March 10, 1970 R. M. RIDDLE, JR., ET AL 3,500,308

COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

Filed May 23, 1966 4 Sheets-Sheet 1

FIG. 1

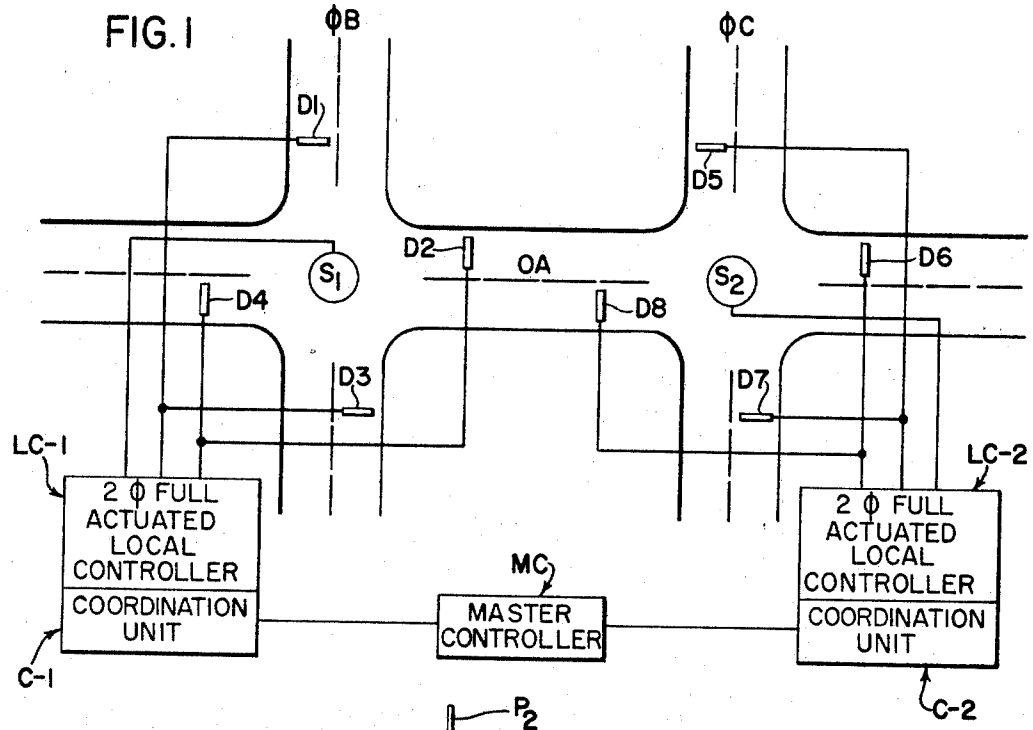
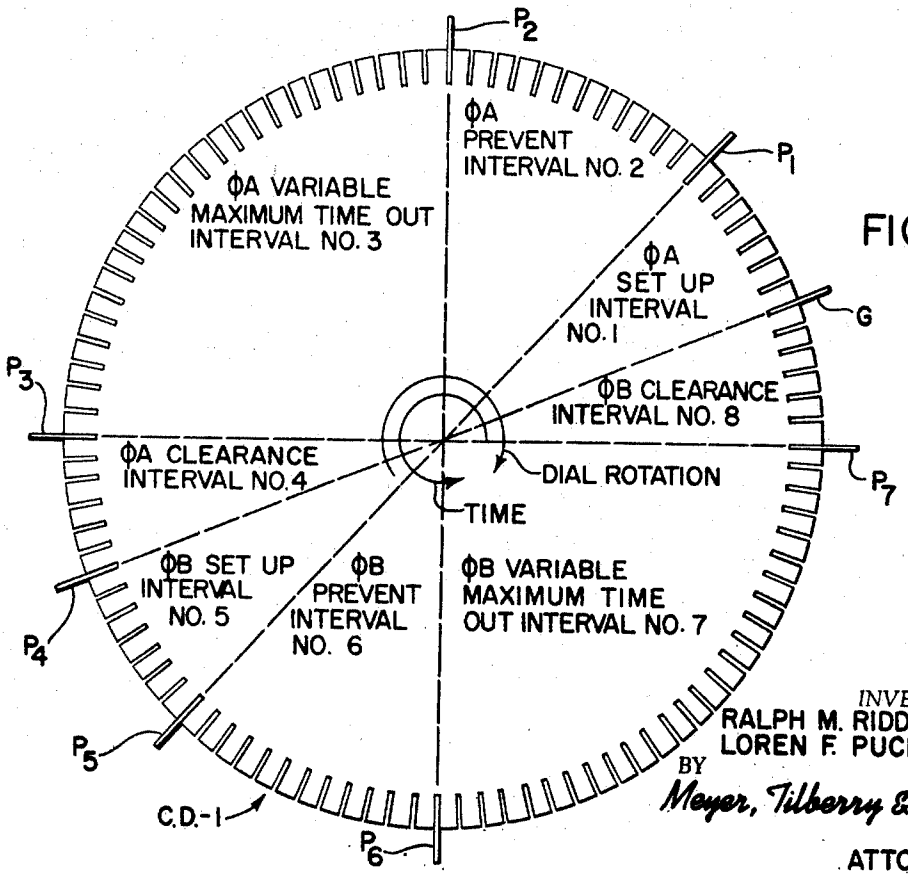


FIG. 4



INVENTORS.
RALPH M. RIDDLE, JR. &
LOREN F. PUCK
BY
Meyer, Tilberry & Body
ATTORNEYS

COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

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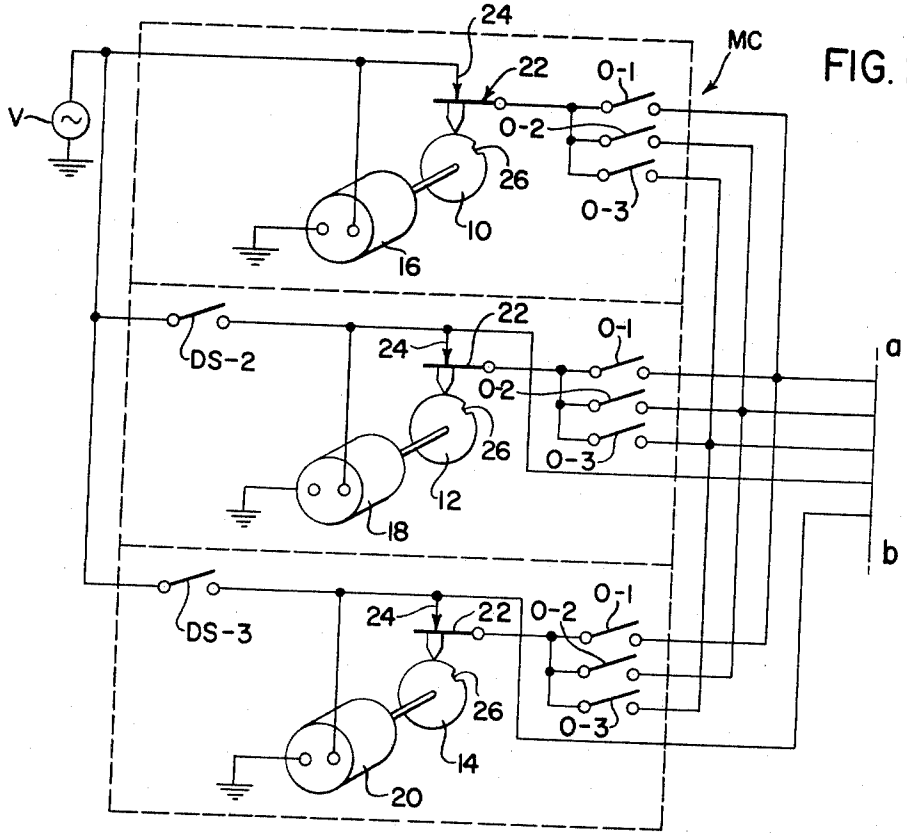


FIG. 2

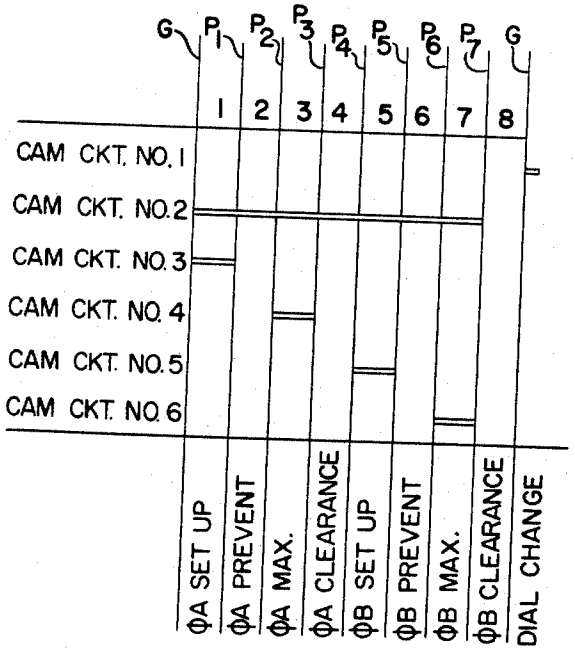


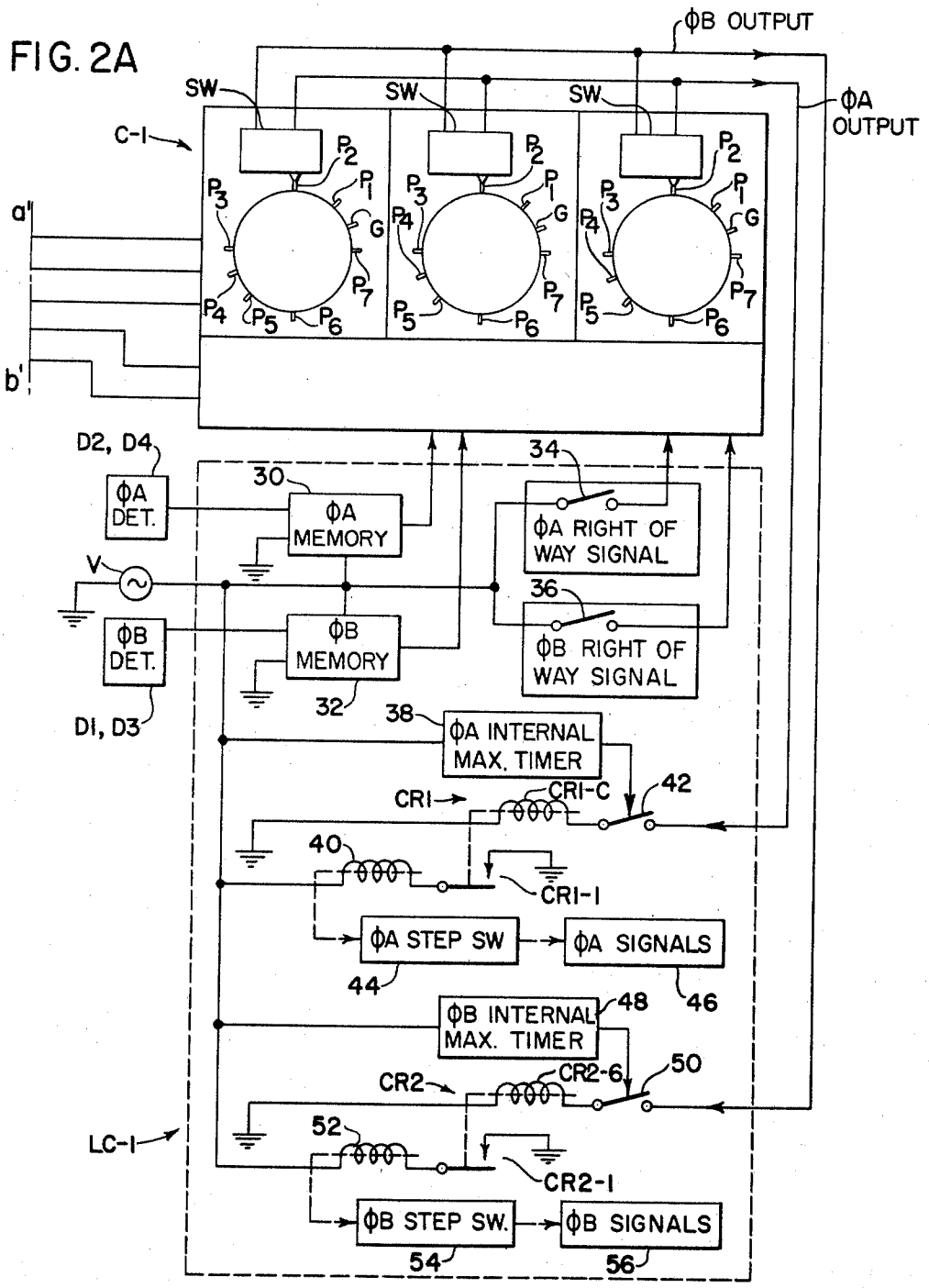
FIG. 5

INVENTORS.
RALPH M. RIDDLE, JR. &
LOREN F. PUCK
BY
Meyer, Tilberry & Body
ATTORNEYS

COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

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FIG. 2A



INVENTORS.
RALPH M. RIDDLE, JR. &
LOREN F. PUCK
BY
Meyer, Tilberry & Body
ATTORNEYS

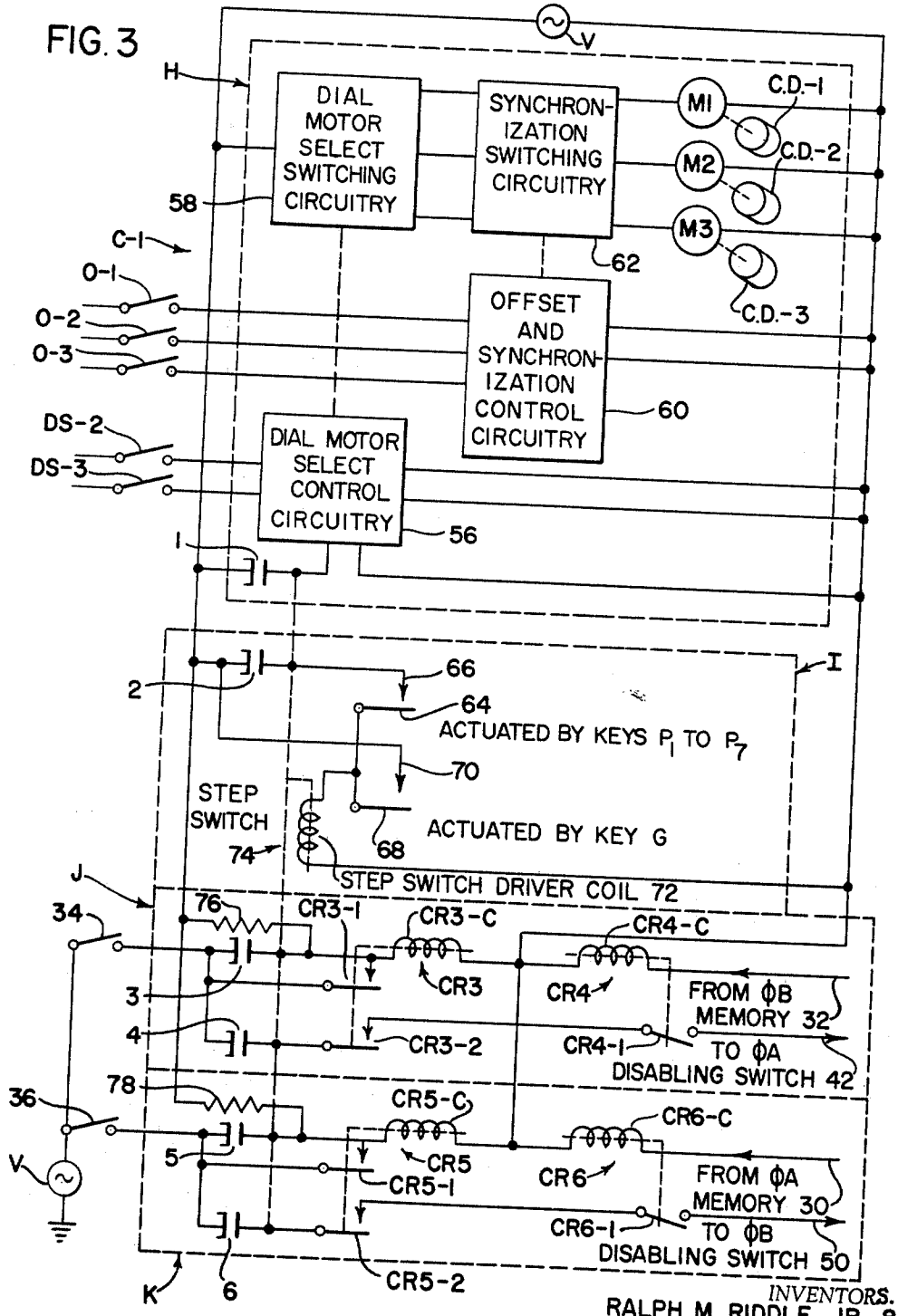
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COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

Filed May 23, 1966

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FIG. 3



INVENTORS.
RALPH M. RIDDLE, JR. &
LOREN F. PUCK
BY
Meyer, Tilberry & Body
ATTORNEYS

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Patented Mar. 10, 1970

3,500,308

COORDINATION OF FULL ACTUATED TRAFFIC CONTROLLERS

Ralph M. Riddle, Jr., Moline, Ill., and Loren F. Puck, Davenport, Iowa, assignors to E. W. Bliss Company, Canton, Ohio, a corporation of Delaware

Filed May 23, 1966, Ser. No. 552,328
Int. Cl. G08g 1/08
U.S. Cl. 340—35 19 Claims

ABSTRACT OF THE DISCLOSURE

There is disclosed a coordination unit for coordinating the operation of a full actuated traffic controller in an interconnected signalized system wherein 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 registering traffic demand with the controller. Also, the controller includes go interval termination means associated with each phase for terminating, when energized a go interval display to the associated phase. The coordination unit includes a coordination dial for cyclically timing a background cycle having a predetermined time duration; key means for dividing the background cycle into at least two successively timed intervals associated with each of the traffic phases; and, circuit means each being associated with one of the traffic phases and being responsive to one of the timed intervals to thereby terminate a go signal displayed to that associated phase.

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

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 semi-actuated 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 semi-actuated 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 is denied to the actuatable 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 occurs 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.

The present invention is directed toward coordination of full actuated traffic controllers in such a manner that the controllers are operated full actuated during coordination by a background cycle so that, contrary to previous methods of coordination, the controllers may yield to the next phase any time there is a lull in traffic.

The invention contemplates that the coordinated full actuated traffic controller serves to control a traffic signal which displays 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. The invention further contemplates that the controller includes go interval termination circuitry associated with each actuatable phase for terminating, when energized, a go interval to the associated actuatable phase.

In accordance with the broad aspects of the invention, the operation of full actuated traffic controllers is coordinated by a background cycle having a time point 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.

Further in accordance with the invention, apparatus and method are provided for dividing the background cycle into at least two successively timed intervals, and for each phase: sensing whether the controller is allocating a go signal to the associated phase during the first interval, and if so, conditioning phase termination circuitry means to a condition whereupon when energized it will terminate the go signal display; commence sensing for a traffic actuation on another actuatable phase; and, energizing the phase termination circuit means only after termination of the second interval when such a traffic actuation is sensed.

In accordance with a still further aspect of the present invention, the background cycle is divided so as to include, for each actuatable phase, a third potential interval of a maximum timed duration, during which the traffic actuation sensing is continued until a traffic actuation is sensed or the third interval is terminated, whichever occurs first.

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

A still further object of the invention is to coordinate the operation of a full actuated local controller so that its cycle length of operation may vary with traffic demand, but not exceed the time duration 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 it allocates go signal display time to the fullest extent in accordance with traffic demand.

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 connection with the accompanying drawings in which:

FIGURE 1 is a plan view schematically illustrating a pair of coordinated, two phase, full actuated local traffic controllers and a master controller within an interconnected, progressive, signalized system;

FIGURES 2 and 2A is a single figure split along lines *a–b* and *a'–b'*, schematically illustrating a coordination unit, in accordance with the invention, connected to a master controller and to a two phase, full actuated local traffic controller;

FIGURE 3 is a schematic circuit diagram of the preferred embodiment of the coordination unit;

FIGURE 4 is a schematic illustration of one coordination dial of the coordination unit; and,

FIGURE 5 is a graphical illustration of intervals of operation and cam circuit closures.

GENERAL DESCRIPTION

Referring now to the drawings, wherein the showings are for the purpose of illustrating a preferred embodiment of the invention only and not for purposes of limiting same, FIGURE 1 schematically illustrates a pair of two phase, full actuated local controllers LC–1 and LC–2 interconnected through coordination unit 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 traffic demand registered with the controller by vehicle actuatable detectors D–1 and D–3 for phase B, and 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 S–1 connected to and 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 traffic demand as registered with the controllers by vehicle actuatable detectors D–5 and D–7 for phase C, and 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 S–2 connected to and controlled by local controller LC–2.

Referring now to FIGURE 2, there is schematically illustrated a master controller MC connected to local controller LC–1 for supervising the operation thereof by means of coordination unit C–1. Coordination unit C–1, which will be described in greater detail hereinafter, 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 through P–7 and G extending radially outward from the dial. Preferably, the 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.

Coordination unit C–1 may, in accordance with the present invention, be utilized in conjunction with various master controllers, and the invention is not limited to any particular master controller. Normally, municipalities require that pretimed traffic controllers and semiactuated controllers, when coordinated, be capable of operating at various cycle lengths in addition to a normal cycle length of operation. Accordingly, when such pretimed and semiactuated local controllers are to operate at a cycle length other than normal in a coordinated, progressive system supervised by a master controller, the master controller should be capable of remotely selecting the cycle length of operation to be in effect for all of the supervised local controllers.

The master controller MC may be pretimed or traffic actuated, as desired, the invention not being limited to either. For purposes of simplifying the explanation of the invention, the master controller MC, illustrated in FIGURE 2, has been simplified and includes three synchronization cam wheels **10**, **12**, and **14**, respectively driven by synchronous motors **16**, **18** and **20**, including suitable gearing, or the like, so that when energized wheels **10**, **12** and **14** rotate at different speeds. Motor **16** is normally connected across an energizing voltage source V, and motors **18** and **20** are connected across 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 normal open position, coordination dial CD–1 is in operation. Closure of dial selector switch DS–2 serves to energize circuitry within coordination unit C–1 for energizing only coordination dial CD–2. Similarly, closure of dial selector switch DS–3 serves to energize circuitry within the coordination unit C–1 for energizing only coordination dial CD–3. A movable switch contact **22** rides on the peripheral surface of an associated synchronization cam wheel **10**, **12** or **14**, and is normally in electrical engagement with a stationary contact **24** for purposes of connecting voltage source V with offset selector switches O–1, O–2 and O–3 connected to coordination unit C–1. Only one offset selector switch O–1, O–2 or O–3 is closed at any one time, and 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 the peripheral surface of the wheel and falls into the arcuate slot **26**, breaking electrical contact with its associated stationary contact **24**. This electrical break extends for approximately 3% of a revolution and, as will be discussed in greater detail hereinafter, is used for synchronized purposes.

Coordination unit C–1 may be used to coordinate the operation of any full actuated traffic controller having external maximum control. That is, the internal maximum timing function of the controller can be disabled so that this function is timed by an external maximum timing device. Normally, semiactuated and full actuated traffic controllers include external maximum control for each actuatable phase being controlled by the controller. The two phase, full actuated local controller LC–1 may, for example, take the form of two interconnected phase units, each being constructed in accordance with that disclosed and illustrated in United States patent application, Ser. No. 463,449, filed May 21, 1965. For purposes of facilitating the understanding of the present invention, however, local controller LC–1, as illustrated in FIGURE 2, has been simplified to illustrate only that which is necessary to understand the present invention. The local controller LC–1, as illustrated, includes a phase A memory circuit **30** connected to a voltage source V, and has an input circuit connected to phase A vehicle actuatable detectors D–2 and D–4, and an output circuit connected to coordination unit C–1. Similarly, the local controller LC–1 also includes a phase B memory circuit **32** connected to voltage source V, and has an input circuit connected to phase B detectors D–1 and D–3, and an output circuit connected to coordination unit C–1. Each memory circuit serves, when its associated detectors have been actuated, to remember the actuation and complete a circuit to the coordination unit. Whereas the vehicle detectors have been illustrated as being spot detectors, such as treadle or magnetic detectors, the invention is not limited to same and the detectors may take the form of presence detectors, such as loop detectors or ultrasonic detectors. In the event that the detectors take the form of presence detectors, memory circuits **30** and **32** may be bypassed since such presence detectors normally provide an output signal so long as a vehicle is present within the zone of detector influence.

Local controller LC–1 also includes means for connecting voltage source V with the coordination unit C–1 so long as the phase A right-of-way signal is being displayed by traffic signal S–1 to phase A. For purposes of simplification, the means for accomplishing this function is illustrated as normally open switch **34** connecting source V with the coordinated unit C–1. It is to be understood that switch **34** is closed by any suitable means so long as a right-of-way signal is displayed by traffic signal S–1 to phase A. Similarly, normally open switch **36** connects voltage source V with the coordination unit C–1, it being understood that the switch is closed by any suitable means so long as a right-of-way signal is displayed by traffic signal S–1 to phase B.

Local controller LC–1 also includes a phase A internal maximum timer **38**, which normally serves to time the maximum duration that right-of-way may be allocated to phase A. The maximum timer **38** is connected across voltage source V through a disabling switch **42** and relay coil CR1–C of a relay CR1. Relay CR1 also includes normally open relay contacts CR1–1, which serve upon energization of the relay to connect a phase A stepping switch driver coil **40** across voltage source V. When the maximum timer **38** completes its timing function a circuit is completed through disabling switch **42** to energize relay CR1. This in turn energizes stepping switch driver coil **40**, which serves to actuate a suitable phase A step switch, designated generally at **44**, which steps one step and in turn serves to actuate suitable phase A signal circuitry, designated generally at **46**, for purposes of terminating allocation of a right-of-way interval to phase A and commence timing in phase A clearance interval, after which phase A is denied right-of-way movement. During coordination, the internal maximum timer circuit **38** is disabled by connecting the disabling switch **42** to the phase A output circuit of coordination unit C–1 so that the maximum timing and, hence, termination of a phase A right-of-way interval, is externally controlled by the coordination unit C–1, to be described in greater detail hereinafter.

In a manner similar to that as discussed with respect to the circuitry associated with phase A, the local controller LC–1 also includes a phase B internal maximum timer **48** normally connected across voltage source V by means of a disabling switch **50**, similar to switch **42** described previously, and a relay coil CR2–C of a relay CR2. Relay CR2 also includes normally open relay contacts CR2–1 which serve upon energization of relay CR2 to connect a phase B step switch device coil **52** across voltage source V. Step switch driver coil **52**, in a manner similar to that discussed with respect to driver coil **40**, serves upon energization to actuate a suitable phase B step switch, designated generally at **54**, which in turn actuates suitable phase B signal circuitry, designated generally at **56**, for purposes of terminating allocation of a right-of-way interval to phase B and commence timing of a phase B clearance interval, after which phase B is denied right-of-way movement.

Whereas the coordination unit C–1 is preferably used in conjunction with a local controller LC–1 having means, such as disabling switches **42** and **50**, for disabling the internal maximum timers associated with each phase to permit the maximum timing function to be controlled by an external mechanism, such as a coordination unit, the invention is not limited to same. Thus, for example, it is contemplated that the coordination unit C–1 may be used in conjunction with a full actuated traffic controller wherein the internal maximum timers are not disabled. With respect to local controller LC–1, illustrated in FIGURE 2, disabling switches **42** and **50** may be replaced with jumpers so that the phase A output circuit of coordination unit C–1 is connected to the junction of the output circuit of internal maximum timer **38** and relay coil CR1–C, and so that the phase B output circuit of coordination unit C–1 is connected to the junction of the output circuit of internal maximum timer **48** and relay coil CR2–C. However, in the event that the local controller includes such jumpers, the internal maximum timers must be set so that they will not complete their timing functions prior to the points in time during the background cycle at which the external timing is completed, i.e., the points in time at which the phase A and phase B output circuits of the coordination unit C–1 communicate energizing signals to energize relays CR1 and CR2, respectively.

COORDINATION UNIT

Having now briefly described a master controller and a two phase, full actuated traffic controller, reference is now made to FIGURE 3 wherein there is schematically illustrated a preferred embodiment of a coordination unit, constructed in accordance with the present invention, for purposes of coordinating the operation of a two phase, full actuated traffic controller in such a manner that the controller may operate full actuated during coordination. Coordination unit C–1 generally comprises: coordination dial, offset synchronizing and control circuits H; background cycle divider circuit I; a phase A coordination circuit J; and, a phase B coordination circuit K.

The coordination unit C–1, in its simpliest form, may include a single timer for timing a particular background cycle for coordination purposes. The timer, for example, may take the form of a coordination dial CD–1, driven by a synchronous motor M1, connected across voltage source V for energization. It is contemplated, however, that the coordination unit C–1, for greater flexibility, in coordinating the operation of a full actuated traffic controller, has the capability of timing different background cycles. This capability is common to coordination units known heretofore for purposes of coordinating the operation of pretimed and semiactuated traffic controllers. To accomplish this and other capabilities, the coordination unit C–1 also includes: additional coordination dials CD–2 and CD–3 driven by synchronous motors M2 and M3, respectively; dial motor select control circuitry **56**; dial motor select switching circuitry **58**; offset and synchronization control circuitry **60**; and, synchronization switching circuitry **62**. As is conventional in previous coordination units for use with pretimed and semiactuated controllers, coordination dial CD–1 is normally in operation during coordination for cyclically timing a first background cycle.

As illustrated in FIGURE 3, the dial motor select switching circuitry **58** and the synchronization switching circuitry **62** are interconnected and serve to connect motors M1, M2 and M3 across voltage source V. The dial motor select circuitry **58** includes circuit means, such as relays and the like, which are ineffective to change the operation from motor M1 to motor M2 or motor M3, except during the period that an associated cam circuit No. 1 is closed. Cam circuit No. 1 connects the dial motor select control circuitry **56** across voltage source V to permit energization of circuitry **56** when the cam circuit is closed, as will be described in greater detail hereinafter. If coordination dial selector switch DS–2 or switch DS–3, in the master controller MC, is closed, circuitry **56** will be effective when cam circuit No. 1 is closed to energize suitable circuitry, such as relay contacts, in the dial motor select switching circuitry **58** for disconnecting the voltage source V from motor M1 and connecting the source to motor M2 if switch DS–2 is closed, or motor M3 if switch DS–3 is closed. In addition, coordination unit C–1 includes offset and synchronization control circuitry **60** connected with offset selector switches O–1, O–2 and O–3 in the master controller MC. Switches O–1, O–2 and O–3 serve when closed to actuate suitable circuitry, such as relays, in the offset and synchronization control circuitry **60** to establish different offsets; such as average, inbound preferential, or outbound preferential. Suitable circuitry, such as relay contacts, in the synchronization and switching circuitry **62** is responsive to the operation of the offset and synchronous control circuitry **60** for establishing the offset relationship selected by closure of one of offset selector switch O–1, O–2 or O–3.

In addition to the foregoing, the coordination unit also includes the capability, known to 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** in the master controller, which, as previously discussed, each include an arcuate cutout portion **26** which breaks an energizing circuit to the offset selector switches O–1, O–2 and O–3 for 3% of the background cycle in effect. The synchronizing wheels **10**, **12** and **14** are driven at speeds corresponding with the background cycle in effect, i.e., motor **16** is energized when coordination dial CD–1 is in effect and drives synchronizing wheel **10** at the same speed as dial CD–1 is 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 supplied through the offset selector switches O–1, O–2 and O–3 for approximately 97% of the background cycle. A key, not shown, carried by the coordination dial opens a switch in circuitry **60** for approximately 1% of the background cycle. If this interruption occurs during the period that power from the master controller is normally interrupted, i.e., for 3% of the cycle, it will not interrupt the 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. However, in the event that the interruption occurs during the 97% period of the background cycle that power is supplied from the master controller through the offset selector switches O–1, O–2 and O–3, then the synchronization control circuitry **60** is effective to de-energize the motor M1, M2 or M3 in operation to stop rotation of the associated coordination dial. As soon as the 3% interruption in power from the master controller occurs, the synchronization control circuitry

serves to re-energize 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.

Since the features of coordination dial select, offset and synchronization of control circuit H are common with previous coordination units, the complete circuitry for obtaining the noted functions has been omitted for purposes of simplifying the understanding of the present invention. For more detailed information as to the circuitry involved, reference may be made, for example, to a coordination unit illustrated and described in United States Patent No. 3,196,387, as well as to the offset, split and synchronization features of a system illustrated and described in United States Patent No. 3,133,264, all assigned to the assignee of the present invention.

Referring now to FIGURE 4, there is schematically illustrated the front face of coordination dial CD–1. The coordination dial preferably includes a cylindrical drum having longitudinal slots extending parallel to the axis of symmetry and spaced arcuately around the circumferential surface of the drum to define one-hundred equally spaced slots. Thus, keys may be placed in the slots spaced from each other in percentages of the background cycle. As shown in FIGURE 4, keys P–1, P–2, P–3, P–4, P–5, P–6, P–7 and G extend radially outward from the circumferential surface of coordination dial CD–1.

BACKGROUND CYCLE DIVIDER CIRCUIT

Referring now to the background cycle divider circuit I, illustrated in FIGURE 3, there is shown a movable contact **64** which is actuated during each repetition of the background cycle by keys P–1 through P–7 to engage a stationary contact **66**. Similarly, a movable contact **68** is actuated once during each repetition of the background cycle by key G to engage a stationary contact **70**. Movable contacts **64** and **68** are connected together in series with a step switch driver coil **72** of a suitable step switch **74**. Stationary contact **70** is connected to one side of voltage source V so that when contact **68** engages contact **70** a circuit is completed across voltage source V for energizing driver coil **72**. The step switch **74** includes, in addition to driver coil **72**, a ratchet mechanism, not shown, and a contact carrying camshaft, not shown, which serve to complete normally open cam circuit Nos. **1**, **2**, **3**, **4**, **5** and **6** in response to energization of the driver coil **72**, in accordance with the cam circuit-interval chart illustrated in FIGURE 5. As will be noted from the chart, the step switch steps, during each repetition of the background cycle, through eight intervals, numbered **1** through **8** on the cam chart. Thus, for example, in response to actuation of movable contact **70** by key G to engage stationary contact **70**, the step switch driver coil is energized, resulting in the step switch advancing to interval No. **1** during which cam circuits Nos. **2** and **3** are completed. Cam circuit No. **2** serves to connect stationary contact **66** with one side of voltage source V and is maintained completed throughout interval Nos. **1** through **7** by a cam, not shown, located on the camshaft of step switch **74**. With cam circuit No. **2** completed, each time that movable contact **64** is actuated by keys P–1 through P–7 a circuit is completed to energize the step switch driver coil **72**. With reference to the cam chart, it will be noted that cam circuit No. **4** is completed in response to key P–2 actuating contact **64**, that cam circuit No. **5** is completed in response to key P–4 actuating contact **64**, and cam circuit No. **6** is completed in response to key P–6 actuating contact **64**. During the time between interval Nos. **8** and **1**, key G actuates contact **68**, and cam circuit No. **1** is completed for purposes of permitting dial motor select control circuitry **56** to affect a dial change from coordination dial CD–1 to coordination dial CD–2 or CD–3, in accordance with closure of dial select switch DS–2 or DS–3 in the master controller MC.

COORDINATION CIRCUITS

Reference is now made to the phase A coordination circuit J illustrated in FIGURE 3. Circuit J includes a normally de-energized relay CR3 having a relay coil CR3–C connected across voltage source V by means of a resistor **76**. Resistor **76** places a bias, or floor potential, on relay coil CR3–C which is not sufficient to either pull in or hold in the relay, and serves the purpose to prevent residual magnetism from accumulating in the relay during operation. Relay coil CR3–C is also connected through normally open cam circuit No. **3** to normally open switch **34** in local controller LC–1. Switch **34** represents, when closed, that a right-of-way signal is being displayed to phase A by local controller LC–1, and during such period completes a circuit to the cam circuit No. **3** for energizing coil CR3–C during interval No. **1**, see FIGURE 5, when cam circuit No. **3** is completed. Relay CR3 also includes normally open relay contacts CR3–1 and CR3–2. Relay contacts CR3–1 serve, when closed upon energization of the relay, to shunt cam circuit No. **3** to provide a holding circuit for maintaining coil CR3–C energized so long as switch **34** in local controller LC–1 is closed. The movable element of normally open relay contacts CR3–2 is connected in series with cam circuit No. **4** to the junction of the movable element of relay contacts CR3–1 and the normally open switch **34** in local controller LC–1. The stationary element of relay contacts CR3–2 is connected through normally open relay contacts CR4–1 to the phase A output circuit of coordination unit C–1, which leads to the phase A disabling switch **42** in local controller LC–1. Relay contacts CR4–1 are closed in response to energization of relay coil CR4–C of relay CR4, which has its energizing circuit completed when phase B memory circuit **32** in local controller LC–1 is energized in response to actuation of either of its associated phase B vehicle actuatable detectors D–1 or D–3.

The phase B coordination circuit K, illustrated in FIGURE 3, is substantially identical to the phase A coordination circuit J, described above. Circuit K includes a normally de-energized relay CR5 having a relay coil CR5–C and a pair of normally open relay contacts CR5–1 and CR5–2. Coil CR5–C is connected across voltage source V by means of a resistor **78** which, in a manner similar to resistor **76** discussed previously with respect to circuit J, places a bias, or floor potential, on relay coil CR5–C which is not sufficient to pull in or hold in the relay, and serves to prevent residual magnetism from accumulating during operation. The junction of resistor **78** and coil CR5–C is connected to normally open phase B right-of-way signal switch **36** in local controller LC–1 by means of cam circuit No. **5**. Relay contacts CR5–1 serve, when closed, to shunt cam circuit No. **5** to provide a holding circuit for relay coil CR5–C to maintain the relay energized so long as a right-of-way signal is being displayed to phase B, as represented by closure of switch **36**. The movable element of relay contacts CR5–2 is connected to the junction of the movable element of relay contacts CR5–1 and normally open switch **36** by means of cam circuit No. **6**. The stationary element of relay contacts CR5–2 is connected through normally open relay contacts CR6–1 of relay CR6 to the phase B output circuit of coordination unit C–1 which leads to the phase B disabling switch **50** in local controller LC–1. Relay contacts CR6–1 are closed upon energization of relay coil CR6–C, which has its circuit completed for energization when the phase A memory circuit **30** is energized in response to actuation of either of its associated phase A vehicle actuatable detectors D–2 or D–4.

OPERATION

For coordination operation of local controller LC–1, internal maximum timer disabling switches **42** and **50** are respectively transferred from the positions as shown in FIGURE 2 to be in circuit with the phase A and phase B output circuits of coordination unit C–1. Depending on

the background cycle in effect, one of the coordination dials CD–1, CD–2 or CD–3 of coordination unit C–1 is in operation. If the coordination dial selector switches DS–2 and DS–3 in the supervising master controller MC are in the open position, as illustrated in FIGURE 2, coordination dial CD–1 is in operation to time a particular background cycle. During coordination operation the cycle length of operation of local controller LC–1 may vary with traffic demand, but will never exceed the time length of the background cycle timed by coordination dial CD–1. With coordination dial CD–1 in operation, motor M–16 in master controller MC is in operation for synchronizing purposes. One of the offset selector switches O–1, O–2 or O–3, associated with motor M–16 in the master controller MC, is closed representative of the particular offset in effect.

Coordination dial CD–1 rotates to cyclically time the background cycle, the time duration to complete one revolution of the dial; the elapsed time and direction of dial rotation being indicated by the arrows in FIGURE 4. During each revolution of dial CD–1, key G actuates movable contact 68, see FIGURE 3, to engage stationary contact 70, completing a circuit for energizing step switch driver coil 72. This advances step switch 74 to interval No. 1, see FIGURE 5, during which cam circuit Nos. 2 and 3 are completed. The time lapse of this interval is determined by the spacing from key G to key P–1, and may be termed as the phase A setup interval. During this timed interval, relay coil CR3–C in circuit J will become energized if a right-of-way signal is being displayed to phase A by local controller LC–1, as represented by closure of switch 34. Once energized, relay CR3 remains energized by virtue of a holding circuit, defined by relay contacts CR3–1 shunting cam circuit No. 3, so long as the phase A right-of-way signal is being displayed, i.e., so long as switch 34 remains closed.

The phase A setup interval No. 1 terminates when key P–1 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances the step switch 74 to interval No. 2 which may be termed as the phase A prevent interval. This timed interval is determined by the spacing between key P–1 and key P–2, and is preferably selected so as to correspond with the normal initial right-of-way interval that would be allocated by controller LC–1 to phase A right-of-way movement so as to eliminate the possibility of allocating a right-of-way interval shorter than the normal initial right-of-way interval. During phase A interval No. 2, cam circuit No. 3 is open. Accordingly, in the event that right-of-way allocation to phase A started during prevent interval No. 2, relay CR3 would not be energized. Likewise, if during this interval right-of-way allocation to phase A is terminated, as represented by an open condition of switch 34, relay CR3, if previously energized during the phase A setup interval No. 1, would now become de-energized. Interval No. 2 serves the purpose of providing a period for preventing an output signal from being communicated from the phase output circuit of coordination unit C–1 to local controller LC–1 in the event that a right-of-way interval was not being allocated by the controller to phase A prior to the termination of phase A setup interval No. 1.

The phase A prevent interval is terminated when key P–2 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances the step switch to interval No. 3 which may be termed as the phase A variable maximum time out interval. During this period, cam circuit No. 4 is completed. The time duration of this interval is determined by the spacing between keys P–2 and P–3. As previously, discussed, if right-of-way is allocated to phase A during the phase A setup interval No. 1, relay CR3 is energized through relay contacts CR3–1 during interval No. 3. If right-of-way is still being allocated to phase A during interval No. 3, switch 34 is closed and a circuit is completed through switch 34 in local controller LC–1, through the now completed cam circuit No. 4, and the now closed relay contacts CR3–2 to the normally open relay contacts CR4–1. Upon energization of relay CR4 its contacts CR4–1 close to complete a circuit through the phase A output circuit of coordination unit C–1 to the phase A disabling switch 42 in local controller LC–1 to energize relay CR1. This energizes step switch driver coil 40, advancing phase A step switch 44. This actuates phase A signal circuit 46 to terminate allocation of a right-of-way interval to phase A and commence timing a phase A clearance interval, after which phase A is denied right-of-way movement. Relay CR4 is energized in response to a vehicle actuation of phase B vehicle actuatable detectors D–1, D–3 which completes a circuit through the phase B memory circuit 32 to relay coil CR4–C. If phase B detectors D–1, D–3 are actuated prior to the termination of phase A prevent interval No. 2, the actuation by key P–2 of movable contact 64 to engage stationary contact 66 results in termination of the right-of-way allocation to phase A as soon as step switch 74 is advanced to the phase A variable maximum time out interval No. 3. In accordance with the invention, however, actuation of phase B detectors D–1, D–3 occurring any time during the phase A variable maximum time out interval No. 3, also serves to terminate allocation of right-of-way interval to phase A, since during interval No. 3 cam circuit No. 4 and relay contacts CR3–2 are closed requiring only the closure of relay contacts CR4–1 to complete the phase A output circuit of coordination unit C–1. The phase B vehicle actuation must, however, occur at a point in time in the background cycle prior to the termination of interval No. 3, as determined by the location of key P–3, in order to terminate right-of-way allocation to phase A.

The phase A variable maximum time out interval No. 3 is terminated when key P–3 actuates movable contact 70 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances the step switch to interval No. 4 which may be termed as a phase A clearance interval. The timing of this interval is determined by the spacing of keys P–3 and P–4, which preferably should be sufficient to provide a normal phase A clearance time interval in the event that a phase B vehicle actuation occurred just prior to the termination of the phase A variable maximum time out interval No. 3. This interval should also be sufficiently long in time duration to permit traffic controller LC–1 to change the signal displays so that right-of-way is allocated to phase B prior to the termination of the interval.

The phase A clearance interval No. 4 is terminated when key P–4 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances the step switch 74 to the phase B setup interval No. 5. Interval No. 5 is similar to the phase A setup interval No. 1, discussed previously, and the time duration of the interval is determined by the spacing between keys P–4 and P–5, which is preferably set to correspond with the normal initial right-of-way interval that would be allocated by local controller LC–1 to phase B right-of-way movement. During the phase B setup interval No. 5, cam circuit No. 5 is completed to energize relay CR5 if a right-of-way interval is being allocated to phase B, as represented by closure of switch 36. Relay contacts CR5–1 and CR5–2 are closed, and contacts CR5–1 parallel cam circuit No. 5 to complete a holding circuit for relay CR5.

The phase B setup interval is terminated when key P–5 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances the step switch to interval No. 6 which may be termed as the phase B prevent interval. Interval No. 6 is similar to and serves the same purpose as the phase A prevent interval No. 2 discussed previously.

If phase B right-of-way has been allocated prior to interval No. 6 to energize relay CR5, then relay CR5 remains energized through its holding circuit, as defined by relay contacts CR5–1, during the phase B prevent interval.

The phase B prevent interval is terminated when key P–6 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing step switch driver coil 72. This advances step switch 74 to interval No. 7 which may be termed as the phase B variable maximum time out interval. The time duration of this interval is determined by the spacing of keys P–6, P–7 and serves the same purpose as phase A variable maximum time out interval No. 3 discussed previously. During this interval, cam circuit No. 6 is completed. Upon actuation of phase A actuatable detectors D–2, D–4, a circuit is completed from the phase A memory circuit 30 to energize relay CR6. This causes relay contacts CR6–1 to close. Accordingly, in a manner similar to that as discussed with respect to the phase A coordination circuit J, a circuit is completed during the phase B variable maximum time out interval No. 7 to the phase B output circuit of coordination unit C–1, which leads to the phase B disabling switch 50. This causes energization of relay CR2 in local controller LC–1, advancing phase B step switch 54. This actuates phase B signal circuit 56 to terminate allocation of a right-of-way interval to phase B and commence timing a phase B clearance interval, after which phase B is denied right-of-way movement.

The phase B variable maximum time out interval No. 7 is terminated when key P–7 actuates movable contact 64 to engage stationary contact 66, completing a circuit for energizing the step switch driver coil 72. This advances the step switch 74 to interval No. 8 which may be termed as the phase A clearance interval. The time duration of this interval is determined by the spacing of keys P–7 and G and, in a manner similar to the phase A clearance interval No. 4, the spacing is preferably sufficient to provide a clearance interval for phase B in the event that phase B right-of-way allocation was terminated at a point in time just prior to termination of interval No. 7. During this interval, cam circuit No. 2 is broken, i.e., open, in preparation for another cycle of operation.

The phase B clearance interval No. 8 is terminated when key G actuates movable contact 68 to engage stationary contact 70, completing a circuit for energizing step switch driver coil 72. Cam circuit No. 1 is completed between interval Nos. 8 and 1 to render the dial motor select control circuitry effective to change the dial operation from coordination dial CD–1 to coordination dial CD–2 or CD–3, dependent on a closure of coordination dial selector switch DS–2 or DS–3 located in master controller MC.

Whereas the background cycle timer has been described as taking the form of a synchronous motor driven coordination dial, the invention contemplates that other forms of timers may be used which have the capability of actuating circuitry during selected points, i.e., at keys G and P–1 through P–7 of coordination dial CD–1, of the background cycle. Similarly, whereas the background cycle divider circuit I has been described in conjunction with dial keys, movable contacts and a step switch, the invention contemplates that this circuitry may be replaced with suitable static, solid state, switching circuitry. Also, whereas the coordination circuits J and K have been described in conjunction with relay circuits, the invention contemplates that this circuitry may be replaced with static, solid state circuitry.

Although the invention has been shown and described in connection 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.

Having thus described our invention, we claim:

1. A coordination unit for coordinating the operation of a full actuated traffic controller in an interconnected signalized system in response to the receipt of signals from a master controller, said controller serving 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 said phase and registering traffic demand with said controller, said controller including go signal display means associated with each said phase for, upon energization, displaying a go interval display to said associated phase, and switching circuit means associated with each said phase for, when energized, de-energizing said associated go signal display means to thereby terminate a go interval display to said associated phase; and coordination unit adapted to be coupled to a said master controller comprising:

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

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

said coordination unit includes for each said phase:

phase termination means for, when energized, energizing the associated said switching circuit means in said controller;

means responsive during the first of said associated intervals to a go signal to said associated phase for conditioning said phase termination means for subsequent energization; and,

means responsive substantially upon the termination of said second interval to a traffic detection by a said detector means associated with another said phase for energizing said switching circuit means to thereby terminate a go interval display to said associated phase.

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 third potential interval of a maximum timed duration and which commences substantially upon termination of said second interval.

3. A coordination unit as set forth in claim 2 wherein said traffic detection responsive means is responsive only during said potential interval to a said traffic detection for energizing said phase termination means.

4. A coordination unit as set forth in claim 1 wherein said background cycle timing means includes a motor driven coordination dial and wherein said dividing means is adjustable for adjustably dividing said background cycle into timed intervals of desired timed durations and includes a plurality of switch actuator keys carried by said dial at preselected angularly spaced locations on said dial.

5. A coordination unit as set forth in claim 1 wherein each said go signal display responsive means includes a first relay coil, and each said phase termination means includes first normally open relay contacts associated with said first relay coil and closed upon energization of said first relay coil.

6. A coordination unit as set forth in claim 5 wherein said traffic detection responsive means includes a second relay coil, and each said phase termination means includes second normally open relay contacts connected with said first relay contacts and closed to complete a circuit with said first relay contacts upon energization of said second coil, and output circuit means connected with said relay contacts and adapted to be connected to said associated go interval termination means in said controller.

7. A plurality of coordination units each for coordinating the operation of a like plurality of full actuated local traffic controllers in response to the receipt of signals from a master controller, said master controller including circuit means for developing a pattern of said signals according to a predetermined program, each said traffic controller serves to allocate go and stop traffic signal intervals to at least first and second traffic actuatable phases

in an interconnected progressive traffic signal system, each said traffic controller including go signal display means associated with each said phase for, upon energization, displaying a go interval display to said associated phase, and sequencer switching means associated with each said phase for, when energized, de-energizing said associated go signal display means to thereby terminate a said go interval display to said associated phase; each said coordination unit being associated with and coupled to one of said plurality of traffic controllers and adapted to receive signals from a said master controller and comprising:

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

means for dividing said background cycle into a plurality of successively timed intervals associated with each of said phases;

first, second, third and fourth switching means associated with each said phase, each said switching means having a normal first condition and a second condition;

said first and second switching means being controlled by said dividing means in such a manner that they are respectively in their second conditions only during a first and a second of said timed intervals associated with said phase, each said first and second switching means connected with a coordination unit input circuit adapted to be connected with an energizing source when said associated local controller is allocating a go interval to said associated phase;

bistable means associated with each phase and having a normal first state and a second state, said bistable means being controlled by said first switching means so as to be actuated to its second state only when said first switching means is in its second condition and is connected to a said energizing source;

said third switching means being controlled by said associated bistable means so as to be in its second condition only when said bistable means is in its second state;

means for actuating said fourth switching means to its second condition, said actuating means adapted to be connected to an energizing source for actuating said fourth switching means to its second condition only in response to an actuation of another said phase to which a stop interval is being allocated by said associated local controller; and,

a coordination output circuit associated with each said phase and adapted to be connected to a go interval termination means in said associated local controller for terminating allocation of a said go interval to said associated phase;

said second, third and fourth switching means being interconnected in such a manner that said output circuit connects said go interval termination means with a said energizing source only when said second, third and fourth switching means are in their second conditions whereupon said terminating means in said associated local controller is energized to terminate allocation of said go interval to said associated phase.

8. A coordination unit as set forth in claim **7** wherein said bistable means includes a relay coil and said third switching means includes normally open relay contacts actuated to a closed condition upon energization of said relay coil.

9. A coordination unit as set forth in claim **7** wherein said bistable means includes a relay coil and a holding circuit connecting said coil to said source of energy for maintaining said bistable means in its second condition when said first switching means returns to its first condition.

10. A coordination unit as set forth in claim **9** wherein said holding circuit includes normally open relay contacts actuated to a closed condition upon energization of said relay coil.

11. A coordination unit as set forth in claim **7** wherein said actuating means includes a relay coil and said fourth switching means includes normally open relay contacts actuated to a closed condition upon energization of said relay coil.

12. A coordination unit as set forth in claim **7** wherein said second, third and fourth switching means define an AND circuit requiring said switching means to be in their second condition for completing an energizing circuit to said associated coordination output circuit.

13. A coordination unit as set forth in claim **7** wherein said background cycle timing means includes a synchronous motor driven coordination dial, and said dividing means includes:

a plurality of movable contact actuator keys extending radially outward from said dial and arcuately spaced from each other in a predetermined pattern; and,

a movable contact means actuatable by said keys for completing, upon actuation, an energizing circuit for a said sequencer switching means.

14. A method of coordinating the operation of a full actuated traffic controller which controls allocations of go, caution and stop intervals to at least two traffic phases, each having traffic detector means associated therewith for detecting traffic and registering traffic demands with said controller;

said method comprising the steps of:

timing a background cycle having a predetermined time duration;

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

during the first of said intervals,

sensing whether said controller is allocating a go signal interval to said associated phase;

conditioning phase termination circuit means, only when a said go signal interval allocation is sensed, to a condition whereupon when subsequently energized it will terminate said go signal interval;

sensing for the occurrence of a traffic detection by a said detector means associated with another said phase; and,

energizing said phase termination circuit means, only after termination of said second interval and when a said traffic actuation is sensed, to terminate said go signal interval to said associated phase.

15. A method as set forth in claim **14** including the further step of:

dividing said background cycle so as to include a third timed interval having a maximum time duration so that said third interval commences substantially immediately upon termination of said second interval.

16. A method as set forth in claim **15** including the further step of:

continuing said traffic detection sensing step during said third interval until a said traffic actuation detection is sensed or said third interval is terminated upon said maximum time duration, which ever occurs first.

17. A method as set forth in claim **16** including the further step of:

dividing said background cycle so as to include a timed clearance interval which commences substantially immediately upon termination of said third interval.

18. A method as set forth in claim **17** including the further step of:

commencing, substantially immediately upon the termination of said clearance interval, the first of said timed intervals associated with another of said phases.

19. A coordination unit as set forth in claim **7** wherein said second switching means, said third switching means, said fourth switching means and said go interval terminating means are each coupled in series connection with each other;

said first switching means, said bistable means, said means for actuating said fourth switching means, and said detector means associated with another said phase are each coupled in series connection with each other;

said bistable means and said means for actuating said fourth switching means being coupled directly to each other so as to define a junction point; and,

said junction point being coupled to a said energizing source wherein when said first switching means is actuated to its second condition said bistable means is energized to thereby actuate said third switching means to its second condition and when said second switching means is actuated to its second condition a circuit is completed so that upon energization of said

means for actuating said fourth switching means said terminating means in said local controller is energized to terminate actuation of said go interval to said associated phase.

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