

Aug. 3, 1937.

T. P. PREIST

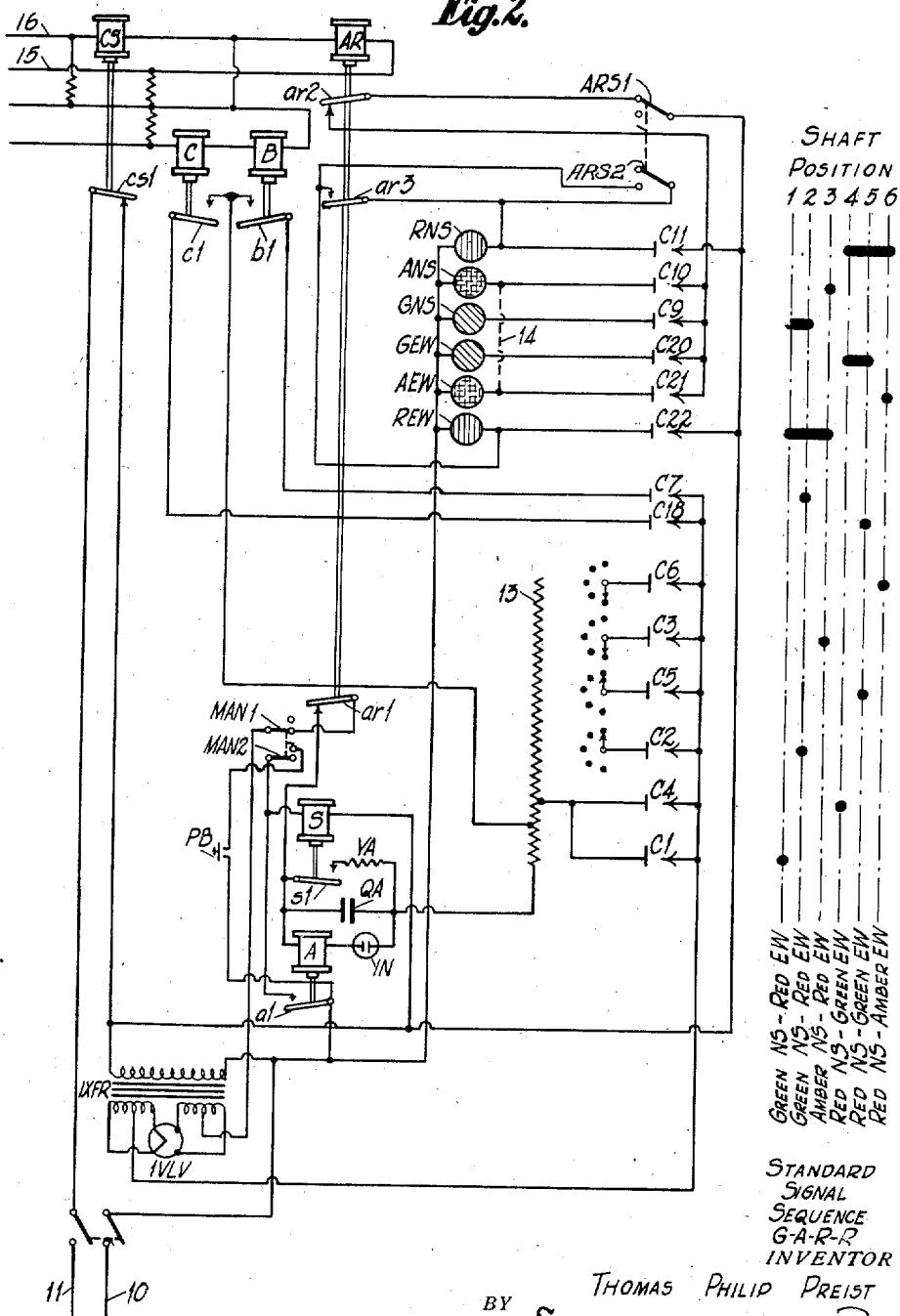
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ELECTRICAL TIMING APPARATUS

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Fig. 2.



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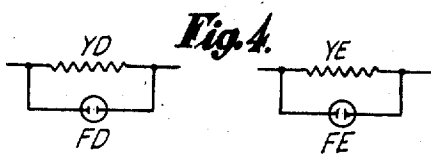
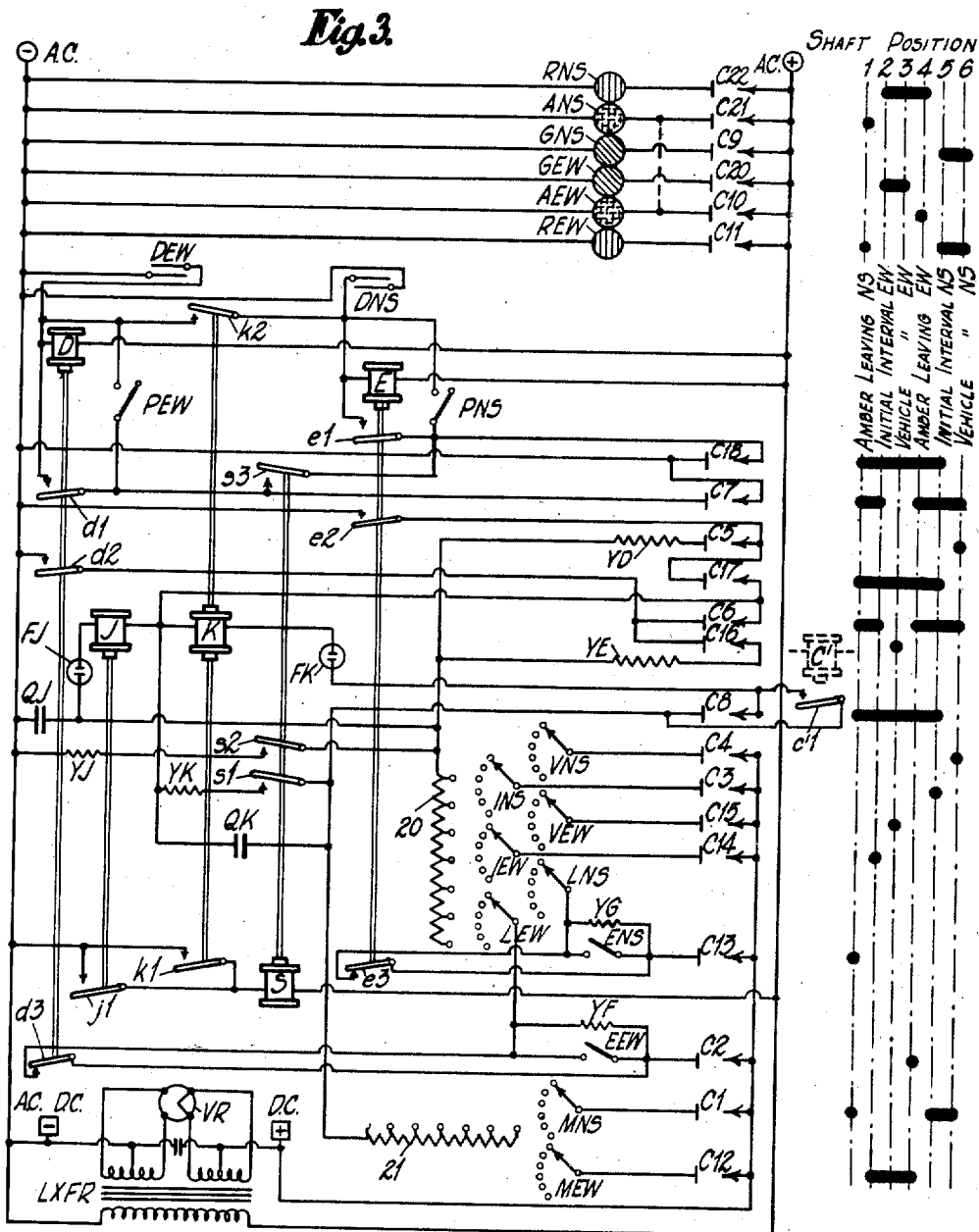
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STANDARD SIGNAL SEQUENCE G-A-R-R-G

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ELECTRICAL TIMING APPARATUS

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12 Claims. (Cl. 177—337)

The present invention relates to electrical timing arrangements for use with traffic control signals employed at road junctions or the like and more particularly systems employing controllers of the type in which the display of the signals is controlled by the traffic passing over the roads in question, for instance by means of contact-making pads let into the road surface. The invention moreover is particularly applicable to systems of the type in which the timing of the various intervals is effected by a condenser which is shunted by a neon lamp in series with a relay, the resistance of the charging circuit being adjustable so that the time taken for a condenser to charge to the striking voltage of the lamp may be varied.

A system illustrating one arrangement of this invention is disclosed in British specification No. 403,732 and portions of the specification describing this arrangement are included in the following material.

The system described in specification #403,732 relates to traffic control signals for use at road crossings or the like and is more particularly concerned with a progressive type traffic control system by means of which a number of controllers located at successive intersections at a main road may be regulated from a master controller in a certain phase relationship to each other, so that if the average speed of the traffic is known it is possible to time the control signals so as to ensure a substantially continuous flow of traffic along the main road. The arrangement moreover is particularly concerned with systems in which the operation of the signals may be controlled in accordance with the density of the traffic by the employment of vehicle detectors located in the roadway.

In such systems the actuation of vehicle detectors by traffic approaching a right of way signal is arranged to prolong the time of display of such signal, and the amount of such prolongation may be made to vary inversely as the speed of the actuating traffic. The system of the British specification referred to for example, employs the charging of an electric condenser to the flash voltage of a discharge tube for timing the right of way signal period and the speed variable prolongation of such period is obtained by partial discharge of the condenser by traffic actuation, the amount of such partial discharge from any degree of charge below the flash voltage being dependent on the time length of traffic actuation. Since the latter can be made substantially inversely proportional to the speed of actuating

traffic the amount of discharge also varies inversely in speed. The condenser discharge tube timer employed may be termed an electrostatic timer.

In this system the termination of the right of way period when the condenser is charged above the flash or threshold voltage of the discharge tube is controlled by traffic actuation on the crossing roadway when the latter does not have right of way, such crossing traffic actuation completing a circuit for discharge of the condenser through the discharge tube in case the condenser voltage is above the threshold value. The supply voltage for charging the condenser is considerably higher than the threshold voltage of the tube, so that in the absence of traffic actuation on both intersecting roadways for an appreciable time the voltage on the condenser will rise considerably above the threshold value. Under these circumstances it will be appreciated that actuation by a very fast vehicle approaching a right of way signal might not discharge the condenser below the threshold value and thus might not properly assure a prolongation of the right of way period.

The present invention provides an arrangement particularly adapted to electrostatic timers for causing substantially instantaneous discharge of the condenser to just below the threshold voltage in case the condenser has been charged above the threshold voltage when a prolonging actuation occurs. This rapid discharge is then cut off somewhat below the threshold voltage so that discharge below this point will be closely proportional inversely to the speed of traffic. It will be obvious to those skilled in the art that the invention is not limited to the specific type of electrostatic timer illustrated in this embodiment, but that other types of tubes might be used for example or other changes in the timing apparatus might be made within the scope of the invention.

Thus it is an object of this invention to provide in an electric timer employing the varying of charge on a condenser over a period of time to the threshold voltage operating value of a charge responsive device and having provision for partial reset of the charge on said condenser by momentary operation of a discharge circuit to prolong the time period of the timer, an arrangement for assuring reset of the charge on the condenser from any point above the threshold value at least down below such value on any resetting operation of the discharge circuit occurring when the charge on the condenser is above such threshold value.

It is also an object of the invention to provide a timing apparatus actuable for partial reset-

ting its time period in which any momentary actuation of any appreciable length will reset the timer to at least a minimum extent.

An additional object of the invention is to provide an improved form of timing apparatus for traffic control systems having an actuatable prolongation of signal display in which a minimum prolongation is assured for even very short momentary actuations and further prolongation is provided in proportion to the time length of actuation.

Referring to the drawings Figures 1, 2 and 3 show a traffic control system of the type described in British specification #403,732 to which this invention may be applied. Figure 1 shows a master control arrangement for controlling the timing phase relation of a plurality of local intersection traffic signal controllers. Figure 2 shows one form of local intersection controller in connection with a set of relays operated by the master controller. Figures 1 and 2 taken together show one form of master-local control arrangement as described in the British specification. Figure 3 shows a modification of the local controller of the general type in Figure 2, in which modification provision is made for operating the local controller by vehicle actuation. Figure 4 shows a modification of Figure 3 made in accordance with the invention. Figure 5 shows in compact form the essential elements of the timing arrangement illustrating the invention as taken from Figure 3 and including the modification shown in Figure 4.

The system shown in Figs. 1 and 2 does not make use of vehicle detectors to regulate the timing of the signals but its operation will be described in order to permit a proper understanding of the system illustrated in Fig. 3 in which vehicle detectors are employed.

It should be explained generally that the system illustrated in Figs. 1 and 2 comprises a master timer, from which separate pairs of conductors radiate to each controller for the purpose of regulating their time periods in relation to each other. The controllers in one embodiment may be conveniently arranged to operate at fixed time periods independent of the traffic flow, that is to say, there is no question of extending their normal period as a result of a continuous flow of traffic passing over a road contact or the like. These controllers will be set to operate at rather long periods, considerably in excess of that required in the progressive system, but the periods will be curtailed by the right amount upon the reception of so-called "light" and "heavy" pulses over the control leads from the master timer.

Referring now to the circuit shown, the system is arranged for operation from A. C. mains and suitable rectifying arrangements are provided for obtaining direct current to operate the relays and neon lamps. In the drawings the alternating current mains designated 10 and 11 are shown incoming from the left hand side of Fig. 1 and for the operation of the master timer a tapping is made from these leads by way of the fuses FUS and main switches MNS to the primary winding of the transformer XFR. This transformer is provided with three secondary windings two of which connect with the thermionic valve amplifier VLV which supplies direct current of the order of 400 volts to the terminals designated + and - in a circle, for the purpose of flashing the neon lamp N. The third winding on the secondary side of the transformer XFR con-

nects with the full wave metal rectifier bridge MRA which supplies direct current of the order of 50 volts to the terminal points marked + and - in a square, for the purpose of operating the relay F and the driving magnet DSM. Essentially the master timer comprises a rotary step-by-step switch DST of the type used in automatic telephone systems which is completely immersed in oil and arranged to be operated step by step from a neon lamp impulser, the speed of which may be altered, by varying the setting of the resistance switch 12 connected in series with the condenser QB.

As regards the automatic stepping circuit it should be explained that when the neon lamp N flashes as the result of the charging of the condenser QB to the required voltage, relay E is operated in series therewith, thereby at armature e1 operating relay F, and at armature e2 connecting negative potential to the wipers of the switch DST. Relay F on operating, at armature f2 completes the circuit for the driving magnet DSM, at armature f1 supplements the connection to the wipers of the switch DST, at armature f3 shunts the neon lamp N and relay E by way of resistance YB and at armature f4 flashes the master fail alarm lamp MFA. Relay E thereupon releases and upon the release of relay F after its slow period due to the copper slug on its core, the driving magnet is de-energized to advance the wipers on to the next set of bank contacts. This action continues automatically so long as the system is in service. One bank and wiper of the switch DST is allotted to each controller to be regulated and the control leads extend from the appropriate contacts in the associated bank. Bank 1a connects with controller No. 1 of which only the regulating relays have been shown in the dotted rectangle; this controller may be located adjacent to the master timer. Bank 2a connects with controller No. 2 shown in Fig. 2, and bank 3a connects with controller No. 3, which is not shown as it is assumed to be identical with controller No. 2.

In the drawings each control lead is shown as making two connections with its associated bank, one of which is direct and the other extends by way of a resistance. Consequently as the switch rotates so-called light and heavy pulses are delivered over the control leads to the respective controllers in turn.

The control leads may comprise light gauge wires, for example telephone lines, and terminate in the controllers on a pair of relays B and C shown in Fig. 2 connected in series, one of which is marginal. As a result of the operation of one or both of these relays from the light and heavy pulses the signal lights of the controller are regulated accordingly.

In this particular example the complete cycle time of the system is represented by 25 steps of the rotary switch DST in the master timer. Each step of the switch therefore represents 4% of the total cycle time so that by varying the connection of the control leads to the banks the phase relationship between the different sets of control signals may be adjusted to a very fine degree.

Each of the controllers, which are all identical, comprises essentially a battery of cams mounted on a common shaft and arranged to close contact springs in a particular order. As regards the No. 2 controller shown in Fig. 2 it should be explained that the cam shaft is rotated step by step under the control of a solenoid S

which is impulsed at predetermined time periods from a neon lamp timing device, comprising the lamp 1N and impulse relay A. The cam assembly is moreover, a standard unit which may be used in different circumstances and controls 22 spring sets with six different positions. The full number of cams is not employed in the present instance and the chart shown in Fig. 2 shows the effect of the various cams which are used in this particular arrangement. The cam contacts which are closed in each of the six positions are designated in the chart by a heavy black circle or line.

If it is assumed with regard to controller No. 2 that the cam shaft is in its first position, cam contacts C1, C9 and C22 will be operated, thereby lighting the green signal lamps GNS for the north-south road, and the red signal lamps REW for the east-west road, while at the same time over cam contacts C1, a circuit is complete from the valve rectifier 1VLV by way of a tapping on the common resistance 13 for charging the condenser QA. After the initial period of for example 10 seconds has elapsed, the condenser QA will be charged sufficiently to cause the neon lamp 1N to flash over, thereby operating relay A which at armature a1 energizes the solenoid S which advances the cam shaft into its second position. In this position, as will be evident from the chart, the signal lamps already lit are maintained and over cam springs C2 and the adjusting switch shown a charging circuit is again completed for the condenser. Four such adjusting switches are shown in the drawings and it should be explained that the terminals of these switches connect with suitable tapping points on the common resistance 13. To meet the requirements of the invention the resistance connected in circuit in this position must be very high to ensure that the condenser charges slowly, and for this reason the adjusting switch C2 in question is preferably turned round into its extreme position where it will be understood that it connects with the end of the common resistance shown.

During progressive working this particular timing circuit will have practically no effect on the operation of the controller since with the normal operation of the master timer a light pulse is delivered over the control leads before it becomes operative. As already explained this light pulse is obtained by including a high resistance in the pulse leads at the banks of the master timer, and as a result relay B only is operated in the controller, thereupon at its armature b1 in conjunction with the cam contacts C7 completing a low resistance charging circuit for the condenser QA. Almost immediately therefore the neon lamp 1N flashes and causes the controller to step to position 3. Non-inductive resistances are connected across the control leads as shown in order to guard against false operation owing to surges and inductive discharges.

In accordance with the change of the cam contacts, the green lights for the north-south road are now replaced with amber lights ANS, and over cam contacts C3 and the adjustable resistance switch a circuit is completed for the condenser QA to control the duration of the amber signal. With this arrangement although the phase of the amber signal may be changed when an adjustment is made in the cycle at the master timer, its actual duration remains constant since it is determined by the setting of the local ad-

justing switches and is not influenced by the relays connected to the control leads.

In case it should be desired to show the amber signal simultaneously to both roads, as is the requirement of certain administrations, this may be achieved by bridging the amber circuits by means of the strap 14 shown dotted in the drawings. After the duration of the amber warning period the solenoid S again operates to step the cam shaft to position 4 and the control signals are then completely reversed while over cam springs C4 a charging circuit is completed for the condenser QA which provides an initial timing period of 10 seconds for the east-west road. When this period has elapsed, the solenoid S steps the cam shaft to position 5 and although the signals previously showing are retained, the charging circuit for the condenser QA is completed by way of the very high resistance as a result of the adjusting switch associated with cam contacts C5 being turned into an extreme position.

Here again this second comparatively long time period has practically no effect upon the controller during normal progressive operation since a heavy pulse will be received from the master timer meanwhile, which results in the operation of both relays B and C, and the latter at armature c1 in conjunction with the cam contacts C18 steps the cam shaft into its final position 6. In this manner the controllers are stepped progressively depending on the connections to the banks of the timing switch, and providing the master timer is functioning correctly, the time periods of their "stop" and "go" signals will be directly regulated therefrom.

If however for any reason the master timer should fall in such a manner that no further impulses are delivered over the control leads, the individual controllers will continue to function satisfactorily at somewhat longer time intervals as a result of the charging circuits completed over the cam contacts C2 and C5. Moreover in case a particular line fault on the control conductors should maintain operated one or both of the signal relays at the controller, the latter will continue to function at somewhat shorter time intervals as determined by the initial timing circuit completed over cam contacts C1 and C4.

In addition to the normal operation of the system and the necessary safeguard against failure, it is also possible to provide special features such as for example causing all controllers to show a red signal to all approaches thereby effecting a complete hold up of the traffic. This condition may be brought about instantaneously from the master timer by the operation of the manual switch which closes the contact marked ARS in the drawings, thereby connecting potential to a common wire 15 extending to all controllers which results in the operation of a relay AR in each. Relay AR at armature ar1 disconnects the operating circuit for the controller which is thus brought to rest in the position to which it is set, at armature ar2 opens the circuit of the green and amber signal lamps and at armature ar3 bridges the circuit of the red signal lamps so that both sets are lighted. It will be appreciated from a consideration of the chart that in all positions of the controller one or other of the red signals will be showing and therefore, the connection described will be effective no matter in what position the controller is brought to rest.

For the purpose of switching the controllers on and off a further common wire 16 is provided which connects with the switch contact CSS3 at the master point and a relay CS in each controller. The operation of the manual switch to a second position disconnects the master timer insofar as its control function is concerned by opening the circuit to the valve rectifier VLV at springs CSS1 and CSS2, and at springs CSS3 connects potential to the common lead 16 to operate a relay CS in all controllers, which thereupon at armatures c1 disconnect the respective controllers from the alternating current mains. This method of control is preferred to the alternative, whereby the relay is operated to connect up the controller since a failure at the master timer might then result in the individual controllers becoming disconnected. In a further position of the manual switch springs CSS1 and CSS2 are opened but springs CSS3 are not closed. In these circumstances the master controller no longer sends pulses but the individual controllers are not switched off and continue to operate independently.

Arrangements are also provided by means of a special manual switch at each controller whereby the all red feature may be brought into action at that particular point only. When this manual key is operated, the springs ARS1 and ARS2 are actuated, thereby disconnecting the circuit for the green and amber signal lamps and also connecting together the red signal lamps so that both sets show simultaneously regardless of the position of the controller.

In case it should become necessary under certain circumstances for a particular controller to be operated manually, the required circuit changes are brought about by the operation of a further key which actuates the springs MAN1 and MAN2 to disconnect the timing circuit of the controller and also connects the solenoid S in circuit with a push button PB. The operation of the push button by the officer in charge causes the controller to step through its cycle and any desired time periods may be allowed.

As already explained, a supervisory lamp MFA is provided which is located in a conspicuous position at the master timer and arranged to flash in synchronism with the stepping switch. Any abnormal condition such as the blowing of the main fuse or failure of the neon lamp will be indicated by the failure of the supervisory lamp to light.

In case the master timer is switched on at a time when certain of the controllers are out of phase, the correct phase setting between each will be restored when the stepping switch in the master timer has made one complete revolution.

Considering now the arrangement of another embodiment of the controller illustrated in Figure 3, this represents the equipment at an individual controller which is intended to perform similar functions to that illustrated in Fig. 2, but is designed for actuation by traffic. It will be appreciated however that the current supply arrangements are shown somewhat differently and also that where complete remote control of the corresponding functions is desired relays such as CS, AR and C will still be required to respond to signals from the master controller. In this illustration relays CS and AR are omitted and the master controller need send only one control impulse per cycle which operates relay C' corresponding to relay C in Fig. 2. The controller of

Fig. 3 is of the same mechanical construction as

that illustrated in Fig. 2, that is to say, it is provided with a number of sets of contacts operated by a cam shaft which is moved step by step by means of a solenoid. Moreover, the stepping of the solenoid is again controlled from a timing circuit employing a neon lamp condenser combination but in this case the timing is variable under the control of vehicle detectors located in the roadway. Moreover, two separate timing circuits are employed and two road relays are provided which respond to the passage of vehicles over the detectors. In view of the description which has already been given it will not be necessary to describe in considerable detail the working of the apparatus illustrated in Fig. 3 but the more salient features of operation will be considered briefly.

The current supply is assumed to be taken from alternating current mains and is rectified to provide direct current for the operation of the neon lamps. The transformer LXFR feeds the valve rectifier VR and also supplies alternating current of a suitably reduced voltage for the operation of the road relays. The live pole of the A. C. circuits is represented by a plus in a circle, the live pole of the D. C. circuits by a plus in a square and the common earthed pole by a minus in a circle and a square. The chart shows as before the positions of the cam shaft in which the various cam contacts are closed. The various interval adjusting switches INS, VNS, IEW, VEW, LNS, LEW are wired to appropriate tapping points of the resistance 20, and similarly the switches MNS and MEW are wired to resistance 21 which gives tapings of higher value.

For convenience of description it will be assumed first of all that the cam shaft is standing in position 6 giving right of way to the street NS and that there is no traffic on either street. In these circumstances a charging circuit is completed over contacts C4 and the adjusting switch VNS for the condenser QJ, but owing to the fact that neither relay D nor relay E is operated, it is impossible for discharge to take place through the neon lamp FJ when the condenser becomes charged to the striking voltage. However, no charging circuit is completed at this time for the condenser QK even should the armature c'1 be operated due to the receipt of a pulse from the master timer.

Suppose now that a vehicle arrives on the road EW, relay D will be energized due to the operation of a detector DEW and since contacts C6 are closed, a circuit is completed over armature d2 and contacts C6 for striking lamp FJ so that relay J is energized and the solenoid is operated at armature j1 and the cam shaft is moved to position 1. In this position the lamp ANS is lighted in place of GNS and lamp AEW is lighted in addition to lamp REW if the dotted connection is used. Moreover, a new charging circuit is completed for condenser QJ over cam contacts C13, the adjusting switch LNS and the appropriate charging resistance. Relay D moreover was locked up over armature d1 and contacts C7 so that as soon as the condenser QJ has been charged sufficiently, which will occur after a few seconds only, relay J is again operated and advances the cam shaft to position 2. In this position lamps GEW and RNS only are lighted and the vehicle in the street EW secures right of way. Furthermore a new charging circuit is now completed for condenser QJ, this time over contact C14 and switch IEW. Consequently, after the

period corresponding to the resistance now included in the charging circuit, relay J is again operated and the solenoid steps the cam shaft to position 3. This produces no change in the lights but the charging circuit for condenser QJ now extends over contact C15 and the switch VEW and moreover relay D is de-energized by the opening of contacts C7 while owing to the closure of contact C16 a circuit is prepared for shunting condenser QJ. If there is no further traffic, right of way will remain on the EW road and the condenser QJ will become fully charged.

If further vehicles arrive on the EW road however relay D is again operated and shunts the condenser by way of the comparatively low resistance YE, cam contacts C16 and armature d2 and thus extends the time which will be required for the condenser to be charged to the striking voltage of the lamp FJ. It may be pointed out that since in these circumstances relay D is only operated while the vehicle is actually passing over the detector pad, the amount of extension obtained is dependent on the speed of the vehicle, being greater for a slow moving vehicle than for a fast moving one.

If now a vehicle should arrive on the road NS, relay E will be operated and locked and contacts C17 will complete a circuit for effecting the operation of relay J as soon as condenser QJ is sufficiently charged. Hence, if a break of sufficient length to permit the striking voltage of the neon lamp FJ to be reached occurs in the traffic on the road EW, relay J will be operated and will advance the cam shaft to positions 4, 5, and 6 in turn in the manner to be described to give right of way to the road NS.

In case, however, the traffic on the road EW should be substantially continuous, that is to say, there should be no break sufficiently long to permit condenser QJ to charge up, the maximum timing circuit involving the condenser QK comes into operation. It will be noted that this circuit comes into operation as soon as there is a waiting vehicle on the road NS at which time relay E is operated and locks up over contacts C18. The charging circuit for condenser QK now extends over contacts C12 and the switch MEW condenser QK, thence over cam contacts C17 and armature e2 by means of which a resistance 21 is connected in circuit which will permit the condenser QK to charge up only after an interval considerably greater than that required for the charging of condenser QJ.

In position 4 of the cam shaft cams C10 and C22 are operated to display NS red and EW amber signal. A charging circuit over cam contacts C2, adjusting switch EEW and the appropriate charging resistance builds up the charge on condenser QJ to the striking voltage or threshold conducting E. M. F. of the lamp FJ. The momentary current flowing thru the lamp FJ energizes relay J which at armature j1 completes a circuit to operate solenoid S, which advances the cam shaft to position 5.

In positions 5 and 6 lamps GNS and REW are lighted to accord right of way to NS traffic. The charging circuit for condenser QJ in position 5 is completed over cam contacts C3 and switch INS. After the period corresponding to the resistance now included in the charging circuit has elapsed, relay J is again operated and the solenoid advances the cam shaft to position 6, the NS vehicle interval, thus completing one cycle of the cam shaft.

In position 6 relay E is not held energized by

the circuit over cam contacts C18 which are open at this time, accordingly additional actuations of detector DNS operate relay E only while the vehicle is actually passing over the detector pad. Operation of relay E at armature e2 completes a circuit over cam contacts C5, low resistance YD to shunt the condenser QJ, and thus extends the time which will be required for the condenser QJ to be charged to the striking voltage of the lamp FJ. Upon an actuation of the detector DEW in position 6 the maximum timing circuit involving condenser QK becomes effective as it did in similar fashion upon actuation of detector DNS in position 3 to prevent the street having right of way from holding right of way more than a predetermined period against a vehicle waiting on the other street. The charging circuit for condenser QK extends over contacts C1, switch MNS, resistance 21, condenser QK, contacts C6, and armature d2. The cycle of operation described repeats itself in accordance with traffic conditions as pointed out.

It is assumed in the present case that the road NS is the main road extending through the various intersections and it will be seen from the fact that cam contacts C8 are only opened in position 6 that if there should be a continuous stream of traffic coming from the road EW, that is the side road, during the EW right of way period, cam shaft positions 2 and 3, the main road will receive right of way as soon as the condenser QK becomes sufficiently charged in position 3. This transfer will take place because relay K which also operates the solenoid S over armature k1 has its operating circuit completed over contacts C8 in position 3 of the cam shaft. In the case, however, of continuous traffic on the main road, that is NS, in the NS right of way period, with traffic waiting on the side road EW, even though the condenser QK becomes sufficiently charged it is impossible for it to discharge through relay K and neon lamp FK until the instant at which a pulse is received from the master timer to energize relay C1 and operate armature c1. Accordingly if the traffic on the main road is substantially continuous so that the individual controllers are working on their maximum periods, the actual instants at which the various controllers withdraw right of way from the main road are controlled by the master controller and thus may be adjusted in phase to permit main road traffic to proceed with the minimum delay.

It will be noted that armatures d3 and e3 when operated serve to include resistances YF and YG in their respective amber timing circuits so that when right of way is being forcibly removed an additional amber period is given to facilitate clearing the crossing. Similar control may be obtained by means of the manual amber extension switches ENS, EEW.

The switches PNS and PEW are so-called arterial switches and when operated ensure that right of way shall return to the associated street in the absence of traffic thereon. Their effect is to simulate the operation of the pads at a time when the street in question is not receiving right of way, though they do not produce any extension effect when the street already has right of way.

For example if switch PEW is closed relay D will be energized by a circuit over switch PEW, cam contacts C7 to minus which circuit will be completed in all the positions in which cam contacts C7 are closed; viz., all cam shaft positions

except the EW vehicle interval, position 3. In position 3 relay D will be operated by detector DEW actuations only, and in the manner described when switch PEW is not closed. Similarly, when PNS is closed, relay E is energized by a circuit over switch PNS and cam contacts C18 to minus in all cam shaft positions except the NS vehicle interval in which contacts C18 are open. Accordingly one or the other of switches PNS and PEW may be placed in the closed position as desired to energize the corresponding detector relay in all positions except its vehicle interval so as to return right of way to its respective street, but produce no right of way extension.

The solenoid S is provided with three sets of contact springs of which s1 and s2 serve to shunt condensers QJ and QK by low resistances YJ and YK respectively. (Springs s3 are effective in conjunction with armature k2 to ensure that without any further operation of the associated detector right of way shall be returned to the street from which it has been forcibly removed.)

It will be understood that the master timer and associated control relays are operated continuously so that relay C1 in each individual controller is operated once each cycle. This operation only produces any effect however if the traffic on the main road is so heavy as to run the controllers up to their maximum timing periods.

It was a feature of the system described above that the time intervals could be extended beyond their initial periods in accordance with the volume of traffic passing over the road pads. This was achieved by arranging for the road pads when operated to shunt the condenser by way of a resistance thereby producing a partial discharge of the condenser and a corresponding increase in the time taken for it to attain the striking voltage of the lamp. Since the length of time the road pad remains operated is inversely proportional to the speed of the vehicle, it follows that the degree of discharge of the condenser and hence the time which the interval is extended will be commensurate with that speed.

The operation of this timing arrangement will be better appreciated by reference to Fig. 3 of the drawings. It will be appreciated that if right of way has remained with one of the roads for an appreciable time, and in the absence of traffic on any of the roads, the condenser QJ will be charged to the full voltage of the supply, which is assumed to be of the order of 400 volts. If now the road EW has right of way and a vehicle crosses one of the associated road pads DEW the corresponding road relay D will be operated to bring about the shunting of the condenser QJ by way of the resistance YE which is of the order of 2000 ohms. Almost instantaneously the voltage across the condenser QA is lowered below 260 volts which is assumed to be the striking voltage, or threshold EMF for conduction, (i. e. the voltage at which the lamp begins to be conducting) of the neon lamp FJ, thereby ensuring an extension of the right of way interval since the lamp FJ cannot strike immediately if relay E is now operated due to the presence of a vehicle on the road NS. If the vehicle is moving at a slow speed, the discharge of the condenser will continue for an appreciable period until the wheels leave the road pad so that the extension may be commensurate with the speed.

It has been assumed in the design of the equipment under consideration that the maximum

speed at which a vehicle will ever pass the crossing will be in the neighborhood of 60 miles an hour, and the value of the discharge resistance YE has been suitably chosen to enable the condenser to be discharged just below 260 volts by a vehicle travelling at this speed.

In these circumstances the rate of discharge of the condenser is fairly constant for vehicle speeds from 60 down to about 30 miles an hour, but for speeds below 30 miles an hour the rate of discharge falls off appreciably or in other words the characteristic curve departs more and more from a straight line.

In general the speed at which vehicles will pass the crossing will probably be below 25 miles an hour, and since as has been shown the rate of discharge is rapidly falling off for such speeds the difference in reduction of potential across the condenser for speeds of 30 miles an hour and 5 miles an hour will not be nearly so great as the difference in the reduction in potential for speeds of 55 miles an hour and 30 miles an hour. In other words the variation of the interval extension with speed is not so sensitive for vehicles travelling at average speed as for vehicles travelling at high speed, and since the latter are without doubt the exception, the arrangement could with advantage be transposed.

The most obvious way to obtain an improvement is to increase the value of resistance YE considerably, for example, up to 8000 ohms, which has the effect of altering the shape of the curve so that the average speed range is shifted on to the straight portion into somewhat the position previously occupied by the high speed range. This expedient has the disadvantage however of displacing the high speed range to such an extent that vehicles travelling at speeds above about 30 miles an hour are unable to discharge the condenser below the striking voltage 260, and consequently they are unable to produce an extension of the time interval.

To overcome this disadvantage it is necessary to provide some means which will enable the high speed vehicles to discharge the condenser to just below the critical voltage of 260 regardless of their speed, so that in effect all the vehicles in the high speed range will receive a fixed extension which will be suitably chosen so as to be adequate for the slowest vehicles in this range. It is important however to ensure that the means which brings about the instantaneous discharge of the condenser to a fixed voltage will cease to be operative when that voltage has been attained, since otherwise it will interfere with the operation of the average speed extension arrangements.

According to the invention this is achieved by connecting a gas discharge tube in parallel with the 8000 ohm discharge resistance, the characteristics of the tube being such that it will cease to glow at a voltage just below 260 volts. This arrangement is shown in the Fig. 4 which represents the application of the invention to Fig. 3 of the drawings the additional lamps FD and FE employed according to the invention being connected across the resistances YD and YE respectively. Operation of the device embodying the invention will be the same as operation of the controller of Figure 3 except in the vehicle interval positions. Assuming for example, then, that the camshaft is in the EW vehicle interval position 3 cams C18 and C17 are closed and if there has been no traffic for some time condenser QJ will be charged to the full voltage of about

400. If a vehicle now arrives on the EW road, relay D will operate, and the lamp FE will immediately strike and reduce the potential across the condenser to its extinguishing voltage whereupon the lamp ceases to pass current. If relay D remains operated for a longer time because the vehicle is slow moving, further discharge of the condenser will take place through the resistance YE in the usual way. Similarly in the NS vehicle interval position 6, if condenser QJ is charged nearly to the full voltage a NS vehicle actuation causing operation of relay E immediately causes the tube FD to strike and if this actuation continues for any appreciable time further discharge of condenser QJ thru resistance YD is produced in the usual way. It is desirable that the extinguishing voltage of the lamps FD and FE should be appreciably below the striking voltage of the lamp FJ in order that even a very fast moving vehicle which actuates the detector for a short time will discharge the condenser below the striking voltage of the lamp FJ.

In case it should be necessary to control the rapid discharge of the condenser to the fixed voltage an adjustable resistance could conveniently be connected in series with the lamp with known results.

Summarizing briefly the operation of the tubes or lamps FD and FE, with particular reference to Fig. 4, in conjunction with the tube FJ, it will be understood that the striking voltage or threshold E. M. F. of FD and FE is higher than that of FJ, and the cut-off E. M. F. of FD and FE is somewhat below the striking voltage of FJ. When the right of way is on the NS street, condenser QJ cooperates with tube FJ to time the minimum period. Condenser QJ is of course subject to resetting, in the building up of its charge, by NS vehicles operating relay E to shunt QJ with low resistance YD over contacts C5 and armature e². Since FD has a high threshold value it is not operative unless the charge on the condenser rises above this high threshold value. At the end of the minimum period if relay E has not been operated by NS vehicles and if relay D has been operated by an approaching EW vehicle, the circuit thru tube FJ and relay J shunting condenser QJ will be completed at armature d2 and the tube and relay J will be operated by the condenser charge to advance the camshaft to its next position. If no EW vehicle has arrived by the end of this minimum period, however, the shunt circuit thru the tube FJ will remain open, the charge on QJ rising above the threshold E. M. F. of FJ toward line voltage in the absence of NS vehicle actuation. If a NS vehicle now causes armature e2 momentarily to shunt QJ over contacts C5, resistance YD and tube FD, the charge on QJ will immediately cause FD to flash and the charge on QJ will be lowered to the value at which FD is no longer conducting, which is a value under the threshold potential of tube FJ. Consequently such a NS vehicle will have time to cross the intersection before FJ can strike if d2 should be closed by an EW vehicle at this time. Should the NS actuation energizing relay E be of any appreciable length so that e2 is still closed after FD has extinguished, discharge of condenser QJ below this value takes place thru resistance YD in the usual way.

It will be understood that many changes in the construction and arrangement of the parts of the apparatus and substitution of equivalent elements might be made in the present embodiment

of the invention without departing from the spirit of the invention as defined by the claims.

Having described my invention what I claim as new and desire to secure by Letters Patent is:

1. In an electrical timing apparatus having a condenser, a charging circuit including a resistance, a particular potential responsive device and switch connected in series and both across said condenser, the time period of said apparatus being determined by the time required to charge the condenser to the particular potential through the resistance, the combination of a discharge circuit including means for effecting closure of the last said circuit across said condenser and also including a gas discharge tube having a minimum potential below which conduction through the tube ceases, said minimum potential being below said particular potential whereby upon such closure of the discharge circuit across the condenser when the condenser potential is above said minimum potential a rapid discharge of the condenser to the minimum potential is secured so that for very short variable periods of closure of the discharge circuit the time required to charge the condenser to the particular potential after any such periods of closure shall be approximately constant.

2. In an electrical timing apparatus having a condenser, a charging circuit including a resistance, a particular potential responsive device and switch connected in series and both across said condenser, the time period of said apparatus being determined by the time required to charge the condenser to the particular potential through the resistance, a discharge circuit including closure means for connecting the last said circuit across said condenser and also including a gas discharge tube having a minimum potential below which conduction through the tube ceases, said minimum potential being below said particular potential, and a resistance in parallel with the discharge tube for effecting further discharge of the condenser when the discharge circuit remains closed after the condenser has been discharged to said minimum potential.

3. In an electrical timing apparatus having a condenser, a charging circuit including a resistance, a particular potential responsive device and switch connected in series and both across said condenser, the time period of said apparatus being determined by the time required to charge the condenser to the particular potential through the resistance, the combination of a discharge circuit including means for connecting the last said circuit across said condenser and also including a gas discharge tube having a minimum potential below which conduction through the tube ceases, said minimum potential being below said particular potential, and a high resistance in parallel with the discharge tube for effecting further discharge of the condenser at a slower rate when the discharge circuit remains closed after the condenser has been discharged to said minimum potential.

4. In an electrical timing apparatus having a condenser, a charging circuit including a resistance, a particular potential responsive device and switch connected in series and both across said condenser, the time period of said apparatus being determined by the time required to charge the condenser to the particular potential through the resistance, the combination of a discharge circuit including closure means for connecting the last said circuit across said condenser and also including a gas discharge tube having a minimum

potential below which conduction through the tube ceases, said minimum potential being below said particular potential, and a resistance in parallel with the discharge tube for effecting further discharge of the condenser when the discharge circuit remains closed after the condenser has been discharged to said minimum potential, the value of said last named resistance being such that further discharge will be approximately proportional to the length of the discharge circuit closure interval.

5. An electrical timing apparatus comprising a source of E. M. F., a condenser and a high resistance connected in series, a gas discharge tube having a threshold E. M. F. value for conduction less than said source, a switch and a relay all connected in series and across said condenser, a control circuit including a lower resistance and a second discharge tube in parallel with said lower resistance, said second tube having a threshold conducting E. M. F. value greater than the first tube, and means for connecting said control circuit across said condenser.

6. An electrical timing apparatus comprising a source of E. M. F., a condenser and a high resistance connected in series, a gas discharge tube having a threshold E. M. F. value for conduction less than said source, a switch and a relay all connected in series and across said condenser, a control circuit including a lower resistance and a second discharge tube in parallel with said lower resistance, said second tube having a threshold conducting E. M. F. value greater than the first and having a minimum E. M. F. for cessation of conduction lower than the threshold E. M. F. of the first tube, and means for connecting said control circuit across said condenser.

7. An electrical timing apparatus comprising a source of E. M. F., a condenser and high resistance connected in series and to said source so as to vary the E. M. F. on said condenser over a period of time, a gas discharge tube having a threshold E. M. F. value for conduction less than said source and a relay connected in series, a switch for alternatively connecting said tube and relay across said condenser and disconnecting the same from said condenser, said tube and relay being operated when so connected by said switch when the E. M. F. on said condenser reaches said threshold value and being unoperated to permit the E. M. F. on said condenser to exceed said threshold value when disconnected by said switch, a control circuit including a lower resistance and a second discharge tube in parallel with said lower resistance, said second tube having a threshold conducting E. M. F. value greater than the first tube and a minimum E. M. F. value for cessation of conduction somewhat lower than the threshold E. M. F. of said first tube, and means for alternatively connecting said control circuit in shunt with said condenser and disconnecting the same therefrom, whereby the time required for the E. M. F. on said condenser and said first tube connected therewith to reach the threshold value of said first tube so that said first tube will pass current to operate the relay will be varied in accordance with the proportions of time that the last named connecting means connects and disconnects said control circuit.

8. A timing apparatus comprising a source of E. M. F., a high resistance and a condenser in series, a gas discharge tube having a predetermined threshold E. M. F. value for conduction, a relay and a control switch in series with said tube and all in shunt across said condenser, said

control switch having an open and closed position and in its closed position completing a circuit for the discharge of the condenser through the tube to operate the relay when the threshold E. M. F. is reached and in its open position maintaining such circuit open so as to permit the condenser E. M. F. to rise above the threshold E. M. F. without operation of the tube and relay, and a discharge circuit including a second switch and a lower resistance in series across the condenser and also including a means operable only upon the closure of said second switch when the condenser is charged above the threshold E. M. F. to discharge the condenser very rapidly to a point below the threshold E. M. F.

9. An electrical timing apparatus comprising a source of E. M. F., a condenser and a high resistance connected in series, a discharge tube having a threshold E. M. F. for conduction and a relay and a control switch connected in series and across the condenser, and a discharge circuit including means operable only when the condenser potential is above the threshold E. M. F. and said switch is open to reset the condenser potential to a point below the threshold E. M. F. substantially instantaneously upon closure of the discharge circuit, and further means effective only when the condenser potential is below said threshold E. M. F. to discharge the condenser below said threshold E. M. F. to an extent approximately proportional to the length of the discharge circuit closure interval.

10. In a traffic signal system having a traffic actuable means, a right of way signal to be displayed for the control of traffic and means for timing the period of display of said signal; the last said means comprising timing apparatus including a condenser, a circuit for charging said condenser to time the period of signal display, a circuit including a discharge tube having a threshold E. M. F. for conduction, means including a relay operable to terminate such signal display and a control switch, said tube, relay and switch all connected in series across the condenser, and a condenser discharge circuit including a second discharge tube having a threshold E. M. F. greater than the first tube, a resistance in parallel with said second tube, and a second control switch in series with said second tube and its parallel resistance, said discharge circuit connected in shunt with said condenser, said traffic actuable means connected for operating said second control switch so as to produce a partial discharge of the condenser upon traffic actuation and thus extending the signal display period until said condenser has again become charged to the threshold E. M. F. of the first tube, said second discharge tube assuring that momentary actuation by traffic will discharge said condenser below the threshold E. M. F. of the first discharge tube in event that said condenser is charged to a higher E. M. F. when the first mentioned control switch is open.

11. In a traffic control system including a traffic actuable means, a right of way signal and means for timing the period of display of said right of way signal; the last said means comprising timing apparatus including a source of E. M. F., a condenser and a high resistance connected in series, a discharge tube having a threshold E. M. F. for conduction and a relay and a switch connected in series and across said condenser, and a discharge circuit including a lower resistance and a control switch in series and a second discharge tube in parallel with said

lower resistance, said second tube having a threshold E. M. F. greater than the first, said discharge circuit being connectable across the condenser by operation of said control switch which
5 is operated by actuation of the traffic actuatable means.

12. In a traffic signal system for intersecting traffic lanes having right of way signals and traffic actuatable means for each of the intersecting lanes, and a timing apparatus connected to
10 said signals and to said traffic actuatable means for causing the display of said right of way signals for time periods for the control of traffic, the traffic actuatable means in one lane acting during
15 the right of way period of the other lane to cause transfer of right of way from such other lane to said one lane by said timing apparatus at the end of a time period, and the traffic actuatable means in the other lane acting upon actuation
20 during said right of way period of said other lane to prolong such period to delay such transfer; said timing apparatus including a source of E. M. F., a

condenser and a high resistance connected in series, a time interval terminating circuit including a discharge tube having a threshold E. M. F. for conduction, means including a relay for
5 terminating the right of way signal period for said other lane and a normally open switch operated by the traffic actuatable means in said one lane, said tube, relay and switch all connected in series across said condenser, and a discharge
10 circuit including a lower resistance and a control switch in series, said control switch operated by the traffic actuatable means in said other lane, and a second discharge tube in parallel with said
15 lower resistance, said second tube having a threshold E. M. F. greater than the first tube, said discharge circuit being connectable across said condenser to discharge the same and thus extend
20 the right of way period in said other lane by operation of the control switch which is operated by actuation of the traffic actuatable means of said other lane.

THOMAS PHILIP PREIST.

CERTIFICATE OF CORRECTION.

Patent No. 2,088,723.

August 3, 1937.

THOMAS PHILIP PREIST.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 69, after "and" insert the words thereupon solenoid S; page 5, first column, line 57, for "switch EEW" read switch LEW; page 7, first column, line 41, for "armature e²" read armature e2; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of December, A. D. 1937.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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10 circuit including a lower resistance and a control switch in series, said control switch operated by the traffic actuatable means in said other lane, and a second discharge tube in parallel with said
15 lower resistance, said second tube having a threshold E. M. F. greater than the first tube, said discharge circuit being connectable across said condenser to discharge the same and thus extend
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