April 7, 1964 J. L. BARKER 3,128,446

TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 1

Fig. 1

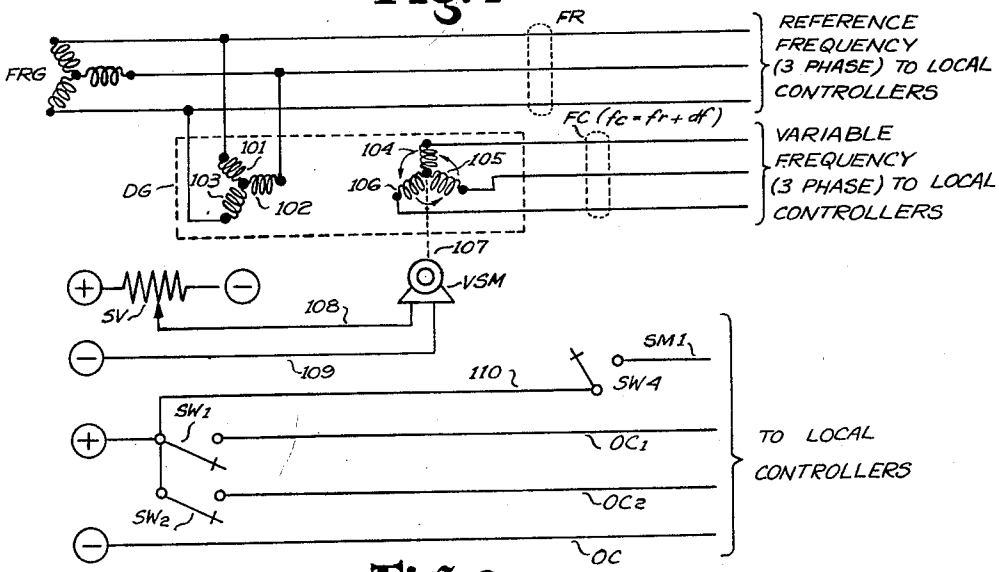


Fig. 2

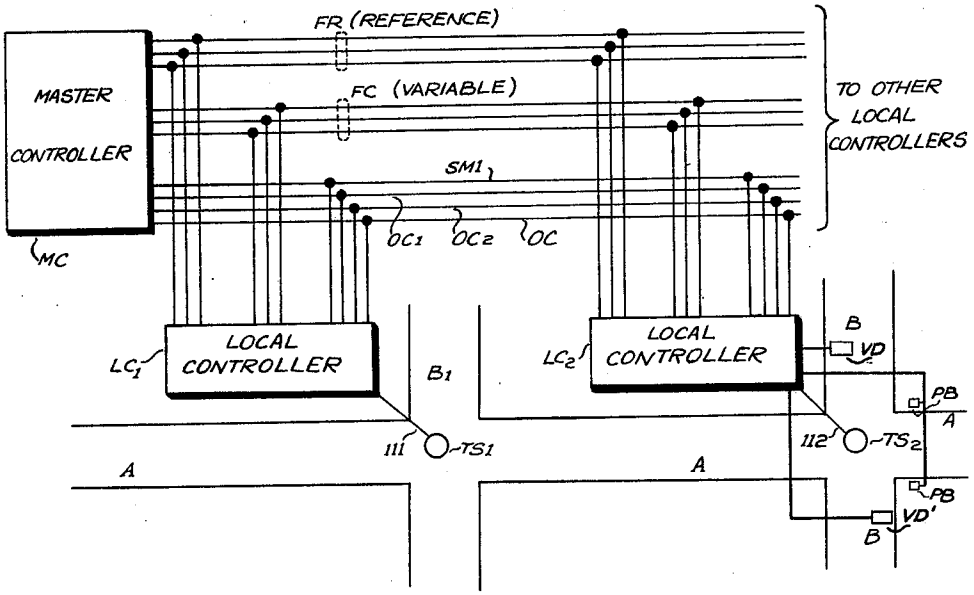


Fig. 4a	Fig. 4b
Fig. 4c	Fig. 4d

Fig. 5

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April 7, 1964 J. L. BARKER 3,128,446

TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 2

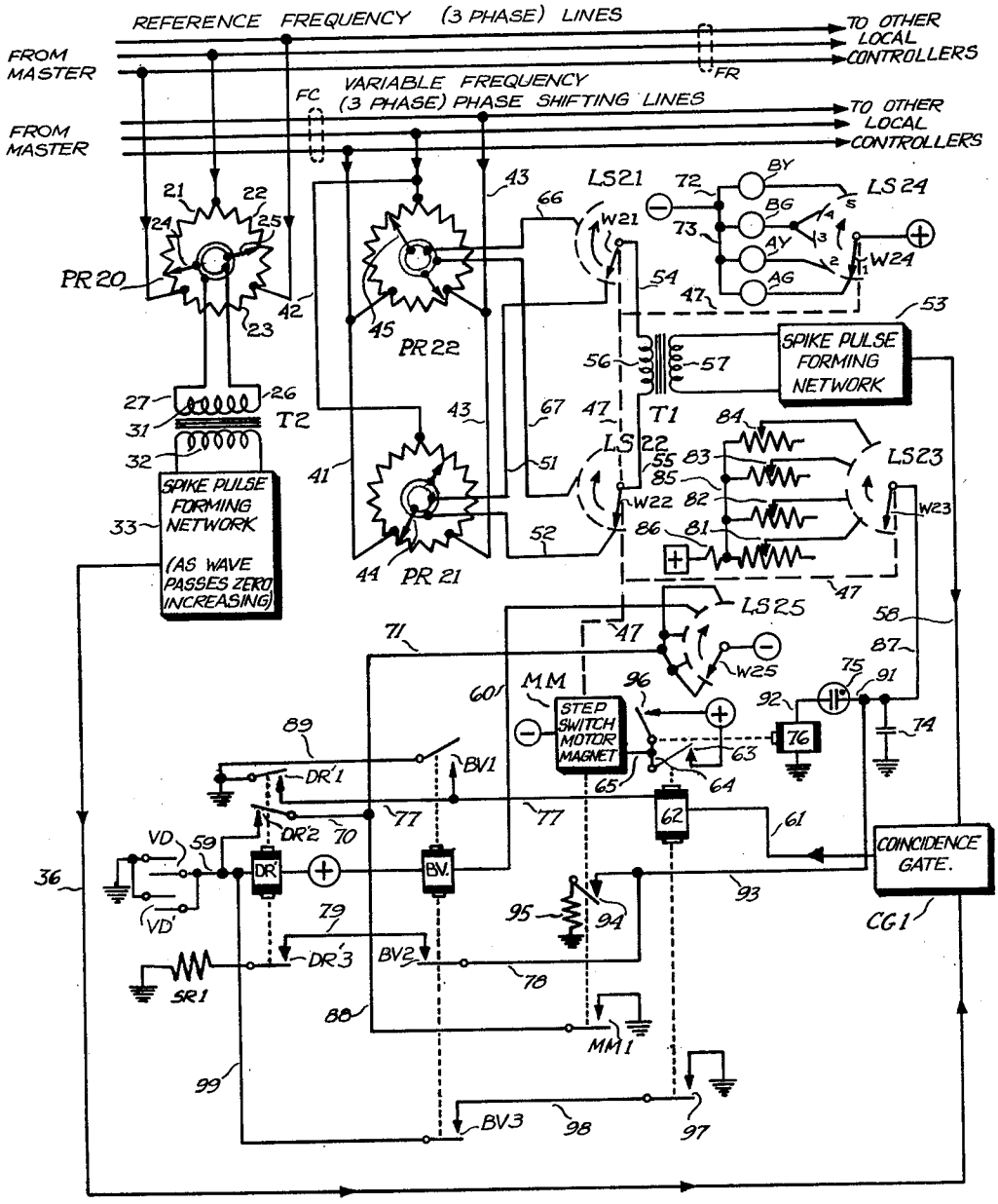


Fig. 3.

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TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 3

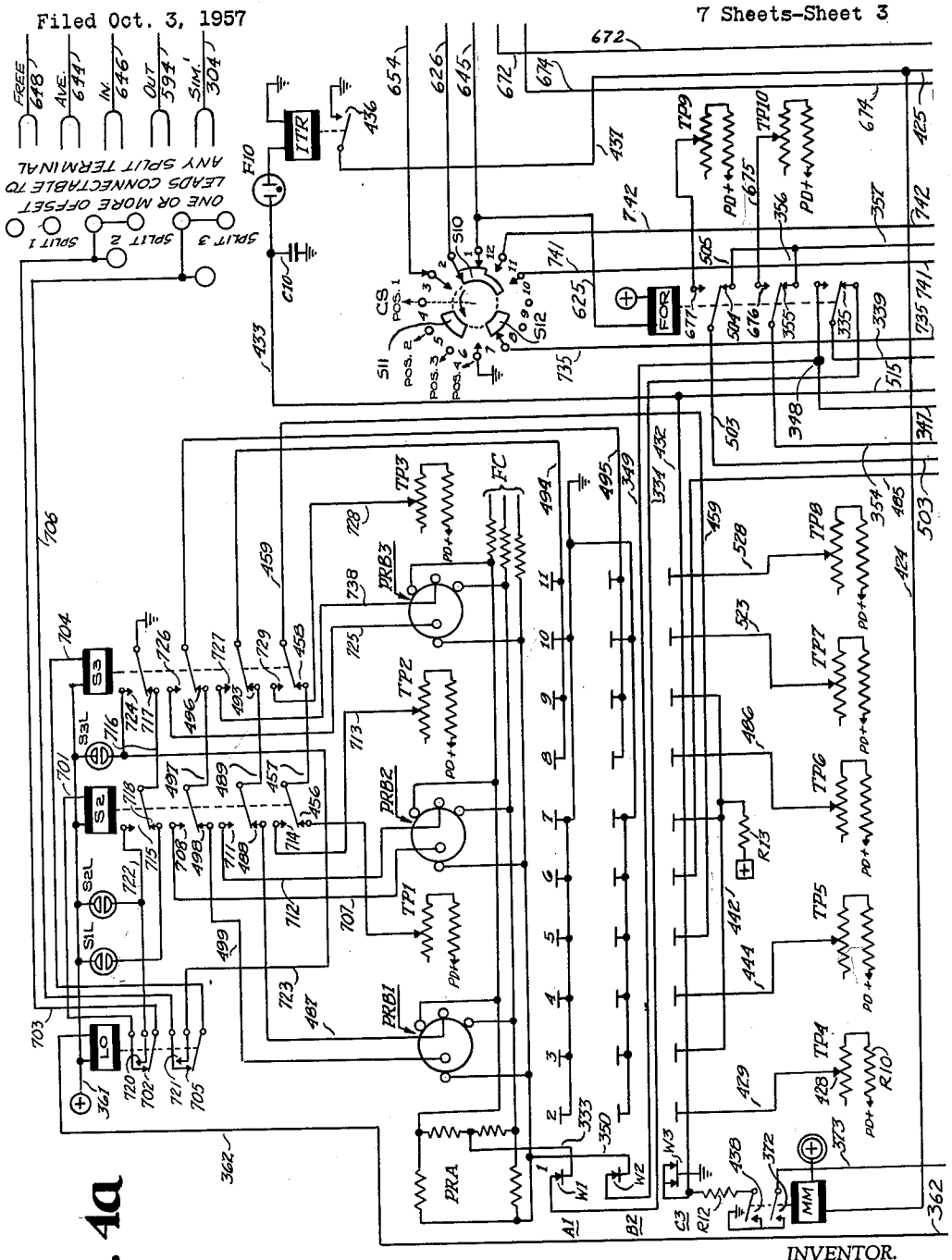


Fig. 4a

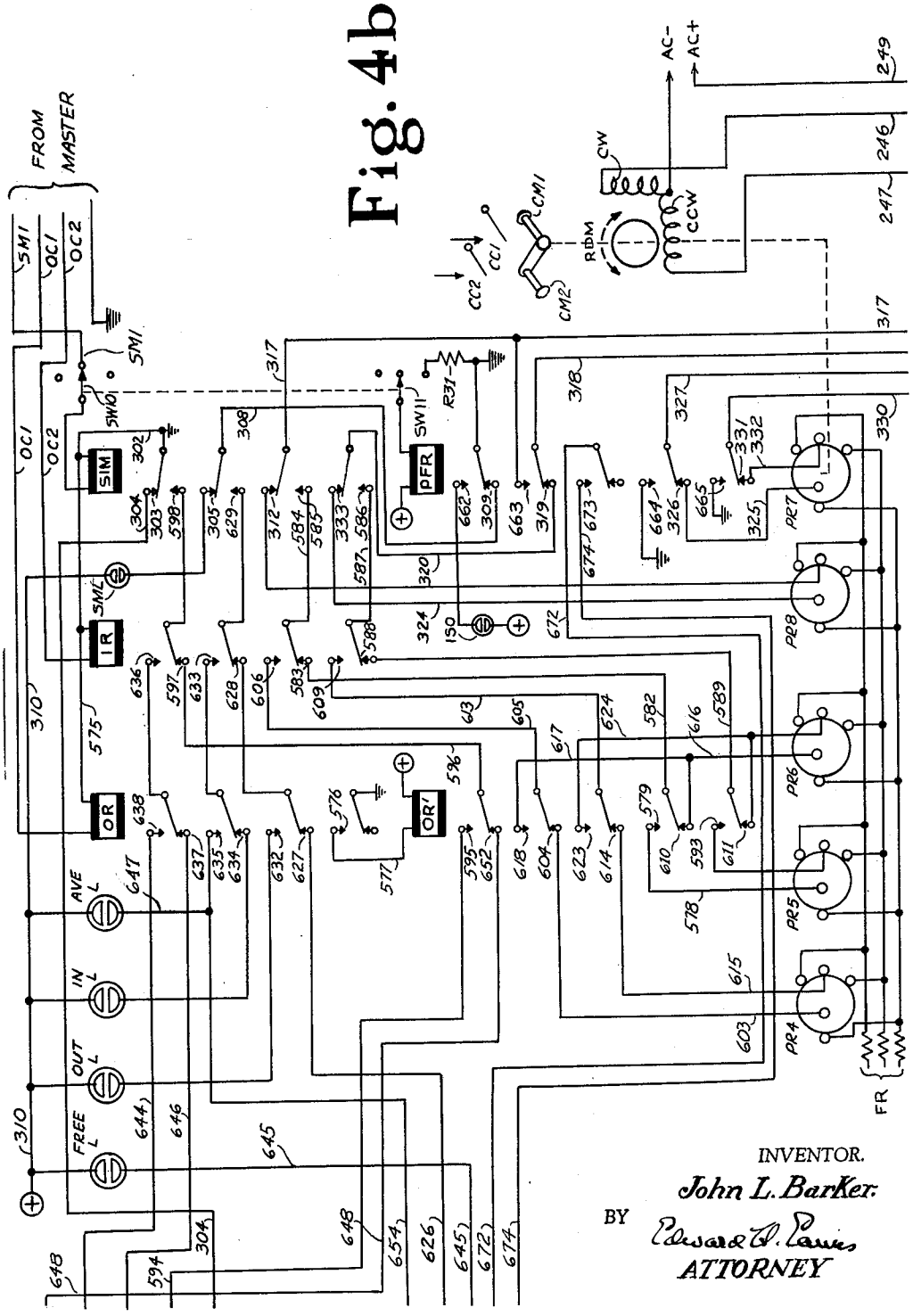
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TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 4

Fig. 4b



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April 7, 1964 J. L. BARKER 3,128,446

TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 5

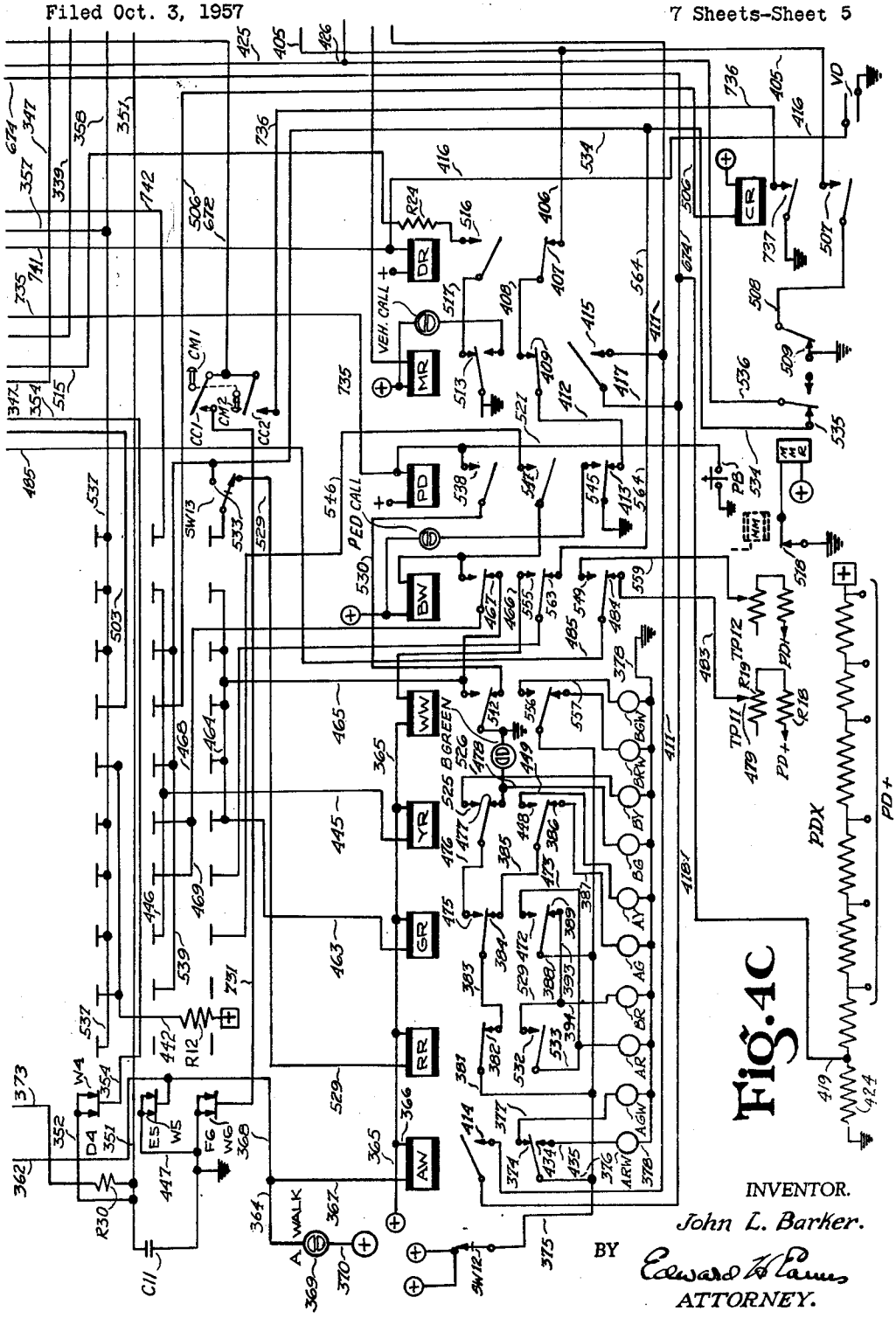


Fig. 4C

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TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 6

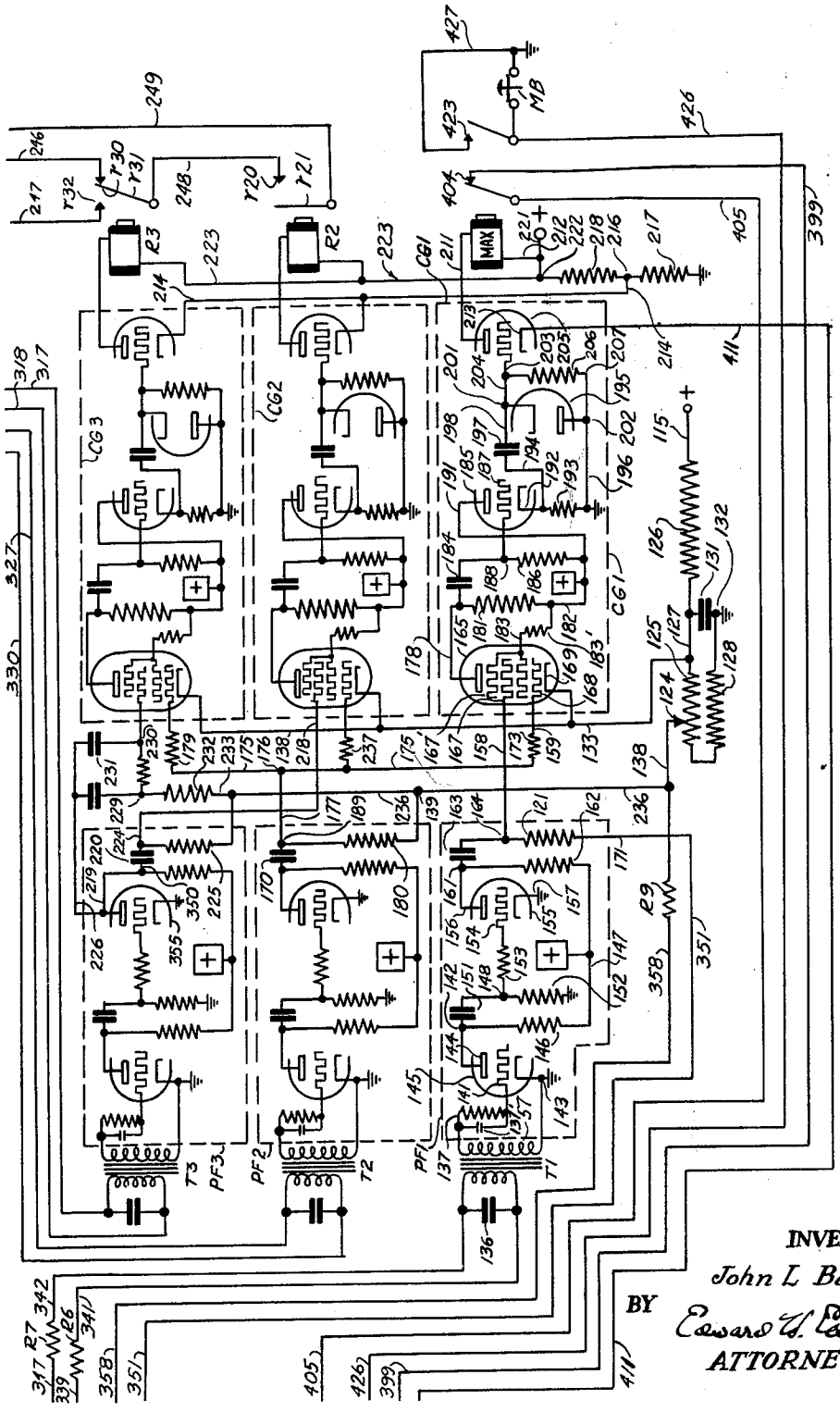


Fig. 4d

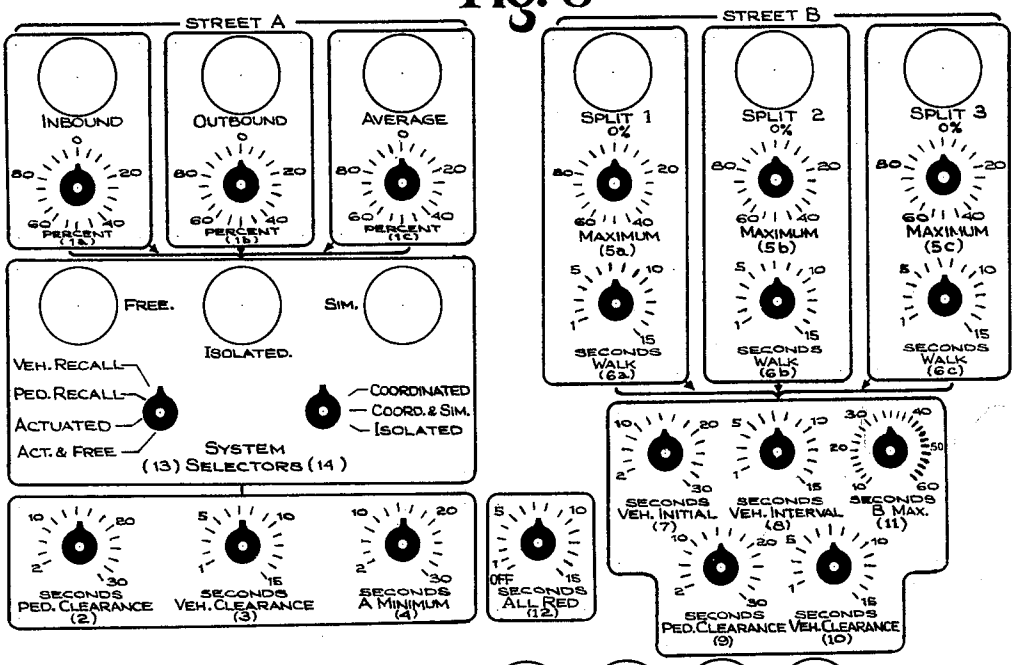
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TRAFFIC ACTUATED CONTROL SYSTEM

Filed Oct. 3, 1957 7 Sheets-Sheet 7

Fig. 6



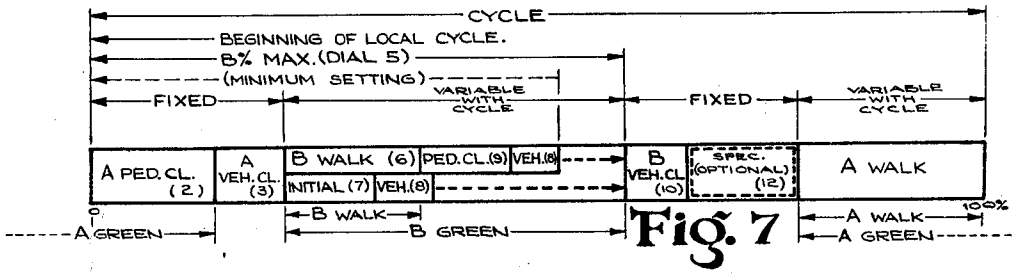


Fig. 7

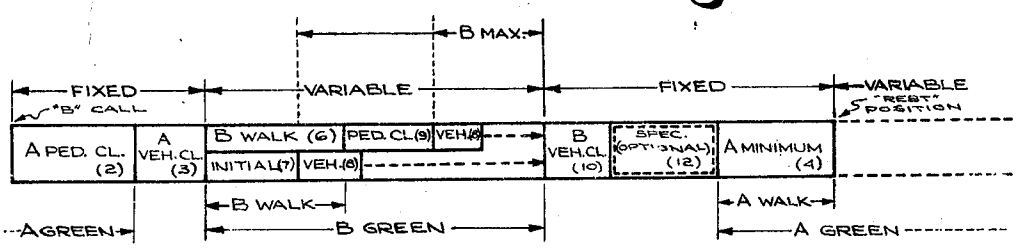


Fig. 8

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United States Patent Office 3,128,446 Patented Apr. 7, 1964

3,128,446

TRAFFIC ACTUATED CONTROL SYSTEM

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Filed Oct. 3, 1957, Ser. No. 688,080
21 Claims. (Cl. 340—35)

This invention relates to a traffic actuated control system and to a traffic signal controller for actuation by traffic in a master-local traffic control system in which a number of local controllers, each controlling the usual traffic signal or signals at an individual street intersection for example, are remotely controlled by a master controller as to some features of their time cycle for operation of the traffic signals in desired coordinated relationship to permit smooth flow of traffic through the several controlled intersections.

Various forms of traffic actuated control systems for individual intersections and groups of intersections are already well known in which the traffic signal time cycle is initiated or modified by actuation by the traffic itself, as are also a number of master-local traffic control systems in which the time cycle of the local controllers is supervised in several ways.

U.S. Patent 2,542,978, issued February 27, 1951 to John L. Barker, assignor to Eastern Industries, Incorporated, for "Traffic Actuated Control Apparatus," illustrates certain forms of master-local control systems in which the total time cycle of the local traffic signal controller and its "offset" from a reference "zero offset," and consequently its time lag or lead with respect to other local controllers, is remotely controlled by the master controller, with the master controller actuated by traffic at sampling points for varying the time cycle length and selecting among several offsets in accordance with traffic demand, for example. This prior patent also illustrates at least one way in which a traffic actuated local controller may be employed in such a master-local system.

The present invention relates particularly to a greatly improved local controller of the type adapted to be remotely controlled by a master controller and to be locally controlled by traffic actuation, as by cross traffic, as well as to a traffic control system of this type.

As far as the present local controller or traffic actuated system is concerned the master controller may be itself actuated by traffic for varying the time cycle length or offset or division or "split" of the right-of-way signal periods between through traffic and cross traffic or other conflicting traffic flows or intersecting streets, or these features may be changed on a program time basis of the master controller or otherwise remotely or by supervisory control, or such variations may be partly by master traffic actuation and partly by program timing, but the control of such variation by traffic actuation is preferred for greater flexibility, and the invention provides a greatly improved combination of local traffic actuated control, local time control and remote time control.

Thus in accordance with one aspect of the invention an improved traffic actuated control system or local controller is provided with the traffic signal time cycle locally adjusted for distribution among several signal periods in desired percentage relation to a variable master controlled cycle and for desired offset relation thereto, and with one of the traffic signal right-of-way periods controlled by local traffic actuation within limits determined by such master control cycle.

The invention more particularly relates to a traffic control system in which individual local controllers of the semi-actuated type may have individually adjusted distribution of their time cycles or "split" of signal periods, as establishing limits for the periods as initiated or varied

in accordance with traffic demand by actuation, or several such individual "splits" with selection among such splits by remote control from the master controller, and with the total time cycles of the several local controllers determined and shortened or lengthened together by remote control from the master, while maintaining substantially the same percentage split of the cycle if desired for example. The invention also is adapted readily to the remote control of the offsets of the time cycles of the several signal controllers, and to a greatly improved method and means of changing offsets.

In its preferred form the traffic actuated controller or control system according to the invention is designed for operation in a master-local control system in which certain of the signal changes in the signal time cycle are controlled or initiated at desired percentage points in the time cycle variably controlled by the master controller or in desired offset relation thereto, and particularly in such master-local control system in which the remote control of timing by the master controller is provided by very gradual progressive phase shift between a reference frequency and a slightly differing control or variable frequency to produce cyclic coincidences of the two frequencies at time periods of the order of the desired traffic signal cycle and by employing coincidence response means such as coincidence gate circuits in the local controller for obtaining the desired percentage control points in the signal cycle. The frequency difference is varied at the master controller as desired to vary the length of the signal time cycle at the local controllers.

In accordance with a further feature of such phase comparison system a local reference frequency element may be automatically rotated from one remotely selected and locally adjusted phase displaced relation to another such relation in response to change between such remote selections.

A traffic control system of the general type employing slow progressive phase shift between two electrical wave energies transmitted to the several local controllers and coincidence response thereto is the subject of a copending application S.N. 510,926, filed May 25, 1955, U.S. Patent 2,989,728, by John L. Barker, and reference may be had to said copending application for a more detailed description of certain features of such phase shift and phase comparison operation and system.

According to one aspect of the prior copending application S.N. 510,926, a multiphase constant reference frequency and a multiphase variable frequency are both generated at the master controller, with the variable frequency derived from but having continuous gradual phase shift with respect to the reference frequency at an adjustable time rate, the time required for the variable frequency to shift one cycle with respect to the reference frequency corresponding to the desired total traffic signal time cycle for example, the "variable frequency" being variable in the sense that it is adjustable to the desired value of difference from the reference frequency for a desired signal cycle length but is constant at such adjusted value for such particular signal length.

The variable and reference frequencies are transmitted from the master controller to the several local controllers and at the latter these frequencies are applied to the stators of individual 360 degrees potentiometers, one potentiometer on each multiphase frequency circuit for example, and rotor arms providing adjustable position taps at 180 degree spacing on such potentiometers take off voltages providing two sine wave outputs, one of which shifts its time phase with respect to the other slowly and uniformly at the desired rate of phase shift of the master controller.

These two sine wave voltages, each of single phase, one derived from the reference frequency and the other

from the variable frequency, are applied to pulse forming circuits to derive a sharp narrow pulse at corresponding points on their respective sine waves, such as at zero on the up-slope of the wave, for example, and the two pulses (one gradually and progressively shifting in time phase with respect to the other) are applied to a coincidence gate circuit to derive an output once per signal cycle at a particular point in the cycle as determined by the position of the potentiometer rotors. This coincidence pulse is then employed to operate a relay or other device to operate a particular signal or to switch signals in a signal cycle.

In a preferred embodiment of the present invention the coincidence of the pulses is employed in combination with traffic actuation to advance a cyclic stepping switch one step in a cycle of traffic signal indications, the stepping switch connecting one or more other response point potentiometers into the pulse forming and coincidence gate circuit at desired points in its step-by-step cycle to control certain signal switching or transfer points such as the maximum limit for the traffic actuated extendible right of way period of the cycle for example, and consequently to control the "split" or distribution of the signal cycle in accordance with the setting of the respective potentiometers.

According to a further aspect of the invention, by remote control of local relay circuits one of several potentiometers associated with the reference frequency may be selected to provide a desired offset or phase relation of the signal cycles, or remote selection between sets of variable frequency potentiometers may be made to select different splits, in association with traffic actuated control.

The invention is described particularly from its preferred aspects of providing both multi-phase reference frequency and multiphase variable frequency, and is illustrated in one preferred form in which both the reference frequency and the variable frequency are three phase, in order to provide the maximum of flexibility in deriving adjustable phase displaced voltages from one of these two frequencies to establish desired response points throughout the time cycle, and in deriving adjustable phase displaced voltages with respect to the other of the two frequencies to enable a desired phase displacement, or offset relationship in the case of traffic signal controllers, to be obtained for the entire time cycle. However, it will be understood that if these local controllers need not have an adjustable phase displaced relationship, as for example, if all of the time cycles are to be on a synchronized basis, with the local time cycles to have no phase displacement or offset with relation to the reference frequency, then such reference frequency need only be single phase rather than multiphase.

Although the control of transfer of right-of-way for a traffic lane by a combination of traffic actuation and a locally adjusted percentage point in a remotely controlled background cycle of variable time length is not itself new in general, there has long been a need for a more flexible and readily adjusted means for varying the percentage points in the background cycle at which the controller is to respond to actuation in initiating transfer of right-of-way and in establishing the desired offset of the local traffic actuated control cycle with respect to the master control cycle.

Also in modern widely varying traffic conditions and rapid changes in such conditions particularly in connection with the morning and afternoon peak traffic periods and the preceding building up periods and in connection with shifts in such periods due to weather, special events and other changeable factors, it has become more important to provide a closer control of the retransfer of right-of-way from a traffic actuated crossroad to a main road for best coordination of the local intersection signal controller with others for through traffic movement for example, as the right-of-way for cross traffic is varied by traffic actuations.

Such closer control of retransfer of right-of-way from the traffic actuated crossroad is provided on a new and much more flexible and readily adjusted basis in the present invention, to meet the varying demands of traffic.

Thus the present system or controller provides a positive control of the limit for retransfer of right-of-way at or in connection with a readily adjusted percentage point in the background cycle and provides for selection among three such individually adjusted percentage points.

The present invention provides such control in a novel and very flexible manner by combining traffic actuated control and background cycle control of the signal through means establishing joint cooperative control of certain signal changes or signal periods in the cycle by traffic actuation and by phase coincidence of two periodic wave energies having cyclic phase coincidences at remotely controlled time intervals by slow progressive phase shift, and by a wide range of adjustment and remote and local selection among multiple individual adjustments to which such means is readily adapted.

The greatly improved flexibility of control of the time cycle both by traffic actuation and by remotely controlled slow progressive phase shift between wave energies is provided by controlling a multi-position cyclic sequence switch at certain positions of its cycle mutually by traffic actuation and by phase coincidence of the remotely controlled and locally adjusted wave energies to achieve control of a right-of-way signal period in desired percentage relation to the remote controlled background time cycle.

It is an object of the invention to provide an improved traffic control system in which a number of local traffic signal controllers have a common total time cycle controlled from a master controller, with individual adjustment of the several signal periods of the time cycle and with the distribution and length of the several signal periods in the time cycle determined in part by traffic actuation at the local controllers and in part by the master controller.

It is another object of the invention to provide a traffic control system in which one or more local traffic actuated signal controllers have a traffic actuated signal time cycle controlled from a master controller within limits of a background cycle for desired coordinated traffic flow with selection by the master controller among individually adjusted offsets at the local controller, and with the time cycle of the local controller shifted gradually in the nearest direction to the new offset relation upon each change of selection.

It is another object of the invention to provide an improved traffic control system in which a signal change in a local controller is controlled by a combination of traffic actuation and phase coincidence between two periodic wave energies supplied from a remote master controller, one such wave energy being shifted progressively in phase relation to the other.

It is also an object of the invention to provide in a master control system having two periodic wave energies, one of which progressively shifts in phase with relation to the other at a slow controlled rate, a traffic actuated signal controller providing a signal change in response to coincidence of a voltage having a predetermined phase relation to one of said wave energies and a voltage having a predetermined phase relation to the other of said wave energies.

It is another object of the invention to provide in a master-local traffic control system having two periodic wave energies, one of which progressively shifts in phase with relation to the other at a slow controlled rate, a traffic actuated signal controller causing a transfer of right-of-way from one traffic lane to another in response to a combination of traffic actuation on said other lane and coincidence of a voltage having a predetermined phase relation to one of said wave energies and a voltage having a predetermined phase relation to the other

of said wave energies, and setting a limit for retransfer of right-of-way from said other lane to said one lane in response to coincidence of a voltage having a further predetermined phase relation to said other of said wave energies and said first mentioned voltage.

It is another object of the invention to provide in a master-local traffic control system having two periodic wave energies, one of which progressively shifts in phase with relation to the other at a slow controlled rate, a traffic actuated controller in which transfer of right-of-way from one traffic lane to another is controlled by a combination of traffic actuation and a predetermined phase relation of said wave energies.

It is another object of the invention to provide in a master-local traffic control system having two periodic wave energies, one of which progressively shifts in phase with relation to the other at a slow controlled rate, a local traffic actuated controller in which transfer of right-of-way from one traffic lane to another is controlled by a combination of traffic actuation and predetermined phase relation of said wave energies with such predetermined phase relation being remotely selectable among a plurality of individually adjustable phase settings at the local controller.

It is another object of the invention to provide in a master-local traffic control ystem having two periodic wave energies, one of which progressively shifts in phase with relation to the other at a slow controlled rate, a traffic actuated signal controller in which transfer of right-of-way from one traffic lane to another is controlled by a combination of traffic actuation and coincidence of wave energies having predetermined adjustable phase relation to the respective first mentioned wave energies.

It is another object of the invention to provide in a master-local traffic control system having master control of variable cycle length and selection among a plurality of locally adjusted offsets and splits for a local desired background cycle for coordination purposes, an improved local controller having a plurality of local adjustable percentage points for desired right-of-way signal changes in relation to the local desired cycle, and traffic actuated control of certain of such right-of-way signal changes at certain of said percentage points.

It is also an object of the invention to provide an improved traffic signal control system having locally or remotely controlled selection among a multiplicity of locally adjusted offsets and among a plurality of locally adjusted splits for a desired local background cycle of remotely controlled variable time length, and having traffic actuated control of transfer of right-of-way in connection with a locally adjusted percentage point in such background time cycle associated with the selected offset, and in which retransfer of right-of-way is assured at or before a further locally adjusted percentage point in the background cycle associated with the selected split.

It is an additional object of the invention to provide an improved traffic signal control system of the type last mentioned above in which the multiplicity of selectable offsets includes inbound, outbound, average and simultaneous offsets.

It is a further object of the invention to provide an improved traffic signal controller system of the type mentioned in the next but last preceding paragraph and which includes among the selectable offsets a non-coodinated or "free" offset or condition, permitting the local controller to act as an independent traffic actuated controller.

Other objects of the invention will appear from the accompanying claims and from the following description of the invention with respect to the drawings in which:

FIG. 1 illustrates in schematic form a master controller for a control system according to one embodiment of the invention.

FIG. 2 illustrates in block diagram form two of a series of intersections along a highway with individual traffic signals and local controllers and connections with the master controller of FIG. 1 for example.

FIG. 3 illustrates in schematic circuit form and partly in block diagram one embodiment of a local traffic actuated controller or system such as indicated applied to intersection A-B in FIG. 2 with connections for cooperation with the master controller of FIG. 1 for example and employing certain aspects of the invention.

FIGS. *4a* through *4d*, when arranged side by side as indicated in FIG. 5, illustrate in detailed schematic circuit form a preferred embodiment of a traffic actuated local controller or system for cooperation with a master controller of FIG. 1 for example and employing several aspects of the invention. The several drawings FIG. *4a*, FIG. *4b*, FIG. *4c* and FIG. *4d* thus together form a circuit diagram which is sometimes referred to herein as FIG. 4 for convenience.

FIG. 5 shows how FIGS. *4a* through *4d* are to be arranged to form a complete circuit diagram.

FIG. 6 is a partly schematic diagram of an illustrative "dial" panel showing adjustment dials, selector switches and indicator lamps for the controller of FIG. 4 for example.

FIG. 7 shows schematically in block form a sample cycle of operation of the local controller of FIG. 4 in response to traffic actuation under coordinated control, with reference in parentheses to the dials shown in FIG. 6 above.

FIG. 8 shows similarly a sample cycle for "free" operation of the same controller in response to traffic actuation, when operating independent of coordinated control.

In considering the more detailed description below of the invention in relation to the several figures of the drawings it will be understood that in the timing of any given length of the time cycle, for traffic signal operation or for other purposes, in accordance with the invention, it is the period between successive phase coincidences of the two wave energies derived from the master controller which is the important timing factor, and consequently the time rate of phase shift of one of these wave energies with respect to the other determines the time cycle as controlled by the master controller. For any given time cycle length this rate of phase shift is constant, or in other words there is a constant frequency difference between the two frequencies of the respective two basic wave energies transmitted from the master controller to the local controllers supervised by the master controller.

If it is desired to change to a longer time cycle for the local controllers, then the frequency difference between the basic wave energies is decreased so that the rate of phase shift of one wave energy with respect to the other is decreased and the period between phase coincidences is thereby increased, to increase the length of the controlled time cycle.

Although such reduction of the frequency difference might be accomplished by increasing the frequency of the lower of the two frequencies and reducing the frequency of the upper of the two frequencies for example, it will be obvious that it is more convenient to keep one of the frequencies constant as a reference and to change only the other frequency, which thus may be considered a variable frequency or control frequency.

Thus for convenience of reference in describing the invention one of the frequencies is assumed to be constant and is referred to as the reference frequency or reference periodic wave energy and the other adjustable frequency is referred to as the variable or control frequency or control wave energy, without intending that the invention shall be limited thereby.

For purposes of illustration and without limiting the invention thereof, the following values may be employed for the two basic periodic wave energies transmitted from the master controller to the local controllers. The refer-

ence frequency may be 400 cycles per second and the variable or control frequency may be adjustable from $400+\frac{1}{40}$ cycles per second to $400+\frac{1}{120}$ cycles per second for a controlled time cycle adjustable between 40 seconds and 120 seconds in length, of the order of those widely used in traffic signals for street and road intersections, for example; and for a controlled time cycle of 60 seconds, the reference frequency may be 400 cycles per second and the control frequency $400+\frac{1}{60}$ cycles per second or 400.0167 cycles per second approximately, for example.

For convenience of illustration the preferred form of the invention is described primarily from the viewpoint that the control frequency is higher than the reference frequency and consequently the reference frequency has a progressive lagging phase shift, or in other words a given point on the reference frequency wave travels slowly to the right with respect to a corresponding point on the control frequency wave, on a left to right time scale.

Referring now to FIG. 1, there is illustrated schematically one preferred form of master controller which may be employed in connection with one or more local controllers as illustrated in the remaining figures.

The three windings of an alternating current three phase generator are shown schematically at the left in FIG. 1 and designated FRG as a group, to indicate that this is the generator of the three phase alternating current constant reference frequency provided on the lines FR extending to the right and corresponding with the similarly designated lines of the other figures. These lines extend to the right of FIG. 1 for connection to the local controllers.

From these three reference frequency lines FR, a group of three branch lines extend downward to supply this three phase reference frequency to the input of a differential generator in block DG. This differential generator essentially adds or subtracts a small difference frequency to or from the reference frequency as desired to provide a new three phase frequency output differing so slightly from the reference frequency that the difference frequency amounts to a very slow progressive phase shift.

The differental generator DG is operated by a mechanical drive from variable speed motor VSM under control of the speed control SV, to vary the rate of progressive phase shift of the wave energy on lines FC with respect to the reference wave energy on lines FR and thus to vary the time cycle between successive phase coincidences of the two wave energies.

By making the variable frequency of lines FC from the reference frequency of lines FR by means of the differential generator, the reference frequency may drift in absolute frequency without upsetting the phase relationship of the variable frequency to the reference frequency, since the difference frequency remains the same as the differential generator is a phase shifter only.

Below the lines FR there is shown schematically the differential generator within the broken line box DG, and the lines FC extending outward to the right. For convenience in explaining the invention in connection with FIG. 1, the parenthetical designation ($fc=fr+df$) is noted along side of FC. This is intended as a reminder that the control frequency output on the lines FC is the sum of the reference frequency and the difference frequency corresponding to the rate of phase shift provided in the differential generator.

It will be understood that the usual 120 degree spaced three phase windings **101**, **102** and **103** at the left of the differential generator DG as shown in FIG. 3 will have a rotating field, and for purpose of illustration this is assumed to be the stator set of windings. The windings to the right with the associated three curved arrows are also 120 degree spaced windings forming the rotor of the differential generator for example. The lines FC extend from these latter rotor windings **104**, **105** and **106** toward the right, and correspond with the lines designated FC in several of the other figures of the drawings.

A variable speed motor VSM is shown schematically below the rotor windings of the differential generator and is indicated as mechanically associated therewith to drive the rotor by the broken line **107**. The motor VSM is illustrated as connected via wires **108** and **109**, and the variable speed control SV, to positive and negative electrical power terminals indicated. The speed control SV is illustrated as a potentiometer adjustable for controlling the voltage or power applied to the motor VSM to vary the speed of the latter as desired to obtain the frequency difference between the reference frequency and the variable control frequency.

It will be understood that the motor VSM has a low speed output, provided by gearing or otherwise as desired, to rotate the rotor windings **104**, **105**, **106** at speeds of the order of one revolution in 40 seconds to one revolution in 120 seconds to derive a time cycle of the order of 40 seconds to 120 seconds for example as described above, one revolution of the motor output shaft being equal to one time cycle of the system. It will be understood by those skilled in the art that when the three phase rotor windings are rotated with respect to the three phase stator windings of the differential generator DG the output frequency from the rotor windings for example will have a phase shift with respect to the input at the stator windings which progresses at a time rate depending upon the rate of rotation of the rotor. In effect the turning of the rotor in the direction of the rotation of the field at the three phase stator windings will provide a slightly lower output frequency in relation to the input frequency which may be expressed $FC=FR-DF$ for example, whereas if the rotor windings are turned in the direction opposite to the rotating field of the stator windings the output will have a slightly increased frequency which may be represented by the expression $FC=FR+DF$ for example. For convenience in describing the invention it is assumed that the rotor windings always are turned in the same direction but at varying time rates to provide a variable time cycle for remote control purposes as described above.

In connection with the offset control lines in the lower part of FIG. 1, it will be noted that the switches SW1 and SW2 are connected at their left ends to the positive power terminal for example and are shown in a normally open position. The switch arm of either switch may be moved into its closed position independently to apply positive power to its associated line, the switch SW1 controlling line OC1 and the switch SW2 controlling line OC2, the remaining line OC being connected as a common line to the negative power terminal. It will be understood that the power terminals designated plus and minus are merely for convenience of identification and may be direct current or alternating current power as desired. The lines OC1 alone may be energized by the closing of switch SW1 and the line OC2 may alone be energized by closing switch SW2 or both lines OC1 and OC2 may be energized by the closing of both switches.

As in the prior copending application above identified, the switches SW1 and SW2 provide control of or selection of offset between inbound, outbound, and average for example, at the local controllers over the lines OC1 and OC2. However, in the present application the simultaneous operation of local controllers at zero offset is provided not by the opening of both switches SW1 and SW2 as in the aforesaid copending application but by employing a third switch SW4 to energize an additional line SM1 extending to the local controllers. Also, in the present application a fifth condition of non-coordinated or "free" operation of the local controllers as independent traffic actuated controllers, is provided by the concurrent opening of switches SW1, SW2 and SW4. The switch SW4 is shown as connecting positive power via wire **110** to the switch to the line SM1.

In the present application a more flexible form of control of the "split" of a traffic signal cycle is provided by having three locally adjusted split controls which may be

cross-connected as desired with the offset controls as seleced from the master controller, as will be more fully described below in connection with FIG. 4.

The switches SW1, SW2 and SW4 may be manually operated as desired by the traffic authorities at the master controller location or may be operated automatically in the form of relay contacts from time switches or from an automatic offset selector system as indicated in prior Patent 2,542,978 referred to above.

Referring now to FIG. 2, there is shown in block diagram form two local controllers, LC1, a local controller of the non-actuated type, and LC2, a local controller of the semi-actuated type, at two intersections along a common through street A, and associated with the several sets of interconnecting lines extending from the master controller MC at the left. As in FIG. 1 the upper group of lines designated FR serve to carry the three phase reference frequency, the middle three lines extending from left to right designated FC carry the variable or control frequency, also three phase, and the lower four lines designated SM1, OC1, OC2 and OC serve as the offset control lines for example.

Along the lower part of FIG. 2 the common through street A is indicated as extending from left to right, with broken lines indicating that this street may extend further to other intersections in each direction and also indicating in the middle that the intersections may be much further apart than shown in the drawing. The intersection at the left has a crossroad or street designated B1 and the intersection at the right may have the crossroad designated as B, for example.

The traffic signals TS1 and TS2, associated with the respective intersections, are shown schematically as circles in the center of the intersection, and may of course have any desired form or location in accordance with common practice. These signals TS1 and TS2 are shown associated by lines 111 and 112 respectively with local controllers LC1 at the first intersection and LC2 at the second or right hand intersection. These local controllers are shown as connected with each of the three sets of lines on the master controller by groups of lines extending downward.

The semi-actuated controller LC2 has vehicle detectors VD and VD' in the cross street B only, and has pedestrian pushbuttons PB on opposite sides of street A at street B. These detectors and pushbuttons may serve to actuate the controller to transfer the right-of-way to cross street B by means of the signal TS2 in desired relation to a background cycle for coordination with other controllers, as described in connection with FIGS. 3 and 4. The detectors and pushbuttons may also serve to extend the B street right-of-way period by further actuation up to a maximum limit, as described below in connection with FIG. 3, or the vehicle detectors may extend the right-of-way and the pedestrian pushbuttons provide a longer minimum right-of-way with "walk" signals supplementing the usual green signals, as described below in connection with FIG. 4. The maximum limit is in each case determined in desired percent or phase relation to the background cycle when coordinated, as described in connection with FIGS. 3 and 4.

FIG. 3 illustrates one form of local controller associated with the reference frequency lines and variable frequency lines extending from the master controller of FIG. 1 to the several local controllers. The reference frequency lines FR starting at the left of FIG. 3 are extensions of the lines FR at the right of FIG. 1, and continue to the right across FIG. 3 for connection to other controllers as desired. Similarly the variable frequency or control lines FC of FIG. 3 are extensions of the lines FC of FIG. 1.

At the left side of FIG. 3 a group of three branch lines extend downward from the lines FR to supply the three phase reference frequency to three tapping points 120 degrees apart on the 360 degree continuous resistance forming the circular stator element of a 360 degree potentiometer PR20, dividing this stator element into three equal sections 21, 22, and 23. These three sections with their tapped connections to the three phase reference lines thus have a delta connected three phase arrangement as it is familiarly known in the electrical art, but with each section of the delta one third of a resistance circle.

The potentiometer PR20 is provided with a two part diametric rotor having two contacts insulated from each other and movable jointly over the circular stator to any diametrically opposite contact positions, the contacts always being 180 degrees apart. The left hand arm 24, as shown is connected to an outer central contact ring and the right arm 25 of the rotor is connected to an inner central contact ring. These rings are in turn connected respectively by familiar contact brush arrangements via wires 26 and 27 to the input winding 31 of isolating transformer T2, the output winding 32 of which is connected to the input of a spike pulse forming network 33.

Since the rotor arms 24 and 25 of potentiometer PR20 provide movable taps 180 degrees apart on the delta three phase connected stator, these rotor arms will take off a single phase sine wave voltage from the three phase reference voltage on the stator, this single phase voltage being at the reference frequency and having a phase relation to the latter depending on the position of the rotor 24—25. Thus by turning the rotor to the desired angular position, any desired phase displacement of the voltage output from the rotor can be obtained with respect to the original three phase reference frequency applied to the stator.

It will be noted in FIG. 3 that the rotor 25—24 is shown as slightly displaced counter clockwise from a position extending from the tap between sections 23 and 22 of the stator, to the opposite section 21 of the stator, as one illustration, and a dial plate-knob arrangement illustrated in FIG. 6 may be associated with the rotor 24—25 to indicate the angle of phase displacement or percentage displacement on the basis of 100 percent for 360 degrees of arm 25 with respect to the top center point as zero displacement, for example.

The single phase sine wave voltage, displaced from the reference frequency by the desired amount by potentiometer PR20, is thus applied via transformer T2 to the input at the top of the pulse forming network 33. This network is identified as a spike pulse forming network (as wave passes zero increasing) in its preferred form, of which one embodiment is shown and described in more detail in connection with FIG. 4*d*. This spike pulse forming network derives a narrow spike pulse output at a particular point on the sine wave voltage applied to its input, this point being chosen for conveneince as the wave becomes positive just beyond zero. For convenience of reference this is considered as substantially as the wave passes zero increasing toward the positive peak. It will be appreciated that some other reference point might be selected within the spirit of the invention, but this point is employed in the preferred form of the invention.

The spike pulse output of network 33 is applied via line 36 to one of the two inputs to coincidence gate CG1.

In the middle of FIG. 3 are shown two additional potentiometers PR21 and PR22, which are of the same type as potentiometer PR20 described above, and have individually adjustable rotors set in different desired phase displaced relation as indicated for example, to determine desired percentage response points in the total time cycle controlled by the master controller via the reference frequency and variable frequency lines FR and FC. These percentage response points are employed to control signal changes in a traffic signal cycle according to one aspect of the invention as more fully described below.

The stators of the potentiometers PR21 and PR22 are connected in parallel in delta arrangement to the three phase variable frequency lines FC by the downward extending branch wires 41, 42 and 43, these wires being connected to corresponding tapping points on these two potentiometers respectively, spaced at 120 degree intervals around the continuous resistance of each stator.

The two arm rotors of the two potentiometers have one contact arm connected with an inner ring and the other connected with an outer ring, as in PR20 described above, and the arm associated with the inner ring is considered to be the phase displacement indicator for convenience in describing FIG. 3.

The rotor arms, 44 and 45, are associated with the inner rings of potentiometers PR21 and PR22 respectively, and these arms are connected via the respective inner contact rings to individual contacts on the upper contact bank LS21 of a step-by-step selector switch, the opposite end arms of the respective rotors of potentiometers PR21 and PR22 and the associated contact outer rings being connected to corresponding individual contacts on the lower contact bank LS22 of this stepping switch respectively. The rotary contact wiper arms W21, W22, W23 and W24 of this stepping switch are associated with the respective contact banks LS21, LS22, LS23 and LS24, and are operated in ganged arrangement in clockwise rotation by the stepping switch motor magnet MM as indicated by the broken line 47 associating these several rotary contact arms with motor magnet MM. The rotation of these several contact arms is indicated by the curved arrows adjacent contact arms W21 and W22.

These several rotary contact arms W21, W22, W23, W24 and W25 are shown as single ended for simplicity of illustration, and similarly only five stationary contacts are shown on the associated contact banks, although it will be appreciated that additional contacts may be employed as needed and the rotary contact arms may be double ended or the like as desired to repeat the rotary traverse of the several successive stationary contacts beginning on the lowest contact position 1 as shown and continuing step-by-step to the uppermost fifth contact position shown and then directly thereafter to contact position 1 again, in which latter position the several rotary contact arms are shown in FIG. 3. The stepping switch operates only one step at a time in its cycle of contact positions upon each operation of its motor magnet MM, such operation including energization and release.

FIG. 3 is illustrated with the rotary contact arms W21, W22, W23, W24 and W25 in a rest position which may be called the street A green position.

Considering the several contact positions of the stepping switch and their connections in more detail in FIG. 3, the inner contact ring and associated rotor arm 44 of potentiometer PR21 is connected via wire 51 to position 1 contact on bank LS21, and the opposite rotor arm and outer contact ring of potentiometer PR21 are connected via wire 52 to the corresponding position 1 contact of bank LS22, and thus in the condition illustrated in FIG. 3 the potentiometer PR21 is connected via the contact banks LS21 and LS22 and the respective rotary contact arms W21 and W22 to control a second spike pulse forming network 53 and a second input line 58 of the coincidence gate CG1 as will be further described below.

Rotary contact arms W21 and W22 are connected respectively via wires 54 and 55 to the input winding 56 of isolating transformer T1. The output winding 57 of this transformer is connected to the input of the spike pulse forming network 53 and the output of the latter is connected as indicated by line 58 to the second input of coincidence gate CG1.

The other input line 36 at the lower side of the coincidence gate CG1 was previously described as controlled by the spike pulse network 33, which is in turn controlled by the output of potentiometer PR20. This coincidence gate CG1 provides an output pulse on line 61 in response to the coincidence of pulses on the two input lines 36 and 58, to operate relay 62, which in turn by closing its contact 63, operates the stepping switch motor magnet MM. The other side of the relay 62 is returned to ground via contact BV1 of the BV relay or DR'1 of the DR' relay.

The contact BV1 of relay BV is open in position 1, however since the relay BV is energized only in No. 4 position. The relay DR' will be energized to close its contact DR'1 when the vehicle detector VD is closed by a vehicle crossing over the same. Assuming vehicle actuation, the relay DR' is thus energized from plus power through its coil, the closed contacts of vehicle detector VD to ground. The relay DR' locks in through its contact DR'2, through lines 70, 71 to the stepping switch bank LS25 through position 1, the wiper arm W25 to ground. The lock-in circuit of the DR' relay will be completed in positions 1, 2, 3 and 5 of the stepping switch bank LS25 to "remember" traffic actuation until accord of right-of-way in response thereto in positions 3–4. Thus upon energization of relay DR' in position 1, the circuit of the coil of relay 62 is completed via wire 77 and contact DR'1 to ground and relay 62 will be energized in response to the output pulse of the coincidence gate CG1 via line 61.

The contact 63 is normally open with relay 62 deenergized, but when relay 62 is energized by the output pulse from coincidence gate CG1 as described, this contact closes to supply power, as indicated by the plus sign in a circle, via contact 63 and wires 64 and 65 to motor magnet MM, the left side of this motor magnet being connected to the negative power return, indicated by minus in a circle.

It will be understood that if reference and control frequencies of the order of 400 cycles per second are used, a series of coincidence pulses will occur in the coincidence gate circuit at the 400 cycle rate throughout the brief time width of overlap of the two spike pulses as one shifts slowly in phase with respect to the other. However as more fully described below, the coincidence gate circuit provides a rectified and capacitance filtered output substantially sustained between the successive pulses of the series, and thus the relay 62 remains energized throughout the series during the brief period of substantial coincidence, which is preferably of the order of a fraction of a second for example.

Operation of relay 62 energizes motor magnet MM for this fraction of a second period of substantial coincidence of pulses from the spike pulse formers 33 and 53 and then releases this motor magnet MM as the coincidence or overlap of such spike pulses ceases to be sufficient to operate the coincidence gate, and the output pulse from the latter ceases. This operation and release of motor magnet MM advances the rotary contact arms W21, W22, W23, W24 and W25 from the lower position 1 to the next above position 2.

Thus as a result of traffic actuation of detector VD or VD' on street B and consequent energization of relay DR', together with phase coincidence of the outputs of the potentiometers PR20 and PR21, one output having adjustable phase relation to the reference frequency and the other output having adjustable phase relation to the control frequency, the stepping switch has been advanced from position 1 to position 2 in its cycle in desired phase relation to the time cycle between coincidence of the reference and control wave energies from the master controller, and this advance of the stepping switch has occurred at a desired percentage point in the locally offset time cycle determined by the relation between the rotors of the potentiometers PR20 and PR21, thus initiating transfer of right-of-way from street A to street B at such desired percentage point, as more fully appears below.

In this discussion the setting of potentiometer PR20 is considered the locally offset zero reference for the percentage settings of potentiometer PR21 and PR22.

If there had been no actuation up to and including the time of operation of the coincidence gate at coincidence in position 1, the controller would remain in position 1 awaiting the next combination of coincidence and actuation at or prior thereto, but upon such coincidence and such actuation relay 62 will be energized as described above to advance the controller to position 2 to terminate the A green signal period and to start the A yellow or clearance signal period.

The wiper arms of the respective rotary stepping switches are now in position 2 which position is timed by an interval timer calibrated in seconds, rather than percentage of the cycle. The timer here illustrated is a familiar resistance-capacitance type employing tube 75 and capacitor 74 to operate relay 76 at the end of its time interval to operate motor magnet MM to advance the stepping switch to its next position, as more fully described below.

Position 2 is the street A yellow or clearance position and position 3 is the street B initial green position as described below, the latter also being timed by the timer to advance the stepping switch to position 4.

Position 4 is the B street green "vehicle interval" position so-called, in which a short period timing of the order of several seconds may be reset by traffic actuation to extend the time in this position and thus extend the B street right-of-way period up to a maximum limit established in a novel manner at a desired percentage point as described below.

Potentiometer PR22 determines the percentage point in the time cycle at which the stepping switch will advance from position 4 to position 5 in the time cycle with relation to potentiometer PR20, as a maximum limit to such traffic actuated time extension.

Thus the rotor arm 45 and associated inner contact ring of potentiometer PR22 are connected via wire 66 to the fourth contact (in position 4) on bank LS21, and the other arm of the rotor and the associated outer contact ring are connected via wire 67 to the corresponding fourth contact on bank LS22. Thus in the position 4 of the stepping switch the potentiometer PR22 is connected to the input of transformer T1 and thence via the pulse former 53 and line 58 for control of the coincidence gate CG1 in conjunction with potentiometer PR20, and therefore potentiometer PR22 controls the percentage point in the time cycle in relation to potentiometer PR20 at which the stepping switch is advanced from position 4 to position 5 by action of the coincidence gate through relay 62 operating the motor magnet MM. Relay 62 is operated in this case by positive power from coincidence gate CG1 via wire 61, relay 62, wire 77 and branch circuit via contact BV1 and wire 89 to ground, the contact BV1 being closed by relay BV being energized in this position 4 as described below.

Position 5 is a timed position for B street yellow or clearance for example and at the end of the timed period the stepping switch is advanced as before to the next position 1, from which the cycle was started.

Contact bank LS24 of the stepping switch in FIG. 3 shows a group of signal lamps in the form of circles designated AG, AY, BG and BY connected with individual contacts or groups of contacts, as an example of one type of traffic signal cycle controlled in part by the master controller and in part by the local controller.

Thus as one illustration the signal lamps AG and AY, may be connected to individual contacts at positions 1 and 2, respectively, and lamp BG may be connected to adjacent contacts in positions 3 and 4, and lamp BY may be connected to the following contact in position 5. Power may thus be applied to these signal lamps in turn from one power terminal indicated as plus in a circle, via rotary contact W24 and the associated stationary contacts in turn on bank LS24 as the stepping switch is advanced through its cycle, the left side of the several signal lamps being connected via the common wires 72, 73 to the negative power terminal.

The several signal lamps AG, AY, BG and BY may represent the respective green "go" and yellow clearance signals for two intersecting roads A and B for example. Although the corresponding red stop signals are not shown, their inverse association with the green signal or with green and following yellow are so well known that their illustration here is omitted to simplify the drawing.

It will be noted that an additional contact bank LS23 is employed in the stepping switch in FIG. 3. This bank and its associated connections to its left and below serve to illustrate how certain steps of the stepping switch cycle (and corresponding steps in the signal operating cycle of bank LS24 for example) may be controlled by local timing so as to maintain a desired locally adjusted but preset time length while the total time cycle and the steps controlled by the percentage potentiometers vary in time length under control of adjustment of the time rate of phase shift by the master controller.

Thus the yellow signal periods are preferably of a constant length such as three seconds each, while the total time cycle may vary from 40 seconds to 120 seconds in length for example.

Similarly one part of a signal display period may be timed locally and another part timed on a percentage basis under control of the total time cycle by the master, as illustrated for example in the division of the BG display period into two time intervals on adjacent signal contacts 3 and 4 on bank LS23 (in positions 3 and 4) of the stepping switch. Thus in this example the end of the time interval in the first of these positions (position 3) is controlled on a locally pre-set time basis previously described, the second of these positions (position 4) is also controlled on a locally preset time basis via contact bank LS23 in part but is controlled on a percentage as a limit in addition.

The timing interval of position 4 differs from the timing interval of position 3 in that the time interval of position 4 is extendible by traffic actuation of detector VD during such interval, as described more fully below. Such extension of the time interval of position 4 is limited to a maximum period controlled on a percentage basis of the cycle by the potentiometer PR22. Thus the B green signal period may be terminated by the maximum percentage limit at coincidence or may be terminated by earlier completion of the timed period in absence of extending traffic actuation.

Obviously, within the scope of the invention, the signal display period can be divided into further parts if desired, as with a timed part followed by a percentage part followed by another timed part as one example, by rearrangement of the contacts on the several contact banks in relation to signals and local timing control and percentage timing control, and more or all of the signal periods could be divided between the local timing and master controlled percentage timing.

Considering now the operation of the timing bank LS23 and the associated timing units according to one embodiment of the invention as shown in FIG. 3, the timing is performed by a familiar method of charging a capacitor 74 slowly to the conduction voltage of gas discharge tube 75 to operate the time interval termination relay 76, the timing rate being varied as desired by control of the charging current by one of the several adjustable resistances 81, 82, 83 and 84, selected by the stepping switch.

These adjustable resistances 81, 82, 83 and 84 are connected via their adjusting taps for example, with individual contacts in positions 2, 3, 4 and 5 of contact bank LS23 as shown, the left ends of these resistances being connected via a common wire 85 and common minimum or current limiting resistance 86 to a direct current power supply. Thus these adjusting resistances respectively are connected via rotary contact arm W23 in their respective

associated positions of the stepping switch via wire 87 to one side of capacitor 74, the other side of which is connected to ground for example.

The upper (positive) side of capacitor 74 is also connected via wire 91 to one side of gas discharge tube 75, the other side of the tube 75 being connected via wire 92 and relay 76 to ground. Thus when one of the adjusting resistances is connected via bank LS23 in a desired position of the stepping switch, the capacitor is charged at the desired timing rate to conduction voltage of the tube 75, at which point the contained gas suddenly conducts to permit the capacitor to discharge through relay 76 to energize the latter and close its contact 96, which in turn connects power, from the terminal marked plus in a circle, via wire 65 to operate motor magnet MM to advance the stepping switch. As the motor magnet MM so operates, it closes its associated contact 94 to complete the discharge of capacitor 74 by connecting its upper side via wire 93, contact 94 and current limiting resistance 95 to ground.

It will be appreciated that other forms of timing might be used within the scope of the invention in relation to FIG. 3.

As previously stated, the preset time interval of position 4 is extendible and the extension of such time interval is obtained in a method well known in the art. Rotary stepping bank LS25 is employed to complete a ground connection, through the wiper arm W25 and position 4 of the rotary stepping switch LS25, wire 60 to the coil of relay BV to the power supply, thus energizing the relay BV.

Relay BV would close its contact BV2 and prepare a discharge circuit for the timing capacitor 74. If the vehicle detector VD contacts should close, due to a vehicle crossing over the same for example, the relay DR' would become energized from the power supply, through the coil of the DR' relay, wire 59 the contacts of the vehicle detector VD to ground. The relay DR' would close its contact DR'3 thereby completing a discharge circuit for timing capacitor 74 from ground through resistor SR, contact DR'3, contact BV2 wire 78 to wire 93 to the upper side of capacitor 74 thereby discharging the timing capacitor 74 to substantially zero with respect to ground. When the vehicle detector contacts VD reopen the relay DR' would become deenergized and the contact DR'3 would open thereby breaking the discharge circuit so that the capacitor 74 would begin to recharge thus in effect beginning a new time interval.

Should multiple timely actuations of the vehicle detector VD cause the capacitor 74 to discharge successively before the charge on the capacitor 74 approaches the breakdown potential of the flasher tube 75 so that the position 4 interval would be extended, the maximum timer as timed by the potentiometer PR22 would energize the relay 62, which circuit is completed from conicidence gate CG1 through the coil of the relay 62 through wire 77, contact BV1, wire 89 to ground.

With the relay BV energized its contact BV1, which would then be closed, would prepare a circuit to ground so that the relay 62 would be energized by power applied from the coincidence gate CG1 at the proper percentage time in the cycle as determined by the potentiometer PR22.

With the termination of the preset time interval or the termination of the time interval based on the percentage of the cycle the motor magnet would be energized to advance the several wiper arms to the next position (position 5) of the rotary stepping switch.

Relay 62 and motor magnet MM cooperate, when energized in position 4 for the maximum limit, to energize relay DR'. Relay DR' is energized by ground via contact 97 of relay 62, wire 98, contact BV3 for relay BV and wire 99. Contact MM1 is adjusted to delay its opening to insure a ground connection for the lock-in "memory" circuit of the DR' relay through contact DR'2 wires 70 and 88, contact MM1 to ground, as the wiper arm W25 advances from position 4 to position 5.

Should the time interval terminate with the termination of the preset time interval the relay 76 would be energized from the charged capacitor 74 via tube 75, wire 92, the coil of relay 76 to ground. The relay 76 would closed its contact 96 thereby energizing the motor magnet from the positive power supply through contact 96, wire 65, the coil of motor magnet MM to negative power.

Although in the illustrated form of the invention of FIG. 3, locally timed steps are interspersed among the percentage timed steps controlled by the potentiometers PR21 and PR22, one or more of such potentiometers might be used to provide desired operation at one percentage point only or at any desired number of such points in the time cycle, more or less than the two illustrated, within the teachings of the invention.

Although the control of the yield of right-of-way from road A to road B in response to traffic actuation on B is illustrated in FIG. 3 as determined at the desired percentage point in the background cycle for the local controller as established by the phase displacement of the adjustable potentiometer PR21, it will be understood that this potentiometer may be set at zero phase displacement with respect to its input from FC or the potentiometer may be replaced by a fixed potentiometer or potenial divider for deriving the single phase potential at a desired fixed phase relation as shown in FIGS. 4*a*–4*d* for example

The pedestrain pushbuttons PB shown on opposite sides of street A in FIG 2 at intersection B, to enable pedestrians to cross street A, are not shown specifically in FIG. 3. These pushbuttons PB may be connected in parallel with the vehicle detector switch VD and may be in the form of similar switches so that the switch VD may serve to illustrate either a vehicle detector switch or a pedestrian pushbutton switch in the simplified form of controller illustrated in FIG. 3.

However, as will be more fully described below in the preferred form of the controller of FIGS. 4*a*–4*d*, the pushbuttons PB are illustrated as connected to a separate relay PD for pedestrians to control walk-wait signals in association with the green signal of street B and to enable the pedestrians to have a longer crossing time than the minimum for vehicles alone.

It is preferred to have the flexibility of traffic actuated time extension of the street B green period between the minimum time and the maximum percentage limits for most applications of the control, to enable the maximum band width of green for thru traffic on street A by permitting early retransfer of right-of-way to street A before the percentage limit on street B if it is not sufficient on street B to prolong the right-of-way on the street B to such maximum limit. However, it will be appreciated that in some applications it may be desired to have a uniform percentage of the cycle for street B in response to actuation so that whether there are one or more actuations the retransfer of right-of-way to street A will always occur at the percentage point established by the setting of the PR potentiometers, so that the street B green period would not in such case vary with traffic actuation but would always terminate on the percentage point established by the coincidence gate operation. Such positive termination at the percentage point, without earlier termiation, can be provided if desired by disconnecting contact 97 and either adjusting potentiometer 83 for a longer time interval setting than the maximum percentage for example so that termination of B street green will always be on percentage as determined by operation of relay 62 by the coincidence gate, or similarly, such termination of street B green at a definite percentage point could also be provided if desired by disconnecting contact 97 and by opening the timing circuit in position 4, the potentiometer 83 for example.

Referring now to FIG. 4 which is composed of FIGS. 4*a*, 4*b*, 4*c* and 4*d*, arranged as shown in FIG. 5, this

FIG. 4 shows a detailed schematic circuit diagram of a preferred embodiment of a local controller combining several features of the invention cooperatively in one system, particularly adapted for operation in a traffic control system of the general type illustrated in block diagram in FIG. 2 and involving master control of the total time cycle for traffic signals for example, with master controlled expansion and contraction of the time cycle, master controlled change of split of the time cycle, and master controlled selection between several locally adjusted offsets of the individual local time cycles at the individual local controllers, and with smooth transition of the local time cycle from one such offset selection to another, the local cycle being partly distributed on a percentage basis by locally adjusted percentage potentiometers to expand with the total time cycle, and also involving local timing of the yellow or clearance signals, along with parts of other signal periods desired, so that the local timing of the several local controllers may be individually adjusted locally while being also jointly adjusted and synchronized by the master controller, and thus the local time cycle is controlled and timed partly from the master controller and partly from the local controller, all in cooperation with traffic actuation at the local controller.

FIG. 4, here presented in four sections, FIGS. 4*a*, 4*b*, 4*c* and 4*d*, is illustrated in a rest position. The signals at the controlled intersection will show a green signal for go for vehicle traffic on street A, a green walk signal for pedestrian to cross street B and a red signal for stop for vehicle traffic on street B with a red or wait signal for pedestrian to cross street A.

It will be assumed for the purposes of illustration that the local controller is in simultaneous offset operation.

FIG. 4 consists of FIGS. 4*a*, 4*b*, 4*c* and 4*d*, which illustrations comprise a complete circuit when arranged so that FIG. 4*b* is to the right of FIG. 4*a* while FIG. 4*c* and FIG. 4*d* are arranged under FIG. 4*a* and FIG. 4*b* respectively, all as shown in FIG. 5.

FIG. 4*a* illustrates three relays LO, S2 and S3 and their associated contacts below the respective relays, serving to control the selection of cycle "splits." Relay LO serving to control the point in cycle at which splits may be changed, and is illustrated as energized, while relays S2 and S3 are illustrated as deenergized. Relays S2 and S3 select the local split adjustments under control of relay LO and the remote offset selection.

Below the contacts of the aforementioned relays is a group of three cycle percentage split adjustment potentiometers PRB1, PRB2 and PRB3 of the types shown as PR22 in FIG. 3. Each potentiometer is associated with timing adjusting resistors TP1, TP2 and TP3, which are connected to a desired calibration point on a potential divider PDX at point PD+. The combination of potentiometer PRB1 and resistor TP1 affect "split" 1, while PRB2 and TP2, and PRB3 and TP3 affect "splits" 2 and 3 respectively. The block of resistors PRA from a potential divider immediately to the left of the potentiometers, serve to produce a voltage from lines FC phased to provide a zero reference point in a cycle, from which "split" percentage points in the local cycle may be obtained by adjustment of the potentiometers PRB1, PRB2 and PRB3 respectively, for remote selection.

The three horizontal lines marked FC are input variable frequency lines from the master controller, and correspond to the lines similarly labeled in FIGS. 1, 2 and 3. Immediately below the lines FC are three banks, A1, B2, and C3 of an eleven position, six bank rotary stepping switch, of the familiar telephone type, with the wiper arms W1, W2 and W3 with wiper arm W3 a bridged wiper. The additional contact banks D4, E5 and F6 and associated wipers W4, W5 and W6 are shown below in FIG. 4*c*. Each wiper arm is illustrated in contact with position number 1 of its associated bank.

The motor magnet MM, located directly below bank C3, to the left of the diagram, with some of its associated contacts, is used to advance the wiper arms of the several banks of the stepping switch step-by-step in a manner familiar to those in the art.

Additional adjustable timing resistors TP4, TP5, TP6, TP7 and TP8 are found below the bank C3 of the rotary stepping switch with which the several timing resistors are associated, each being connected to a certain position on the bank C3 while the terminals marked PD+ are connected to a selected position on the potential divider shown in FIG. 4*c*.

On the upper right of the diagram are six fixed terminals that may be in the form of insulated screw terminals, for example, and five adjustable forked terminal leads. The adjustable leads, which may be called "offset" leads for example, are connected to the desired fixed terminals, which may be called "split" terminals, for example. Any one or more "offset" leads may be connected to any "split" terminal to obtain the desired split of the cycle during any selected offset operation of the local controller. These terminals are shown unconnected for convenience of illustration. It will be observed if the adjustable offset leads are not connected to any of the "split" terminals or if the offset leads are connected to the two uppermost split terminals the split number 1 will be in effect via back contacts of relays S2 and S3 as described below. It will be understood that the leads may be cross connected to the split terminals as desired.

Below the several terminals are the timing capacitor C10, flasher tube F10 and the relay ITR, with its associated contacts, which form part of the preset timing circuit.

A selector switch CS, of the wafer type for example, is illustrated as having four possible positions, for different forms of operation of the controller. This switch is illustrated fully clockwise in an actuated and free position. However, by turning the three central elements of switch CS to the next position counter clockwise the "actuated" condition may obtained. The next position would provide "pedestrian recall," while the fourth and last position places the local controller on "vehicle recall," all as described more fully below.

The relay FOR is located below the selector switch CS. Relay FOR would be energized for "free" operation of the local controller but is shown deenergized in the condition assumed. The timing adjustment resistors TP9 and TP10 used during "free" operation are associated with several of the contacts of the relay FOR.

FIG. 4*b* shows five relays OR, OR', IR, SIM, and PR with their associated contacts below the respective relays. On the upper right of the diagram are four lines OC, OC1, OC2, and SM1, which lines corresponding to the lines similarly labeled in FIG. 1. These lines are three offset selection input lines from the master controller OC1, OC2 and SM1 and a common ground line OC from the master controller.

A selector switch SW10–SW11 is shown in its position 2 which position will cause the local controller to be in coordination with the system and also to provide simultaneous operation, when called for by the master controller.

If the selector switch SW10–SW11 were connected to position 1 the local controller would be in the coordinated system but not allowed to go into simultaneous operation. Position 3 of the selector switch SW10–SW11 would place the local controller in isolated operation.

In the upper left of FIG. 4*b* are four indicator lamps of a neon type for example, which will be illuminated individually to indicate when the local controller is in "free," outbound, inbound or average offset operation.

Switch SW11 is linked with switch SW10 and when switch SW10 is placed in position 3, switch SW11 will be placed in position 3 to supply a ground line to relay PFR and thus place the local controller in isolated operation, however PFR is deenergized with SW11 in position 2 as shown.

Four potentiometers PR4, PR5, PR6 and PR8 are associated with inbound offset, outbound offset and average offset and simultaneous offset. Potentiometer PR7 provides the local reference wave energy for establishing the offset effective for the local controller. A reversible motor RDM is illustrated to the right of the potentiometers. The thru lines bracketed and labeled FR are input variable frequency lines from the master controller, corresponding to those similarly marked in FIGS. 1–2.

FIG. 4*c* of the diagram illustrates the remaining 3 banks D4, E5 and F6 of the eleven position 6 bank rotary stepping switch. Below the bank F6 there are illustrated nine relays AW, RR, GR, YR, WW, BW, PD, MR and DR with their associated contacts below each relay respectively. Relays AW and MR are illustrated as energized while the remaining seven relays of this group are illustrated as deenergized.

Ten circles below the relays illustrate signal lights of the conventional colors, green for go, yellow for caution or clearance and red for stop, plus pedesterian "walk" and "wait" signals as desired.

In the lower section of FIG. 4*c* is a potential divider PDX made up of several resistors with taps so that the several adjustable timing resistors may be connected to the desired tap from points PB+ on the timing potentiometer.

Two timing resistors TP11 and TP12 are also illustrated in FIG. 4*c*. A phantom form of the motor magnet MM is illustrated since its one contact is removed from the location of the motor magnet MM in FIG. 4*a* for convenience in the drawing.

The relays MMR and CR are illustrated with their associated contacts in FIG. 4*c*, and are shown energized and deenergized respectively. The button PB, associated with relay PD, represents a pedestrian pushbutton which is located externally as in FIG. 2 but is here shown nearby for convenience.

The vehicle detector VD, associated with the relay DR, is also illustrated nearby, for convenience, but is an external part of this semi-actuated local controller, as shown in FIG. 2.

On the extreme left center of the diagram is selector switch SW12, which is an on/off switch which supplies power to illuminate the several traffic signals.

Near the right end of bank F6 of the rotary stepping switch is located switch SW13, which switch when in the position as illustrated, will cause the local controller to show an all-red signal when the stepping switch is in position 11. Should the switch SW13 be otherwise set the position 11 will become a skip position and the local controller will substantially omit the all-red signal display.

FIG. 4*d* generally is a diagram of three pulse former networks PF1, PF2 and PF3, arranged in a vertical column at the left, and three coincidence gate circuits CG1, CG2, CG3 and their associated output relays, MAX, R2 and R3 respectively arranged in a column at the right and each with its input at the left side and output at the right side.

These three pulse former circuits PF1, PF2 and PF3 are indicated in general by the dashed line blocks so designated and are associated on their input sides with the respective transformers T1, T2 and T3 at the left, and the coincidence gate circuits CG1, CG2 and CG3 are similarly indicated by dashed line blocks and control the respective output relays MAX, R2 and R3 at the right. The pulse former of each horizontal row extends to the right of the output winding at the right of its associated transformer about one third of the way across the figure as indicated by the broken line block designated PF1 in connection with the lowermost row, and the coincidence gate circuit is in general at the right half of each row as indicated in the broken line block designated CG1 for example in connection with the lowermost row, but the pulse former of each row is not necessarily associated only with the coincidence gate of the same row, as will be described below.

In the intermediate vertical zone between the three pulse former blocks and the three coincidence gate blocks are certain cross connections between pulse formers and coincidence gates, and other connections as will be more fully described below.

The lowest of the three coincidence gate blocks, CG1 and its output relay MAX, is concerned at its output end with control of the stepping switch magnet MM (in FIG. 4*a*) and the advance of the stepping switch in certain steps as desired, such as steps 1 and 8.

The pulse former PF1 is concerned at its input end with the output of the potentiometers PRA, PRB1, PRB2, and PRB3, establishing the locally adjusted percentage points for the control of the advancing of the stepping switch at the desired steps in its cycle, in association with the control lines FC from the master controller, the output of pulse former PF1 being supplied to the input of coincidence gate CG1.

The middle pulse former PF2 is concerned at its input end with the output of the potentiometer PR7 via transformer T2, the output of potentiometer PR7 serving as what might be called a local reference voltage, which in its normal stable condition on completion of its homing operation is in phase with the output of whichever one of the several potentiometers PR4, PR5, PR6 or PR8 is selected by remote control from the master controller, all of the several potentiometers just mentioned being associated with the reference frequency line FR.

As more fully described below the output from one of the potentiometers PR4, PR5, or PR6 is selected by operation of either one or both of the relays OR (and OR') or IR over the offset control lines OC1, OC2 and OC from the master controller, or potentiometer PR8 is selected by the operation of relay SIM over the offset control lines SM1 and OC from the master controller. The reversible motor unit RDM in FIG. 4*b* is controlled by the outputs of the middle and upper coincidence gates of FIG. 4*d* to drive the rotor of potentiometer PR7 in FIG. 4*b* in the nearest direction at a relatively slow rate to coincidence of phase displacement with the one of the four potentiometers selected by the master controller to determine the offset of the local controller cycle.

Relays OR, OR' and IR are for convenience shown deenergized with relay SIM energized indicating simultaneous offset demand as assumed, but it will be understood that relays OR and OR' or relay IR, or both relays OR (and OR') and IR may be energized with relay SIM, and in most cases likely would be so energized, although this would not prevent simultaneous offset selection with relay SIM energized.

Relay OR' is merely a contact multiplying relay for relay OR.

It will be understood that from the moment of change in offset selection by the master controller until the rotor of potentiometer PR7 has completed its rotation in its homing operation to coincide with the newly selected offset or phase relation, the output of potentiometer PR7 will be slowly changing in phase, and will be controlling pulse former PF2 in FIG. 4*d* during such change as well as when at rest in its final position. The output of this pulse former PF2 will be applied to the input of the coincidence gate CG1 for comparison with the output of pulse former PF1 to control the stepping switch in each desired percentage controlled point in its cycle. However, as more fully explained below, the output of pulse former PF2 is also applied to the coincidence gates CG2 and CG3 to control the homing operation of the rotor of potentiometer PR7 by means of the reversible motor RDM. In this connection the coincidence gate CG2 is employed to stop the motor at coincidence of the output voltage wave of PR7 with the output of the selected voltage wave of one of the potentiometers PR4, PR5, PR6 or PR8.

The output of pulse former PF2 is also applied to the input of the coincidence gate CG3, the output of which controls relay R3 which controls the direction of rotation of the reversible motor RDM, this being accomplished by phase comparison of the spike pulse output of pulse former PF2 with the square wave output of the pulse former PF3 of FIG. 4*d*, this latter pulse former having both a square wave output and a spike pulse output.

Reference may be had if desired to my aforesaid co-pending application for a more detailed description of this operation.

The operation of the controller through its cycle will now be described more fully in relation to the circuit in FIGS. 4*a* through 4*d*, such cycle being provided by the stepping of the stepping switch from position 1 through its 11 step cycle of positions and returning to position 1 to transfer right-of-way from street A to street B and retransfer right-of-way to street A.

As previously stated, it will be assumed that the local controller is in simultaneous operation and is at rest with a green signal illuminated for both vehicle and pedestrian traffic on street A and a red signal for both vehicle and pedestrian traffic on street B. It is further assumed that split 1 will be in effect to control certain positions of the rotary stepping switch.

Simultaneous operation of the local controller is obtained when switch SW10 in FIG. 4*b* is in position 2 and the line SM1 from the master controller is energized while lines OC1 and OC2 are deenergized. Relay SIM would be energized from the input line SM1 thru the switch SW10, line 301 to the coil of the relay SIM to line 302 to ground.

Contact 303 would be closed to place a ground connection on the adjustable lead SIM', in FIG. 4*a* via line 304 while contact 305 would be closed to complete a circuit to illuminate the indicator lamp SML from the alternating current power supply, represented by a plus in a circle thru line 310, indicator lamp SML, contact 305 of the relay SIM, line 308, contact 309 of the relay PFR to ground.

Contact 312 of the relay SIM completes a circuit from one of the input lines FR, through the potentiometer PR8, lines 316, contact 312, line 317 to the transformer T3, through the coil of the transformer T3 through line 318, contact 319 of the relay PR, line 320, contact 323 of the relay SIM, line 324 to the potentiometer PR8 to apply a selected adjusted phase input signal on transformer T3 with respect to three phase lines FR.

The output from the potentiometer PR7 is applied to the input of transformer T2 via a circuit from the potentiometer PR7, thru line 325, contact 326 of the relay PFR, line 327 to the primary transformer T2, thru line 330, contact 331 of the relay PFR to the potentiometer PR7 via line 332 to apply a single phase voltage to transformer T2, the phase angle of which is adjustable with respect to the three phase lines FR by means of the reversible motor RDM through suitable gearing.

If a change of offset to simultaneous has just now been called for by the master controller by operation of relay SIM the potentiometer PR7 will be in transition to the simultaneous offset condition for the local controllers, and will be driven by motor RDM gradually from its prior position of prior offset toward the new position matching in phase the simultaneous offset in the nearest direction, thus speeding up or slowing down the actual local time cycle respectively for decreased or increased offset angle in the nearest percentage change direction. However, for purposes of the present it will be assumed that potentiometer PR7 has already reached its rest condition matching potentiometer PR8 for simultaneous offset, with the time cycle of the controller matching the length of the master time cycle, i.e. the time spacing between phase coincidence between the wave energies on lines FR and FC.

When the local controller is at rest the wiper arms of the several banks of the rotary stepping switch would be in position 1.

Wiper arm W1 of bank A1 in FIG. 4*a* connects the potential divider PRA, via line 333 to line 334 to the contact 335 of the relay FOR to line 339, through resistor R6, to line 41 to transformer T1, through the input of the transformer T1, line 342, resistor R7, line 347 to point 348, through line 349 to wiper arm W2 in position 1 of bank B2 to line 350 to the reference frequency line FC1 from the master controller.

Wiper arm W4 in position 1 of bank D4 completes a circuit from the resistor 121 in the pulse former PF1 in FIG. 4*d* through lines 351 to 352 to the wiper arm W4, position 1 of the bank D4, line 354 to contact 355 of the relay FOR to line 356, line 357, line 358, resistor R9 to line 236 to establish an operating bias for the grid 167 of tube 165 in the coincidence gate CG1 so that the tube 165 will be in condition to receive pulses from the pulse former PF1.

Wiper arm W5 in position 1 of bank E5 completes a circuit to energize the relay LO in FIG. 4*a* from the power supply represented by a plus in a circle through line 361, the coil of the relay LO, line 362 to line 363 to position 1 of bank E5 to wiper arm W5, line 447 to ground. A connection is also completed for the relay AW from the power supply represented by a plus in a circle, line 365, line 366, the coil of relay AW, line 367, line 368, line 363 to position 1 of the bank E5, wiper arm W5, line 447 to ground. A parallel circuit to illuminate the lamp 369 is also completed from the power supply, line 370, lamp 369, lines 364, 368 and 363 to position 1 of bank E5, wiper arm W5, line 447 to ground.

The relay LO in FIG. 4*a* thus energized closes certain of its contacts to allow a change in split at this time. However, it is assumed for the present that no change in split will occur and split 1 remains in effect with relays S2 and S3 deenergized.

The relay AW closes its contact 374 to illuminate signal AGW, the green walk signal for street A which circuit is complete from the power supply, through switch SW12, line 375, line 376, contact 374 of the relay AW, line 377, signal AGW to line 378 to ground.

It will be noted here that relay MMR is normally energized by circuit from plus power via coil MMR, contact 518 of motor magnet MM to ground.

The signal AG, the green vehicle signal for street A, is also illuminated from the power supply through switch SW12, line 375, line 381, contact 382 of relay RR, line 383, contact 384 of relay GR, line 385, contact 386 of relay YR, line 387 to signal AG, line 378 to ground.

The signal BR, the red vehicle signal of street B is illuminated from the power supply through switch SW12, line 375, line 388, contact 389 of relay GR, lines 393, 394, signal BR, line 378 to ground.

The BRW signal, the red pedestrian signal of street B, is illuminated from the power supply through switch SW12, line 375, contact 395 of relay WW, line 398, signal BRW, line 378 to ground.

The relay MR would also be energized at this time through a circuit from the power supply through the coil of relay MR, line 399, contact 404 of the MAX relay, line 405, line 406, contact 407 of relay DR, line 408, contact 409 of relay MR, line 412, contact 413, of relay PD to ground, which circuit is a lock-in circuit.

The rest condition of the local controller having been fully described, it shall now be assumed that the local controller has been at rest in the above described condition for an appreciable time. The pulse former PF1 and coincidence gate CG1 of FIG. 4*d* cannot energize the relay MAX because the cathode 213 of tube 205 is open at contact 414 of relay AW and contact 415 of relay MR of FIG. 4*c*, so that the controller cannot leave position 1 until a traffic actuation of relay PD or relay DR releases relay MR to connect cathode 213 for operation at the next coincidence response.

Let us now assume that an actuation of vehicle detector VD on street B occurs by a vehicle approaching the intersection on street B. When contact VD closes, a circuit would be complete to energize relay DR from the power supply, through the coil of relay DR, line 416, contact VD to ground. When relay DR is energized the contact 407 of DR relay is opened to break the energizing circuit for relay MR as previously described so that relay MR would become deenergized and close its contact 415. Relay MR remains deenergized to "remember" the actuation because its lock-in contact 409 is open.

The circuit of cathode 213 in FIG. 4*d* would now be complete from cathode 213 through line 411, contact 415 of relay MR, line 417, line 418, point 419 on potential divider PDX, resistor 422 to ground.

With completion of the cathode circuit the tube 205 may now permit the coincidence gate CG1 to pass current to energize relay MAX in FIG. 4*d*. The relay MAX thus energized closes its contact 423 to complete a circuit to ground for motor magnet MM from the 12 volt power supply, indicated by a plus through the coil of motor magnet MM, lines 424, 425, 426, contact 423 of the MAX relay to ground.

The motor magnet thus energized would ratchet a step-by-step ratchet gear (not shown) and upon the motor magnet being deenergized, the ratchet wheel would be partially rotated to advance the wiper arms of the rotary stepping switch, in unison, to the next position 2. The deenergization of motor magnet MM would occur as the relay MAX is deenergized and permits its contact 423 to open and break the energizing circuit for the motor magnet MM as previously described.

The normal operating bias for grid 167 of coincidence gate tube 165 in FIG. 4*d* is available at arm 124 on potentiometer 125, and this bias potential is connected via wire 133, resistor R9, wires 358, 357, contact 355 on relay FOR, wire 354, wiper W4, position 1 of bank D4, wire 352 to capacitor C11, as well as being connected via wire 351, resistor R121, wire 158 to the grid 167. Upon energization of motor magnet MM in position 1 as described above, its contact MM372 completes a circuit from ground via wire 373, resistor R30, to capacitor C11. This ground provides a cut-off bias to grid 167 via its connection traced to capacitor C11. This terminates the coincidence pulses in tube 165 and thus cuts off the output of CG1 to the relay MAX to release the latter.

With the wiper arms in position 2 of the stepping switch, the wiper W1 of the bank A1 and the wiper W2 of the bank B2 are grounded, so that there is no input to pulse former PF1 of FIG. 4*d*. Positions 3, 4, 5, 6, 7, 10 and 11 are also grounded at these banks A1 and B2 to insure timing of the intervals via the pretimed timing potentiometers or resistors.

The wiper arm W3 of the bank C3, in position 2 connects the timing resistor TP4 connected at PD+ to a tap on the potential divider PDX so that a circuit is now complete from the direct current input, represented by a plus in a square, via the potential divider PDX at a point PD+, through the minimum resistor R10 to potentiometer TP4, tap 428, line 429 to position 2 of bank C3, wiper W3, line 432, line 433 to charge the timing capacitor C10.

Position 2 of bank D4 completes circuit from resistor 121 in FIG. 4*d* through lines 351, 352, wiper W4, position 2, line 537, 358, resistor R9 to line 236. A similar circuit is also completed in positions 4, 5, 6, 9, 10 and 11 of bank D4, to keep bias on CG1, from operating in these intervals by having the input of PF1 shorted out.

The wiper arm W5 of bank E5 in position 2 breaks the ground connection for both relays LO and AW, the circuits being previously described.

With the relay AW deenergized its contacts would be released to effect a change in signals. The green walk signal AGW for the pedestrian traffic along street A would be extinguished and the red wait signal ARW for the pedestrian traffic along street A would be illuminated from the power supply through switch SW12, lines 375, 376, contact 434 of relay AW, line 435, signal ARW, line 378 to ground.

The interval now being timed would be preset and timed through the potentiometer TP4 so that when the charge on capacitor C10 approaches the breakdown potential of flasher tube F10, the tube F10 will pass current from capacitor C10 to energize the relay ITR. Energized relay ITR would close its contact 436 to supply ground connection for the motor magnet MM, to complete an energizing circuit from the direct current supply, through motor magnet MM, lines 424, 437, contact 436 of the relay ITR to ground.

The motor magnet MM would notch the ratchet (not shown) upon energization and would also close its contact 438 to discharge timing capacitor C10 through lines 433, 432, resistor R12, contact 438 of motor magnet MM to ground, thus reducing the charge on timing capacitor C10 to substantially zero.

With the charge on timing capacitor C10 so reduced, the passage of current through tube F10 stops and relay ITR is deenergized. The energizing circuit for motor magnet MM is broken with the release of contact 436 of the ITR relay, and the motor magnet becomes deenergized and advances the wiper arms of the several banks of the rotary stepping switch to the next position, position 3.

The position 3 is a skip position as are positions 7 and 9. The position 3 of bank E5 completes a circuit to ground for the motor magnet MM, through the line 447, wiper W5, position 3 of bank E5, line 539, line 534, contact 535 of relay MMR, lines 536, 425, 424, to motor magnet MM to ground. A similar circuit is completed through positions 7 and 9 of bank E5. Motor magnet MM is released to advance the stepping switch when its contact 518 opens the circuit to and releases relay MMR, which opens its contact 535 to open the circuit to MM. A second circuit through position 3 of bank C3 applies a rapid charge to timing capacitor C10 from D.C. plus thru resistor R12, line 442, position 3 of bank C3, wiper W3 through the circuit previously described to rapidly charge capacitor C10 as a safety for the skip positions so that should the circuit through the bank E5 fail to complete a ground connection for the motor magnet MM the relay ITR will be energized to effect energization of motor magnet MM.

The motor magnet advances the wiper arms to the next position (position 4) of the stepping switch as previously explained.

While in position 4, bank E5 completes an energizing circuit for relay YR from the input supply through line 365, the coil of the relay YR, line 445, line 446 to position 4 of bank E5, wiper W5, line 447 to ground. The green signal AG is extinguished via open contact 386 of relay YR, and the yellow signal AY, the street A clearance signal, is illuminated from the input supply through switch SW12, line 375, line 381, contact 382 of relay RR, line 383, contact 384 of relay GR, line 385, contact 448 of relay YR, line 449 to signal AY, line 378 to ground.

The interval, timed through the wiper arm W3 of bank C3, is timed by charging capacitor C10 from PD+ through timing potentiometer TP5, and its minimum resistor below, line 444 to position 4 of bank C3, wiper W3, and the circuit previously described to timing capacitor C10. At the termination of the interval the wiper arms are advanced to the next position (5) as previously described.

In position 5 the relay GR is energized from input power through line 365, the coil of relay GR, line 463, line 465, line 466 to contact 467 of relay BW, line 468, line 469 to position 5 of bank E5, wiper arm W5, line 447 to ground.

The red signal AR for vehicle traffic on street A would now be illuminated and the yellow signal AY would be

extinguished. The signal AR would be illuminated from input power, through switch SW12, line 375, line 388, to contact 472 of GR relay, line 473, line 474 to signal AR, line 378 to ground.

The red signal BR is extinguished and a green signal BG for vehicle traffic on street B is illuminated from input power, through switch SW12, line 375, line 381, contact 382 of relay RR, line 383, contact 475 of relay GR, line 476, contact 477 of relay YR, line 478 to signal BG, line 378 to ground.

In the absence of a pedestrian pushbutton actuation, as has been here assumed, the position 5 becomes a skip position since a circuit is complete from ground, through wiper W6, position 5 of bank F6, line 553, contact 563 of relay BW, lines 564 and 534, contact 535 of relay MMR, line 536, line 425, line 424 to motor magnet MM to the power supply thereby immediately energizing motor magnet MM. The motor magnet MM opens its contact 518 to release relay MMR to release motor magnet MM to advance the several wiper arms as previously explained to position 6.

With the wiper W3 of bank C3 in position 6 an "initial" interval would be timed for vehicles on street B, timing potentiometer TP11, in FIG. 4*c*, by charging timing capacitor C10, in FIG. 4*a* from PD+ through potentiometer TP11 and its associated minimum resistor, line 483, contact 484 of relay BW, line 485, to position 6 of bank C3, wiper W3, and to timing capacitor C10 as previously described.

A parallel circuit through position 6 of bank F6 and wiper W6 now completes the energizing circuit for relay GR along with the circuit previously described.

When the timing capacitor C10 becomes sufficiently charged the flasher tube F10 will pass current and effect the advance of the wiper arms to the next position (position 7) as previously described.

The position 7 is a skip position similar to position 3, and actions similar to those described with reference to postion 3 take place except that the wiper arms are in position 7.

The wiper arms are advanced to position 8, during which interval, the timing capacitor C10 of FIG. 4*a* is charged through the timing potentiometer TP6 from PD+ through TP6, line 486, to position 8 of bank C3, to wiper W3 to timing capacitor C10 as previously described. The "vehicle" interval timing circuit just described is an extendible interval, which is extended by traffic actuation of the vehicle detector VD during such interval as explained below.

While the resettable vehicle interval timer is connected as previously described, a maximum limit control circuit is also connected in position 8 through banks A1 and B2, which determines the extension limit of street B green on the basis of a percentage of the cycle, controlled by the "split" in effect at the time. Here it has been assumed that "split" 1 is in effect so that potentiometer PRB1, of "split" 1 would control the percentage basis. The input of potentiometer PRB1 is connected to the three phase reference frequency lines FC from the master, and the output of potentiometer PRB1, of a single phase voltage is connected through line 487, contact 488, of relay S2, line 489, contact 493 of relay S3, line 494, to poistion 8 of bank A1, wiper W1, line 334, contact 335 of relay FOR, line 339, resistor R6, line 341, to transformer T1 primary, line 342, resistor R7, line 347, to point 348, line 349, to wiper arm W2 of bank B2, position 8 of bank B2, line 495, to contact 496 of relay S3, line 497, contact 498 of relay S2, line 499 to potentiometer PRB1.

The bank D4 completes a circuit from resistor 121 in pulse former PF1 in FIG. 4*d*, through lines 351, line 352 to wiper W4, position 8 of bank D4, line 503, contact 504 of relay FOR, line 505, line 357, line 358, resistor R9, to line 236 in FIG. 4*d* to establish an operating bias for the grid 167 as previously described.

The position 8 of bank E5 completes a circuit to energize the relay CR in FIG. 4*c* from the power supply, through the coil of relay CR, line 506, position 8 of bank E5, wiper W5, line 447 to ground.

When the relay CR is energized its contact 507 is closed to complete an energizing circuit for relay MR in FIG. 4*c* from the power supply, through the coil of relay MR, line 399, contact 404 of relay MAX, line 405, to contact 507 of relay CR, line 508, contact 509 of relay MMR to ground.

With the relay MR energized, a circuit is prepared through its contact 513 to discharge capacitor C10 if an actuation of the vehicle detector VD should occur during the presently timed interval. Assuming such an actuation did occur, the contact VD would close to complete an energizing circuit for relay DR as previously described.

When energized, the relay DR would close its contact 516 to complete the prepared discharge circuit for the capacitor C10, from the upper side of this timing capacitor, through line 433, line 515, resistor R24, contact 516 of relay DR, line 517, contact 513 of relay MR to ground, thus reducing the charge of the capacitor to substantially zero for example, for resetting its timing.

With the passage of the vehicle across the vehicle detector VD, the contacts VD would then reopen and open the energizing circuit of relay DR. Thus contact 516 of relay DR would reopen and break the discharge circuit of timing capacitor C10 so that the timing capacitor C10 would begin to recharge to retime this "vehicle interval."

Subsequent actuation of the vehicle detector VD would cause additional discharging of the timing capacitor C10 so that the time in the B green position 8 may be extended. In the absence of actuations on the vehicle detector, or if the actuations are sufficiently far apart, the timing capacitor C10 will charge sufficiently to reach the breakdown potential of tube F10 so that the charge on capacitor C10 will pass through the tube F10 and energize the relay ITR, to effect the advance of the stepping switch to its next position 9.

However, if multiple actuations of the vehicle detector should keep capacitor C10 from becoming charged to the breakdown potential of the tube F10, then the maximum limit control will terminate the interval at the predetermined percentage point of the cycle, set by the potentiometer PRB1. The output of the potentiometer PRB1 would be applied to the pulse former PF1, while the output of potentiometer PR7 would be applied to the pulse former PF2, and compared in coincidence gate circuit CG1. At the predetermined percentage point of the cycle, determined by the coincidence gate CG1 would pass current to energize relay MAX. Relay MAX would close its contact 423 to complete a ground connection for motor magnet MM as previously described. The relay MAX would also open its contact 404 to break the energizing circuit for the relay MR to release MR to leave a vehicle call for return of right-of-way to street B in the next cycle.

Relay MMR would also be deenergized as the motor magnet MM opened its contact 518.

The return circuit of cathode 213 of tube 205 in CG1 was completed in position 2 over contact 414 of relay AW. This circuit extends from cathode 213 via line 411, line 416, back contact 414 of relay AW (which was released in position 2), line 418 to junction 419 on potential divider PDX near ground to provide normal operating bias for the tube 205. This cathode return circuit remains completed until the rest position 1 is reached at which time relay AW is operated to open its contact 414, and at which point the cathode return circuit becomes dependent on closure of parallel circuit via contact 415 of relay MR.

In the present case it was assumed above that the B green interval was terminated by the MAX relay on the percentage maximum limit, thus having relay MR deenergized.

If however, the interval timed in position 8 of the stepping switch had been terminated by the action of the relay ITR as previously described, prior to the maximum limit, the contact 404 in FIG. 4*d* would not be broken since the relay MAX would not be energized. Thus the energizing circuit of the relay MR would remain complete to keep the relay MR energized until the next traffic actuation. Consequently the contact 415 of relay MR would remain open to break the cathode circuit at that point.

It will be assumed that no further actuations are received and that the local controller was advanced via the energization of the relay ITR to the next position (position 9).

Position 9 of the stepping switch is a skip position similar to positions 3 and 7 previously described, so that the wiper arms are advanced to the next position (position 10) via the self interrupting action of the relay MMR and motor magnet MM. The signals remain the same in position 9.

Position 10 of banks A1 and B2 ground the input to PF1 as in positions 2 through 7. Bank C3 provides a connection via wiper W3 in position 10 to time an interval through the timing potentiometer TP7 from the direct current input PD+ through potentiometer TP7, line 523 to position 10 of bank C3, wiper W3 connected to the capacitor C10 as previously described.

Bank E5, in position 10, completes a circuit to energize relay YR, which relay was deenergized in positions 5 thru 9. The relay YR is energized from the power supply through line 365, the coil of relay YR, line 445, line 524, position 10 of bank E5, wiper W5, line 447 to ground.

The relay YR opens its contact 477 to extinguish the green signal BG for street B vehicle traffic and closes its contact 525 to illuminate the yellow signal BY for street B vehicle traffic, the circuit being complete from the input supply, through switch SW12, line 375, line 381, contact 382 of relay RR, line 383, contact 475 of relay GR, line 476, contact 525 of relay YR, line 526, signal BY, line 378 to ground.

At the termination of this interval as timed through timing potentiometer TP7, the wiper arms will advance to the next position (position 11) as previously explained.

Position 11 may be a skip position or, if so desired a pretimed all-red position in the cycle, as determined by the setting of switch SW13. The switch SW13 is illustrated in an all-red position for the position 11.

If the all-red signals in position 11 are desired, as illustrated, the interval is timed via the timing potentiometer TP8, from the direct current supply from PD+ through TP8, line 528 to position 11 of bank C3, wiper W3 to capacitor C10 as previously described.

While the interval is timed, bank F6 completes a circuit to energize relay RR from the input supply through line 365, the coil of relay RR, line 529, switch SW13 to position 11 of bank F6, wiper W6 to ground. The relay GR would become deenergized in position 11 because its circuit would be broken by wiper arm W6 moving off position 10 in bank F6.

Both red signals BR and AR would now be illuminated, while all yellow and green signals would be extinguished due to the open common contact 382 of relay RR.

The red signal AR would be illuminated from the input supply through switch SW12, line 375, line 388, contact 389 of relay GR, line 393, line 529, contact 532 of relay RR, line 533, line 474 to signal AR, to line 378 to ground.

The red signal BR would be illuminated as previously described in connection with position 1 for example.

At the termination of the interval as timed in position 11, the stepping switch would be advanced to the next position (position 1) and resume its rest position as originally assumed. If however, the switch SW13, had been adjusted to eliminate the all-red condition during position 11 a skip step would have been accomplished by applying ground to motor magnet MM through wiper W6 of bank F6, position 11 through switch SW13, switch point 533, line 534, contact 535 of relay MMR, line 536, line 425, line 424, to motor magnet MM, to power. MM is deenergized by action of MMR as previously described, to advance the controller to its rest position (position 1).

It was assumed that the previous cycle was initiated in response to an actuation of vehicle detector VD without an actuation of the pedestrian button PB. However, an actuation of the pedestrian button PB will also initiate a cycle of the controller from its rest position (position 1). In each case the initiation of the cycle also requires coincidence gate operation at the desired percentage point.

Assuming now that the local controller is at rest as previously described, and that an actuation is received by the pedestrian pushbutton PB, the controller advances out of its rest position as previously described, except that the relay DR will remain deenergized and the relay PD will be energized from a low voltage input represented by a point with a plus, through the coil of the relay PD, line 521, to the pedestrian pushbutton PB to ground. The holding circuit for relay MR as previously described will be broken at contact 413 of relay PD so that the contact 415 of relay MR would close to complete the cathode 213 circuit as previously described.

The relay PD would lock in and remain energized via a circuit from the low voltage input, through the coil of relay PD, line 521, contact 538 of relay PD, line 530, contact 542 of relay WW to ground.

The indication lamp "Ped. call" would also be illuminated from the input supply through line 543, the "Ped. call" lamp, line 544, contact 545 of relay PD to ground.

The wiper arms would advance as previously described through the several positions until in position 4, through bank F6, wiper arm W6 connects ground to complete a circuit via line 546, contact 547 of relay PD, line 548, through coil of relay BW, to the power supply, thus energizing relay BW.

The relay BW closes its contact 552 to prepare an energizing circuit from the power supply, through the coil of relay BW, line 548, contact 552, of relay BW, line 468, line 469, to position 5 of bank E5, so that when the several wipers are advanced to the next position (position 5) the relay BW will remain energized. The wiper arms C3, D4, E5 and F6 are bridged so that the wiper arm E5 will make contact with its position 5 before the wiper arm W6 of bank F6 breaks its contact with its position 4.

In position 5 of bank F6, the wiper W6 completes a circuit from the input supply, through line 365, the coil of relay WW, line 466, contact 555 of relay BW, line 553, to position 5 of bank F6, wiper W6 to ground.

With relay BW energized, the circuit to apply ground to the motor magnet MM as previously described would be opened at contact 563 so that the interval is timed via the adjustable resistor TP1 and not skipped as previously described. The adjustable timing resistor TP1 charges the timing capacitor C10 from the direct current input, PD+ via TP1, line 455, contact 456 of relay S2, line 457, contact 458 of relay S3, line 459, to position 5 of bank C3, to wiper W3 to charge the capacitor C10 as previously described. This operates relay ITR to operate motor magnet MM to advance from position 5 to position 6.

The signal BGW, the "Walk" signal for B street pedestrian traffic is illuminated from the power supply, through switch SW12, line 375, contact 556 of relay WW, line 557, signal BGW, to line 378 to ground. The signal BRW, the pedestrian "Wait" signal, is extinguished as contact 395 of relay WW is opened.

When relay WW is energized, the contact 542 of relay WW is open to break the holding circuit for the relay PD so that the relay PD would become deenergized.

In position 6, a "pedestrian clearance" interval would be timed by the adjustable timing resistor TP12, instead of a "vehicle initial" interval by the adjustable timing re-

sistor TP11 as previously explained, from the direct current input PD+, line 559, contact 549 of relay BW, line 485 to position 6 of bank C3, to wiper W3, to capacitor C10 as previously described, to operate relay ITR at the end of the interval, to advance to position 7, as previously described. The controller skips quickly through position 7 as previously described, and continues through its cycle to position 8 the same as described for vehicle actuation.

Additional actuations of the pedestrian pushbutton PB during the interval would not cause an extension of the interval. However, additional actuation of the pushbutton PB after the walk interval will be "remembered" by relay PD locking in over its contact 538 and contact 542 of relay WW as previously traced.

After the controller has reached the street B vehicle clearance interval, position 10, the open PD contact 413 will release relay MR which will assure another cycle initiation at the next coincidence in the rest position 1.

It is obvious that combinations of vehicle actuations of the vehicle detector VD and actuations of the pedestrian pushbutton PB preceding position 5 will produce a timed interval during positions 5 and 6 as described with respect to actuation of the pushbutton only.

It will be noted that simultaneous operation of the local controller will occur regardless of the energized or deenergized conditions of the relays OR—OR' and IR in FIG. 4*b* so long as the relay SIM is energized. The several contacts of relay SIM are so arranged as to complete direct circuits from the potentiometer PR8 alone to the pulse former PF3 via contacts of relay PFR as previously described, independently of any contacts on relays OR—OR' and IR. Operation of the local controller other than simultaneous may occur only with the relay SIM deenergized.

It will now be assumed that the master controller calls for a change to outbound offset for example, energizing line OC1 in FIG. 4*b* and deenergizing line SM1 to the local controller, so as to energize the relays OR—OR' and deenergize the relay SIM.

The relay OR would be energized from the master controller via line OC1, through the coil of relay OR, line 575, line 302 to ground. The relay OR closes its contact 576 to complete the energizing circuit for the relay OR' from input power through the coil of relay OR', line 517, contact 576 of relay OR to ground. Relay OR' serves in effect to multiply the number of contacts controlled by the coil of relay OR.

With relay SIM deenergized and the relays OR—OR' energized the output circuit from the potentiometer PR8 to the pulse former PF3 in FIG. 4*d* is opened at contacts 323 and 312 of relay SIM. The relays OR—OR' thus energized closes their contacts so that the output from potentiometer PR5 is applied to transformer T3 of the pulse former PF3 from the potentiometer PR5 through lines 578, contact 579 of relay OR', line 582, contact 583 of relay IR, line 584, contact 585 of relay SIM, line 317 to the coil of the transformer T3, of the pulse former PF3, line 318, contact 319 of relay PFR, line 320, contact 586 of relay SIM, line 587, contact 588 of relay IR, line 589, contact 593 of relay OR' to the potentiometer PR5.

The output from the potentiometer PR5 adjusted for the desired percentage offset for "outbound," will be applied to the transformer T3 of pulse former PF3 for comparison with the pulse output of PF2 derived from the controller offset potentiometer PR7, in coincidence gate CG2 and CG3 to drive potentiometer PR7 slowly in the nearest direction by motor RDM to the new desired percentage point established by PR5.

Although the change toward the new offset is initiated by selection over lines SM1, OC1, OC2, the change to full outbound offset for the controller cycle is completed when potentiometer PR7 is at rest matching potentiometer PR5 as determined by coincidence gate CG2.

With relay OR' energized, a ground is provided for the adjustable lead and lug "Out" through line 594, contact 595 of relay OR', line 596, contact 597 of relay IR, contact 598 of relay SIM to ground, to effect change in cycle split if desired as described below.

If however, the master controller calls for a change to inbound offset for example by energizing line OC2 and deenergizing the lines OC1 and SM1, the relay IR would be energized from the input line OC2 through the coil of relay IR, line 575, line 302 to ground, while relays OR—OR' and SIM remain deenergized. The energizing of relay IR would close contacts to apply the output of potentiometer PR4 to the pulse former PF3, from potentiometer PR4 via lines 603, contact 604 of relay OR', line 605, contact 606 of relay IR, line 584, contact 585 of relay SIM, line 317 to the transformer T3 of the pulse former PF3, line 318, contact 319 of relay PFR, line 320, contact 586 of relay SIM, line 587, contact 609 of relay IR, line 613, contact 614 of relay OR', line 615 to the potentiometer PR4.

The actions of the pulse former PF2 and PF3 and the coincidence gates CG2 and CG3 cause the motor RDM to drive potentiometer PR7 slowly to the position of potentiometer PR4, in the manner previously explained, as moving the offset of the local controller gradually to the desired inbound percentage offset.

The operation of relay IR also connects ground to the lead and lug "In" via line 646, contact 637, contact 636, contact 598, to ground for connection to one of the split selection terminals as desired.

Should the relays OR—OR' and IR both be energized by the master controller and relay SIM deenergized, offset condition termed average offset would similarly control the percentage based timing through the output of potentiometer PR6. The output of potentiometer PR6 would be applied to the pulse former PF3 via line 616, line 617, contact 618 of relay OR', line 605, contact 606 of relay IR, line 584, contact 585 of relay SIM, line 317, to the transformer T3 of pulse former PF3, line 318, contact 319 of relay PFR, line 320, contact 586 of relay SIM, line 587, contact 609 of relay IR, line 613, contact 623 of relay OR', line 624 to potentiometer PR6.

Lead and lug AVE. will have ground applied via line 644, contact 638, contact 636, contact 598, to ground, for connection to the desired split selection terminal for association with the average offset.

Associated with relays OR, IR and SIM are indicator lamps Out L, In L, Ave. L and SML, which are controlled by contacts of these several relays to indicate master demand for outbound, inbound, average and simultaneous offset respectively. Lamp Out L is energized via contact 632, contact 628, contact 629 and contact 309 in series. Lamp In L is energized via contact 634, contact 633, contact 629 and contact 309 in series. Lamp SML is energized via contacts 305 and 309 in series. Lamp AVE. L is normally energized via contact 635, contact 633, contact 629 and 309 in series. Lamp Ave. L is also illuminated in average offset operation, if the local controller is set by switch CS in positions 2, 3 and 4 so as not to respond to the master call for "free" operation. This circuit is from lamp Ave. L via line 647, line 654, segment SLO, line 626, contact 627, contact 628, and contacts 629 and 309 in series.

It should be noted that if switch CS is not in position 1, the average offset will be called when relays OR—OR', IR and SIM are all deenergized. Thus in this condition average potentiometer PR6 is connected to T3 for PF3 from line 616 via contact 610, contact 583, contact 585, T3, contact 319, contact 586, contact 588, and contacts 611 in series to PRG.

Should the relays OR—OR', IR and SIM all be deenergized the controller would operate under "Free" condition so long as the selector switch CS in FIG. 4*a* is in its position 1 as illustrated. If the selector switch CS were placed in the next position (position 2) the local

controller would operate under average offset conditions, even though the master controller called for "free" operation. This permits some local controllers to go to "free" operation while others remain on average offset in light traffic as locally desired.

In any event a lead and lug "Free" provide means for connection to the desired split, with relays OR—OR', IR and SIM all deenergized, regardless of position of selector switch CS. This circuit provides ground on the Free lead via line 648, contact 652, contact 597, contact 598 to ground.

Free operation of the local controller is obtained by energization of relay FOR with relays OR—OR', IR and SIM deenergized and with switch CS in position 1 shown. The relay FOR would be energized from the input supply, through the coil of relay FOR, line 625, segment SLO, line 626, contact 627 of relay OR, contact 628 of relay IR, contact 629 of relay SIM, line 308, contact 309 of relay PFR to ground.

The free offset indicator light FREE L is connected when free operation is in effect, by being connected in parallel with relay FOR via lines 625 and 645.

The operation of the local controller would now differ from the operation previously described in this respect; the interval timed in position 1, heretofore described with reference to the percentage timing through the potential divider PRA, would now be timed via the adjustable resistor TP10 from the direct current input, through potential divider PDX, tap PD+, adjustable timing resistor TP10, line 675, contact 676 of relay FOR, line 354, to wiper W4 of bank D4, line 352, to charge capacitor C11.

As the capacitor C11 is charged the bias potential on grid 167 in CG1 in FIG. 4*d* is decreased, through a circuit from the upper side of capacitor C11, line 351, resistor 121, point 164, line 158, to grid 167 of tube 165. When the potential on capacitor C11 becomes sufficiently high the bias on grid 167 becomes sufficiently low so that tube 165 begins to pass pulses through the coincidence gate CG1 to provide a positive voltage on the control grid 203 of tube 205. This positive voltage on the control grid 203 prepares the tube 205 for the passage of current when the cathode 213 circuit is completed via contact 415, relay MR by an actuation as previously described.

In free operation the 400 cycle input to PF1 is shorted out at contact 673 of relay FOR, so that the circuit just traced provides control of one input to CG1 at grid 167, from the timing voltage on capacitor C11. The 400 cycle output of PF2 provides the pulses on the second input to CG1 at grid 168, for operation of CG1.

In position 8, the interval there timed is extendible by capacitor C10, timing resistor TP7, tube F10 and relay INT as previously described. However, the maximum time of the interval is determined by a preset maximum time interval as follows. The maximum limit is timed from the direct current input, PD+ through the adjustable timing resistor TP9, contact 677 of relay FOR, line 503, to position 8 of bank D4 to charge the capacitor C11 as previously described with reference to the timing of the interval in position 1 above. During the interval timed in position 8 the cathode 213 circuit is held closed so that the interval will terminate as previously described.

The split changing feature will now be described. In this embodiment three different adjustable splits are provided for selection from the master controller by locally chosen association with the several offsets.

The splits 1, 2 and 3 are provided by control of relays S2 and S3, in connection with the split change locking relay LO. A call for split change is initiated by a selection of one of the offsets by control relays OR—OR', IR, SIM from the master controller over lines OC1, OC2, SM1 and OC as described above. By cross connection of, as desired locally, of one or more of the offset leads-lugs FREE, AVE, In, OUT and SIM' at the right of FIG. 4*a* to any of the split terminals immediately to the left, the actual change of split can take place by energization or deenergization of relays S2 or S3, under control of the relay LO.

Relay LO is energized only in position 1 of the cycle of the stepping switch, which is the street A green walk position, and which is the zero point in the local controller cycle. Since the split changes affect the end of the street B green interval in position 8 of the cycle, the making of a split change only in position 1, by control of relay LO, avoids skipping a cycle in case of switching from one split percentage to an earlier split percentage after passing the earlier point.

A circuit previously described energizes the coil of relay LO only when the line switch is in position 1.

When relay LO is energized, a circuit is completed from input power through line 361, relay coil S2, via line 701, relay LO contacts 702, line 703, to split 2 terminals. Also from AC+, via line 361, through coil of relay S3, line 704, contacts 705 of relay LO, line 706 to split 3. These circuits prepare for operation of relay S2 or S3 when ground is applied to the associated split terminal.

Assuming that a ground connection is applied to split 2 terminal via adjustable lead-lug "Out" over the circuit of this lead previously described, relay S2 would be energized through the above described circuit via contacts of relay LO, to open the input circuit of the potentiometer PRB1 at contacts 493 and 488 of relay S2. Potentiometer PRB2 would apply an input to the transformer T1 of the pulse former PF1, FIG. 4*d*, through line 707, contacts 708, line 497, contact 496 of relay S3, line 495, to position 8 of bank B2 of the stepping switch, wiper W2 through line 349, to junction 348, line 247, resistor R7, line 342, primary of transformer T1, line 341, resistor R6, line 339, contact 335 of relay FOR, line 334, wiper arm W1, position 8 of stepping switch A1, line 494, contact 493 of relay 33, line 489, contacts 711 of relay S2, line 712 to the potentiometer PRB2.

The potentiometer PRB2 of split 2 would now serve a similar purpose as that previously described with reference to potentiometer PRB1 of split 1.

The preset adjustable timing resistor TD1 associated with potentiometer PRB1 as previously explained also has its circuit broken at contacts 456 of relay S2 while preset adjustable timing resistor TP2 associated with the potentiometer PRB2 would be employed to charge the timing capacitor C10 from the direct current input through the potential divider PDX to a tap PD+ to which the adjustable timing resistor is connected, through the adjustable timing resistor TP2, to line 713, contacts 714 of relay S2, line 457, contacts 458 of relay S3, line 459, to position 5 of bank C3 of the stepping switch, wiper arm W3, line 432, line 433 to capacitor C10.

With relay S2 energized a circuit would be completed from input supply via line 361, indicator lamp S2L, to contact 715 of relay S2, line 716, contacts 717 of relay S3 to ground, thereby illuminating the indicator lamp S2L. The circuit for indicator lamp S1L would be broken at contacts 718 of relay S2, extinguishing the indicator lamp S1L.

When the stepping switch leaves position 1 the energizing circuit for relay LO as previously described is broken at bank E5, position 1, which deenergizes the relay LO. On deenergization of relay LO its contacts 702 and 705 are opened, however before contacts 702 and 705 break, the contacts 720 and 721 of relay LO close. Contact 720 completes a holding circuit for relay S2 from the input power through line 361, the coil of relay S2, line 701, contact 720 of relay LO, line 722, contact 715 of relay S2, line 716, contact 717 to ground. This locks up relay S2 and prevents any change in the state of relay S2 and S3 until relay LO is again energized in the next cycle position 1.

Assuming now, for example, that the master controller effected an inbound offset and that the inbound adjustable lug-lead were connected to the split 3 terminal, when the relay LO was energized the relay S2 would become de-

energized. Its pull-in circuit via lug-lead Out would have been opened at contact 595 of relay OR.

The relay S3 would now be energized through a circuit from the input power through line 361, the coil of relay S3, line 704, contact 705 of relay LO, line 706, the split 3 terminal, the inbound adjustable lug-lead In over the inbound lug-lead circuit to ground via relay contacts on OR, IR and SIM as previously described.

When the relay LO would become deenergized the relay S3 would lock up through a circuit from the input power, through line 361, the coil of relay S3, line 704, contact 721 of relay LO, line 723, contact 724 of relay S3 to ground.

The indicator lamp S2L would be extinguished when contact 715 of relay S2 opened and indicator lamp S3L would be illuminated from the input power through line 361, indicator lamp S3L, contact 724 of relay S3 to ground.

The input circuit for the potentiometer PRB2 would be broken at contacts 708 and 711 of relay S2 while the adjustable timing resistor circuit would be opened at contact 714 of relay S2.

The potentiometer PRB3 and adjustable timing resistor TP3, both associated with split 3 would now be connected into the timing circuits. The circuit for the potentiometer PRB3 would be completed through line 725, contact 726 of relay S3, line 495, position 8 of the bank B2, wiper arm W2, line 349, point 348, line 347, resistor R7, line 342, to transformer T1 of the pulse former PF1, line 341, resistor R6, line 339, contact 335 of relay FOR, line 334, wiper arm W1, position 8 of the bank A1, line 494, contact 727, of relay S3, line 738 to the potentiometer PRB3.

The adjustable timing resistor TP3 is employed to charge the capacitor C10 from the direct current input, through the potential divider PDX, to a tap PD+, through the adjustable timing resistor TP3, line 728, contact 729 of relay S3, line 459, to position 5 and to the capacitor C10 as previously described.

The foregoing description has assumed that the ganged switches SW10 and SW11 were placed in contact with the center tap as illustrated. If the switches SW10 and SW11 were placed in the upper position the local controller could not assume a simultaneous condition due to the lack of an energizing circuit for the relay SIM via input line SM1, which line is only connected to the center position.

If, however, the switches SW10–SW11 were placed in the lower position the local controller would assume isolated operation via energization of the relay PFR from the input supply through the coil of the relay PFR switch SW11 resistor R31 to ground.

The indicator lamp ISO would be illuminated from the input power through the lamp ISO contact 662 of relay PFR to ground.

The contact 663 of relay PFR shorts out the transformer T3 via a circuit from the contact 633 of relay PFR, line 318, the coil of transformer T3, line 317 to the contact 663.

The contact 664 of relay PFR closes to short circuit the primary of transformer T2 from ground through contact 664 of relay PFR, line 327 to the coil of the transformer T2, line 330, contact 665 of relay PFR to ground. This short circuit on transformer T2 will prevent the pulseformer PF2 from operating and prevent the coincidence gate CG2 from being triggered by extraneous noises. Relay R2 will be deenergized since no pulses are formed in the pulseformer PF3. With relay R2 deenergized the energizing circuit for the motor RDM through contact *r*20 will be complete. Relay R3 will also be deenergized so that the contact *r*30 will remain closed. Motor RDM will be energized from AC+ through line 249, contact arm *r*21 and contact *r*20 of relay R2, line 248, contact arm *r*31 and contact *r*30 of relay R3, line 246, coil CW to the AC— to keep the motor RDM rotating at a constant speed and constant direction.

Motor RDM will rotate the cam shaft to rotate cams CM1 and CM2 to close cam contact CC1 and CC2 respectively at different periods in the cycle.

Cam contact CC1 will be closed when the stepping switch is in position #1 and cam contact CC2 will be closed when the stepping switch is in position #8.

When, in position #1, the cam contact CC1 closes a circuit from ground through wiper arm W6 of the bank F6, position #1 of bank F6, line 731, cam contact CC1, via line 672, contact 673 of relay PFR, lines 674, 417 and contact 415 of relay MR, line 411, to cathode 213 of tube 205 of coincidence gate CG1, thereby removing the bias on the cathode 213 permitting tube 205 to pass current thus energizing relay MAX.

Relay MAX closes its contact 423 thereby completing the energizing for motor magnet MM as previously described.

When the stepping switch is in position #8 relay CR is energized through the circuit previously described. A circuit is then completed from ground through contact 737 of relay CR, line 736, cam contact CC2, line 672, contact 673 of relay PFR, lines 674, 418, contact 414 of relay AW, line 411 to the cathode 213 causing the relay MAX to operate as heretofore described. This circuit will serve as the maximum timing circuit for the interval timed during position #8 and will only advance the wiper arms if actuations of the vehicle detector extend the extendable interval during such interval.

With the transformer T3 of the pulseformer PF3 shorted out via the contact 663 of relay PFR as previously described the pulseformer PF3 is inoperative causing the coincidence gates CG2 and CG3 to also be inoperative, thereby maintaining the relay R2 and R3 deenergized.

It will be noted that the button MB found in FIG. 4*d* connects lines 426 to ground. Button MB is a manual control button which would connect ground to the motor magnet MM through line 426 and the previously described circuit to cause the motor magnet to advance the wiper arms as desired.

It will also be noted that the selector switch CS in FIG. 4*a* has four possible positions. It is here shown in position 1 so that when relays OR—OR', IR and SIM are deenergized the local controller will run in "Free" operation.

Position 2 however connects lines 654 and 626 through the segment S10 and disconnects the line 625 from the segment S10 so that the relay FOR would not be energized. This position of selector switch CS will cause the local controller to operate an average offset when the relays OR—OR' IR and SIM are deenergized.

Position 3 of the selector switch CS will cause segment S11 to make contact between ground and line 735 so that the relay PD is energized from the input supply through the coil of relay PD, line 735 to segment S11 of the selector switch CS to ground. This circuit holds the relay PD energized so that a pedestrian call is not required to obtain a pedestrian interval during phase B of the cycle.

Position 4 of the selector switch CS will cause the segment S12 to complete a circuit to energize the relay DR from the input supply through the coil of relay DR, line 741, segment S12, line 742 to position 11 of bank E5, wiper arm W5, line 447 to ground to cause a vehicle call to register when the local controller is in position 11.

The diagram of the several pulse forms PF1, PF2 and PF3, and the several coincidence gates CG1, CG2 and CG3 of the FIG. 4*d* have not herein been described in detail. Reference is made to the copending application mentioned above, which describes in detail the operation of the pulse formers and coincidence gates.

It will be noted that certain modifications have been made in the pulse formers PF1, PF2 and PF3 in that a capacitor 137' has been added to each of the pulse formers. The capacitor 137' establishes a small operating bias for the grid 141 of tube 145.

By maintaining a small bias on the grid 141 the pulses

generated by the several pulse forming networks will occur as the input sine wave passes through zero in an increasing direction.

A further modification in the several coincidence gates is the addition of resistor 183'. This resistor 183' serves to reduce the current drawn by the tube 165. A double screen grid 167' is illustrated in place of the single screen grid as illustrated in the diagram of the copending application above mentioned to more closely represent the tube employed in the circuit.

The cathode 213 is herein illustrated connected to line 411 through which the bias of the cathode is controlled, as explained above, rather than connecting the cathode 213 to line 214 to be biased at point 216.

Reference will now be made to FIG. 6, showing a sample dial panel for the controller of FIGS. 4*a*–4*d*, and to the associated FIGS. 7 and 8 below FIG. 6, the FIGS. 7 and 8 showing sample cycles of operation of the controlled with the several signal periods or functional periods identified by numbers in parenthesis with the similarly identified adjusting dials in FIG. 6.

These FIGS. 6–8 are largely self-explanatory but will be supplemented with a brief description of some features below. The several adjusting dials are shown with their knobs all pointed directly upward for simplicity in the drawing although it will be understood that they will normally have different percentage or time settings as the case may be.

The large circles identified "Inbound," "Free," "Split 1," "A Walk," etc. in FIG. 6 illustrate indicator lamps, corresponding to those identified in a generally similar manner in FIG. 4.

The several switch and dial adjustments are more fully described below.

The manual switch (14) in FIG. 6, corresponding to SW10–SW11 in FIG. 4*b*, permits selection of coordinated or isolated operation. Under coordinated operations, positions 1 or 2, the local controller is subject to the control of the master controller with regard to cycle and offset.

Under isolated operation, position 3, the controller is disconnected from the master controller. However, the cycle and split under isolated operation are suppled by a synchronous motor RDM and cam CM1–CM2 arrangement, operating the associated contacts CC1 and CC2. The "split" set by these cams in such operation determines the side street maximum interval, as explained above, while the side street interval timing, up to the maximum, is determined by vehicle and pedestrian actuations.

For normal coordinated operation under the control of the master controller, the system selector switch (14) on FIG. 6 corresponding to SW10–SW11 on FIG. 4, is set in either the "coordinated" position or the "coordinated and simultaneous" position. In the former position 1, the local controller will switch to the inbound, outbound or average offsets on demand from the master controller, but will ignore any call for simultaneous offset. With the switch set in the latter position 2, the local controller will respond to a demand for simultaneous offset, as well as to a demand for inbound, outbound, or average offset. Response to a master call for free operation may be made in either position 1 or position 2 of SW10–SW11, depending also on the position of switch CS.

System selector switch (13) in FIG. 6, corresponding to CS in FIG. 4, is then set in the desired position. When in the "actuated" position the controller will perform as a coordinated semi-actuated controller, governed by the master controller, but will ignore any call from the master controller to go to "free" or independent operation.

With switch (13) in the "actuated and free" position, the controller will operate as described above, but will also go to "free" operation when so instructed by the master controller.

Putting switch (13) in the "vehicle recall" or "pedestrian recall" position will modify the operation to the extent of recalling the controller to the minor street B after each major street A period, with the initial timing of the street B green period determined by either the vehicle or pedestrian interval settings.

Dials (1*a*), (1*b*) and (1*c*), corresponding to phase adjusting potentiometers PR4, PR5, and PR6, determine the offset, in percent of total cycle, by which the local controller cycle will lag behind the zero point in the master controller cycle, for inbound, outbound and average respectively. The potentiometer PR8 determines the offset for simultaneous, but is not shown in FIG. 6.

These settings determine the location of the beginning of the major street A pedestrian clearance period, the first interval in the local controller cycle following the major street A pedestrian walk period in position 1 of the cyclic step-by-step switch. See FIG. 8. Thus the local zero point or the start of the local controller cycle is in the stepping of the stepping switch from position 1 to position 2 to terminate the A green walk, and start the A green wait or pedestrian clearance period in position 2.

Dial (2), corresponding to potentiometer TP4, is used to set the length of the street A pedestrian clearance period. Dial (3), corresponding to potentiometer TP5 determines the length of the street A vehicle clearance period or a yellow period.

Dial (4), corresponding to potentiometer TP10, is used to set the street A minimum green period under "free operation" as described below.

Dials (5*a*), (5*b*), and (5*c*) corresponding respectively to potentiometers PRB1, PRB2 and PRB3 are used to set the maximum length of the street B green intervals for the three available splits. These dials are calibrated from zero to 100% for example, and set the maximum termination point of the street B green as measured from the zero point in the local controller cycle. In adjusting these dials, it will be noted that the street A clearance period will be deducted from the apparent length of the maximum settings. The dial (5) settings must be high enough to cover the sum of the street A pedestrian and vehicle clearance periods and the street B "pedestrian minimum" green (described below) during the shortest time cycle to be used. Dials (6*a*), (6*b*) and (6*c*), corresponding respectively to potentiometers TP1, TP2, and TP3, determine the length of the "initial" side street green whenever pedestrian pushbuttons are used, as shown in the preferred form of the invention in FIG. 4. This guaranteed "walk" interval forms the first part of the street B green whenever a pedestrian actuation is received prior to the end of the street A vehicle clearance.

Dial (7), corresponding to potentiometer TP11, is used to set the length of the street B "vehicle initial" interval. This interval forms the first part of the side street green in the absence of pedestrian actuations.

Dial (8), corresponding to potentiometer TP6, times the vehicle extension interval. This interval operates to extend the side street green up to the maximum under substantially continuous actuation by traffic.

Dial (9), corresponding to potentiometer TP12, is used to determine the length of the street B pedestrian clearance interval and its timing function as inserted in the cycle only upon actuation of pushbutton PB in FIG. 4, and is effective regardless of whether or not walk-wait signals are used.

As indicated in FIGS. 7–8, the minimum street B green is composed of either one walk, one pedestrian clearance, and one vehicle extension interval, dials (6), (8) and (9), or 1 vehicle initial and 1 vehicle extension interval dials (7) and (8). The former will be obtained as a result of a pedestrian call only, or as a result of both pedestrian and vehicle calls. The latter will be obtained as a result of a vehicle call alone.

Dial (10), corresponding to potentiometer TP7, sets the length of the street B vehicle clearance interval, and dial (11) corresponding to potentiometer TP9 is used to set the

side street maximum limit under "free" operation as described below.

Dial (12), corresponding to potentiometer TP8, is used when a special all-red interval is inserted in the cycle in advance of the street A periods. This dial has an "off" position for example, at the beginning of its timing range to reduce the period to negligible time if desired.

Free operation is obtained at a local controller when specified by the master controller during light traffic periods, but only if selector switch (13), i.e. CS, on the local controller has been set at the "actuated and free" position.

During free operation the master controller functions if cycle and offset selection are suspended with respect to this local controller, and the latter operates as an independent semi-actuated controller.

Dials (6), (7), (8), (9) and (10) determine the timing interval for street B as explained above. Dials (*5a*), (*5b*) and (*5c*) are ineffective, and the side street maximum interval is set on dial (11). The street B minimum green is composed of one walk interval, dial (6), one pedestrian clearance interval, dial (9), and one vehicle interval, dial (8), or one initial interval, dial (7), and one vehicle interval, dial (8). In either case, the timing of the maximum street green is started simultaneously with the beginning of the first vehicle extension interval. Following the side street periods and after the special all-red interval is interposed, the street A minimum green, as set on dial (4) is timed. If a call is received from a street B detector VD prior to the end of the street A minimum green, the controller will go directly into the A pedestrian clearance, dial (2), at the end of the minimum timing. In the absence of either pedestrian or vehicle calls the controller will "rest" on A green at the end of the minimum. Upon receipt of a street B call by actuation there, the street A pedestrian clearance is initiated followed by the vehicle clearance, and the street B green.

Referring to FIGS. 7 and 8, these illustrate schematically cycles of operation of the controller of FIGS. *4a–4d* in coordinated operation and in free operation respectively.

The cycle diagrams show a horizontal dividing line in the B green period for illustration of vehicle actuation alone in the lower two blocks "Initial" and "Veh." and for illustration of pedestrian actuation, with or without vehicle actuation, in the upper three blocks "B Walk," "Ped. Cl." and "Veh." The designation "Ped." is abbreviation for pedestrian, "Veh." for vehicle, and "Cl." for clearance. The term "Fixed" is applied to locally timed periods set by the time adjustment dial.

The notation "Minimum Setting" in FIG. 7 indicates the lowest limit for setting of the B% maximum by dial (5) to cover the several "fixed" intervals on the shortest time cycle of the master controller. This percentage maximum on the respective dials *5a*, *5b* and *5c* would normally be set somewhat above this minimum setting.

The notation "B" Call in FIG. 8 indicates traffic actuation on street B.

Several embodiments and connections providing various aspects of the invention have been illustrated or described, and several modifications have been pointed out, but it will be understood that the above description and accompanying drawings are merely illustrative, and that the invention is capable of use in a variety of forms, and it will be obvious to those skilled in the art that various further modifications in structural details or in arrangement or character of parts may be made within the spirit of the invention.

I claim:

1. In a traffic control system having two periodic electrical wave energies, one of which is progressively shifting in phase with relation to the other at a slow controlled rate, a traffic actuated signal controller for control of right-of-way between interfering traffic lanes and including means connected for receiving and for responding to phase coincidence of said wave energies, means for responding to passage of traffic, and means controlled by the last two responsive means for operating the traffic signal to transfer right-of-way from one traffic lane to another in response to conjoint operation of said two responsive means.

2. In a traffic control system for interfering traffic lanes and having two periodic electrical wave energies, one of which is progressively shifting in phase relation to the other at a slow controlled rate, a traffic actuated signal controller for controlling a traffic signal in response to said wave energies and including means for deriving further wave energies in predetermined phase relation to the respective first mentioned wave energies, means for responding to phase coincidence of said derived wave energies, means for responding to passage of traffic on one of said lanes, and means for controlling transfer of right-of-way between said lanes by said signal in response to conjoint operation of said last two responsive means.

3. In a traffic signal controller for the control of a traffic signal for control of right-of-way between interfering traffic lanes, means for operating in response to vehicle detection in one of said lanes, input circuit means for connection to a remotely controlled source of periodic electrical wave energy, second input circuit means for connection to a second remotely controlled source of periodic wave energy having a slow progressive phase shift with respect to the first mentioned wave energy at a controlled time rate, means in said controller for deriving local first and second wave energies in predetermined phase relation to the respective first and second mentioned wave energies, and means for controlling transfer of right-of-way in response to a combination of operation of said vehicle detection means and phase coincidence of derived wave energies.

4. In a traffic signal controller for operation of a traffic signal having signals for controlling right-of-way for interfering traffic lanes in response to remotely controlled periodic electrical wave energies, one of which is progressively shifting in phase in relation to the other at a slow controlled time rate to provide phase coincidences at time intervals of the order of a desired traffic signal cycle, the combination in said controller of means for deriving further periodic wave energies in predetermined phase relation to the respective first mentioned wave energies and at least one of said predetermined phase relations being adjustable, cyclic switching means having a cycle of positions through which it is adapted to be operated for controlling the said signals for such control of right-of-way, traffic actuated means for responding to traffic in one of said lanes, means controlled by said cyclic switch means at one position for operation of said switch means to its next position for control of transfer of right-of-way to said one lane in response to a combination of traffic actuation of said traffic actuated means and coincidence of phase of said two derived wave energies.

5. A combination as in the claim 4 and including further means controlled by said cyclic switch at a further position in its cycle for controlling retransfer of right-of-way from said one lane to another by operation of said cyclic switch from said latter position in response to phase coincidence of one of said derived wave energies with a third wave energy derived from the corresponding other of the first two mentioned wave energies.

6. A combination as in the claim 5 and including means controlled by the cyclic switch in the last mentioned position in response to actuation of said traffic actuated means for extension of right-of-way therefor up to a maximum limit established by the last mentioned phase coincidence responsive means.

7. A traffic control system for interfering traffic lanes including right-of-way signal circuits for the respective

lanes, cyclic switching means for operating one of signal circuits in one part of its cycle and for operating another of said switching signal circuits in another part of its cycle, two remotely controlled sources of periodic wave energy with one of said wave energies progressively shifting in phase relation to the other at a slow controlled time rate to provide phase coincidences at spaced time intervals of the order of a desired signal cycle, traffic actuated means for responding to traffic in one of said lanes, means for responding to said phase coincidences, means for operating said cyclic switching means from said one part of its cycle to said other part of its cycle in response conjointly to traffic actuation of said traffic actuated means and to coincidence response of said coincidence responsive means, and means for operating said cyclic switch means from said other part of its cycle to said one part of its cycle thereafter within a predetermined adjustable percentage of the cycle.

8. In a traffic control system having two periodic electrical wave energies, one of which is progressively shifting in phase with relation to the other at a slow controlled rate to provide phase coincidences at time spacing of the order of a desired traffic signal cycle, cyclic switch means for providing a cycle of signal changes for the traffic signal, traffic actuated means for responding to traffic, means for responding to phase coincidence of said two periodic wave energies, and means controlled by said cyclic switch means in a part of its cycle for controlling a signal change in response to conjoint action of said traffic actuated means and said phase coincidence responsive means.

9. In a master-local traffic control system having a master background time cycle of remotely controlled variable time length, local traffic actuated means for operating in response to traffic, local means for deriving from said master background time cycle a local background time cycle normally of said time length and of locally adjustable offset with reference to said master cycle, said local cycle deriving means including a plurality of individually adjustable and selectable means for adjusting such offset when selected, means for remote selection among said individual adjusting means for providing a selected offset, a plurality of local means for providing a control output at individually adjustable percentage points in the local offset cycle when selected, means for remote selection among said last named means for so providing said control output at a selected said percentage point, means for providing a local operating cycle for a local traffic signal including a plurality of right-of-way signal periods in sequence for the control of traffic when initiated, means for initiating said local operating cycle in one of said right-of-way periods in predetermined relation to said selected offset in response to operation of said local traffic actuated means by traffic actuation, and means controlled by said control output for the percentage point selected for controlling termination of a further one of said right-of-way periods in said cycle in predetermined relation to the percentage point selected, said local cycle providing means including means for providing a right-of-way signal period extendible in response to operation of said traffic actuated means and including means for setting a maximum limit to such extendible right-of-way period in predetermined relation to said remotely selected percentage split.

10. A combination as in claim 9, in which said local offset adjusting means include means for providing inbound, outbound, average and simultaneous offsets for such selection.

11. A combination as in claim 9, and including means for selectively linking the respective offset adjusting means with the desired percentage point adjusting means for joint such remote selection of desired combinations of particular said offset means and particular said percentage point means for determining desired combinations of signal cycle offset and signal cycle split.

12. A combination as in claim 9, in which said local offset adjusting means includes means for providing inbound, outbound, average and simultaneous offsets, and local switch means for selectively providing simultaneous offset or one of the other offsets locally in response to remote selection of simultaneous offset by the master.

13. A combination as in claim 9 in which the local cycle means includes means for providing a pedestrian walk signal time period followed by a pedestrian wait signal time period in a vehicle right-of-way period respectively before and after a rest point in the signal cycle for such initiation of the cycle at such point in predetermined relation to said offset.

14. In a local traffic controller in which the occurrence of phase coincidence of two periodic waves at time intervals of the order of a traffic signal cycle controls a traffic signal, the combination in the local controller comprising means for responding to traffic actuation, and means controlled by said traffic responsive means and by said phase coincidence for initiating a traffic signal cycle in response to traffic actuation of said traffic responsive means and phase coincidence of said periodic waves conjointly.

15. A combination as in claim 14 in which the means for initiating a traffic signal cycle includes phase coincidence circuit means whose circuit is closed by the traffic actuated means for responding to phase coincidence of the waves to so initiate the cycle.

16. A combination as in claim 14 in which the means for initiating the traffic cycle includes a relay and phase coincidence responsive means for operating said relay in response to phase coincidence of said waves only if the traffic responsive means has been actuated.

17. In a local traffic actuated controller in which two periodic waves are utilized with one wave slowly progressively shifting in phase with respect to the other wave so that phase coincidence occurs at time intervals of the order of a traffic signal cycle, means at the local controller for deriving two additional periodic waves from the same one of said first mentioned two periodic waves and including means for adjusting one of said additional periodic waves in phase, means for initiating a traffic signal cycle in response to traffic actuation and phase coincidence of the other of said first two periodic waves and one of the additional periodic waves and means for again switching the traffic signals in response to phase coincidence of the other of said first two periodic waves and the other of said additional periodic waves to adjustably apportion the traffic signal cycle.

18. A combination as in claim 17 in which the means for initiating a traffic signal cycle in response to a phase coincidence includes cyclic stepping switch means having a plurality of positions for switching the traffic signal, and in which one position includes circuit means for making the first phase coincidence effective for so initiating the traffic signal cycle and another of said positions includes circuit means for subsequently making the second of said phase coincidences effective for so switching the traffic signals.

19. In a local traffic actuated traffic controller in which two periodic waves are employed with one wave slowly progressively shifting in phase with respect to the other wave so that phase coincidence occurs at time intervals of the order of a traffic signal cycle, means at the local controller for deriving two additional periodic waves from the same one of said first mentioned two periodic waves, said means including a plurality of locally adjustable remotely selectable means for providing in response to remote selection one of said additional waves having a desired split percentage of the traffic signal cycle, means responsive to traffic actuation and to phase coincidence of the other of said first two periodic waves and one of the additional periodic waves for initiating a traffic signal cycle thereby switching the traffic signals and means for again switching the traffic signal in re-

sponse to phase coincidence of the other of said first two periodic waves and the other of said additional periodic waves.

20. In a master-local traffic control system having master traffic controller means for providing cyclic timing signals of variable time cycle length, local means for deriving from said master timing signals a local timing signal of the same time cycle length as the master timing signals and of adjustable offset in timing from said master timing signals, said local timing means including a plurality of individually adjustable means for adjusting such offset in timing when selected, means for remote selection by said master among said individual offset adjusting means, a further plurality of individually adjustable local timing means for deriving adjustable timing signals from the master timing signals and the local adjusted offset timing signals to provide local split timing signals at particular predetermined percentage points in the locally offset cycle, means for remote selection of the last named means by the master, means for providing a local operating cycle for a local traffic signal including a plurality of right of way periods in sequence for the control of traffic when initiated, local traffic actuated means for responding to traffic, means for initiating said local operating signal cycle in one of said right of way periods in predetermined relation to said selected offset in response to traffic actuation of said traffic actuated means, and means for controlling termination of a further one of said right-of-way periods in said cycle in predetermined relation to the percentage split point adjusted.

21. In a traffic control system, means for providing two periodic electrical wave energies, one of which is shifting progressively in phase relation to the other at a controlled slow time rate to provide phase coincidences at time intervals of the order of the desired traffic signal time cycle, traffic actuated means for responding to traffic, coincidence responsive means for responding to phase coincidence of said two wave energies, and means for controlling a traffic signal change in response to conjoint operation of said traffic actuated means and said coincidence responsive means.

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