United States Patent

[11] 3,618,004

[72] Inventor **Ralph M. Riddle, Jr.**
Moline, Ill.

[21] Appl. No. **814,407**
[22] Filed **Apr. 8, 1969**
[45] Patented **Nov. 2, 1971**
[73] Assignee **Gulf & Western Industries**
New York, N.Y.

[54] COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

11 Claims, 6 Drawing Figs.

[52] U.S. Cl. 340/35
[51] Int. Cl. G08g 1/08
[50] Field of Search 340/35, 37, 40, 41

[56] **References Cited**

UNITED STATES PATENTS

3,500,308 3/1970 Riddle, Jr. et al. 340/35

Primary Examiner—Kathleen H. Claffy
Assistant Examiner—Randall P. Myers
Attorney—Meyer, Tilberry and Body

ABSTRACT: There is disclosed a coordination unit for coordinating the operation of a full actuated traffic controller in an interconnected signalized system. The controller serves to control a traffic signal which displays go, caution, and stop intervals to at least two traffic phases each having associated therewith traffic detector means for detecting traffic in that phase and developing a go interval initiating control signal in response to the detection of traffic and developing a go interval terminating control signal in the other phase or phases. Also, the controller includes control circuit means associated with each phase and comprising, go interval actuation means associated with each phase for commencing a go interval display to the associated phase, and go interval terminating means for terminating the go interval displayed upon removal of a said signal from the control circuit means. The coordination unit comprises means for cyclically timing successive background cycles having each a predetermined time duration; means for dividing the background cycle into at least two background-cycle time intervals respectively associated with each of the phases; actuatable means responsive during one of the associated intervals for coupling one of the traffic detector means to an associated one of the control circuit means for the duration of the associated interval so that a control signal developed by the traffic detector means is applied to the control circuit means only during that interval; and, actuatable means responsive during the other associated interval for coupling the other traffic detector means to the associated control circuit means so that a said control signal developed by the other traffic detector means is applied to the other control circuit means only during the other associated interval.

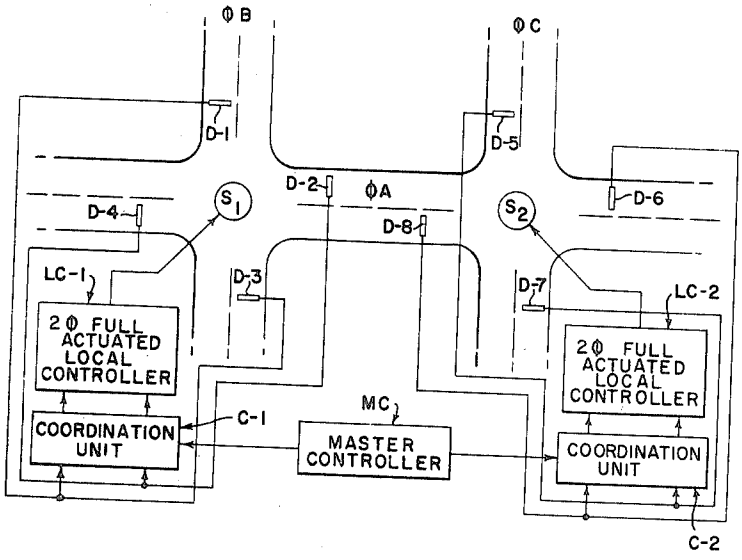


FIG. 1

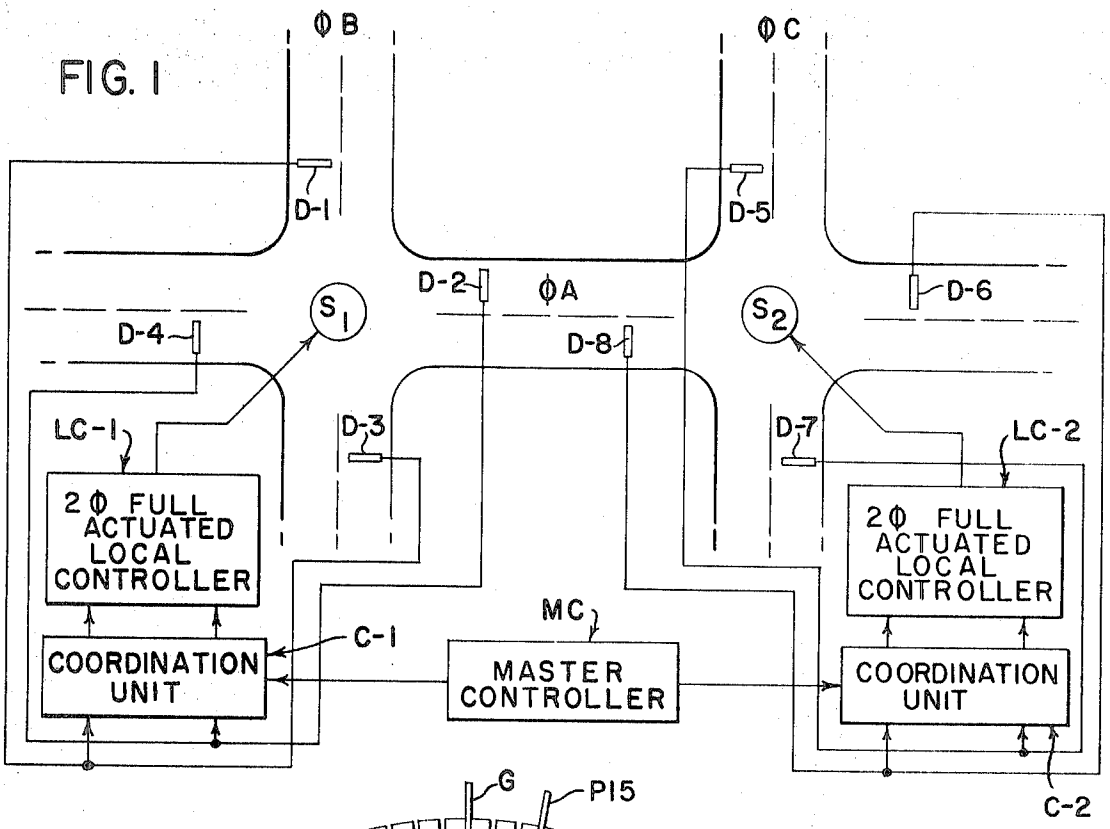
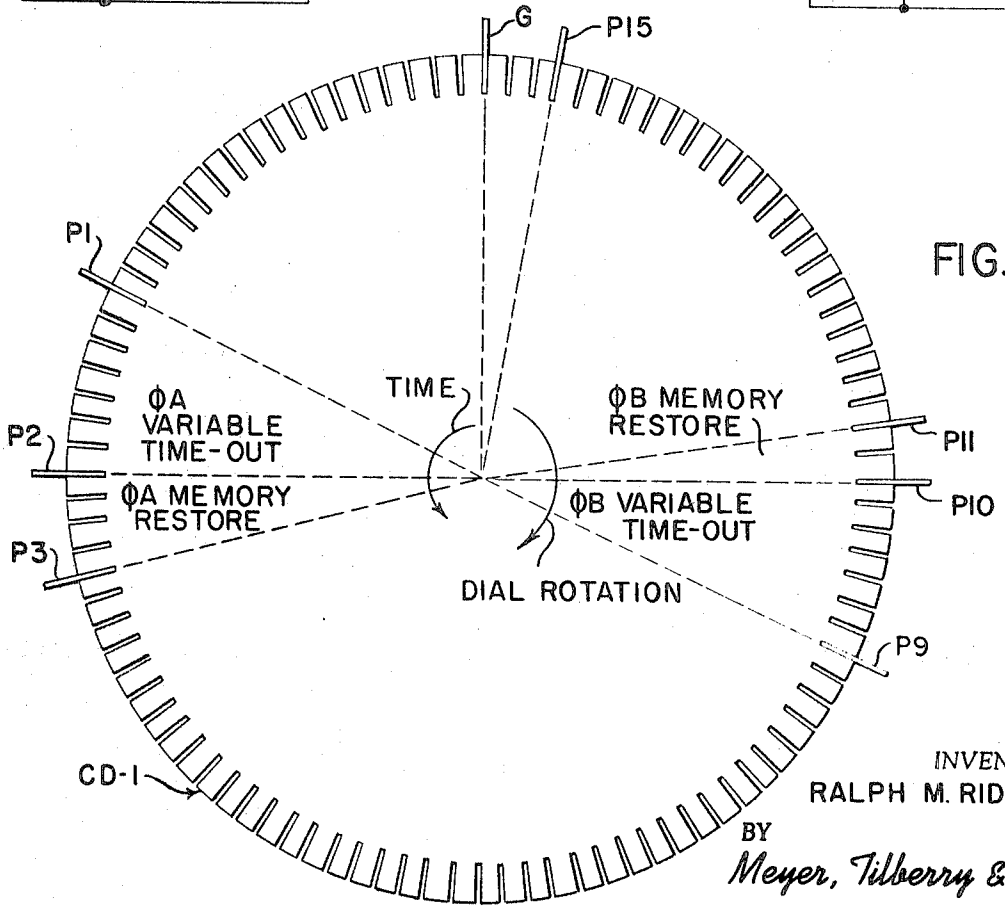


FIG. 4



INVENTOR.
RALPH M. RIDDLE, JR.
BY
Meyer, Tilberry & Body
ATTORNEYS

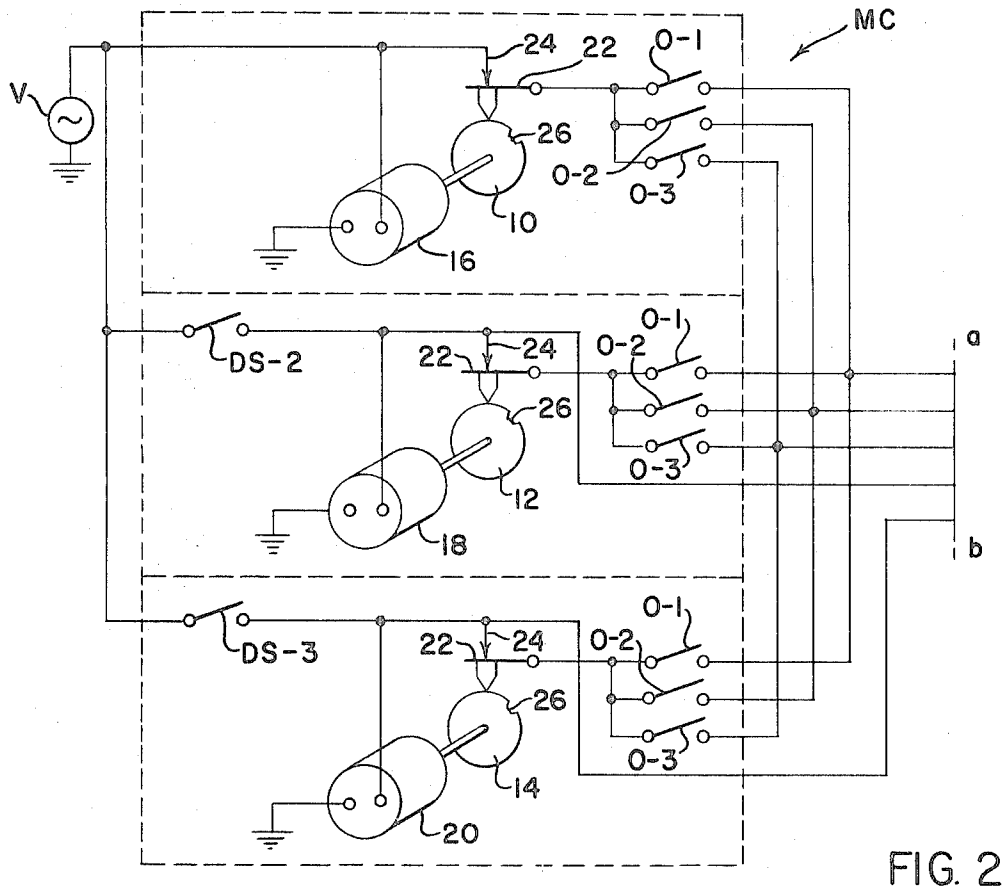


FIG. 2

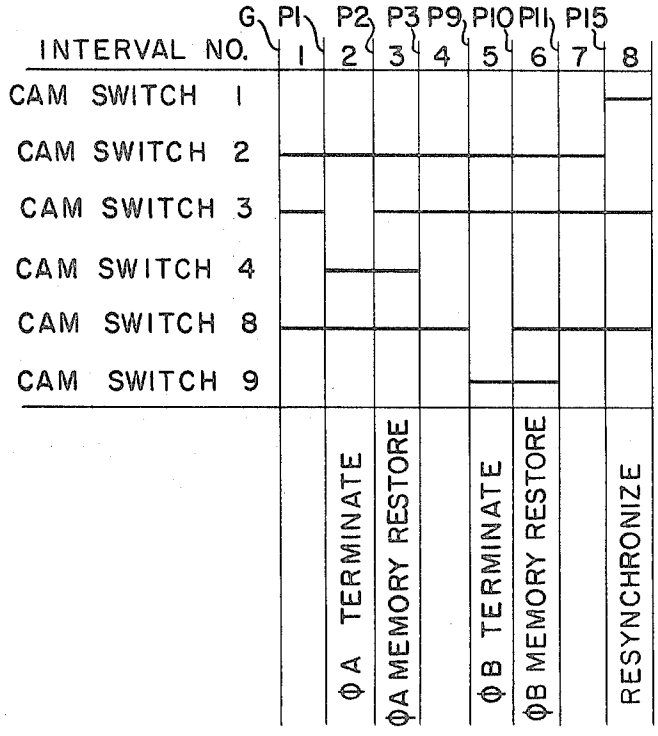


FIG. 5

INVENTOR.
RALPH M. RIDDLE, JR.
BY
Meyer, Tilberry & Body
ATTORNEYS

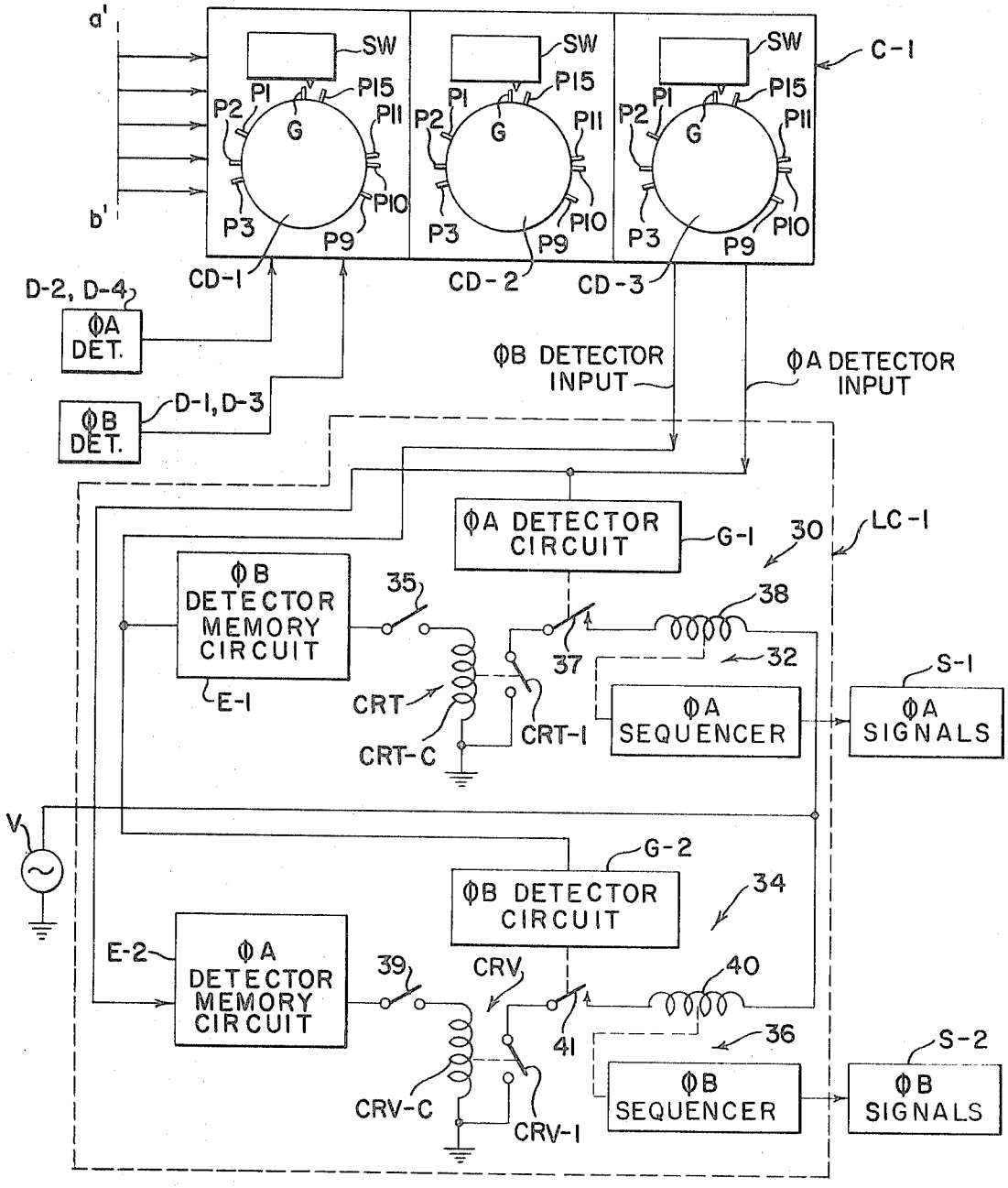


FIG. 2A

INVENTOR.
RALPH M. RIDDLE, JR.

BY
Meyer, Tilberry & Body

ATTORNEYS

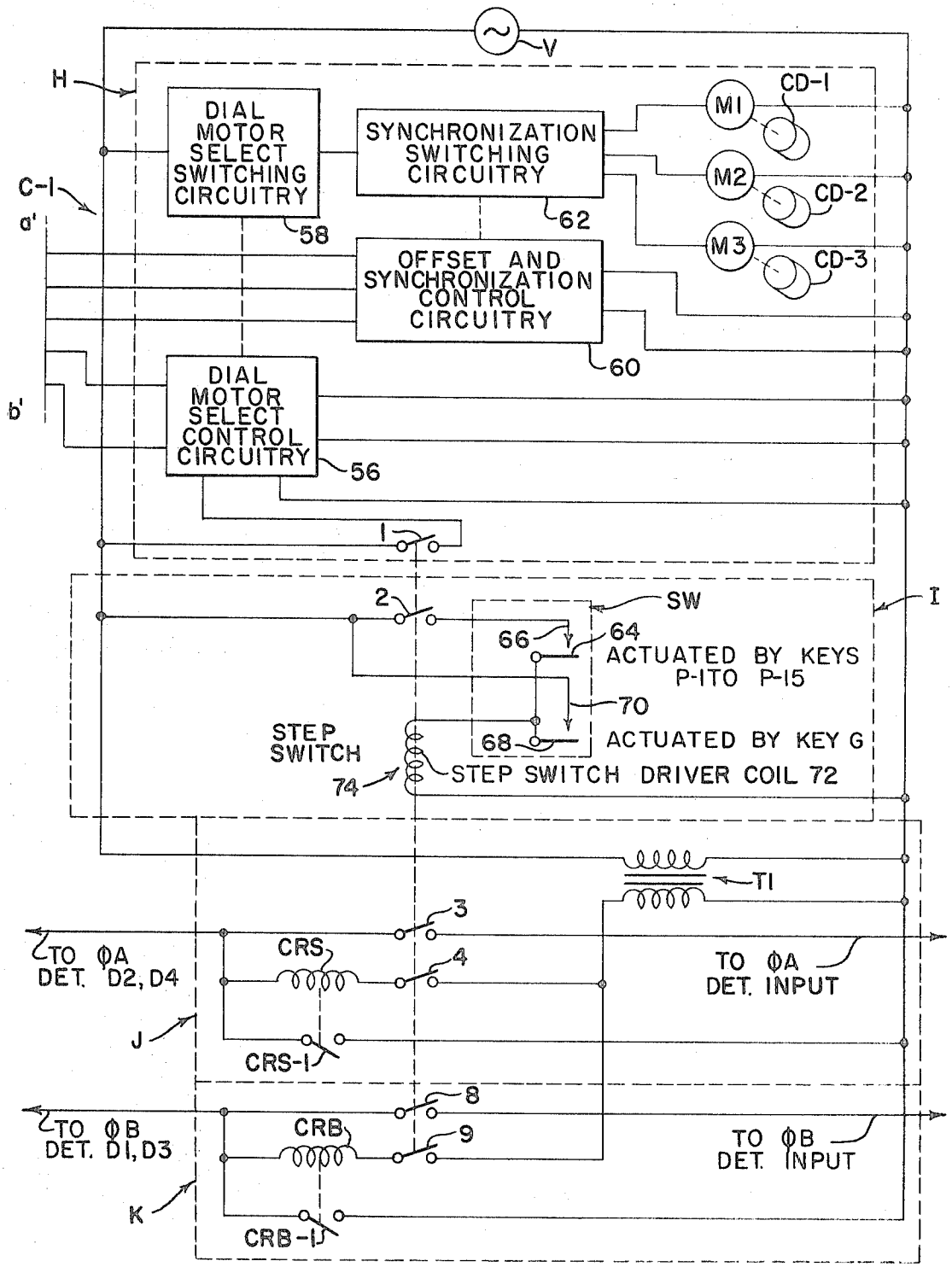


FIG. 3

INVENTOR.
RALPH M. RIDDLE, JR.

BY
Meyer, Tilberry & Body
ATTORNEYS

COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

This invention pertains to the art of traffic control and, more particularly, to apparatus and method for coordinating the operation of full-actuated local traffic controllers in an interconnected, progressive, signalized system.

This invention is particularly applicable to two-phase, full-actuated local traffic controllers, and will be described with particular reference thereto, although it will be appreciated that the invention has broader applications and may be employed with any two or more phase, full-actuated or semiactuated local controller.

A full-actuated local traffic controller has associated therewith traffic actuatable detectors for each traffic phase, i.e., movement, being controlled. Thus, a three-phase, full-actuated traffic controller, for controlling traffic flow through an intersection of three traffic phases, has associated therewith at least one detector for each phase for detecting traffic, i.e., vehicles in that phase, and registering traffic demand with the controller. The controller serves to allocate right-of-way intervals by means of a signal light located at the intersection to each of the phases in accordance with traffic demand. A semiactuated traffic controller is similar to a full-actuated traffic controller, but at least one phase is a nonactuatable phase; that is, there is no detector associated with that phase. The nonactuatable phase, usually reserved for phases having heavy traffic flow, such as main street, is allocated a minimum fixed time right-of-way interval by the controller during each cycle of operation, with right-of-way intervals being allocated to the actuatable phases dependent on traffic demand. Thus, a full-actuated traffic controller allocates right-of-way intervals in a more efficient manner than a semiactuated controller, since the latter must allocate a minimum right-of-way interval to the nonactuatable phase during each cycle of operation whether there is traffic demand on that phase or not.

Frequently, municipalities require that all of the local controllers at various street intersections, whether the controllers be full-actuated, semiactuated or pretimed controllers, be interconnected in a coordinated signal system supervised by a master controller. The purpose of coordinated operation of local intersection controllers is to obtain a smooth progression of traffic within the signal system. In such a coordinated signal system, the maximum time length of the traffic signal cycle of each of the interconnected local controllers is determined by the time length of a background cycle established by a master controller. The background cycle may in turn be determined by a pretimed or programmed schedule, or on the basis of varying traffic demands, as registered with the master controller by vehicle detectors located at various locations in the signal system.

Heretofore, coordination of actuated local controllers has been directed to coordination of semiactuated local controllers, or full-actuated local controllers, which for purposes of coordination have been converted to semiactuated local controllers, with the end result being to allocate a fixed minimum amount of right-of-way time to main street traffic flow to facilitate traffic flow through the intersections along the main street. Both semiactuated and full-actuated traffic controllers normally include maximum time-out circuits for the actuatable phase, or phases, which serve upon the completion of predetermined time to terminate allocation of a right-of-way interval to the actuatable phase, whereupon a timed caution interval is allotted to that phase, after which that phase is denied right-of-way movement during that cycle.

Coordination of such actuated controllers is accomplished with a coordination unit associated with each controller. Such a coordination unit determines the proper time for releasing the controller to end allocation of a right-of-way interval to the nonactuatable phase after an actuation has occurred on an actuatable phase, and for forcing the controller to terminate allocation of a right-of-way interval to an actuatable phase and commence allocation of a right-of-way interval to the nonactuatable phase. In order to maintain efficient traffic flow within the signalized system, the point in time, during the master determined background cycle, that the right-of-way interval of a nonactuatable phase is terminated, must be accomplished at the proper split of the cycle as determined by the master controller. The master controller, which may be traffic adjusted, serves to determine the most efficient traffic cycle duration, the best division of the cycle between main street and cross street traffic, and the most effective offset of the start of the cycle at each succeeding intersection. After these parameters are determined they are imposed on each interconnected local controller in the coordinated signal system by means of the coordination units.

Coordination units known heretofore for coordinating the operation of actuated local controllers generally include a motor driven wheel, known as a coordination dial, carrying a plurality of switch actuating elements, known as keys. The time cycle length to complete one revolution of the coordination dial corresponds with the time length of the background cycle determined by the supervising master controller. One revolution of the coordination dial times one complete traffic signal cycle for the associated traffic controller. One of the keys, known as the release key, is placed at or near the zero point or release point of the coordination dial, and serves to initiate termination of allocation of a right-of-way interval to the nonactuatable phase after an actuation has occurred on an actuatable phase. A second key, spaced a predetermined angular distance from the release key, and known as a split key or maximum time out key, serves to initiate termination of allocation of a right-of-way interval to an actuatable phase if a right-of-way interval has not been previously terminated by lack of detector actuations. The release key serves once during each revolution of the coordination dial to actuate a switch which connects a source of power to a timing circuit in the controller associated with the nonactuatable phase, such as to the plate circuit of a vacuum tube in an RC timing circuit or to a step switch driver coil. This causes the timing circuit for the nonactuatable phase to terminate its timing function and thereby terminate allocation of a right-of-way interval to the nonactuatable phase, whereupon the controller then normally times a caution clearance interval for the nonactuatable phase, after which right-of-way movement is denied to the nonactuatable phase during that cycle. Similarly, the maximum time-out key, or split key, serves once during each revolution of the coordination dial to actuate a second switch which serves to connect a source of power to a second timing circuit in the controller associated with the actuatable phase. This causes the timing circuit to terminate its timing function, whereupon allocation of a right-of-way interval to the actuatable phase is terminated, which is normally followed by a timed clearance interval, after which right-of-way denied to the acutatable phase.

The purpose of such a coordination unit as described above is to allocate during the background cycle a fixed minimum amount of right-of-way time to the main street, or nonactuatable phase, to facilitate traffic flow along the main street through the various intersections. Accordingly, the time lapse during the background cycle from the point in time at which the maximum time out or split key actuates the switch associated with the actuatable phase, to the point in time at which the release key actuates the switch associated with the nonactuatable phase, is the guaranteed period of time during the background cycle that a right-of-way interval is allocated to main street traffic flow. The time lapse from the point in time at which the release key actuates the switch associated with the nonactuatable phase, and the point in time at which the maximum time out or split key actuates the switch associated with the actuatable phase, is the potential period of time during the background cycle that a right-of-way interval may be allocated to cross street traffic flow. The vehicle detector associated with the actuatable phase must be actuated prior to the release point in the background cycle before a right-of-way interval can be actually allocated to the actuatable phase. If the vehicle detection on the actuatable phase oc-

curs at a point in time just after the release point in the background cycle, the actuatable phase will be denied right-of-way movement until the next cycle of operation, or substantially the entire time period of the background cycle which, for example, may be on the order of 120 seconds. A further disadvantage of previous methods of coordinating the operation of semiactuated controllers or full-actuated controllers, which have been converted to semiactuated controllers for coordination purposes, is that when cross street traffic flow is heavy and main street traffic flow is light, traffic on the cross street must be denied right-of-way movement while the guaranteed right-of-way interval is allocated to the main street although there may be little or no traffic demand on the main street.

Coordination of full-actuated local controllers has heretofore included a traffic controller which serves to control a traffic signal for displaying go, caution and stop intervals to at least two traffic actuatable phases, each having associated therewith vehicle actuatable detector means for registering traffic demand with the controller. In addition, the operation of the full-actuated traffic controllers is coordinated by a coordination unit having a background cycle in which a predetermined point on the cycle was selected for guaranteeing when each actuatable phase controlled by the full actuated controller is required to yield to another actuatable phase in accordance with traffic demand. One such coordination system is described in U.S. Pat. No. 3,350,308, issued Mar. 10, 1970 upon application Ser. No. 552,328, entitled COORDINATION OF FULL-ACTUATED TRAFFIC CONTROLLERS, filed May 23, 1966, and assigned to the assignee of the present invention.

The present invention is directed toward coordination of full-actuated traffic controllers, but contrary to previous methods of coordination, the present coordination unit provides termination of a go interval display by preventing signals that are developed by a traffic detector from being applied to the detector input terminals of the traffic controller.

In accordance with one aspect of the present invention, the operation of actuated traffic controllers is coordinated by a background cycle having a first time interval for coupling the traffic detectors associated with one phase to the traffic controller, and a second interval for coupling the other traffic detectors associated with the other traffic phase to the traffic controller to thereby provide coordination of actuated traffic controllers.

In accordance with a more limited aspect of the present invention, apparatus and method are provided for dividing the background cycle into at least two timed intervals respectively associated with each of the phases, and actuatable means responsive during one of the intervals for coupling one of the traffic detectors to the traffic controller for the duration of that interval so that a signal developed by the traffic detectors is applied to the traffic controller only during that interval, and actuatable means responsive during the other interval for coupling the other traffic detector to the traffic controller for the duration of that interval so that a said signal developed by the other traffic detector is applied to the traffic controller only during that interval.

In accordance with a more limited aspect of the present invention, the background cycle is divided so that each phase includes a second interval which commences substantially upon termination of the first interval; and, the coordination unit includes for each phase, actuatable memory means for receiving and storing a control signal during the second interval and for applying a signal, representative of the stored control signal, to the traffic controller upon termination of the second interval.

The primary object of the present invention is to provide coordination of the operation of a full-actuated local controller controller so that the controller operates full-actuated during coordination.

Another object of the present invention is to coordinate the operation of a full-actuated local controller so that signals are applied to the controller by the traffic detectors only during a preselected interval of a background cycle.

A still further object of the present invention is to coordinate the operation of a full-actuated local controller so that during the background cycle, the controller allocates go signal display time to the fullest extent in accordance with traffic demands.

These and other objects and advantages of the invention will become apparent from the following description of the preferred embodiment of the invention as read in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram illustrating a pair of coordinated, two-phase, full-actuated local traffic controllers, a master controller, and associated coordination units in accordance with the present invention;

FIGS. 2 and 2A are a block diagram, schematic illustration, split along lines A–B and A′–B′, illustrating a coordination unit, in accordance with the present invention, connected to a master controller and to a two-phase, full-actuated local traffic controller;

FIG. 3 is a schematic diagram illustrating the preferred embodiment of the coordination unit;

FIG. 4 is a schematic diagram of one of the coordination dials of the coordination unit; and,

FIG. 5 is a graphical chart illustrating the intervals of operation.

GENERAL DESCRIPTION

Referring now to the drawings, wherein the showings are for the purposes of illustrating the preferred embodiment of the invention only, and not for purposes of limiting same, FIG. 1 generally illustrates a pair of two-phase, full-actuated local controllers LC–1 and LC–2 interconnected through coordination units C–1 and C–2, respectively, with a master controller MC in an interconnected, progressive, coordinated, signalized system. Local controller LC–1 controls traffic flow through an intersection of traffic movements, or phases A and B in accordance with the traffic demand registered with the controller by vehicle actuatable detector D–1 and D–3 for phase B, and detectors D–2 and D–4 for phase A. Right-of-way, clearance, and stop signals are displayed to phases A and B by a traffic signal device S–1 connected to the controlled by local controller LC–1. Similarly, local controller LC–2 controls traffic flow through an intersection of traffic movements, or phases, A and C in accordance with the traffic demand as registered with the controller by vehicle actuatable detectors D–5 and D–7 for phase C, and detectors D–6 and D–8 for phase A. Right-of-way, clearance, and stop signals are displayed to phases A and C by means of a traffic signal device S–2 connected to and controlled by local controller LC–2.

Reference is now made to FIGS. 2 and 2A which generally illustrate a master controller MC connected to a local controller LC–1 through a coordination unit C–1. Coordination unit C–1, takes the form of a three dial coordination unit, similar to that known heretofore, for coordinating semiactuated traffic controllers, and includes three synchronous motor driven coordination dials CD–1, CD–2 and CD–3, which are separately energized to rotate at different speeds and time different background cycles. Each coordination dial carries a plurality of keys P–1, P–2, P–3, P–8, P–9, P–10, P–11, P–15 and G extending radially outward from the dial. In the preferred embodiment, each dial is provided with one hundred equally spaced, longitudinal slots extending around the circumferential surface of the dial so that the keys may be spaced from each other in percentages of the background cycle. The keys carried by each dial serve to actuate suitable switches, generally designated as SW in FIGS. 2A and 3.

MASTER CONTROLLER

Master controller MC is preferably a pretimed or traffic actuated controller; however, it is to be appreciated that various other master controllers may be employed with the present in-

vention. In order to simplify the explanation of the invention, master controller MC has been greatly simplified and includes three synchronization cam wheels 10, 12 and 14, each being respectively driven by synchronous motors 16, 18 and 20, through suitable gearing, so that when energized, cam wheels 10, 12 and 14 rotate at different speeds. As illustrated, motor 16 is connected across an energizing voltage source V, and motors 18 and 20 are connected across voltage source V by means of normally open coordination dial selector switches DS–2 and DS–3. With switches DS–2 and DS–3 in their normally open position, coordination dial CD–1 is energized by voltage source V. Upon closure of dial selector switch DS–2, circuitry within coordination unit C–1 is energized to thereby energize only coordination dial CD–2. Further, upon closure of dial selector switch DS–3, circuitry within coordination unit C–1 is energized to thereby energize only coordination dial CD–3. With reference to FIG. 2, a movable switch contact 22 rides on the peripheral surface of an associated synchronization cam wheel 10, 12 or 14, and in the normal condition, is electrically connected with a stationary contact 24 for purposes of connecting voltage source V with offset selector switches 0–1, 0–2 and 0–3 within master controller MC. Switches 0–1, 0–2 and 0–3, are connected to coordination unit C–1 so that when one of the offset selector switches 0–1, 0–2 or 0–3 is closed, the switch serves to select the particular offset in effect in the progressive, coordinated, signalized system. An arcuate slot 26 is provided in the peripheral surface of each synchronization wheel 10, 12 and 14. Once during each revolution of a synchronization wheel, the associated movable contact rides off of the peripheral surface of the wheel and falls into the arcuate slot 26, thereby breaking electrical contact with the associated stationary contact 24. This electrical break extends for approximately 3 percent of the revolution and, is used for synchronization purposes.

Coordination unit C–1 may be employed to coordinate the operation of any two or more phase, semiactuated or full-actuated traffic controllers and may, for example, take the form of two interconnected phase units, each being constructed in accordance with the units disclosed and described in U.S. Pat. application Ser. No. 463,449, entitled TRAFFIC CONTROL UNIT AND SYSTEM, filed May 21, 1965, and assigned to the same assignee as the present invention. Another type of traffic controller which may be coordinated with coordination unit C–1 is the traffic controller disclosed and described in U.S. Pat. applications, Ser. Nos. 812,476 and 812,480 respectively entitled MULTIPHASE TRAFFIC CONTROL SYSTEM and APPARATUS FOR ALLOCATING AND TIMING A PLURALITY OF LOAD INTERVALS, and both filed on Aug. 20, 1969. In order to simplify the description of the resent invention, only those circuits of local traffic controller LC–1 which are necessary for an understanding of the present invention, have been illustrated. With reference to FIG. 2A, local controller LC–1 is preferably comprised of a phase A go interval termination circuit 30 which includes a phase B detector memory circuit E–1 and a normally open relay CRT coupled through a phase A sequencer circuit 32 to a phase A signal circuit S–1. Similarly, local controller LC–1 includes a phase B go interval termination circuit 34 having a phase A detector memory circuit E–2 and a normally open relay CRB coupled through a phase B sequencer circuit 36 to the phase B signal circuit S–2. Sequencer circuits 32 and 36 take the form of various circuits for sequencing signal circuits S–1 and S–2, respectively, and may take the form of an electromechanical step switch a right counter, a solid-state load sequencer, such as the sequencer disclosed and described in Patent Applications Ser. Nos. 682,814 and 748,583, respectively entitled LOAD SEQUENCER CONTROLLER and SOLID-STATE STEP SWITCH, filed on Nov. 14, 1967 and July 10, 1968, respectively, and assigned to the same assignee as the present invention. More particularly, normally open relay CRT includes a relay coil CRT–C having one terminal connected to ground and the other terminal thereof connected through a normally open switch 35, contacts 37 of a phase A detector circuit G–1, and detector memory circuit E–1 to the phase B detector input terminal of traffic controller LC–1. For purposes of simplification, normally open switch 35 serves the function of coupling detector memory circuit E–1 to relay CRT for so long as the phase A right-of-way signals are displayed by traffic signal circuit S–1, and contacts 37 of the phase A detector circuit serve the function of preventing actuations of the phase A sequencer 32 for so long as signals are applied to phase detector circuit G–1. The normally open contacts CRT–1 of relay CRT are connected between one terminal of the coil 38 of sequencer 32 and ground, and the other terminal of coil 38 is connected to a voltage supply source V. The output terminals of sequencer 32 are coupled to the phase A signal circuit S–1. Similarly, the normally open relay CRV includes a coil CRV–C having one terminal connected directly to ground and the other terminal thereof connected through a normally open switch 39, contacts 41 of a phase B detector circuit G–2, and the phase A detector memory circuit E–2 to the phase B detector input terminal of traffic controller LC–1. For purposes of simplification, normally open switch 39 serves the function of coupling detector memory circuit E–2 to relay CRV for so long as the phase B right-of-way signals are displayed by traffic signal circuit S–1, and contacts 41 serve the function of preventing an actuation of sequencer 36 when signals are applied to phase B detector circuit G–2. Also, the normally open contacts CRV–1 of relay CRV are connected between the coil 40 of phase B sequencer 36 and ground, and the output terminal of the phase B sequencer 36 is coupled to the phase B signal circuit S–2.

Thus, when a signal is applied by one of the phase A detectors D–2, D–4, through coordination unit C–1 to the phase A detector input terminal of local controller LC–1, this signal is stored in detector memory circuit E–2. Upon closure of normally open switch 39, i.e., upon display of a right-of-way signal by the phase B signal circuitry S–2, the stored signal energizes relay CRV to thereby actuate the phase B sequencer 36 which sequences one step, and in turn, serves to allocate suitable phase B signal circuitry S–1. Upon allocation of signal circuitry S–1, the right-of-way interval to phase B is terminated and a phase B clearance is displayed at phase B, after which phase B is denied right-of-way movement. As is apparent, actuation of the phase A sequencer 32 is not possible if phase A traffic detection signals are being applied to the phase A detector circuit G–1. Similarly, upon application of a signal to the phase B detector input terminal of local controller LC–1, this signal is stored in phase B detector memory circuit E–1. Upon closure of normally open switch 35, i.e., upon display of a right-of-way signal by signal circuitry S–1, the stored signal energizes relay CRT to thereby actuate the phase A sequencer 32 which moves to the next step, and in turn, serves to allocate suitable phase A signal circuitry S–2. Upon allocation of phase A signal circuitry S–2, the right-of-way interval to phase A is terminated and a phase A clearance signal is displayed at phase A, after which phase A is denied right-of-way movement. Similarly, actuation of the phase B sequencer 34 is not possible for so long as traffic detection signals are being applied to phase B traffic detector circuit G–2.

COORDINATION UNIT

Reference is now made to FIG. 3 which illustrates in more detail coordination unit C–1. Coordination unit C–1 generally includes coordination dials CD–1, CD–2 and CD–3; dial motor select control circuitry 56; dial motor select switching circuitry 58; offset and synchronization control circuitry 60; synchronization switching circuitry 62; background cycle divider circuitry I; phase A coordination circuit J; and, phase B coordination circuit K.

Preferably, coordination unit C–1, includes a single timer for timing a particular background cycle for coordination purposes. The timer, may take the form of a coordination dial CD–1, driven by a synchronous motor M1, being connected across voltage source V for energization. It is contemplated,

however, that coordination unit C–1, for greater flexibility in coordinating the operation of a full-actuated traffic controller, have the capability of timing different background cycles. This feature is common to coordination units known heretofore for purposes of coordinating the operation of pretimed and semiactuated traffic controllers. In order to accomplish this feature, coordination unit C–1 also includes additional coordination dials CD–2 and CD–3 which are respectively driven by synchronous motors M2 and M3. Dial motor select circuitry **56**, dial motor select switching circuitry **58**, offset and synchronization control circuitry **60**, and synchronization switching circuitry **62** provide the desired selection and control of synchronous motors M1, M2 or M3.

Dial motor select circuitry **58** includes circuit means, such as electromechanical relay or solid-state switching circuitry, which is ineffective to change the operation of motor M1 to one of the other motors M2 and M3, except during the period that a cam switch **1** is closed. Thus, cam switch **1** connected the dial motor select control circuitry **56** across voltage source V thereby energizing control circuitry **56** only during the time that cam switch **1** is in the closed position. Further, if coordination dial selector switch DS–2 or switch DS–3, in master controller MC, is closed, circuitry **56** will effectively energize dial motor select switching circuitry **58** to thereby disconnect the voltage source V from across motor M1 and connect the source V across dial select motor M2 if switch DS–2 is closed, or motor M3 of switch DS–3 is closed. In addition, coordination unit C–1 includes offset and synchronization control circuitry **60** connected with offset selector switches **0–1**, **0–2** and **0–3** in master controller MC. Thus, switches **0–1**, **0–2** and **0–3** serve when closed, to actuate suitable circuitry within offset and synchronization control circuitry **60** establish different offsets; such as average, inbound preferential, or outbound preferential. Synchronization switching circuitry **62** includes electromechanical relays or solid-state control circuitry, and is responsive to the operation of offset and synchronization control circuitry **60** for establishing the offset relationship selected by closure of one of offset selector switches **0–1**, **0–2** or **0–3**.

Coordination unit C–1 also includes the capability, known in prior coordination units, for maintaining each local controller in synchronism with the master controller. This is accomplished with the synchronizing cam wheels **10**, **12** and **14** of the master controller, which as previously discussed, each includes an arcuate cutout portion **26** which breaks an energizing circuit to the offset selector switches **0–1**, **0–2** and **0–3** for approximately 3 percent of the background cycle in effect. The synchronizing wheels **10**, **12** and **14** are driven at speeds corresponding with the background cycle in effect. Thus, motor **16** is energized when coordination dial CD–1 is in effect and drive synchronizing wheel **10** at the speed as dial CD–1 driven by motor M1. Similarly, synchronizing wheels **12** and **14** are respectively driven at speeds corresponding with the background cycles timed by coordination dials CD–2 and CD–3. Power from the master controller is normally applied through the offset selector switches **0–1**, **0–2** and **0–3** for approximately 97 percent of the background cycle. A key, not shown, carried by the coordination dial opens a switch in circuitry **60** for approximately 1 percent of the background cycle. If this interruption occurs during the period that power from the master controller is normally interrupted, i.e., for 3 percent of the cycle, it will not interrupt operation of motors M1, M2 or M3, since such an occurrence is indicative that the local controller is operating in synchronism with the master controller. In the event the interruption occurs during the 97 percent period of the background cycle that power is supplied from the master controller through the offset selector switches **0–1**, **0–2** and **0–3**, then the synchronization control circuit **60** is effective to deenergize the motor M1, M2 or M3 in operation, to stop rotation of the associated coordination dial. As soon as the 3 percent interruption in power from the master controller occurs, the synchronization control circuitry serves to reenergize the selector motor M1, M2 or M3 so that the coordination dial in effect may commence rotation for timing the background cycle in synchronization with the supervising master controller.

In order to simplify the description of the present invention, offset and synchronization control circuitry **60** is similar to previous coordination units, such as the coordination unit illustrated and described in the U.S. Pat. to Frank W. Hill, No. 3,196,387 as well as the offset, split and synchronization features of a system illustrated and described in the U.S. Pat. to Garland E. Fieser and Donald W. Schrepel, No. 3,133,264, both assigned to the same assignee as the present invention.

Reference is now made to FIG. **4** which illustrates the phase of coordination dial CD–1. Coordination dial CD–1 preferably includes a cylindrical drum having longitudinal slots extending parallel to the axis thereof and spaced arcuately around the surface of the drum to thereby define one hundred equally spaced slots. Thus, keys may be placed in the slots, spaced from each other in percentages, to thereby define a background cycle. FIG. **4** illustrates one particular arrangement of keys P–1, P–2, P–3, P–9, P–10, P–11, P–15 and G extending radially outward from the surface of coordination dial CD–1.

Reference is now made to FIG. **3**, there is schematically illustrated background cycle divider circuit I which generally includes a switch SW comprised of a pair of normally open switches each having a movable contact **64**, **68** and a stationary contact **66** and **70**. Movable contact **64** is actuated by keys P–1 through P–15 mounted on coordination dial CD–1. Similarly, movable contact **68** is actuated by key G also mounted on coordination dial CD–1. Movable contacts **64** and **68** are connected in common with a step switch driver coil **72** of a step switch **74**. Stationary contact **66** is connected through a normally open step switch cam circuit **2** to one terminal of voltage supply source V, and stationary contact **70** is connected directly to that terminal of voltage source V. Step switch **74** includes a rachet mechanism, not illustrated, and a contact-carrying cam shaft, not illustrated, which serve to actuate normally open cam switches **1**, **2**, **3**, **4**, **8** and **9** in response to energization of driver coil **72** in accordance with the interval chart illustrated in FIG. **5**. Thus, for example, in response to actuation of movable contact **68** by key G to engage stationary contact **70**, the step switch drive coil **72** is energized, resulting in step switch **74** being actuated such that normally open cam switches **2**, **3** and **8** are closed. Cam switch **2** serves to connect stationary contact **66** with one side of voltage source V and is maintained throughout intervals numbers **1** through **7** by a cam, not illustrated, located on he cam shaft of step switch **74**. With normally open cam switch **2** closed, upon closure of movable contact **64**, a circuit is completed to energize the step switch drive coil **72** thereby moving the cam shaft to the next position. During the time of interval number **8**, key G actuates contact **68** to close cam switch **1** thereby allowing dial select control circuitry **56** to effect a change from coordination dials CD–1 to either coordination dial CD–2 or CD–3, in accordance with the closure of dial select switch DS2 or DS3 in master controller MC.

Phase A coordination circuit J includes a normally open cam switch **3** coupled between phase A traffic detectors D–2 and D–4 and the phase A detector input terminal of local controller LC–1 for, upon closure of cam switch **3**, connecting the phase A traffic detector directly to the phase A detector input terminal of local controller LC–1. Coordination circuit J also includes a relay coil CRS having one terminal connected to phase A traffic detectors D–2 and D–4, and the other terminal connected to one terminal of a normally open cam switch **4**. The other terminal of cam switch **4** is connected to one terminal of the secondary coil of a step down transformer T1 having its primary coil connected across voltage source V. The other output terminal of the secondary winding of transformer T1 is connected directly to voltage source V, and is also connected through the normally open contacts CRS–1 of relay coil CRS to phase A traffic detectors D–2 and D–4. Thus, the circuitry including relay coil CRS and its associated

contacts CRS–1 serve as a detector circuit during the period of time normally open cam switch 3 is in the open position. During interval number 2, cam switch 4 will be in the closed position, and upon detection of traffic by phase detector D–2 or D–4, relay coil CRS becomes energized. Upon energization of relay coil CRS, normally open relay contact CRS–1 will close to thereby maintain relay coil CRS in an energized condition even after a signal is no longer developed by phase A detectors D–2 and D–4. During interval number 3, cam switch 3 will again close and the signal developed upon closure of relay contacts CRS–1 is fed back to phase A detector input terminal through this cam switch.

Phase B coordination circuit K is substantially identical to phase A coordination circuit J as described above. Coordination circuit K includes a normally open cam switch 8 coupled between phase B traffic detectors D–1 and D–3, and the phase B detector input terminal of local controller LC–1. Connected between phase B traffic detectors D–1 and D–3 and one terminal of the secondary winding of transformer T1 is series-connected relay coil CRB and normally open cam switch 9. Also, the normally open relay contacts CRB–1 of relay coil CRB are connected between the other terminal of the secondary winding of transformer T1 and phase B traffic detectors D–1 and D–3. The circuitry including relay coil CRB and its associated contacts CRB–1 provides a holding circuit for information received during the period of time that normally open cam switch 8 is in the open position, i.e., during interval number 5, and functions in substantially the same manner as the holding circuit including relay contacts CRS–1 in the phase A coordination circuit J.

OPERATION

Upon energization of master controller MC and coordination unit C–1, a selected one of the synchronous motors M1, M2 and M3 is energized to drive its associated coordination dial CD–1, CD–2 or CD–3. Thus, with dial selector switches DS2 and DS3 in the open position as illustrated, synchronous motor M1 will be energized to place in effect the background cycle exhibited by keys P–1 through P–15 and G on coordination dial CD–1. Similarly, if dial selector switch DS–2 is closed, synchronous motor M2 becomes energized to place in effect the background cycle exhibited by coordination dial CD–2, and finally, if dial selector switch DS–2 is moved to the open position and dial switch DS–3 is closed, synchronous motor M3 will become energized. Thus, the desired background cycle may be placed in effect by altering the position of coordination dial selector switches DS–2 and DS–3 in master controller MC. In addition, one of the offset selector switches O–1, O–2 or O–3, associated with the selected motors 16, 18 or 20 in master controller MC, is closed representative of the particular offset in effect.

Assuming coordination dial CD–1 to be in effect, this dial rotates in a clockwise manner as illustrated in FIG. 4 to cyclically time a background cycle. With reference to FIGS. 3 and 4, it may be seen that during each revolution of dial CD–1, key G actuates movable contact 68 of switch SW thereby completing a circuit for energizing driver coil 72 of step switch 74. Upon initial energization of driver coil 72, step switch 74 advances to interval number 1, during which time cam switches 2, 3 and 8 are in a closed position. The time duration of this interval is determined by the spacing from key G to key P–1, and by the speed of rotation of synchronous motor M1. During this timed interval, signals developed by phase A traffic detectors D–2 and D–4 are applied directly to the phase A detector input terminal of local controller LC–1 through cam switch 3. Similarly, during interval number 1, signals developed by phase B traffic detectors D–1 and D–3 are applied through cam switch 8 to the phase B detector input terminal of local controller LC–1. Thus, for the duration of interval number 1, local controller LC–1 operates in a manner similar to a two-phase, full-actuated traffic controller without external control by a coordination unit. Also, during interval number 1, normally open cam switch 2 closes so that all actuations of movable contact 64 of switch SW by keys P–1, P–2, P–3, P–9, P–10, P–11 and P–15 advance step switch 74 to the next position.

Interval number 1 is terminated when step switch 74 is advanced to the second position by actuation of movable switch contact 64 by key P–1. Upon termination of interval number 1, cam switch 3 opens and cam switch 4 closes. With cam switch 3 in the open position, signals developed by the phase A traffic detectors D–2 and D–4 are prevented from being applied to the phase A detector input terminals of local controller LC–1. As previously discussed, the circuitry including relay coil CRS, and its associated relay contacts CRS–1, provides a detector memory circuit for storing information representative of a traffic actuation during interval number 2. Accordingly, if traffic is detected by the phase A traffic detectors D–2 or D–4 during interval number 2, relay contacts CRS–1 close and remain closed until cam switch 4 opens.

Upon actuation of movable contact 64 of switch SW by key P–2, step switch 74 advances to interval number 3. During interval number 3 as indicated in FIG. 5, cam switch 3 returns to the closed position thereby again coupling phase A detectors D–2 and D–4 to the phase A detector input terminal of local controller LC–1. If during interval number 2, traffic is detected by either phase A detectors D–2 or D–4, relay contacts CRS–I will be in a closed position to thereby apply a signal, representative of a traffic detection by phase A detectors D–2 or D–4, through cam switch 3 to the phase A detector input terminal. As may be readily apparent, the latching circuitry including relay coil CRS and its associated contacts CRS–1 may be eliminated from the circuit if presence type detectors are substituted for spot detectors D–2 and D–4 of the referred embodiment. In such a case, the presence detectors, once actuated by traffic, remain actuated so long as traffic remains within that phase; therefore, during interval number 3, if traffic remains in phase A, a signal representative of the traffic will be applied to the phase A detector input terminal of local controller LC–1 at the commencement of interval number 3.

Upon actuation of movable contact 64 of switch SW by key P–3, step switch 74 advances to interval number 4. During interval number 4, as during interval number 1, cam switches 2, 3 and 8 are in the closed position. In addition, cam switch 4, being closed prior to interval number 4, opens to thereby reset the latching circuit including relay coil CRS and its associated contact CRS–1. Also, during interval number 4, local controller LC–1 functions as a conventional two-phase, full-actuated traffic controller having no external control by a coordination unit.

During interval number 5, i.e., upon actuation of movable contact 64 of switch SW by key P–9, normally open cam switch 8 opens and cam switch 9 closes. Cam switches 8 and 9 provide functions, with respect to the phase B detectors D–1 and D–3, are analogous to the functions provided by cam switches 3 and 4, respectively. Accordingly, during interval number 5, the contacts of cam switch 8, being in an open position, prevent signals developed by phase B traffic detectors D–1, and D–3 from being applied to the phase B detector input terminal of local controller LC–1. In addition, the latching circuit, including relay coil CRB and its associated contact CRB–1, provides memory retention of traffic detected during interval number 5.

Upon commencement of interval number 6, i.e., upon actuation of movable contact 64 of switch SW by key P–10, cam switch 8 again closes thereby again coupling the phase B detectors D–1 and D–3 to the phase B detector input terminal of local controller LC–1. As before, if relay contact CRB–1 is in a closed position, resulting from a traffic detection by detectors D–1 or D–3 during interval number 5, a signal is applied through contacts CRB–1, and cam contact 8, to the phase B detector input terminal of local controller LC–1.

Upon actuation of movable contact 64 by key P–11, step switch 74 is advanced to interval number 7, and as during intervals 1 and 4, cam switches 2, 3 and 8 remain in the closed position. In addition, cam switch 9, being closed during inter-

vals number 5 and 6, opens to thereby reset the latching circuit including relay coil CRB and its associated contacts CRB–1. A resynchronizing interval, or interval number 8, occurs when key P–15 actuates movable contact 64 of switch SW, which in turn causes cam switch 1 to close thereby energizing dial motor select circuitry 56. Only during the period of time that motor select control circuitry 56 is energized, will coordination dial select switches DS–2 and DS–3 be effective to disconnect motor M1 from across voltage source V, and connect one of the other motors M2 or M3 across the voltage source V.

From the foregoing description of operation it is apparent that coordination unit C–1 serves to provide four primary functions, to wit, the coupling and decoupling of phase A traffic detectors D–2 and D–4 from the phase A detection input terminal, and the coupling and decoupling of phase B traffic detectors D–1 and D–3 from the phase B detection input terminal of local controller LC–1 at predetermined times during the coordinated background cycle.

Accordingly, upon detection of traffic by either of the phase A detectors D–2, D–4, a signal is applied through coordination unit C–1 to the phase A detector circuit E–2, assuming the coordination unit C–1 is in any interval of operation other than interval number 2. If, however, coordination unit C–1 is in interval number 2 when traffic is detected by either of the phase A traffic detectors D–2, D–4, the detector memory circuit including relay coil CRS and its associated contacts CRS–1 retain an indication of traffic detection during interval number 2 and applies a signal to the phase A detector memory circuit E–2 during interval number 3. Similarly, upon detection of traffic by either of the phase B traffic detectors D–1, D–3, a signal is applied through coordination unit C–1 to the phase B detector memory circuit D–1, assuming the coordination unit C–1 is in any interval of operation other than interval number 5, If, however, coordination unit C–1 is in interval number 5 when traffic is detected by either of the phase B traffic detectors D–1, D–3, the detector memory circuit including relay coil CRB and its associated contacts CRB–1 retains an indication of traffic detection during interval number 5 and applies a signal representative of this detection to the phase B detector memory circuit E–1 during interval number 6.

Thus, assuming a phase B right-of-way signal is exhibited by local controller LC–1, i.e., assuming normally open switch 39 is in the closed position, assuming no traffic is being detected by traffic detectors D–1, D–3, i.e., contacts 41 are in a closed position and assuming the coordination unit is in any interval of operation other than interval number 2, upon detection of traffic by either of the phase A traffic detectors D–2, D–4, a signal is applied through the phase A detector memory circuit E–2, switch 39 to thereby energize relay CRV. Upon energization of relay CRV, the coil 40 of phase B sequencer 36 is energized to thereby actuate sequencer 36 to the next position. When sequencer 36 is actuated to the next position, this circuit serves to actuate suitable phase B signal circuitry S–1, for purposes of terminating allocation of a right-of-way interval to phase B and commence timing a phase B clearance interval, after which phase B denied right-of-way movement.

In a similar manner to that discussed with respect to the circuitry associated with phase B, assuming a phase A right-of-way signal is exhibited by local controller LC–1, i.e., normally open switch 35 is in the closed position, assuming no traffic is being detected by the phase A traffic detectors D–2, D–4, i.e., contacts 37 are in the closed position, and assuming the coordination unit is in any interval of operation other than interval number 5, upon detection of traffic by the phase B traffic detectors D–1, D–3, a signal is applied through detector memory circuit E–1, switch 35, to thereby energize relay CRT. Upon energization of relay CRT, a signal is applied to the coil 38 of phase A sequencer 32 to thereby actuate sequencer 32 to the next position. When sequencer 32 is actuated to the next position, this circuit serves to actuate suitable phase A signal circuitry S–1 for purposes of terminating allocation of a right-of-way interval to phase A and commence timing a phase A clearance interval to phase A, after which phase is denied right-of-way movement.

Assuming that a phase B right-of-way signal is exhibited by local controller LC–1, and traffic is present in phase B, right-of-way signals will remain in phase B until either traffic is no longer detected in phase B or the phase B detectors D–1, D–3, are decoupled from the phase B detection circuit G–2 by coordination unit C–1. Thus, assuming a phase B right-of-way signal is exhibited by local controller LC–1, and assuming a continuous flow of traffic in phase B, right-of-way will remain in phase B until interval number 5 of coordination unit C–1 commences, at which time the signals developed by the phase B traffic detectors D–1, D–3 are no longer applied to the phase B detection circuit G–2. Upon removal of these signals from the phase B detector circuit G–2, contacts 41 close, and as previously discussed, traffic actuations in phase A cause a transfer of right-of-way from phase B to phase A. Thus, if at interval number 5, traffic is present in phase A, right-of-way signals will immediately be transferred to phase A irrespective of the presence of traffic in phase B. Similarly, assuming a phase A right-of-way signal is exhibited by local controller LC–1, and that a continuous flow of traffic exists in phase A, right-of-way signals will remain in phase A until the commencement of interval number 2, at which time the phase A traffic detectors D–2, D–4, will become decoupled from the phase A circuitry, thereby allowing right-of-way transfer to phase B, assuming traffic detection by the phase B detectors D–1, D–3, irrespective of the presence of traffic in phase A.

Accordingly, when coordination unit C–1 commences interval number 3, signals developed by the phase A detectors D–2, D–4, are removed from the local controller LC–1. If at this time, there is a detection by either of the phase B detectors D–1, D–3, right-of-way will be immediately transferred from phase A to phase B. So as to remember traffic detection in phase A during interval number 2, normally open cam switch 4 is closed so as to retain an indication of traffic detection during interval number 2. During interval number 3, this information is fed back into local controller LC–1 through cam switch 3.

Thus, there is provided a method of coordinating the operation of a full-actuated traffic controller LC–1 which controls allocations of go, caution and stop intervals to at least two traffic phases, phase A and phase B, each having traffic detector means D–1, D–2, D–3 and D–4 associated therewith for detecting traffic and developing a signal in response to the detection of traffic, the controller LC–1 including go interval actuation means associated with each phase for commencing a go interval display. The method comprises the steps of: timing a background cycle having a predetermined time duration; dividing the background cycle into at least two timed intervals respectively associated with each phase controlled by the controller LC–1, during one of the intervals, electrically coupling one of the traffic detector means D–2, D–4 to an associated one of the go interval actuating means R–1; commencing a go interval display with the go interval actuating means R–1; electrically decoupling that traffic detector means D–2, D–4 from the associated go interval actuating means R–1; and, terminating the go interval display with the go interval actuating means R–1 at a predetermined period of time after the traffic detector means D–2, D–4 is electrically decoupled from the associated go interval actuating means R–1.

Whereas the background cycle timer has been described as taking the form of a synchronous motors within a coordination unit C–1, driven by corresponding synchronous motors within a master controller MC, the invention contemplates that other forms of timers may be used which have the capability of actuating circuitry during selected times, i.e., time periods analogous to keys G and P–1 through P–15 of coordination dial CD–1. Similarly, whereas the invention has been described in conjunction with electromechanical circuitry such as dial keys and movable contacts of a step switch, the invention contemplates that this circuitry may be replaced with suitable solid-state switching circuitry.

Although the invention has been shown and described with a preferred embodiment, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and the scope of the invention.

I claim:

1. A coordination unit for coordinating the operation of a full-actuated traffic controller in an interconnected signalized system, said controller serving to control a traffic signal which displays go, caution and stop signals for at least two traffic phases each having associated therewith traffic detector means for detecting traffic in their respective phase and developing a go termination control signal for one phase in response to the detection of traffic in another phase, said controller having control circuit means, each associated with one of said phases; each said control circuit means including go interval terminating means for, upon receipt of a said control signal by the control circuit means associated with a second phase, terminating the display of said go signal for a first phase; said coordination unit comprising:

background-cycle means for cyclically timing successive background cycles, each having a predetermined time duration;

means for dividing each said background cycle into at least two timed background intervals respectively associated with each of said phases;

actuatable means responsive during one of said associated background intervals for directly connecting one of said traffic detector means to an associated one of said control circuit means for the duration of said one associated background interval so that a said traffic detection responsive control signal developed by said one traffic detector means is applied to said one control circuit means only during said one associated background interval; and,

actuatable means responsive during another of the said associated background intervals for directly connecting the other said traffic detector means to the other associated one of said control circuit means so that a said traffic detection responsive control signal developed by the other traffic detector means is applied to the other control circuit means only during said other associated background interval.

2. A coordination unit as set forth in claim 1 wherein said dividing means divides said background cycle so as to include for each phase a second background interval which commences substantially upon termination of said first background interval; and,

said coordination unit includes for each phase, actuatable memory means for storing a said go interval termination signal during an associated said second background interval, said acutatable memory means having an input circuit means for receiving a said go interval termination signal during an associated said second background interval and an output circuit means for applying said stored signal to an associated control circuit means upon termination of an associated said second background interval.

3. A coordination unit as set forth in claim 1 wherein each said actuatable means includes actuatable control means having a first and second condition, said control circuit means being coupled to said background-cycle timing means for actuating each said control circuit means to said first condition during the associated said background interval and to said second condition during the remainder of the associated said background interval so that said signals developed by said traffic detector means are applied to said control circuit means only during the associated background intervals.

4. A coordination unit as set forth in claim 3 wherein each said actuatable control means is connected directly between the associated said traffic detector means and the associated said control circuit means.

5. A coordination unit as set forth in claim 4 wherein said dividing means is adjustable for adjustably dividing said background cycle into timed background intervals of desired timed durations.

6. A coordination unit as set forth in claim 5 wherein said background-cycle timing means includes a motor driven coordination dial and wherein said dividing means includes a plurality of switch actuator keys carried by said dial at preselected angularly spaced locations on said dial.

7. A coordination unit as set forth in claim 2 wherein each said actuatable memory means includes an actuatable control means, for upon energization, storing a said go termination control signal; and switch means associated with each said actuatable control means for coupling each said actuatable control means to a voltage supply source during an associated said second background interval; and said traffic detector means, upon detection of traffic, coupling said actuatable control means to another source of potential so that said actuatable control means is energized during said second background interval upon detection of traffic by said traffic detector means.

8. A coordination unit for coordinating the operation of a full-actuated traffic controller in an interconnected signalized system, said controller serving to control a traffic signal which displays go, caution and stop signals for at least two traffic phases each having associated therewith traffic detector means for detecting traffic in their respective phase and developing a go interval initiation control signal for any phase in response to the detection of traffic in such phase, said controller having phase detector input circuit means, each associated with one of said phases for, upon receipt of a said go interval initiation control signal associated with a phase developing a signal for commencing the display of said go signal for the associated phase; said coordination unit comprising:

background cycle means for cyclically timing successive background intervals each having a predetermined time duration;

means for dividing each said background cycle into at least two time background intervals respectively associated with each of said phases;

actuatable means responsive during one of said associated background intervals for coupling one of said traffic detector means to an associated one of said phase detector input circuit means for the duration of said one associated interval so that a said go interval initiation control signal developed by said one traffic detector means is applied to said one phase detector input circuit means only during said one associated background interval; and,

actuatable means responsive during the other said associated interval for coupling the other said traffic detector means to the other associated one of said phase detector input circuit means so that a said go interval initiation control signal developed by the other traffic detector means is applied to the other phase detector input circuit means only during said other associated background interval.

9. A coordination unit as set forth in claim 8 wherein said dividing means divides said background cycle so as to include for each phase a second background interval which commences substantially upon termination of said first interval; and,

said coordination unit includes for each phase, actuatable memory means for storing a said control signal during an associated said second background interval, said actuatable memory means having an input circuit means for receiving a said control signal during an associated said second background interval and an output circuit means for applying said stored signal to an associated control circuit means upon termination of an associated said second background interval.

10. A method of coordinating the operation of a full-actuated traffic controller which controls allocations of go, caution, and stop intervals for at least two traffic phases, each having traffic detector means associated therewith for detecting traffic and developing a signal in response to the detection

of traffic, said controller including go interval actuation means associated with each phase for commencing display of a go interval signal;

said method of coordination comprising the steps of:

timing a background cycle having a predetermined time duration;

dividing said background cycle into at least two timed background intervals respectively associated with each said phase controlled by said controller;

electrically coupling one of said traffic detector means directly to one of said go interval actuating means during one of said background intervals;

commencing display of a go interval signal with said one go interval actuating means;

electrically decoupling said one traffic detector means from said one go interval actuating means; and,

terminating display of said go interval signal with said go interval actuating means at a predetermined period of time after said one traffic detector means is electrically decoupled from said one go interval actuating means.

11. A method of coordinating the operation of a full-actuated traffic controller as set forth in claim **10** including the additional steps of:

electrically coupling the other of said traffic detector means directly to the other said go interval actuating means;

commencing display of a second go interval signal with said other go interval actuating means;

electrically decoupling said other traffic detector means from said other go interval actuating means; and

terminating said display of a second go interval signal with said other background interval actuating means at a predetermined period of time after said other traffic detector means is electrically decoupled from said other go interval actuating means.

* * * * *