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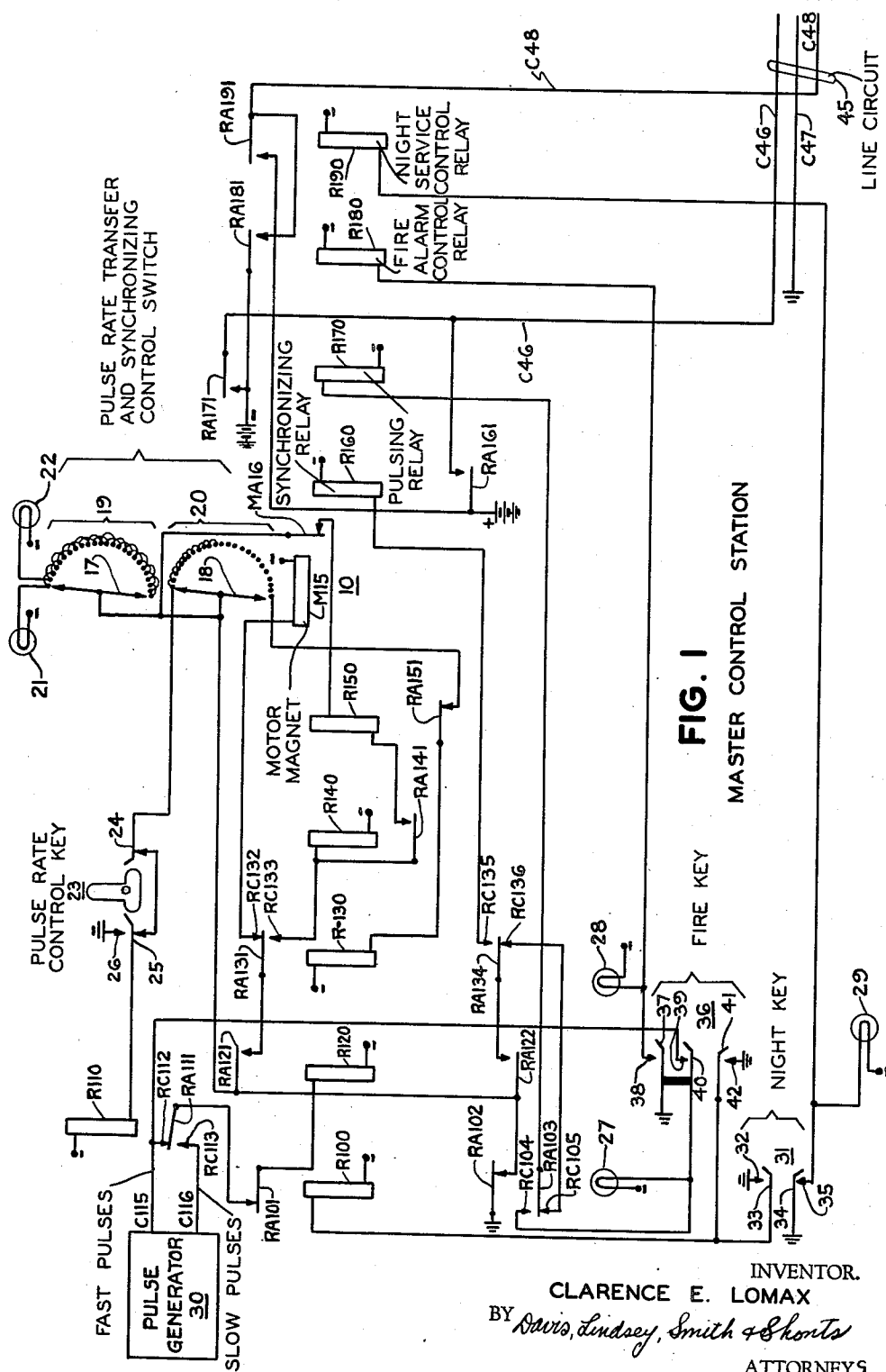
C. E. LOMAX

2,214,199

TRAFFIC SIGNALING SYSTEM

Filed Nov. 26, 1937

5 Sheets-Sheet 1



Sept. 10, 1940.

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TRAFFIC SIGNALING SYSTEM

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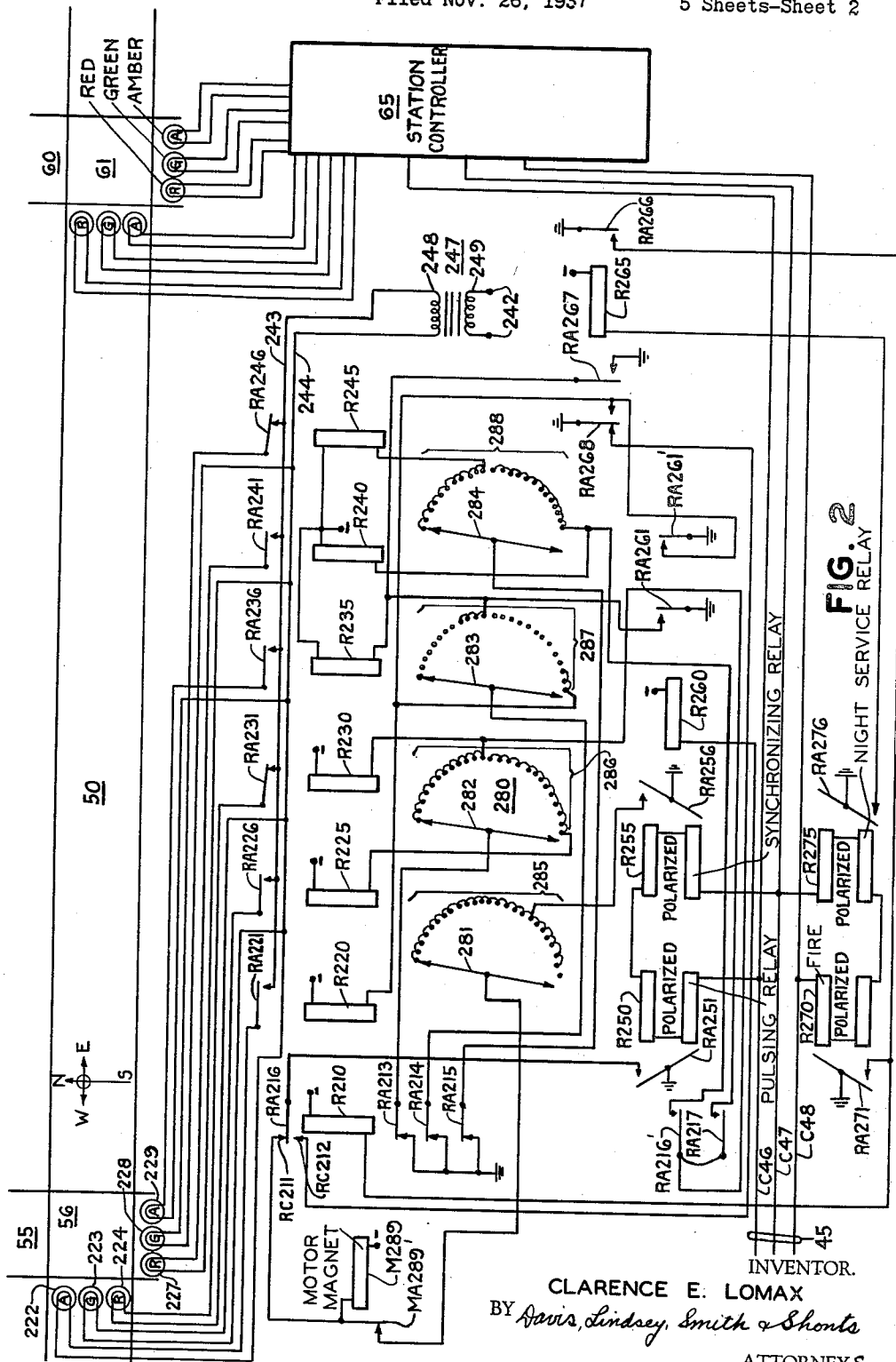


FIG. 2

NIGHT SERVICE RELAY

SYNCHRONIZING RELAY

PULSING RELAY

POLARIZED

POLARIZED

POLARIZED

POLARIZED

POLARIZED

POLARIZED

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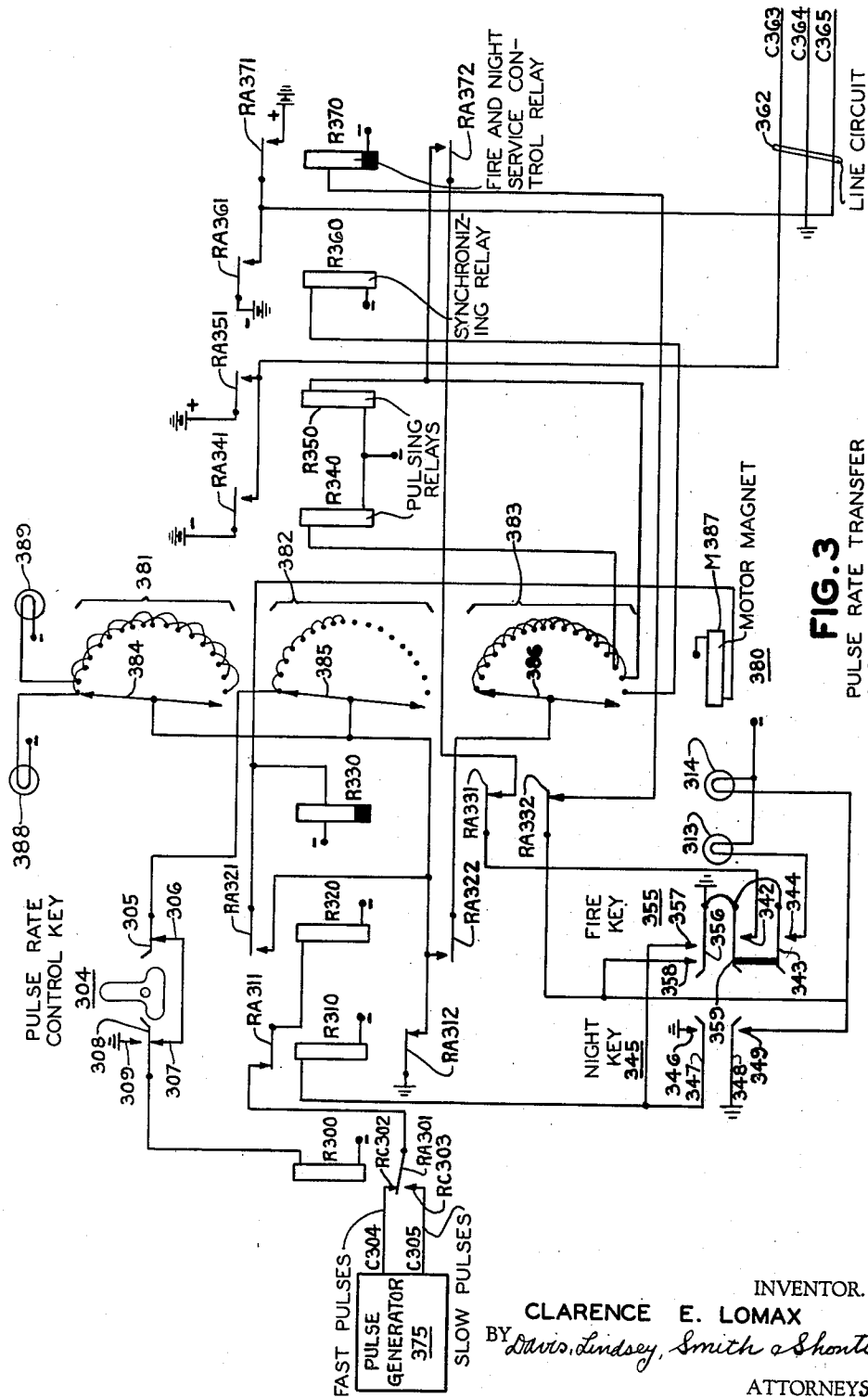


FIG. 3
PULSE RATE TRANSFER
AND SYNCHRONIZING
CONTROL SWITCH.

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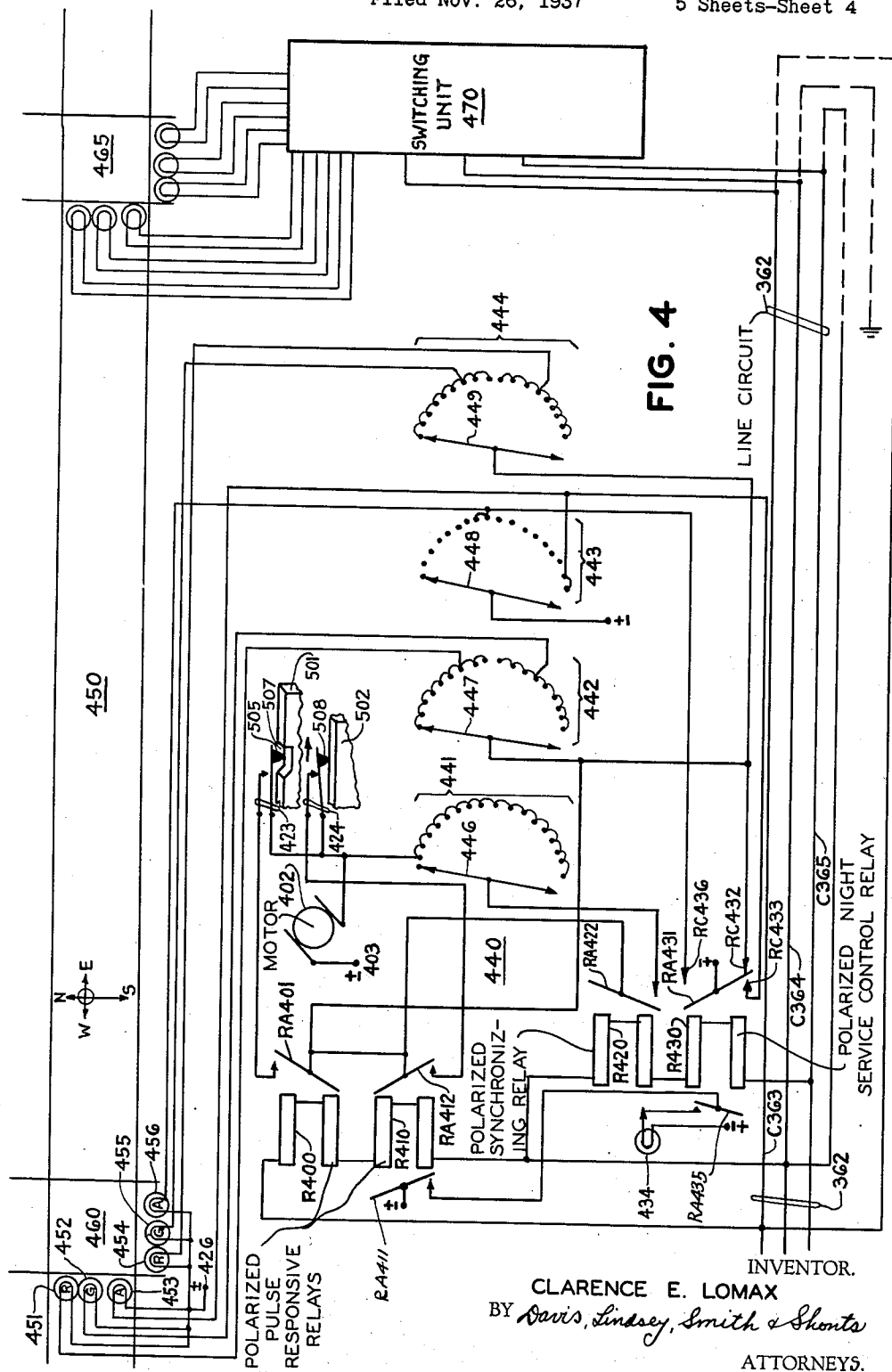
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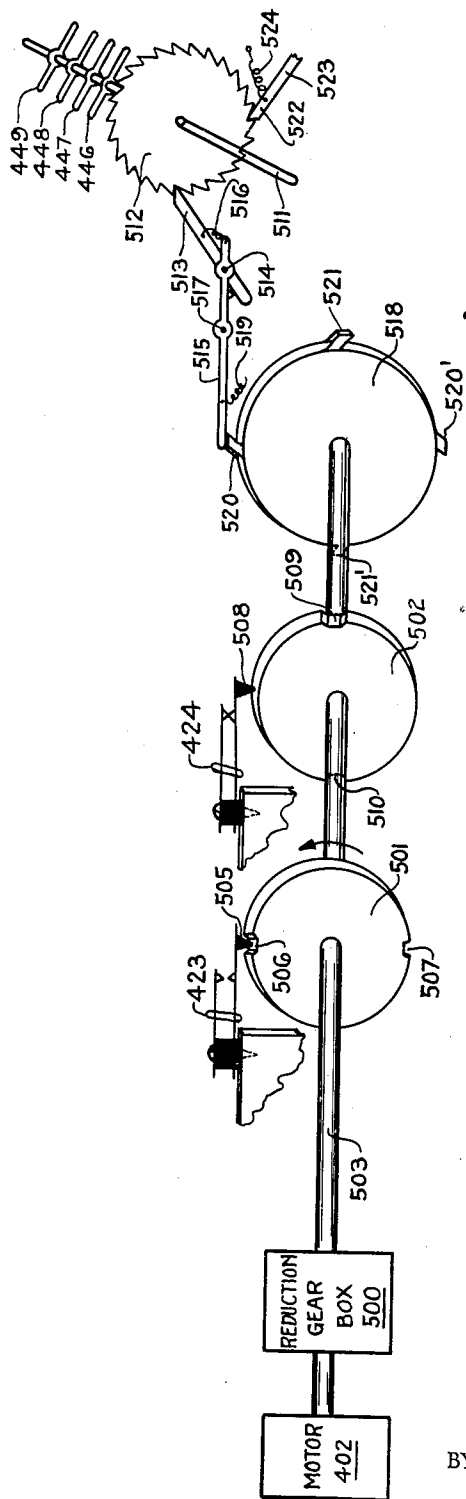
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,214,199

TRAFFIC SIGNALING SYSTEM

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Application November 26, 1937, Serial No. 176,502

29 Claims. (Cl. 177—337)

The present invention relates to signaling systems and more particularly to improvements in highway traffic signaling systems wherein traffic control signal devices located at a plurality of highway intersections along a highway or a street are controlled from a master control station over lines interconnecting the master control station and signaling device switching units or control boxes located at the respective traffic intersections.

In signaling systems of the character noted the plurality of signaling devices located at each traffic intersection conventionally comprise a plurality of groups of lamps, each group including red, green, and amber signal lamps positioned to face in one traffic approach direction, thereby to give universally recognized indications to approaching motor vehicle operators. In a four-way intersection four such groups of lamps are usually provided for properly signaling in each of the four traffic approach directions. The lamps at each intersection are arranged automatically to be controlled by the apparatus embodied in an associated control box or switching unit, which apparatus functions repeatedly to energize the lamps in a definite cyclic order. Thus on a north-south-east-west intersection the north-south right of way signals are energized for a portion of each operating cycle simultaneously with the east-west stop signals. During another portion of each operating cycle the north-south stop signals are energized simultaneously with the east-west right of way signals. Between the respective portions of each operating cycle allotted to traffic right of way to the respective intersecting traffic lanes are periods conventionally known as change-over intervals during which the amber or caution signals are alone energized or are energized in conjunction with the right of way or stop signals. A complete operating cycle for the group of lamps at any intersection includes, therefore, the two periods respectively giving right of way to the two intersecting traffic lanes, and two change-over periods.

In any system of the form described which involves a plurality of intersections to be controlled it is desirable that the operating cycles of the signal devices located at the various intersections be related in a particular manner such that the most expeditious movement of heavy traffic may be obtained. As an example of related control of the traffic signal operating cycles there may be cited those systems which are provided for controlling the traffic along

main thoroughfares and wherein the so-called progressive type of traffic control is employed. In this, as in other similar modes of traffic control, the proper relation between the operating cycles of the signal lamps at the various traffic intersections is attained through the expedient of synchronizing the operating cycles of the switching units controlling the lamps at the respective intersections. Obviously, if a non-synchronous relation develops between the operating cycles of the switching units it is followed by an alteration of the desired relation between the operating cycles of the signaling devices. Another desirable feature usually incorporated in such a system relates to the provision of means whereby the percentage of a signal operating cycle allotted to traffic right of way in a particular direction may be changed at will, thereby to adapt the signaling to changing traffic conditions. Still another feature to be found in modern systems of the character described relates to the provision of means for interrupting the normal operation of the signaling apparatus in case of fire or other emergencies and for displaying a characteristic signal indicating the emergency condition in all of the approach directions at each intersection, and means for displaying the caution signal only during periods of light traffic. While all of the above noted features are to be found in prior arrangements, the apparatus involved is quite complicated in character and expensive to manufacture and install. Moreover, in the prior systems having incorporated therein all of the features outlined above, a complicated line circuit including an unduly large number of relatively heavy gauge line conductors is required for interconnecting each of the switching units or control boxes with the master control station.

It is an object of the present invention, therefore, to provide an improved signaling system of the general character briefly described above which is of simple and economic construction, which operates in a thoroughly reliable manner to provide all of the above-mentioned control features, and which requires an inexpensive line circuit including a very small number of line conductors.

It is an additional object of the invention to provide in a system of the form described, an improved line circuit interconnecting the various control boxes or switching units and the master control station, which circuit is so connected and arranged that the possibility of any switching

unit being rendered inoperative, due to a fault in the line circuit, is practically eliminated.

It is a further and more specific object of the invention to provide a signaling system of the character described wherein improved and exceedingly simple circuit arrangements are employed for maintaining synchronized the operating cycles of a plurality of interconnected switching units.

The invention as described in detail hereinafter is illustrated in its application to a traffic control signaling system wherein a single line circuit interconnects the control apparatus located at the master control station with the control apparatus embodied in each of the plurality of switching units. The objects as set forth above are in part attained in accordance with the present invention by providing in each switching unit a cyclically operating rotary switch for controlling the energization of the various associated signaling devices. In one embodiment of the invention the actuating means incorporated in each unit for driving the wipers of the associated switch over its associated bank contacts comprises a motor magnet which is connected and arranged to be energized in accordance with spaced pulses applied to the line circuit at the master control station. In a modification of the switching unit the switch wipers are arranged to be driven by a motor which is operated through one cycle, to advance the associated wipers, during each pulse applied to the line circuit. In each modification there is provided in the master control station pulse generating means, and means comprising a relay operative in accordance with the pulse output of the pulse generator for applying to the line circuit voltage pulses, corresponding to the generated pulses. These voltage pulses are utilized to energize means embodied in each switching unit for controlling the energization of the switch wiper driving means. Also located at the master control station is a cyclically operating rotary switch arranged to be driven in accordance with the generated pulses so that the operating cycles thereof are synchronized with the operating cycles of each of the rotary switches respectively embodied in the various switching units connected to be controlled over the line circuit. In other words, with the system operating properly, the operating position of the rotary switch located at the master control station corresponds at all times with the operating positions of each of the rotary switches embodied in the respective switching units. At a predetermined point in each operating cycle of the switch located at the master control station, means controlled by this switch are caused to operate to impress on the line circuit a control voltage which causes synchronizing means embodied in the respective switching units to operate and correct any non-synchronous relation between the operating cycles of the units.

In accordance with a further feature of the invention the pulse generating means located at the master control station is arranged to produce pulses at two different rates and, in order that the percentage of each signaling cycle allotted to traffic right of way in a given direction may be altered to conform to changing traffic conditions,

the rotary switch located at the control station is arranged to change the pulse transmission over the line circuit from one rate to the other at a predetermined point in each cycle of its operation. As an adjunct to this feature, manually operable means are provided at the master con-

trol station whereby the selective and continuous transmission of pulses over the line circuit at either of the two rates may be achieved.

In one embodiment of the invention the fire alarm or emergency signaling consists in the continuous energization of the stop signals in all directions and the intermittent energization of the caution signals in all directions, this mode of energizing the signaling lamps being achieved through the provision of a manually operable switch at the master control station which, when operated to its off-normal position, functions to cause the interruption of the normal operation of the switching units. With this switch operated to its off-normal position the various switching units are conditioned to cause the energization of the signaling devices noted, the flashing of the caution or amber lamps being achieved through the continuous transmission of pulses at one rate from the master control station and over the line circuit to each of the switching units. In the other embodiment of the invention the normal operation of the switching units is also interrupted through the actuation of a manually controlled switch provided at the master control station, but in this embodiment a distinct signaling device is provided at each intersection which is continuously energized following the operation of the fire or emergency switch to discontinue the normal operation of the associated switching unit. In order to adapt the system to conditions of extremely light traffic such as ordinarily occur in the early morning hours, an additional manually operable switch is provided at the master control station which, when operated, functions to cause the normal operation of the switching units to be discontinued and the caution signals at the various intersections to be intermittently or continuously energized, as desired.

Various additional features of the invention pertain to the specific arrangement of the circuit elements, whereby the above referred to and additional operating features not specifically mentioned are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention both as to its organization and method of operation together with further objects and advantages thereof will best be understood by reference to the specification taken in connection with the accompanying drawings in which Figs. 1 and 2 illustrate a traffic signaling system having embodied therein certain features of the present invention; Figs. 3 and 4 illustrate a second embodiment of the invention; and Fig. 5 illustrates the details of certain of the elements embodied in the arrangement of Figs. 3 and 4.

Referring now more particularly to Figs. 1 and 2 of the drawings the system there illustrated comprises a plurality of switching units, as shown in Fig. 2, a master control station, as shown in Fig. 1, and a three-conductor line circuit interconnecting the control station with each of the switching units. Only one of the switching units, namely, that located in proximity to and arranged to control the signaling devices at the traffic lane intersection 56, is illustrated in detail, but it will be understood that each of the other switching units, including the unit associated with the signaling devices serving the traffic lane intersection 61, are identical in character with that illustrated. As shown, the signaling devices at the intersection 56 of the east

and west highway 50 and the north and south highway 55 comprise a red or stop signal lamp 224, a green or right of way signal lamp 223, and an amber or caution signal lamp 222, arranged to give indications to the traffic traveling east and west along the highway 50. Also included in the plurality of signaling devices at the intersection 56 are the red, green, and amber signal lamps 227, 228 and 229, respectively, which are arranged to govern traffic traveling in the north and south directions along the intersecting highway 55. These signaling devices have operating circuits traced hereinafter, all of which include the bus conductors 243 and 244, and which are arranged selectively to be completed in the manner pointed out in detail hereinafter through the operation of the relays included in the group comprising R220, R225, R230, R235, R240, and R245. Voltage is impressed across the bus conductors 243 and 244 from the secondary winding 248 of a transformer 247 having its primary winding 249 connected to any suitable source of commercial frequency current at its terminals 242. In this embodiment of the invention it is contemplated that the direct current required for energizing the above enumerated relays shall be obtained through the provision of a full wave rectifying unit, not shown, connected between the commercial frequency current source and the direct current bus conductors commonly included in the operating circuits of the relays. In order to simplify the description of these circuits the direct current source is individually indicated for each of the relays as comprising a battery having its positive terminal grounded, but it will be understood that a single current source of the form described will, in practice, be used.

For the purpose of energizing the enumerated signaling devices or lamps in a definite cyclic order there is provided a cyclically operating switch in the form of a rotary stepping switch 280. This switch, which may be of any standard commercial construction, includes a plurality of sets of bank contacts 285, 286, 287, and 288, wipers 281, 282, 283, and 284, respectively associated with the contact sets in the order of their enumeration, and means comprising a motor magnet M289 and a ratchet and pawl mechanism, not shown, for driving the wipers over the contacts of the respective associated sets. Specifically, the operating circuits for the various relays referred to above have embodied therein the contacts and wipers of the switch 280 and are arranged so that the circuit connections for energizing the signaling devices are controlled by the movement of the wipers noted over their associated contacts.

The magnet M289 is arranged to be energized from the full wave rectifying unit mentioned above and for the purpose of controlling the energization of this magnet in its operation to step the enumerated wipers of the switch 280 over the contacts of the respective associated contact sets, there is provided a polarized relay R250 having its winding connected in series with an oppositely poled polarized relay R255 across two conductors C46 and C47 of the three-conductor line circuit 45. This relay R250 is so poled that it operates only when voltage of one polarity is impressed across the two line conductors noted. Similarly, R255, which is provided for the purpose of maintaining a synchronous relation between the operating cycle of the rotary switch 280 and the operating cycles of the correspond-

ing rotary switches embodied in the various other switching units, operates only in response to voltage applied between the two line conductors noted of a polarity opposite that of the voltage to which R250 responds. Specifically, R250 is energized when negative potential is applied to C46 and the opposite positive terminal of the potential source is connected to the grounded or common conductor C47, and R250 operates when the polarity of the voltage applied to the conductors noted is reversed.

As pointed out previously, there is provided in each of the switching units means controllable from the master control station for interrupting the normal operation of the apparatus in cases of emergency and for displaying in each direction of traffic flow along an intersection, signals indicating the emergency condition. In the present embodiment of the invention this means comprises the polarized relay R270 and the relay R210 having its operating circuit arranged to be controlled by R270. The winding of R270 is connected in series with the winding of R275 across a different pair of conductors of the line circuit, namely, C47 and C48. The emergency condition is indicated through the continuous display of the red or stop signals in all directions supplemented by the intermittent or flashing display of the caution or amber signals in all directions. This mode of operation is achieved through the continuous energization of R210 to hold operated the two relays R230 and R240 thereby to maintain the red signal lamps energized and through the intermittent operation of the polarized relay R250 in response to voltage pulses applied to the conductors C46 and C47, thereby repeatedly to operate R260. This repeated operation of R260 results in the intermittent energization of R220 and R235 which relays control, respectively, the amber or caution signal lamps 222 and 229.

In order to modify the circuit arrangement of the apparatus to make the operation of the signaling devices at the intersection 56 conform to the requirements of light traffic, as for example that which occurs in the early morning hours, there is provided means comprising the polarized relay R275 for interrupting the normal operation of the unit and for causing all of the amber lamps located at the intersection to be energized. As noted above, these amber lamps are indicated at 222 and 229 and the operating circuits therefor are under the control of R220 and R235, respectively. These two relays in turn are arranged to be energized in response to the operation of R265 which latter relay includes an obvious operating circuit controlled by the above noted polarized relay R275. The polarized relays R250, R255, R270 and R275 are arranged to be energized by way of the line circuit from current sources located in the master control station in the manner described with greater particularity hereinafter.

Referring now more particularly to the details of the master control station illustrated in Fig. 1, the apparatus located at this station comprises a cyclically operating rotary stepping switch 10 which is arranged to be operated in accordance with the pulses transmitted from the pulse generator 30 in synchronism with each of the rotary switches, corresponding to and including the switch 280, included in the various switching units which are controlled from the master control station. The rotary switch 10 may be of any standard commercial construction

which comprises two sets of bank contacts 19 and 20 of twenty-five points each, wipers 17 and 18 respectively associated with the contact sets 19 and 20, and means comprising a motor magnet M15 and a ratchet and pawl mechanism, not shown, for driving the enumerated wipers over the contacts of the associated contact sets. As indicated previously the pulse generator 30 operates to produce spaced control pulses at two different rates. This generator, which is only diagrammatically shown, may, if desired, take the form of a circuit breaker driven by a synchronous motor through a gear reduction box and arranged intermittently to apply ground potential to C115 at one rate and to C116 at a different rate. In the arrangement illustrated it is contemplated that the fast pulses shall be applied to C115 and the slow pulses to the conductor C116. These pulses control the energization of R120 which relay includes contact springs embodied in the operating circuits for M15 and R170. As indicated, the relay R170 is provided with a set of armature springs for impressing voltage across the line conductor C46 and C47 of the correct polarity to cause the operation of all of the polarized relays, corresponding to R250, individually included in the respective switching units.

In order to control the elapsed time interval required for a complete operating cycle of each of the switching units and of the associated plurality of signaling devices, thereby to adapt the traffic control to changing traffic conditions, there is provided means comprising the relay R110 for selectively connecting R120 to be energized in accordance with the pulses applied to C115 or C116, whereby R170 is energized at the selected pulse rate to repeat the pulses, through the application of voltage across C46 and C47, to the above noted polarized relays embodied in the respective switching units. During the normal operation of the controller, the relay R110 is arranged to be energized for a portion of each operating cycle of the switch 10 and to be deenergized during the remaining portion of each operating cycle, so that unequal time intervals are required for the display of the right of way signals along the respective intersecting highways. Alternatively, the change over from fast pulsing to slow pulsing may be attained through the provision of a time clock or time controlled switch for controlling the relay R110 in lieu of the switch 10. Such automatic control of the pulse rate selecting relay R110 may be interrupted through the operation of the key switch 23 to one or the other of its two off-normal positions, thereby to cause this relay to be continuously deenergized or continuously energized in the manner described more particularly hereinafter.

For the purpose of maintaining the operating cycles of the various rotary switches corresponding to and including switch 280 synchronized with each other and with the operating cycles of the rotary switch 10 the last mentioned switch is arranged to control R130 which latter relay functions to control the operation of R160. The relay R160, when operated, applies voltage across C46 and C47 of a polarity opposite that applied to these conductors through the operation of R170, thereby to cause the energization and operation of the polarized relays, corresponding to and including R255, which relays, as was pointed out above, function to cause any non-synchronous condition between the operating cycles of the various switches to be corrected.

Fire alarm control is achieved through the provision of the manually operable key switch 36 which normally occupies the position indicated in the drawings and, when operated to its off-normal position, completes circuits for energizing R100 and R180, thereby to interrupt the normal operation of the switch 10 and the various rotary switches embodied in the several switching units controlled by way of the line circuit 45. With this key switch operated a circuit is also completed for energizing R170 in accordance with the fast pulses applied to C115 by the pulse generator 30, whereby the amber or caution signal devices located at the respective controlled intersections are energized.

Control of the switching units to interrupt the normal mode of operation thereof and to render the same effective continuously to energize the amber or caution signal devices located in the controlled intersections during the hours when light traffic persists is attained by providing a second manually operable key switch 31 which is arranged to control the energization of the cycle interrupting relay R100 and the relay R190. The last mentioned relay when energized applies voltage between C47 and C48 of the correct polarity to cause energization of all of the polarized relays corresponding to and including R275 associated with the line circuit 45. As pointed out above, these polarized relays, when energized, cause the continuous energization of all of the amber signal devices located at the associated traffic intersection. In addition to the elements in the master control station briefly referred to above there are provided signal lamps 21, 22, 27, 28 and 29 which function in the manner pointed out in detail hereinafter visually to indicate to an attendant or operator the particular operating condition of the system at any given time. Current for energizing the various relays, indicating lamps and the operating magnet of the switch 10 is preferably supplied from a common bus, not shown, to which is applied the output voltage of a full wave rectifying unit having its input terminals connected to the usual source of commercial frequency alternating current. For convenience in describing the circuits, however, the source of current for energizing each element of the apparatus has been individually indicated, in accordance with conventional practice, as comprising an isolated battery. As regards the current source for applying voltage to the line circuit 45, it is pointed out that two electrically independent batteries are employed. The positive terminal of one of the two batteries is connected to the grounded common return conductor C47 and the negative terminal is arranged to be connected to the conductor C46 through the operation of either of the two relays R170 and R180. The negative terminal of the other of the two batteries is connected to the common conductor C47 and the positive terminal thereof is arranged to be connected to the conductor C48 through the operation of R160 or R190. It will be understood that a single source or battery may be used providing the four relays noted are suitably arranged to prevent short circuiting of the source when the terminals thereof are switched from one side of the line circuit 45 to the other.

Referring now more particularly to the operation of the apparatus illustrated in Figs. 1 and 2 and assuming that the elements of the master control station occupy the positions illustrated in the drawings, ground pulses applied to C115 by the pulse generator 30 are effective to cause the

intermittent energization of R120 over a circuit extending from ground on the conductor noted by way of RC112, RA111, RA101, and through the winding of R120 to battery. This relay, upon operating, completes at RA121 a circuit for energizing the motor magnet M15, thereby to prepare this magnet to step the wipers 17 and 18 from engagement with the respective first contacts of the sets 19 and 20 and into engagement with the respective second contacts of these contact sets. The circuit noted extends from ground at RA102 by way of RA121, RA131, RC132, and through the winding of M15 to battery. The stepping operation of the switch 10 occurs when the magnet M15 is deenergized at the end of the ground pulse on C115. Simultaneously with the completion of the above traced circuit for M15 a circuit is completed at RA122 for energizing R170, this circuit extending from ground at RA102 by way of RA122, RA134, RC136, RC105, RA103, and through the winding of R170 to battery. The relay R170 upon operating applies negative battery potential, as indicated, to C46, the opposite terminal of the potential source being connected to C47 through the ground connections indicated. Thus, voltage of one polarity is impressed across the line conductors C46 and C47 for the duration of the ground pulse applied to C115 and during the interval when the relays R120 and R170 are held energized. This voltage pulse results in the energization and operation of R250 and the corresponding relays embodied in the various other switching units associated with the line circuit 45. Due to the polarity of this voltage, however, the polarized relay R255 is not energized and remains inactive.

The relay R250, upon operating, completes, at RA251, a circuit for energizing M289, which circuit extends from ground at the armature noted by way of RA216, RC211, and through the winding of M289 to battery. When energized over the above traced circuit M289 prepares the switch 280 to step the enumerated wipers thereof one step. When the magnet M289 is subsequently deenergized at the end of the ground pulse applied to C115 these wipers are moved into engagement with their respective associated second contacts. It is to be observed that with the wipers of the switch 280 standing in engagement with any of their respective associated contacts numbered from 1 to 12 and with R210 deenergized, circuits are completed for energizing R230 and R245. The operating circuit for R230 extends from ground at RA213 by way of the switch wiper 282, any one of the first twelve contacts of the set 286 and through the winding of R230 to battery. With this relay in its operated position an obvious circuit is completed at RA231 for energizing the stop signal device 224 controlling traffic traveling in an east-west direction. The circuit for energizing R245 extends from ground at RA215 by way of the switch wiper 284, any one of the first twelve contacts of the set 288, and through the winding of R245 to battery. With this relay energized, an obvious circuit is completed at RA246 for energizing the green or traffic right of way signal 228 controlling traffic proceeding in the north and south directions.

It will be apparent from the preceding description that the above described operations of R120, the switch 10, R250, and the switch 280, occur each time a ground pulse is applied to C115, thus causing the two switches 10 and 280, together with the other switches similar to the switch 280

and embodied in the other switching units, to be stepped in synchronism, thereby to measure the time interval during which right of way is given to the traffic traveling in the north and south directions. The stepping operations noted have no effect upon the energized condition of the relays R230 and R245 since the respective wipers of the switch 280 are of sufficient width to bridge two contacts during the transition interval when the wipers are being stepped from one position to another.

As noted above, the first portion of the operating cycles of the respective rotary switches embodied in the various switching units controlled over the line circuit 45 corresponds to twelve steps of the wipers respectively embodied therein. During the interval required for the last four of the first twelve steps, however, a circuit is completed for energizing R235 thereby to energize the amber or caution signal device 229 so that an overlapping energization of this signal and the traffic right of way signal 228 occurs. The circuit noted extends from ground at RA214 by way of switch wiper 283, any of the contacts numbered from nine to twelve of the set 287 and through the winding of R235 to battery. Obviously with R235 energized a circuit is completed at RA236 for energizing the signal device 229. When the wipers of the switch 280 are stepped into engagement with their respective associated thirteenth contacts, the first change-over period of the operating cycle is completed. Thus, when this occurs, the above traced operating circuits for R230, R235, and R245 are interrupted at the switch wipers 282, 283, and 284, respectively, and circuits are completed for energizing R225 and R240. The circuit for energizing R225 extends from ground at RA213 by way of the switch wiper 282, the multiplied thirteenth to twenty-fifth contacts of the set 286, and through the winding of R225 to battery. The operating circuit for R240 extends from ground at RA215 by way of the switch wiper 284, the multiplied thirteenth to twenty-fifth contacts of the set 288, and through the winding of R240 to battery. With R225 energized an obvious circuit is completed at RA226 for energizing the green or right of way signaling device 223 controlling traffic in an east-west direction. Concurrently with the energization of the device 223 the red or stop signaling device 227, governing traffic proceeding in the north-south directions, is energized through the operation of R240 to complete, at RA241, the operating circuit for this device. Hence the traffic right of way is transferred from the north-south highway 55 to the east-west highway 50. Assuming that the bank contact wiring of each of the unit shown, the traffic right of way is simultaneously transferred to the east and west highway 50 at each of the other intersections having signaling devices controlled by the other switching units.

Since the switch 10 embodied in the master control station is operated in synchronism with the switch 280 and the other switches corresponding thereto, the wipers thereof will be stepped into engagement with their respective associated thirteenth contacts substantially simultaneously with the transfer of traffic right of way in the manner described above. When this occurs the operating circuit for R110 is interrupted at the switch wiper 18 causing this relay to restore its armature RA111 so that the ground pulses applied to C116 control the operation of R120. Since these pulses occur at a much

slower rate than the pulses applied to C115 it will be apparent that a considerably longer time interval will be required for the wipers of the switch 10 and the wipers of the other synchronously operating switches embodied in the respective switching units, to be stepped over the remaining contacts of their respective associated sets. Hence, traffic right of way is given to the traffic traveling along the highway 50 for a time interval which is considerably longer than the interval during which traffic right of way is allotted to the traffic traveling on the intersecting highways. The mode of operation of the apparatus is, however, exactly the same as that described above irrespective of the rate of the control pulses.

During the continued operation of the switch 280 and when the wipers of the switch 280 are stepped into engagement with their respective associated twenty-third contacts a circuit is completed for energizing R220, this circuit extending from ground on RA214 by way of the switch wiper 283, the twenty-third contact of the set 287, and through the winding of R220 to battery. This relay upon operating completes, at RA221, an obvious circuit for energizing the amber or caution signal device 222 governing traffic proceeding along the highway 50. Since the above traced operating circuit for R220 is held energized until the wiper 283 is stepped from engagement with its associated twenty-fifth contact, an overlapping amber and green signal is given to the east-west traffic during the period just preceding the transfer of traffic right of way from the highway 50 to the intersecting highways.

As indicated previously, provisions are made for correcting any non-synchronous relation between the operating cycles of the cycle control switch 10 embodied in the master control station and the operating cycles of the various stepping switches included in the respective switching units. To this end and when the wiper 18 of the switch 10 is stepped into engagement with its twenty-fifth contact a circuit is completed for energizing R130, which circuit extends from ground at RA102 by way of the switch wiper 18, RA151, and through the winding of R130 to battery. The relay R130, upon operating, interrupts, at RA131 and RC132, the pulsing circuit extending to M15 and prepares, at RA131 and RC132, a circuit for energizing R140. The relay R130 also interrupts, at RA134 and RC136, the above-traced operating circuit for R170 and prepares, at RA134 and RC135, a circuit, traced hereinafter, for energizing R160. When R120 operates following the operation of R130, both of the prepared circuits referred to above are completed, that for energizing R140 extending from ground at RA102 by way of RA121, RA131, RC132, and through the winding of R140 to battery, and that for R160 extending from ground at RA102 by way of RA122, RA134, RC135, and through the winding of R160 to battery. The relay R140, upon operating, prepares, at RA141, a circuit for energizing itself in series with R150, this circuit extending from ground at RA102 by way of MA16, the winding of R150, RA141, and through the winding of R140 to battery. The above-traced circuit is completed shortly following the operation of R140 and when R120 restores to remove, at RA121, the short circuit placed across the winding of R150 through the operation of R140. The relay R150, upon operating, interrupts at RA151 the above-traced operating circuit for R130. When R130 restores, it reprepares, at

RA131 and RC132, the above-traced pulsing circuit for M15 and interrupts the operating circuit for R140.

The relay R160, upon operating shortly following the operation of R130, applies, at RA161, positive battery potential to C46. Hence, voltage of a polarity opposite that applied between C46 and C47 through the operation of R170 is now impressed across the two line conductors noted. This voltage is not effective to cause the energization and operation of R250, but is effective to energize the polarized relay R255, which relay now operates to complete, at RA256, a circuit for causing the switch 280 to operate to a position corresponding to that of the switch 10, in the event the first-named switch has failed to operate in synchronism with the cycle control switch 10. To clarify this point, let it be assumed that the wipers of the switch 280 have fallen two steps behind the wipers of the switch 10 so that when the last-mentioned switch has completed its operating cycle the wipers of the switch 280 stand in engagement with their respective associated twenty-third contacts. When R255 operates and with the wipers of switch 280 standing in the position noted, a circuit is completed for energizing M289, this circuit extending from ground at RA256 by way of the multiplied contacts of the contact set 285, the switch wiper 281, MA289', and through the winding of M289 to battery. By virtue of the self-interrupting contacts associated with MA289', the magnet M289 operates buzzer fashion to drive the associated wipers 281 to 284, inclusive, instantly to restore these wipers to a position corresponding to that occupied by the wipers of the switch 10, or into engagement with their respective associated twenty-fifth contacts. When the wiper 281 is stepped from engagement with its associated twenty-fourth contact and into engagement with its associated twenty-fifth contact, the above-traced operating circuit for M289 is permanently interrupted so that no further operation of the switch 280 occurs until the next operating cycle is initiated. It will be understood that if any of the switches corresponding to the switch 280 and embodied in the other switching units are out of synchronism with the switch 10 similar operations will occur to restore these switches to positions such that the desired synchronous relation prevails.

Shortly following the restoration of R130 in the above-described sequence of operations and when R120 is again energized, the operating circuit for M15 is completed, causing this magnet to attract its armature MA16, thereby to interrupt the circuit over which R140 and R150 are held energized in series. This operation corresponds to the beginning of a new operating cycle for the switch 10 and the various synchronously operating switches embodied in the respective switching units. When R140 restores it interrupts, at RA141, a further point in the circuit for energizing R150 and R140 in series and, hence, the apparatus is restored to the condition which prevailed at the beginning of the operating cycle just described. The operation of the apparatus during succeeding cycles is exactly the same as that described above and is continuous for so long as the various manually operable key switches 23, 31, and 36 are maintained in the positions shown in the drawings. An indication that this mode of operation persists is given by the alternate energization of the signal lamps 21 and 22 during the operation of the switch 10. Thus, with the wiper 17 standing in engagement with any

odd numbered contact of the contact set 19, a circuit is completed for energizing the lamp 21, this circuit extending from ground at RA102 by way of the switch wiper 17 and the filament of the lamp 21 to battery. Similarly, with the switch wiper 17 standing in engagement with any even numbered contact of the contact set 19, a circuit substantially similar with that traced above is completed for energizing the signal lamp 22.

As pointed out above, the key switch 23 is provided for the purpose of changing the time interval required for each operating cycle of the signaling devices located at the various intersections and for the additional purpose of changing the percentage or portion of each operating cycle which is allotted to traffic right of way in the two traffic approach directions. It has also been pointed out that with the switch 23 standing in its normal position preference is given to traffic traveling along the highway 50 in that the right of way signals governing traffic along this highway are maintained energized for a longer period than are the right of way signals governing traffic on the intersecting highways. If the prevailing traffic is such that equal right of way periods should be assigned to traffic in the two intersecting directions of traffic movement, the switch 23 may be operated to either of its two off-normal positions so that R110 is either continuously energized or continuously deenergized. Thus, with the actuating element of this switch operated to its right off-normal position, the above-traced operating circuit extending by way of the switch wiper 18 is interrupted at the switch spring 25 and a new operating circuit extending from ground at the spring 26 is completed. Hence, R110 is maintained energized so long as the actuating element of the switch 23 is restrained in the off-normal position noted and the fast ground pulses applied to C115 are utilized exclusively in controlling the apparatus at the master control station as well as the apparatus embodied in the various switching units. When, on the other hand, the actuating member of the switch 23 is moved to its left off-normal position, the operating circuit for R110 is opened at the switch spring 24, so that this relay is restored to place the apparatus in the master control station and the various switching units under the control of the slow ground pulses applied to C116. Obviously, this condition prevails until such time as the actuating element of the switch 23 is restored to its normal position.

The control of traffic in cases of emergency, such, for example, as in instances where it is desired to give right of way to a fire truck or an ambulance, is achieved through the operation of the switch 36 to its off-normal position, thereby to interrupt the normal operation of the cycle control switch 10 and each of the switches, corresponding to and including the switch 280 individually embodied in the respective switching units. Thus, when the key switch 36 is operated to its off-normal position, a circuit is completed for energizing R100, this circuit extending from ground at the switch spring 42 by way of the spring 41 and through the winding R100 to battery. At the switch springs 37 and 38, an obvious circuit is completed for energizing the indicating lamp 28 and R180 in parallel, and, at the springs 39 and 40, a circuit is prepared for energizing R170 and the indicating lamp 27 in accordance with the pulses applied to the conductor C115. The relay R100, upon operating, functions to interrupt, at RA101, the pulsing circuit for

R120; to interrupt, at RA102, a point in the common portion of the above-traced circuits for energizing M15, R110, R130, R140, and R150; and to interrupt, at RA103 and RC105, a point in the first-traced pulsing circuit for R170. The circuit for energizing R170 and the lamp 27 is completed upon the operation of R100 and extends from C115 by way of the spring 39 to the spring 40 where it divides, one branch extending through the lamp 27 to battery and the other branch extending by way of RC104, RA103, and the winding of R170 to battery.

When R180 operates it impresses, at RA181, battery potential across the pair of line conductors C47 and C48, the negative terminal of the voltage source being connected to C48 and the opposite positive terminal being connected to C47. Through the operation of R170 in accordance with the ground pulses applied to C116, voltage pulses corresponding to the ground pulses are also impressed across the conductors C46 and C47, it being pointed out that the negative terminal of the voltage source associated with these conductors is connected to C46 at RA171 during each interval when R170 is operated.

Turning now to the operations which occur in each of the switching units in response to the operation of the switch 36 to its off-normal position and considering only the unit illustrated in detail in Fig. 2, it is pointed out that the voltage impressed across C47 and C48 through the operation of R180 is of the correct polarity to cause the energization and operation of R270. This relay, upon operating, completes, at RA271, an obvious circuit for energizing R210, which latter relay, upon operating, interrupts, at RA216 and RC211, a point in the above-traced circuit for energizing M289. At RA213, RA214, and RA215, the relay R210 interrupts points in the above-traced operating circuits for R220, R225, R230, R235, R240, and R245, thus causing any energized ones of the signal devices to be deenergized. Substantially simultaneously, alternate circuits are completed for energizing R230 and R240, these circuits both starting from ground at RA268 and one thereof extending by way of RA216' and through the winding of R240 to battery, and the other thereof extending by way of RA217 and the winding of R230 to battery. The resulting operation of these two relays causes the two red or stop signal devices 224 and 227 to be energized, which condition prevails until such time as the key switch 36 is restored to its normal position.

During the period when R270 is energized, the polarized relay R250 responds to the voltage pulses impressed between the line conductors C46 and C47 by the relay R170. Each time R250 operates it completes, at RA251, a circuit extending by way of RA216 and RC212 for energizing R260. Hence, the relay R260 is caused to operate in accordance with the voltage pulses impressed across C46 and C47. Each time this relay operates it completes at RA261 and RA261' obvious circuits for respectively energizing the relays R235 and R220. This last-mentioned pair of relays control, in the manner pointed out above, the energization of the caution or amber signal devices 222 and 229. Thus, it will be understood that flashing amber signals are exhibited to the traffic on each of the highways 50 and 55 for so long as the switch 36 is maintained in its off-normal position. The fact that the red or stop signal devices located in the various intersecting points along the highway 50 are energized is indicated by the illuminated condition of the indi-

cating lamp 28 and the further fact that flashing amber is also being exhibited to the traffic on these highways is indicated by the intermittent flashing of the indicating lamp 27, this latter lamp being energized each time a ground pulse is applied to C115.

When the switch 36 is restored to its normal position, the above-traced operating circuits for R100 and R180 are obviously interrupted, as are also the circuits for energizing the indicating lamps 27 and 28. When R180 restores it disconnects, at RA181, battery from the line conductors C47 and C48, thereby to cause the deenergization of all the relays corresponding to and including the polarized relay R270 in the switching unit illustrated. As a result, R210 is caused to restore so that the switch 280 is again conditioned to respond to impulses transmitted by way of the line conductors C46 and C47. When R100 restores, the above-traced circuit for transmitting pulses to R170 is opened at RA103 and RC104, thereby to stop the transmission of voltage pulses by way of the conductors C46 and C47 to R250. With R210 and R250 deenergized, it is apparent that the operating circuits for R230, R240, and R260 are interrupted. Hence, the red and amber signal lamps at the intersection 56 are deenergized.

When R100 restores it also functions to prepare the circuit for energizing R120 in accordance with the pulses generated by the pulse generator 30 and the circuit for energizing R170 in accordance with the operation of R120. Thus, the apparatus is restored to normal and the cyclic operation of the various rotary switches is continued from the point at which it was interrupted when the switch 36 was operated to its off-normal position.

As pointed out above, the manually operable key switch 31 is provided for the purpose of interrupting the normal operation of the switching units controlled over the line circuit 45 and for causing these units to function to energize the caution signaling devices located at the respective intersections. When this switch is operated to its off-normal position, there is completed at the contact springs 32 and 33 an obvious circuit for energizing R100, which relay functions in the manner described above to interrupt the operation of the rotary switch 10 and each of the synchronously operated rotary switches individually embodied in the various switching units. Briefly summarized, the relay R100 functions to interrupt the operating circuit of R120 in accordance with the pulses applied to either C115 or C116, and with R120 inactive the relays R160 and R170 are maintained deenergized so that no voltage pulses are applied across the line conductors C46 and C47. With R120 deenergized, the operating circuit for M15 is held open at RA121. When the application of voltage pulses to C46 and C47 is discontinued the operation of rotary switches corresponding to and including the switch 280 is stopped. Hence, the cyclic energization of the various signaling devices controlled by the switches is discontinued.

With the key switch 31 standing in its off-normal position a circuit is completed for energizing R190 and the indicating lamp 29 in parallel, this circuit extending from ground at the switch spring 34 to the spring 35 where it divides, one branch extending through the lamp 29 to battery and the other branch extending through the winding of R190 to battery. With R190 energized, voltage is impressed between the line con-

ductors C47 and C48 of the line circuit 45, it being observed that the polarity of this voltage is such that positive potential is applied to the conductor C48. This voltage is correctly poled to cause the operation of the polarized relay R275 and the relays corresponding thereto in the respective other switching units controlled over the line circuit 45. Only the operations which occur in the switching unit illustrated in detail in Fig. 2 and resulting from the operation of R275 will be considered in detail, it being understood that identical operations occur in each of the other switching units controlled by way of the line circuit shown. With R275 energized, an obvious circuit is completed at RA276 for energizing R265. The last-mentioned relay, upon operating, completes, at RA266, an obvious circuit for energizing R210. The relay R210 in turn interrupts, in the manner pointed out previously, the operating circuits for any energized ones of the relays R220, R225, R230, R235, R240 and R245, so that the circuits extending by way of the wipers and bank contacts of the switch 280 are rendered ineffective to energize any one of the group of enumerated relays. At its armatures RA216' and RA217, the relay R210 prepares the previously-traced circuits for energizing R230 and R240, these circuits being held open, however, due to the operated condition of R265. At RA216, the relay R210 interrupts a point in the above-traced operating circuit for M289 and prepares a point in the circuit for energizing R260.

The relay R265, upon operating, further functions to complete circuits for energizing R220 and R235, these circuits extending from ground at RA268 and RA267, respectively, and extending over obvious paths, including the respective windings of the relays noted to battery. With this pair of relays energized, the operating circuits for the caution or amber signaling devices 222 and 229 are completed at the armatures RA221 and RA236, respectively. Thus, caution signals are continuously displayed at each of the controlled intersections for so long as the key switch 31 is restrained to its off-normal position. This energized condition of the amber signaling devices is indicated at the master control station through the energization of the indicating lamp 29 upon the operation of the switch 31 in its off-normal position.

When the key switch 31 is restored to its normal position the above-traced operating circuits for R100 and R190 are interrupted, causing these relays to restore. The relay R100, upon restoring, reconditions, in the manner pointed out in detail above, the apparatus at the master control station to respond to the impulses applied to C115 or C116, depending upon the position of the switch 10, whereby the normal operation of the system is again resumed. When the relay R190 falls back, the operating circuit for R275 is interrupted, causing the last-mentioned relay to restore and open the operating circuit for R265. When R265 falls back, the operating circuits for R210, R220, and R235 are opened in an obvious manner. Following the deenergization of these three relays the apparatus embodied in the switching unit illustrated in Fig. 2 is reconditioned to operate in the normal manner as described above. In a similar manner each of the other switching units associated with the line circuit 45 is reconditioned for normal operation.

As pointed out previously, the system of Figs. 1 and 2 requires that a separate full wave rectifier be provided in each switching unit for the pur-

pose of energizing the various relays included in the unit. In the system illustrated in Figs. 3, 4 and 5, on the other hand, no rectifying apparatus is required at any of the switching units for the reason that the wipers of the rotary switches embodied in the respective units are arranged to be driven by alternating current motors and the only relays required are those controlled directly by way of the line circuit interconnecting the master control station and each of the switching units. Here again only one switching unit is illustrated in detail, namely, that for controlling the traffic signaling devices governing traffic proceeding through the intersection 460 of the east-west highway 450. Of the signaling devices indicated, the red, green, and amber lamps 451, 452 and 453, respectively, are suitably arranged to govern traffic proceeding along the highway 450 while the red, green, and amber lamps 454, 455, and 456, respectively, are suitably arranged to govern traffic proceeding along the north-south intersecting highway. It will be understood that similar signaling devices are provided at each of the other intersections, such, for example, as the intersection 465, which devices are controlled by switching units identical in arrangement to that illustrated in detail in Fig. 4. The unit for controlling the signaling devices governing traffic through the intersection 465 is diagrammatically illustrated at 470. The above-enumerated signaling devices at the intersection 460 are arranged to be energized in a predetermined cyclic manner in accordance with the operation of a cyclically operating rotary switch indicated generally at 440. This switch comprises four sets of bank contacts, 441, 442, 443, and 444, and wipers 446, 447, 448, and 449, respectively, associated with the contact sets in the order of their enumeration. The enumerated wipers are arranged to be driven by the alternating current motor schematically indicated at 402 through the driving mechanism depicted with particularity in Fig. 5 and described in detail hereinafter. This motor includes an operating circuit having three branches arranged respectively to be completed by way of the cam actuated switch springs 423 and 424, and the wiper 446 of the switch 440. Also included in the branch of the operating circuit controlled by the springs 423 are the armature springs of a polarized relay R400 having its winding connected in series with that of an opposite polarized relay R410 across the line conductors C363 and C364 of the line circuit 362. In a similar manner the second branch of the operating circuit for the motor 402 includes armature springs under the control of the polarized relay R410, and the third branch of the operating circuit for the motor 402 includes armature springs under the control of a polarized relay R420. As will be noted from the detailed description of the operation of the switching unit following hereinafter, the polarized relay R400 comprises means responsive to impulses of one polarity applied between the line conductors C363 and C364 for causing the motor 402 to drive the wipers of the switch 440 in accordance with these pulses. Similarly, the oppositely poled polarized relay R410 comprises means responsive to voltage pulses of opposite polarity applied between the line conductors noted for causing the motor 402 to drive the enumerated switch wipers of the rotary switch 440 in accordance with the pulses of opposite polarity. The polarized relay R420 comprises a portion of means for maintaining the switch 440 operating in synchronism with the

other similar switches embodied in the various other switching units and the cycle control switch included in the apparatus at the master control station, and includes a winding connected in series with the winding of a fourth polarized relay R430 across the two line conductors C364 and C365 of the line circuits 362. This last-mentioned relay, which is responsive only to voltage of a particular polarity impressed between the line conductors noted, is provided for the purpose of energizing predetermined ones of the signaling devices located at the intersection 460 when voltage of the correct polarity is impressed across the line conductors C364 and C365. More specifically, this relay is responsive to the operation of the manually operable night switch provided at the master control station and functions to cause the continuous energization of the amber signaling devices located at the intersection noted. The relay R430 also comprises a portion of means for giving a special traffic indication in instances requiring traffic emergency signaling along the highway 450 and the intersecting highways. Such emergency traffic signaling is attained through the energization of the special lamp 434 which is provided at the intersection 460 and is located in a strategic position such that its illumination may be observed from any one of the four directions of approach. The circuit for energizing this lamp not only includes the armature springs controlled by the polarized relay R430 but also armature springs controlled by the polarized relay R410.

All of the signaling devices or lamps are energized from a standard commercial frequency alternating current source, one side of the current source being connected to the terminal 426 and the opposite side of the source being connected to the switch wiper 448 and the armature RA431 of R430. The same source is included in the operating circuit for the motor 402, this source being connected between the terminal 403 and the armature RA431 of the relay R430. For the purpose of energizing the special lamp 434 from the same source, one side of this source is connected to the armature RA411 of the polarized relay R410 and the opposite side of the source is connected to the lower terminal of the lamp as indicated. Since the four relays R400, R410, R420 and R430 are controlled directly through the application of voltage between the line conductors of the line circuit 362, it will be apparent that the requirement for a rectifier in the switching unit is obviated.

Before describing the details of the apparatus located at the master control station, attention is directed to the mechanism diagrammatically illustrated in Fig. 5, which mechanism functions to drive the wipers of the switch 440 from the motor 402 and to control the switch springs 423 and 424. As indicated, the two sets of springs, namely, the spring sets 423 and 424, are arranged to be controlled by camming elements 501 and 502, respectively, these elements being mounted to rotate with a shaft 503 which is driven by the motor 402 through a gear reduction mechanism 500. The springs making up the spring assemblies 423 and 424 are insulated from each other and are mounted on a frame member which may comprise a portion of the housing for the apparatus illustrated in Fig. 4. The lower spring of the assembly 423 is provided at its free extremity with a cam follower projection 505 which is arranged to drop in either of the two camming depressions 506 and 507 cut at diamet-

rically opposite points along the periphery of the camming element 501. Similarly, the lower spring of the assembly 424 is provided at its free extremity with a camming projection 500 which is arranged to drop in either of the two camming depressions 509 and 510 provided at diametrically opposite points around the circumference of the camming element 502. It will be understood from the description which follows that the lower springs of each of the assemblies 423 and 424 are biased away from the respective associated upper springs so that there is a tendency for the oppositely disposed contacts carried by the respective springs of each set to assume an open circuit position. Considering the spring assembly 423, this position is only attained, however, when the position of the shaft 403 is such that the projection 505 nests in one of the depressions 506 or 507. Similarly, the cooperating contacts carried by the springs of the assembly 424 are only disengaged when the projection 508 is dropped into one of the two depressions 509 and 510. In this connection it is pointed out that the elements 501 and 502 are so mounted on the shaft 503 that the depressions 506 and 509 are not in angular coincidence, but are displaced with respect to each other about the axis of the shaft by a right angle. It is evident, therefore, that the springs 423 and the springs 424 cannot occupy open circulated positions at the same time.

The wipers 446 to 449, inclusive, of the rotary switch 440 are mounted for rotation on a shaft 511 which carries a ratchet wheel 512 at one end thereof. Rotary movement is imparted to the shaft 511 during rotation of the shaft 503 through the operation of a pawl mechanism comprising a pawl 513 pivotally mounted at 514 on a rocker arm 515 and biased into engagement with the ratchet wheel 512 by means of a coil spring 516. The arm 515 is, in turn, pivotally mounted at 517 and includes a free end biased, by means of a coil spring 519, into engagement with the periphery of a camming element 518 carried by the shaft 503. The element 518 is provided at points displaced by ninety degrees around the periphery thereof with camming projections 520, 520', 521 and 521' which serve to rock the arm 515 about its pivot point 517, thereby to condition the ratchet and pawl mechanism to step the enumerated wipers one step during each quarter revolution of the shaft 503. Preferably the camming projections 520, 520', 521 and 521' are arranged angularly to coincide with the four camming depressions 506, 507, 509 and 510, respectively, whereby the ratchet and pawl mechanism is prepared to step the wipers of the switch 440 at the end of each period during which the motor 402 is energized. During the portions of each revolution of the shaft 503 when the ratchet and pawl mechanism is being rocked by the camming element 518, the ratchet wheel 512 is restrained against backward movement through the provision of a locking pawl 522 pivotally mounted at 523 and biased into engagement with the teeth of the ratchet wheel by a coil spring 524. It will readily be apparent that when the projection 520, for example, rides against the left extremity of the arm 515, this arm is rocked in a clockwise direction regressively to step the pawl from one tooth of the ratchet wheel 512 to the preceding tooth. Thereafter, and when the projection 520 rides from beneath the left extremity of the arm 515, the bias exerted on this arm by the spring 519 rocks the arm in a counterclockwise direction to rotate the shaft 511 and the wipers car-

ried thereby through an angle required to step the wipers from engagement with one set of bank contacts and into engagement with the next succeeding set of bank contacts.

Returning now to a consideration of the apparatus located at the master control station and illustrated in detail in Fig. 3, it will be noted that there is a marked resemblance between this apparatus and that shown in Fig. 1. Thus, it will be recognized that the pulse generator 375 corresponds to the similar device 30 embodied in the system of Fig. 1, and that the switches 304, 348, and 355, correspond respectively to the similar switches 23, 31, and 36 of the Fig. 1 arrangement. The relay network comprising the relays R310, R320, R330, R340, R350, R360, and R370 is somewhat different from that shown in Fig. 1, both as regards the functions performed thereby and the mode of interconnecting the operating circuits thereof with the cycle control switch indicated generally at 380. This last-mentioned switch is of conventional construction and is in all mechanical respects similar to the switch 10 embodied in the master control station of Fig. 1, but differs therefrom in that only eighteen points, corresponding to the eighteen points of the switch 440 and the other rotary switches embodied in the various other switching units, are provided. The relays R340, R350, and R360, which control the application of voltage across the conductors of the line circuit 362, have their operating circuits arranged to be controlled directly by the switch 380, rather than by certain others of the relays embodied in the master control station. Current for energizing the various relays, indicating lamps and the motor magnet of the switch 380 is supplied from a common direct current bus, not shown, which may be energized either from a battery or by connecting the same to the output terminals of a full wave rectifier. Here, as in Fig. 1, individual current sources for each of the circuit elements are shown, however, in order to facilitate a description of the many circuits involved. Voltages of opposite polarity are applied to the conductors of the line circuit 362 through the provision of two independent batteries in the exact manner set forth above in the description pertaining to the arrangement of Fig. 1.

Before describing the detailed operation of the system illustrated in Figs. 3 and 4 attention is directed to the arrangement of the line circuit interconnecting the master control station with each of the several switching units. This circuit is connected to form a continuous loop as indicated by the dash lines appearing in the lower right-hand portion of Fig. 4, so that control current from the master control station is fed to each of the switching units over two branches in parallel. Since a common grounded return conductor C364 is used in conjunction with each of the conductors C363 and C365, it is unnecessary to complete the loop of the common conductor for, by grounding the common conductor at each end thereof, the effect of a complete loop is simulated. It will be observed that by providing a line circuit in the form of a continuous loop or ring, none of the switching units can be rendered inoperative through the occurrence of an open-circuit line fault in the line circuit. This is true for the reason pointed out above, namely, that control current is fed to each of the switching units through two branches of the line circuit in parallel.

Referring now in greater detail to the opera-

tion of the apparatus illustrated in Figs. 3, 4, and 5, and assuming that the elements of the master control station occupy the positions illustrated in the drawings, a circuit is completed for energizing R300 to maintain this relay in its operated position. This circuit extends from ground at RA312 by way of the switch wiper 385, the multiplied bank contacts of the contact set 382, the switch springs 305, 306, 307, and 308 and through the winding of R300 to battery. With this relay operated, the pulse responsive relay R320 is connected to be energized in accordance with ground pulses applied to C304 by the pulse generator 375. When a ground pulse is applied to C304 the operating circuit for R320 is completed, this circuit extending by way of RC302, RA301, RA311, and through the winding of R320 to battery. The relay R320, upon operating, completes, at RA321, an obvious circuit for energizing the slow-to-release relay R330. This last-mentioned relay, upon operating, opens, at RA331 and RA332, points in the circuits, traced hereinafter, for energizing the relays R350 and R370, respectively.

At RA322, the relay R320 completes a circuit for energizing R350, this circuit extending from ground at RA312 by way of RA322, the switch wiper 386, the multiplied odd contacts of the contact set 383, and through the winding of R350 to battery. The relay R350, upon operating, completes, at RA351, a circuit for impressing direct voltage between the line conductors C363 and C364. As indicated in the drawings the polarity of this voltage is such that a positive potential is applied to C363, the negative terminal of the source being connected to the grounded return conductor C364 as indicated.

Simultaneously with the operation of R350 a circuit is completed, at RA321, for energizing the motor magnet M387, this circuit extending from ground at RA312 by way of RA321 and through the winding of M387 to battery. The magnet M387 upon being energized conditions its associated ratchet and pawl mechanism to step the wipers 384, 385 and 386 of the switch 380 from engagement with their respective associated first contacts and into engagement with their respective associated second contacts. Thereafter and when the ground pulse responsible for the operation of R320 is terminated to cause this relay to restore, the circuit for energizing M387 is interrupted at RA321. With this magnet deenergized, the ratchet and pawl mechanism noted operates to step the wipers of the switch 380 one step. When R320 restores at the end of the ground pulse applied to C304, the operating circuit for R350 is interrupted at RA322, causing the last-mentioned relay to restore to disconnect the direct current voltage source from across the line conductors C363 and C364. It is believed obvious that the above described operations occur each time a ground pulse is applied to C304 by the pulse generator 375, and, further, that the wipers of the switch 380 are stepped at the rate of one step for each ground pulse impressed on C304. It is pointed out, however, that R350 does not operate each time R320 operates. Thus, when the wipers of the switch 380 are stepped into engagement with their respective associated second contacts the operating circuit for R350 is opened at the switch wiper 386 and a circuit is prepared at this same wiper for energizing R340. This last-mentioned circuit is completed upon the subsequent operation of R320 when the next succeeding ground pulse is applied to C304 and ex-

tends from ground at RA312 by way of RA322, the switch wiper 386, the multiplied even contacts of the set 383, and through the winding of R340 to battery. The relay R340, upon operating, applies direct current voltage between the line conductors C363 and C364, which is of a polarity opposite that of the voltage applied between these conductors through the operation of R350. Thus, when R340 operates it connects at RA341 the negative terminal of the direct current source to C363, the positive terminal being connected to the grounded return conductor C364 as indicated. From the above it will be apparent that R350 and R340 are alternately energized in response to alternate operations of R320 and function to apply voltage pulses of alternate opposite polarity between the line conductors C363 and C364. These pulses are applied to the line conductors noted for so long as the rotary switch 380 operates.

It will be observed that when the rotary switch 380 is operated to a position such that the switch wiper 385 no longer stands in engagement with any one of the first nine conductors of the set 382, the operating circuit for R300 is interrupted. When this relay falls back the pulse responsive relay R320 is connected by way of RA301 and RC303 to be energized in accordance with the ground pulses applied to C305 rather than the pulses applied to C304. The purpose of this arrangement is exactly the same as that set forth above with reference to the similar arrangement illustrated in Fig. 1, and hence need not be further described.

The response of each of the switching units to the voltage pulses of alternate opposite polarity impressed between the line conductors C363 and C364 of the line circuit 362 is identical, and accordingly a consideration of the operation of the apparatus illustrated in detail in Fig. 4 will suffice to render clear an understanding of the operation of the system as a whole. With the wipers of the switch 440 standing in their respective home positions as illustrated in the drawings, a circuit is prepared at the switch springs of the assembly 424 for energizing the motor 402 from the alternating current source connected to the terminal 403. When, therefore, a positive potential pulse is impressed on C363 by the relay R350, the polarized relay R410 operates to complete the branch of the operating circuit for the motor 402 which extends from one side of the alternating current source at the armature RA431 and by way of RC432, RA412, the springs of the assembly 424 and through the motor 402 to the opposite side of the source at the terminal 403. The motor 402 is now energized and drives the shaft 503 through one-quarter of a revolution, at which time the cam projection 508 on the lower spring of the assembly 424 drops into the cam depression 510 of the element 502 to open the above-traced branch of the motor operating circuit. During this rotation of the shaft 503, the camming element 518, in cooperation with the ratchet and pawl mechanism associated with the shaft 511, rotates the wipers 446 to 449, inclusive, through an angle such that they are moved into engagement with their respective associated second contacts. Since the camming depressions cut in the respective peripheral surfaces of the camming elements 501 and 502 are angularly displaced with respect to each other by ninety degrees, it will be understood that when the projection 508 drops into the depression 510 the projection 75

505 extending from the lower spring of the assembly 423 rides on the outer peripheral surface of the element 501. Hence, the second branch of the operating circuit for the motor 402 is prepared at the springs of the assembly 423.

This last-mentioned circuit is completed upon the subsequent operation of R340 to apply a voltage pulse across C363 and C364 of the correct polarity to cause the operation of the polarized relay R400 and extends from one side of the source by way of RA401, the springs of the assembly 423, and through the motor 402 to the opposite side of the source. With the motor again energized the shaft 503 is driven through another quarter of a revolution, at which time the projection 505 extending from the lower spring of the assembly 423 drops into the cam depression 507 to interrupt the above-traced second branch of the operating circuit for the motor 402. During this rotation of the shaft 503, the ratchet and pawl mechanism functions to rotate the shaft 511 to step the wipers of the switch 440 a second step, or into engagement with their respective associated third contacts. Obviously with the shaft 503 standing in a position such that the springs of the assembly 423 are disengaged, the projection 508 carried by the lower spring of the assembly 424 rests on the outer peripheral surface of the camming element 502. Hence, the contacts carried by the springs of the assembly 424 are brought into engagement to prepare the first-mentioned branch of the operating circuit for the motor 402. Since voltage pulses of alternate opposite polarity are impressed across C363 and C364 for so long as the apparatus in the master control station is functioning in the manner just described, the motor 402 is alternately energized over the two branches of its operating circuit traced above and the wipers of the switch 440 are stepped successively into engagement with their respective associated contacts. In this connection it is pointed out that the duration of the voltage pulses applied to the line circuit must be sufficient to permit the motor 402 to drive the shaft 503 through a complete operating cycle each time the motor is energized. With the arrangement shown it is contemplated that approximately one second shall be required for the motor 402 to drive the shaft 503 the one-quarter revolution representing each operating cycle. This means, of course, that each ground pulse applied to C304 or C305 by the pulse generator 375 must endure for a time interval slightly greater than one second. The difference in the pulse rates of the pulses applied to C304 and C305 is attained through changing the spacing interval between successive pulses.

Assuming that the switch 440 is started in operation from its home position as illustrated in the drawings, the stop or red signaling device 451 governing traffic proceeding along the highway 450 and the traffic right of way signaling device 455 governing traffic on the intersecting highway are maintained energized during the interval when the wipers of the switch 440 are being advanced over the first nine of their respective associated contacts. The path of the current for energizing the signaling device 451 extends from one terminal of the current source as indicated at 426 by way of the signaling device noted, the multiplied first nine contacts of the set 442, the switch wiper 447, RC432, and RAA431 to the opposite side of the current source. The circuit for energizing the signaling device 455 extends from one

side of the current source at the terminal 426 by way of the device 455, the multiplied first nine contacts of the set 444, the switch wiper 449, RC432, and RA431 to the opposite side of the current source. During the period just preceding transfer of traffic right of way from the north-south highway to the east-west highway 450, the north-south amber or caution signaling device is energized. Thus, when the switch wiper 448 is driven into engagement with the eighth contact of the set 443, a circuit is completed for energizing the device 456. This circuit extends from one side of the source at the terminal 426, through the device 456 and by way of the switch wiper 448 to the opposite side of the source. Since the eighth and ninth contacts of the set 443 are multiplied together the device 456 is maintained energized until the wipers of the switch 440 are stepped into engagement with their respective associated tenth contacts, at which time the above-traced operating circuit for this device is interrupted at the wiper 448. Simultaneously with the deenergization of the north-south caution signal the operating circuits for the signaling devices 451 and 455 are interrupted at the wipers 447 and 449, respectively, and circuits are completed for energizing the signaling device 452 and 454, thereby to give traffic right of way to the traffic proceeding along the highway 450. These last-mentioned signaling devices are continuously energized over obvious circuits until the wipers of the switch 440 are stepped from engagement with their respective associated eighteenth contacts and into engagement with their respective associated first contacts to initiate another operating cycle of the switching unit. During the interval just preceding the retransfer of traffic right of way to the north-south intersecting highway a caution signal is displayed to the traffic proceeding along the highway 450 through the energization of the signaling device 453. The circuit for energizing this device extends from one side of the source at the terminal 426 through the device noted by way of the multiplied seventeenth and eighteenth contacts of the set 443 and the switch wiper 448 to the opposite side of the source.

From the preceding description it will be apparent that the switch 440 is synchronously operated with the cycle control switch 380 located at the master control station. Specifically each time the wipers of the switch 380 are stepped one step the wipers of the switch 440 are also stepped one step. It is possible that the synchronous relation between the operating cycles of the two switches noted may be disturbed and, in order to correct any such non-synchronous relation, provisions are made for bringing the operating positions of the wipers embodied in the respective switches into coincidence at the end of each operating cycle of the switch 380. To this end a circuit is provided for energizing R360 at the end of each operating cycle of the switch 380 and when the switch wiper 386 is driven into engagement with the eighteenth contact of the set 383. This circuit extends from ground at RA312 by way of RA322, the switch wiper 386, the eighteenth contact of the contact set 383 and through the winding of R360 to battery. The relay R360, upon operating, impresses a control voltage between the line conductors C364 and C365, the polarity of this voltage being such that negative potential is impressed on C365. This control voltage is of the proper polarity to cause the operation of the polarized relay R420, which

relay, upon operating, completes a circuit for energizing the motor 402, this circuit extending from one side of the source at RA431 by way of RC432, RA422, the wiper 446, the multiplied contacts of the contact set 441 and through the motor 402 to the opposite side of the source at the terminal 403. As a result, the motor 402 drives the wipers of the switch 440 until they reach their respective home positions as indicated in the drawings, at which time the above-traced operating circuit for the motor 402 is interrupted at the wiper 446. Obviously, if the switch 440 is operating in synchronism with the switch 380 the only effect produced by the operation of R420 is that of completing a multiple branch circuit for energizing the motor 402, it being understood from the previous description that the other branch circuit extends by way of the springs included in the assembly 423.

The method by which the normal operation of the various switching units connected to the line circuit 362 is interrupted in cases requiring emergency traffic indications along the highway 450 is somewhat similar to that described above with reference to the apparatus illustrated in Figs. 1 and 2. Thus, when the key switch 355 is operated from its normal position as indicated in the drawings to its off-normal position, a circuit is completed for energizing the relay R310, this circuit extending from ground at the switch spring 356 by way of the spring 357 and through the winding of R310 to battery. The relay R310, upon operating, interrupts, at RA312, a point in the common portion of the circuits for energizing R300, R330, M387 and the two indicating lamps 388 and 389. At RA311, the relay R310 opens a point in the pulsing circuit for R320, thereby to interrupt the operation of the switch 380 and to stop the alternate operation of the relays R340 and R350. With the switch 355 operated to its off-normal position an alternate circuit is prepared for energizing R350, this circuit extending from ground at the switch spring 356 by way of the springs 359 and 342, RA331, RA372, and through the winding of R350 to battery. This relay, which only operates following the operation of the slow-to-release relay R370 as described hereinafter, functions to impress a direct voltage across C363 and C364 in a manner such that the positive terminal of the voltage source is connected to C363. At the switch springs 356 and 358, a circuit is completed for energizing R370, which circuit extends from ground at the spring 356 and by way of the spring 358, RA332 and the winding of R370 to battery. This relay, upon operating, applies at RA371 direct voltage between the line conductors C364 and C365, this voltage being so poled that positive potential is applied to C365, and completes the above-traced circuit for energizing R350. At the springs 343 and 344 an obvious circuit is completed for energizing the indicating lamp 313, thereby to indicate the emergency condition which prevails.

When voltage of the polarity described is applied between C364 and C365 through the operation of R370, the polarized relay R430 is caused to operate to prepare, at RA435, the previously-mentioned circuit for energizing the emergency signaling device 434.

Similarly and when voltage of the polarity noted is impressed between C363 and C364 through the operation of R350, the polarized relay R410 is caused to operate, and, upon operating, completes, at RA411, the above-mentioned circuit for energizing the emergency signaling

device 434 located at the intersection 460. The operation of R410 further results in the preparation of one branch of the operating circuit for the motor 402, but, due to the operation of R430 before the operation of R410, this branch circuit is now open at RA431 and RC432. The energization of the device 434 indicates to traffic traveling in all directions the emergency condition which exists. When R430 operates it interrupts, at RA431 and RC432, a point in the common portion of the operating circuits for all of the red and green signaling devices located at the intersection 460, and completes, at RA431, RC433 and RC436, obvious circuits for energizing the caution or amber lamps 453 and 456 located at this intersection. Hence, the indication occasioned by the energization of the lamp 434 is supplemented by the indication given by the illuminated caution lamps.

The restoration of the apparatus to its normal operating condition following the above-described sequence of operations is achieved by returning the switch 355 to its normal position at which time the operating circuits for R310, R350, R370, and the indicating lamp 313 are opened in an obvious manner. When R310 restores, it prepares, at RA312, the operating circuits for R300, R330, the indicating lamps 388 and 389, M387, and the two relays R340 and R350, and, at RA311, the pulsing circuit extending to the pulse responsive relay R320. When R350 and R370 restore to disconnect the above-mentioned control voltages from the conductors of the line circuit, the polarized relays R410 and R430 restore. When the two polarized relays restore, the operating circuits for the signaling devices 434, 453 and 456 are interrupted and the apparatus of the switching unit resumes its normal operation as described above.

It is noted that when the switch 355 is restored to its normal position the operating circuits for R350 and R370 are simultaneously opened. Due to the slow-to-release characteristic of R370, however, R350 is the first of these two relays to restore. Hence, R410 is caused to restore, to open, at RA412, the prepared point in the operating circuit for the motor 402, before R430 is deenergized to prepare, at RA431 and RC432, another point in this circuit. The described order in which R410 and R430 are caused to operate and restore is important since it eliminates any possibility of the motor 402 being falsely energized to drive the wipers of the switch 440 to a position ahead of the position occupied by the wipers of the cycle control switch 380 in response to the operation of the key switch 355 between its normal and off-normal positions.

The normal operation of the apparatus may not only be discontinued through the operation of the switch 355 to its off-normal position, but also through the operation of the night switch 345 to its off-normal position. This latter switch is provided for the purpose of conditioning the apparatus to energize only those signaling devices located at the various intersections which function to give caution indications during periods when light traffic conditions exist. Specifically, when this switch is actuated to its off-normal position an obvious circuit is completed at the springs 346 and 347 for energizing the relay R310. A circuit is also completed at the springs 348 and 349 for energizing the indicating lamp 314 in parallel with the relay R370, this circuit dividing at the spring 349 with one branch extending through the lamp 314 to battery and

the other branch extending by way of RA332 and the winding of R370 to battery. When R310 operates, it functions, in the manner described previously, to stop the operation of the switch 380 and to deenergize R340 and R350 so that voltage pulses are no longer applied to C363 and C364. With R370 energized, voltage is applied at RA371 between the line conductors C364 and C365, this voltage being of the proper polarity to cause the energization and operation of the polarized relay R430 embodied in the switching unit illustrated in Fig. 4, and of the other relays, corresponding to R430, including in the various other switching units controlled over the line circuit 362. When R430 operates, it opens, at RA431 and RC432, a point in the common portion of the above-traced circuits for energizing the signaling devices at the intersection 400. The operation of R430 also results in the completion of obvious circuits for energizing the caution signaling devices 453 and 456. The energized condition of the two signaling devices noted prevails until such time as the key switch 345 is restored to its normal position. When this last-mentioned operation is performed, the operating circuits for R310, the indicating lamp 314, and R370 are interrupted. When R370 restores, the operating circuit for the polarized relay R430, and the other relays corresponding thereto, is opened. When R430 falls back the apparatus embodied in the switching unit shown is again conditioned to respond to the voltage pulses of alternate opposite polarity impressed across C363 and C364 through the alternate operation of R340 and R350. The operation of the relays noted is initiated upon the restoration of R310 to recondition the apparatus at the master control station to operate in the normal manner as set forth above.

Although in each of the embodiments of the invention as described above the circuit connections for controlling the energization of the signaling devices are indicated as being of a permanent nature, it will be understood that manually operable switching means may be provided in each switching unit for changing at will the rotary switch bank contact multiple connections which govern the percentage of each operating cycle allotted to traffic right of way in each direction. In certain installations this may be desirable for the purpose of adapting the operation of the system to widely divergent traffic conditions occurring at different periods during the day. Considering specifically the arrangement illustrated in Fig. 2, it will be appreciated that if the multiples between the contacts forming the set 286 and between the contacts forming the set 288 are arranged so that the first portion of each operating cycle is completed upon movement of the wipers of the switch over their respective associated first eight contacts, the portion of each operating cycle allotted to traffic right of way in the east and west directions will be much greater than with the particular multiple arrangement shown wherein twelve points of the switch are allotted to traffic right of way along the north-south highway 55. The same is true of the arrangement illustrated in Fig. 4. Hence, through the provision of suitable means for changing at will the rotary switch bank contact multiple arrangements, the percentage of each switch operating cycle allotted to traffic right of way in each direction may be varied to suit the requirements of any prevailing traffic condition.

It is further pointed out that the operating cycles of the signaling devices located at the respective intersections need not necessarily coincide as regards the simultaneous energization of the corresponding signaling devices at each intersection. Indeed, in those arrangements wherein the so-called progressive type of traffic control is utilized, the corresponding signaling devices at successive intersections in any desired direction must necessarily be energized successively and not in unison. It will readily be apparent that this type of control may be secured with the arrangement illustrated by using progressive multiples in successive ones of the switching units so that the traffic right of way change-over periods occur at different times and in a definitely spaced order.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be understood that various modifications may be made therein without departing from the invention, and it is contemplated in the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a line circuit interconnecting said unit and said station, means at said station for impressing voltage pulses on said line circuit, said pulses being of alternate opposite polarity, a switch included in said unit, said switch comprising contacts and a wiper associated with said contacts, a motor for driving said wiper over said contacts, means responsive only to pulses of alternate opposite polarity impressed on said line circuit for causing the operation of said motor, and circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of said signaling devices.

2. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a line circuit interconnecting said unit and said station, means at said station for impressing voltage pulses on said line circuit, said pulses being of alternate opposite polarity, a switch included in said unit, said switch comprising contacts and a wiper associated with said contacts, a motor for driving said wiper over said contacts, a pair of polarized relays including windings connected to said line circuit, said windings being so poled that one of said relays responds to voltage pulses of one polarity impressed on said line circuit and the other of said relays responds to voltage pulses of opposite polarity impressed on said line circuit, an operating circuit for said motor, said circuit comprising two branches each including a switch controlled by said motor, said circuit branches being so connected and arranged that one thereof is completed upon operation of one of said relays and is opened by the motor controlled switch included therein when the motor has operated through a predetermined cycle and the other thereof is prepared at the end of said predetermined cycle, is completed upon operation of the other of said relays and is opened by the motor controlled

switch included therein when the motor has operated through another predetermined cycle, and circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of said signaling devices.

3. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a line circuit interconnecting said station and said unit, means including a relay at said station for impressing voltage of one polarity on said line circuit, means including a second relay at said station for impressing voltage of a polarity opposite said one polarity on said line circuit, a switch at said station, said switch including contacts, a wiper associated with said contacts and a motor magnet for driving said wiper over said contacts, means for generating spaced pulses, means operative in accordance with said pulses for energizing said magnet, circuit connections controlled by the movement of said wiper over said contacts for alternately energizing said relays, whereby voltage pulses of alternate opposite polarity are applied to said line circuit, a switch included in said unit, said last-named switch comprising contacts and a wiper associated with the contacts, a motor for driving said last-named wiper over the associated contacts, means responsive only to pulses of alternate opposite polarity impressed on said line circuit for causing the operation of said motor and circuit connections controlled by the movement of said last-named wiper over the associated contacts for controlling the energization of said signaling devices.

4. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a line circuit interconnecting said station and said unit, means including a relay at said station for impressing voltage of one polarity on said line circuit, means including a second relay at said station for impressing voltage of a polarity opposite said one polarity on said line circuit, a switch at said station, said switch including contacts, wiper associated with said contacts and a motor magnet for driving said wiper over said contacts, means for generating spaced pulses, means operative in accordance with said spaced pulses for energizing said magnet, circuit connections controlled by the movement of said wiper over said contacts for alternately energizing said relays, whereby voltage pulses of alternate opposite polarity are applied to said line circuit, a pair of polarized relays included in said unit and including windings connected to said line circuit, said windings being so poled that one of said polarized relays responds to voltage pulses of one polarity impressed on said line circuit and the other thereof responds to voltage pulses of opposite polarity impressed on said line circuit, a switch included in said unit, said last-named switch comprising contacts and a wiper associated with the contacts, a motor for driving said last-named wiper over the associated contacts, an operating circuit for said motor, said operating circuit comprising two branches each including a switch controlled by said motor, said circuit branches being so connected and arranged that one thereof is completed upon operation of one of said polarized relays and is opened by the

motor controlled switch included therein when the motor has operated through a predetermined cycle and the other thereof is prepared at the end of said predetermined cycle, is completed upon operation of the other of said polarized relays and is opened by the motor controlled switch included therein when the motor has operated through another predetermined cycle, and circuit connections controlled by the movement of said last-named wiper over the associated contacts for controlling the energization of said signaling devices.

5. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit including a cyclically operating switch for causing said signaling devices to be energized in a definite order, a master control station, a line circuit interconnecting said station and said unit, means for applying control voltage to said line circuit, means included in said unit and energized by said voltage for controlling the operation of said switch, a cyclically operating switch in said station, means energized in accordance with said voltage for causing said second-named switch normally to operate in synchronism with said first-named switch, and means controlled by said second-named switch for maintaining said switches operating in synchronism.

6. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit including a cyclically operating switch for causing said signaling devices to be energized in a definite order, a master control station, a line circuit interconnecting said station and said unit, means for applying voltage pulses of one polarity to said line circuit, a polarized relay included in said unit and energized by said voltage pulses for controlling the operation of said switch, a cyclically operating switch at said station, means energized in accordance with said pulses for causing said second-named switch normally to operate in synchronism with said first-named switch, said switches having corresponding predetermined operating positions, means operated in response to the operation of said second-named switch to its said predetermined position for applying voltage of a polarity opposite that of said voltage pulses to said line circuit, a polarized relay included in said unit and energized only by said second-named voltage, and circuit means controlled by said last-named relay for causing said first-named switch to be operated to its said predetermined position only in the event said first-named switch has not previously been operated to its said predetermined position.

7. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit at said intersection and including a stepping switch, said switch including contacts, a wiper associated with said contacts and a motor magnet for driving said wiper over said contacts, circuit connections controlled by the movement of said wipers over said contacts for energizing said signaling devices in a definite cyclic order, a master control station, a line circuit interconnecting said unit and said station, an operating circuit for said magnet, a polarized relay connected to said line circuit and operative to complete said operating circuit, means for applying voltage

pulses of one polarity to said line circuit thereby to energize said relay, a stepping switch at said station, said second-named switch including contacts, a wiper associated with said last-named contacts, a motor magnet for driving said last-named wiper over the associated contacts, means for energizing said second-named motor magnet in accordance with said voltage pulses, whereby said switches are normally operated in synchronism, means controlled by said second-named switch and energized once during each operating cycle thereof for applying voltage of a polarity opposite that of said voltage pulses to said line circuit, a second polarized relay in said unit and energized by said last-named voltage, and a second operating circuit for said first-named motor magnet, said second circuit being controlled by said first-named switch and said second-named polarized relay and being so arranged that it is only effective to cause the operation of said first-named switch when said switches are not operating in synchronism.

8. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit at said intersection and including a switch, said switch comprising contacts and a wiper associated with said contacts, a motor for driving said wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for energizing said signaling devices in a definite cyclic order, a master control station, a three conductor line circuit interconnecting said unit and said station, another switch at said station, said second-named switch comprising contacts, a wiper associated with said last-named contacts and a motor magnet for driving the last-named wiper over the associated contacts, means at said station for generating spaced pulses, means for energizing said motor magnet in accordance with said pulses, means at said station and controlled by said second-named switch for impressing voltage pulses of alternate opposite polarity across two conductors of said line circuit, means included in said switching unit and responsive only to voltage pulses of alternate opposite polarity impressed on said two conductors for causing the operation of said motor, the operation of said motor being so related to the operation of said second-named switch that normally said switches operate in synchronism, means controlled by said second-named switch for impressing voltage across a different pair of the conductors of said line circuit only when said second-named switch is operated to a predetermined position, and means energized by said last-named voltage for causing said motor to drive said first-named switch to a position corresponding to the said predetermined position of said second-named switch in the event said two switches are not operating in synchronism.

9. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit at said intersection and including a switch, said switch comprising contacts and a wiper associated with said contacts, a motor for driving said wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for energizing said signaling devices in a definite cyclic order, a master control station, a three-conductor line circuit interconnecting said

unit and said station, another switch at said station; said second-named switch comprising contacts, a wiper associated with said last-named contacts and a motor magnet for driving the last-named wiper over the associated contacts, means for generating spaced pulses, means for energizing said motor magnet in accordance with said pulses, means including a relay for applying voltage of one polarity across two conductors of said line circuit, means including a second relay for applying voltage of a polarity opposite said one polarity across said two conductors, circuit connections controlled by the movement of said last-named wiper over the associated contacts for alternately energizing said relays, whereby voltage pulses of opposite polarity are impressed across said two conductors, a pair of polarized relays included in said unit and including windings connected across said two conductors, said windings being so poled that one of said relays responds to voltage pulses of said one polarity impressed on said line circuit and the other of said relays responds to voltage pulses of opposite polarity impressed on said line circuit, switching means controlled by said motor, an operating circuit for said motor, means including said relays and said switching means for controlling the condition of said operating circuit, the operation of said motor being so related to the operation of said second-named switch that normally said switches operate in synchronism, a relay at said station for applying voltage across a different pair of the conductors of said line circuit, an operating circuit for said last-named relay, said last-named operating circuit being completed upon operation of the switch wiper of said second-named switch to a predetermined position, and means energized by said last-named voltage for causing said motor to drive said first-named switch to a position corresponding to the said predetermined position of said second-named switch in the event said two switches are not operating in synchronism.

10. Traffic signaling apparatus for interfering traffic lanes comprising, in combination, a plurality of right of way and stop signals located at a traffic intersection, a switching unit for energizing said signals in a definite cyclic order, said unit being operative to maintain the right of way signals governing traffic on one lane and the stop signals governing traffic on the intersecting lane energized for a portion of each operating cycle and to maintain the stop signals governing traffic on said one lane and the right of way signals governing traffic on said intersecting lane energized for another portion of each operating cycle, and means for controlling said switching unit to vary the time interval of only one of said portions of each operating cycle, thereby to vary the total time interval of each cycle and to change the percentage of each cycle during which right of way is given to the respective lanes.

11. Traffic signaling apparatus for interfering traffic lanes comprising in combination, a plurality of right of way and stop signals located at a traffic intersection, a pulse responsive switching unit for energizing said signals in a definite cyclic order, said unit being operative to maintain the right of way signals governing traffic on one lane and the stop signals governing traffic on the intersecting lane energized for a portion of each operating cycle and to maintain the stop signals governing traffic on said one lane and the right of way signals govern-

ing traffic on said intersecting lane energized for another portion of each operating cycle, and means for automatically transmitting pulses to said unit at each of two different rates during the respective portions of each operating cycle, whereby the respective time intervals of said portions of said operating cycles are different.

12. Traffic signaling apparatus for interfering traffic lanes comprising in combination, a plurality of right of way and stop signals located at a traffic intersection, a pulse responsive switching unit for energizing said signals in a definite cyclic order, said unit being operative to maintain the right of way signals governing traffic on one lane and the stop signals governing traffic on the intersecting lane energized for a portion of each operating cycle and to maintain the stop signals governing traffic on said one lane and the right of way signals governing traffic on said intersecting lane energized for another portion of each operating cycle, means operative automatically to transmit pulses to said switching unit at one rate during one portion of each operating cycle, means operative automatically to transmit pulses to said unit at a different rate during another portion of each operating cycle, and additional means selectively operable to cause pulses to be transmitted to said unit at a uniform rate for all portions of each operating cycle.

13. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a cyclically operating switch, means for generating spaced pulses at two different rates, means for controlling the operation of said switch in accordance with the pulses of one rate, pulse controlled means included in said switching unit and responsive to said pulses for controlling the energization of said signaling devices, each operating cycle of said switch corresponding to an operating cycle of said signaling devices, and means controlled by said switch and operative when said switch attains a predetermined operating position in each operating cycle for connecting said pulse controlled means and said switch to be controlled by the pulses of the other rate.

14. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said signaling devices in a definite cyclic order, a switch, said switch including contacts, a wiper associated with said contacts and a motor magnet for driving said wiper over said contacts, means for generating spaced pulses at two different rates, means for energizing said motor magnet in accordance with the pulses of one rate, pulse controlled means included in said switching unit and responsive to said pulses for controlling the energization of said signaling devices, each operating cycle of said switch corresponding to an operating cycle of said signaling devices, a relay for connecting said pulse controlled means and said magnet to be energized in accordance with the pulses of the other rate, and an operating circuit for said relay controlled by movement of said wiper over said contacts, said circuit being completed at a predetermined point in each operating cycle of said switch.

15. A traffic signaling system for interfering traffic lanes comprising in combination, a plurality of traffic control signaling devices located

at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a three conductor line circuit interconnecting said unit and said station, means at said station for applying voltage pulses across two conductors of said line circuit, a switch included in said unit, said switch comprising contacts, a wiper associated with said contacts and means for driving said wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of said signaling devices, means included in said unit and responsive to the voltage pulses applied to said two conductors for energizing said driving means, a manually operable switch at said station having a normal position and an off-normal position, means responsive to the operation of said last-named switch to said off-normal position for discontinuing the operation of said first-named switch, means also responsive to the operation of said last-named switch to said off-normal position for impressing voltage across a different pair of conductors of said line circuit, and means included in said switching unit and responsive to the application of said last-named voltage to said line circuit for energizing a predetermined one of said signaling devices to give a particular traffic indication.

16. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a line circuit interconnecting said unit and said station, means at said station for impressing spaced voltage pulses on two conductors of said line circuit, a switch included in said unit, said switch comprising contacts, a wiper associated with said contacts and a motor magnet for driving said wiper over said contacts, an operating circuit for said motor magnet, a relay including a winding connected to said line circuit, said relay being operative to complete said operating circuit in accordance with said voltage pulses, circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of said signaling devices, a manually operable switch having a normal position and an off-normal position, means included in said unit and responsive to the operation of said last-named switch to said off-normal position for interrupting said operating circuit and for deenergizing any of said signaling devices energized by way of said connections, means included in said unit and responsive to the operation of said last-named switch to said off-normal position for continuously energizing a predetermined one of said signaling devices, and means included in said unit and responsive to the operation of said last-named switch to said off-normal position for energizing another of said signaling devices in accordance with said voltage pulses, whereby a predetermined traffic indication is given by said devices.

17. A traffic signaling system for interfering traffic lanes comprising, in combination, a plurality of traffic control signaling devices located at a traffic intersection, a switching unit for energizing said devices in a definite cyclic order, a master control station, a three-conductor line circuit interconnecting said unit and said station, means at said station for applying voltage pulses across two conductors of said line circuit, means included in said unit and responsive to said pulses

for controlling the energization of said signaling devices, a manually operable switch at said station having a normal position and an off-normal position, means responsive to the operation of said switch to said off-normal position for discontinuing the normal operation of said switching unit and for impressing voltage across a different pair of the conductors of said line circuit, means included in said switching unit and responsive to the application of said last-named voltage to said line circuit for energizing a predetermined one of said signaling devices to give a particular traffic signal indication, a second manually operable switch at said station, said second switch having a normal position and an off-normal position, means responsive to the operation of said second switch to its said off-normal position for discontinuing the normal operation of said switching unit, and means included in said unit and responsive to the operation of said second switch to its said off-normal position for energizing predetermined ones of said signaling devices to give a second particular traffic signal indication.

18. In a traffic signaling system, a master control station for controlling a plurality of traffic signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch, a pulse generator, means controlled by said generator for applying voltage pulses to said line circuit, means for operating said switch in accordance with said voltage pulses, means controlled by said switch for applying a synchronizing voltage pulse to said line circuit, and means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit.

19. In a traffic signaling system, a master control station for controlling a plurality of traffic signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch, a pulse generator, means controlled by said generator for applying voltage pulses to said line circuit, means for operating said switch in accordance with said voltage pulses, means controlled by said switch for applying a synchronizing voltage pulse to said line circuit, means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit, and selectively operable means for rendering said last-named means nonresponsive to operation of said switch.

20. In a traffic signaling system, a master control station for controlling a plurality of traffic signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch, a pulse generator, means controlled by said generator for applying voltage pulses to said line circuit, means for operating said switch in accordance with said voltage pulses, means controlled by said switch for applying a synchronizing voltage pulse to said line circuit, means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit, selectively operable switching means having a normal position and an off-normal position, and means responsive to the operation of said last-mentioned switching means to said off-normal position for interrupting the operation of said cyclically operating switch and for applying a control voltage to said line circuit.

21. In a traffic signaling system, a master control station for controlling a plurality of traffic signaling device switching units by way of a line

circuit and comprising, in combination, a cyclically operating switch, a pulse generator, means controlled by said generator for applying voltage pulses to said line circuit, means for operating said switch in accordance with said voltage pulses, means controlled by said switch for applying a synchronizing voltage pulse to said line circuit, means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit, a switch having a normal position and an off-normal position, means responsive to the operation of said last-named switch to said off-normal position for interrupting the operation of said cyclically operating switch and for applying a control voltage to said line circuit, a second switch having a normal position and an off-normal position, and means responsive to the operation of said second switch to its said off-normal position for interrupting the operation of said cyclically operating switch and for impressing a control voltage on said line circuit different from said first-named control voltage.

22. In a traffic signaling system, a master control station for controlling a plurality of traffic signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch, a pulse generator, means controlled by said generator for applying voltage pulses to said line circuit, means for operating said switch in accordance with said voltage pulses, means controlled by said switch for applying a synchronizing voltage pulse to said line circuit, means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit, selectively operable means for rendering said last-named means nonresponsive to operation of said switch, a switch having a normal position and an off-normal position, and means responsive to the operation of said last-named switch to its said off-normal position for interrupting the operation of said cyclically operating switch and for impressing a control voltage on said line circuit.

23. In a traffic signaling system, a switching unit adapted to be controlled by way of a line circuit connected thereto and operative to energize a plurality of associated traffic control signaling devices in a definite cyclic order comprising, in combination, a stepping switch including contacts, a wiper associated with said contacts and motor means for driving the wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of the associated signaling devices, a pair of polarized relays connected and arranged alternately to operate in response to pulses of alternate opposite polarity impressed on said line circuit, and circuit connections partially controlled by said relays for energizing said motor means, said circuit connections being so connected and arranged that said motor means is caused to advance said wiper one step each time one of said relays operates.

24. In a traffic signaling system, a switching unit adapted to be controlled by way of a line circuit connected thereto and operative to energize a plurality of associated traffic control signaling devices in a definite cyclic order comprising, in combination, a stepping switch including contacts, a wiper associated with said contacts and motor means for driving the wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of the associated signaling devices, a pair of polarized relays con-

ected and arranged alternately to operate in response to pulses of alternate opposite polarity impressed on said line circuit, circuit connections partially controlled by said relays for energizing

5 said motor means, said circuit connections being so connected and arranged that said motor means is caused to advance said wiper one step each time one of said relays operates, and syn-
10 chronizing means adapted to be energized by way of said line circuit for energizing said motor means to drive said wiper to a predetermined position once during each operating cycle of said switch in the event said wiper is not already in
15 said predetermined position when said synchronizing means is energized.

25 25. In a traffic signaling system, a switching unit adapted to be controlled by way of a line circuit connected thereto and operative to energize a plurality of associated traffic control signaling devices in a definite cyclic order comprising, in combination, a switch including con-
30 tacts, a wiper associated with said contacts and motor means for driving the wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for
35 controlling the energization of the associated signaling devices, pulse responsive means adapted to be connected to the line circuit for controlling the energization of said motor means,
40 synchronizing means adapted to be energized by way of said line circuit for energizing said motor means to drive said wiper to a predetermined position once during each operating cycle of said switch in the event said wiper is not al-
45 ready in said predetermined position when said synchronizing means is energized, and means adapted to respond to a predetermined control voltage applied to said line circuit to interrupt the operation of said switch, deenergize any of
50 said signaling devices energized by way of said circuit connections, and energize a predetermined one of said signaling devices to give a particular traffic signal indication.

55 26. A traffic signaling system comprising, in combination, a master control station, a plurality of switching units each arranged to energize a plurality of traffic control signaling devices associated therewith in a definite cyclic order, a line circuit interconnecting said switch-
60 ing units and said control station, said control station and each of said units respectively including a cyclically operating switch, means at said station for applying voltage pulses to said line circuit, means included in each switching
65 unit and energized in accordance with said pulses for driving the switch of the corresponding unit, means at said station for driving the switch thereat in accordance with said pulses, means controlled by said last-named switch for main-
70 taining the operating cycles of said switches synchronized, means controlled by said last-named switch for changing the rate at which said voltage pulses are applied to said line circuit, selectively operable means for rendering said last named means nonresponsive to operation of said last-named switch, a switch at said station having a normal position and an off-normal position, and means responsive to the operation of said last-named switch to its off-normal position for discontinuing the operation of the cyclically operating switches included in said units, deenergizing any energized ones of

the signaling devices and energizing predetermined ones of the signaling devices at each intersection to give a particular traffic signal indication.

27. In a traffic signaling system, a master control station for controlling a plurality of signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch including motor means, a pulse generator, means controlled by said generator for energizing said motor means to drive said switch, means also controlled by said generator for applying voltage pulses to said line circuit, and means controlled by said switch for changing the rate of the voltage pulses applied to said line circuit.

28. In a traffic signaling system, a master control station for controlling one or more signaling device switching units by way of a line circuit and comprising, in combination, a cyclically operating switch having a plurality of operating positions and including motor means, pulse generating means operative to generate pulses at two different rates, means controlled by said pulse generating means for energizing said motor means in accordance with the pulses of one rate, thereby to cause the operation of said switch, means also controlled by said generating means for impressing voltage pulses of said one rate on said line circuit, means responsive to operation of said switch to a predetermined one of said positions for energizing said motor means in accordance with the pulses of the other rate, and means also responsive to operation of said switch to said predetermined position for causing voltage pulses of said other rate to be impressed on said line circuit.

29. In a traffic signaling system, a switching unit adapted to be controlled by way of a line circuit connected thereto and operative to energize a plurality of associated traffic control signaling devices in a definite cyclic order, said unit comprising, in combination, a switch including contacts, a wiper associated with said contacts and motor means for driving said wiper over said contacts, circuit connections controlled by the movement of said wiper over said contacts for controlling the energization of the associated signaling devices, a pair of polarized relays including windings adapted to be connected to said line circuit, said windings being so poled that one of said relays responds to voltage pulses of one polarity impressed on said line circuit and the other of said relays responds to voltage pulses of opposite polarity impressed on said line circuit, and an operating circuit for said motor means, said circuit comprising two branches each including a switch controlled by said motor means, said circuit branches being so connected and arranged that one thereof is completed upon operation of one of said relays and is opened by the motor controlled switch included therein when said wiper is operated through a predetermined movement and the other thereof is prepared at the end of said predetermined movement, is completed upon operation of the other of said relays and is opened by the motor controlled switch included therein when said wiper has been operated through a second predetermined movement.

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