.

The specific signal operating cycle illustrated by the chart, Fig. 3, is the most commonly used 4-period cycle. This consists of two right-of-way positions for each of two intersecting highways, and a caution period between each change. It is often desired, however, to use additional periods, such as, for example, periods during which certain turns are permitted, or periods during which pedestrian traffic is permitted exclusively. To provide for such contingencies, the drum 12 is provided with a 6-position star wheel 28 requiring six operations for a complete revolution of the drum. The timing dial 11 is correspondingly provided with five keys 20, and one key 21, by means of which the coil 25 is energized six times during each revolution of the dial. The cams 30 on the drum 12 are, however, arranged for the 4-period cycle, and in order to provide for the discrepancies between the number of positions on the drum and the number of periods in the cycle, one period of the cycle is spread over three positions of the drum.

Referring to the chart again, it will be noted that the green lamp for the E—W street and the red lamp for the N—S street are energized in each of positions 1, 2, and 3. It will also be noted that the drum interlock contacts are opened in position 3. The drum cannot be moved therefore, from position 3 to position 4 by a key 20, as has explained above. Key 21, which is preferably

painted green, is chosen to move the drum at this time, or conversely, the drum lock contacts 37—37' are opened in this position of the drum, for the reason that if a delay should occur due to the non-synchronism of the drum with the dial, it is preferable to hold the drum in the position in which it delays the least amount of traffic. This position is, therefore, that position in which the right-of-way is indicated to the more important of the two intersecting streets.

Referring to the dials illustrated in Figs. 1 and 2, it may be stated that the two keys 20 preceding the green key 21 (in the direction of rotation) are the keys which effect a movement of the drum from position 1 through position 2 to position 3. These two keys are painted black to distinguish them from the signal changing keys. The key 20, following key 21, effects an operation of the drum from position 4 to position 5. The second key following key 21 and illustrated as closing the contacts 22, effects a movement of the drum from position 5 to position 6. The sixth key is the key immediately below the key which is in the act of closing the contacts 22. This key effects a movement of the drum from position 6 to position 1, and marks the beginning of what is preferably termed "the main street green period," that is, the period in which the more important of two intersecting streets is given the right of way. The actual spacing of the keys in the slots of the dial 11 is arranged separately for each intersection, and in the illustrated example, no specific timing is intended to be shown.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a traffic signal system, the combination of a group of traffic signals, a motor operated switch operable to energize said signals in a predetermined sequence and at predetermined time intervals, a relay responsive to current flowing to said signals and arranged to operate its contacts to closed position upon the failure of one of said signals, a second relay operated to closed contact position only when current is available for operating said signals, signal failure indicating means, and a third relay energized through the contacts of said first two relays upon the failure of said signal, said third relay operating to interrupt said sequence operation of said group of signals and to energize said failure indicating means.

2. In a traffic signal system the combination of a group of electrically operated traffic signals, a motor operated switch operable to energize said signals in a predetermined sequence and at predetermined time intervals, a relay in the circuit of said signals and operated to close its contacts when current is available for energizing said signals, a second relay energized to open its contacts only when current is available for a predetermined one of said signals, and a third relay energized through the said first two relays upon the failure of said one signal during its signaling period, said third relay interrupting said sequence operation and energizing a predetermined other one of said signals to indicate the failure of said first mentioned signal.

3. In a traffic signal system the combination of a group of traffic signals, a motor operated switch operable to energize said signals in a predetermined sequence and at predetermined time intervals, a relay in the circuit of said lamps and operated to closed contact position when current is available for operating said signals, a second relay energized and operated to open contact position only when current is connected to one of

said signals, and a third relay energized through the contacts of said first two relays upon the failure of said one signal during its signaling period, a second circuit for another of said signals, a flashing mechanism in said circuit, said third relay interrupting said sequence operation and energizing said predetermined other one of said signals through said second circuit for obtaining a flashing operation of said last mentioned signal.

4. In a traffic signal system, the combination of a group of traffic signals, a switch operable to energize said signals in a predetermined sequence and at predetermined time intervals, a relay responsive to current available for operating said signals and arranged to operate to closed-contact position when current is available for operating said signals, a second relay operated to open-contact position when current flows to one of said signals and operated to closed position when current fails in that signal circuit, signal failure in-

dicating means, and a third relay energized through the closed contacts of said first two relays to operate said failure indicating means.

5. In a traffic signal system the combination of a group of traffic signals, a switch operable to energize said signals in a predetermined sequence at predetermined time intervals, a relay responsive to current available for operating said signals, a second relay operated by current flowing in one of said signals to one position and operable to a second position upon failure of said signal, failure indicating means, a third relay energized in response to a failure of said signal through said first two relays, said last relay being operated to interrupt said sequence operation and to energize said failure indicating means, and means for operating said last relay to restore normal sequence operation in response to a resumption of current flow in said failed signal circuit.

VINCENT W. LEONARD.