Feb. 27, 1951 J. L. BARKER 2,542,978

TRAFFIC ACTUATED CONTROL APPARATUS

Filed Aug. 16, 1949 4 Sheets-Sheet 1

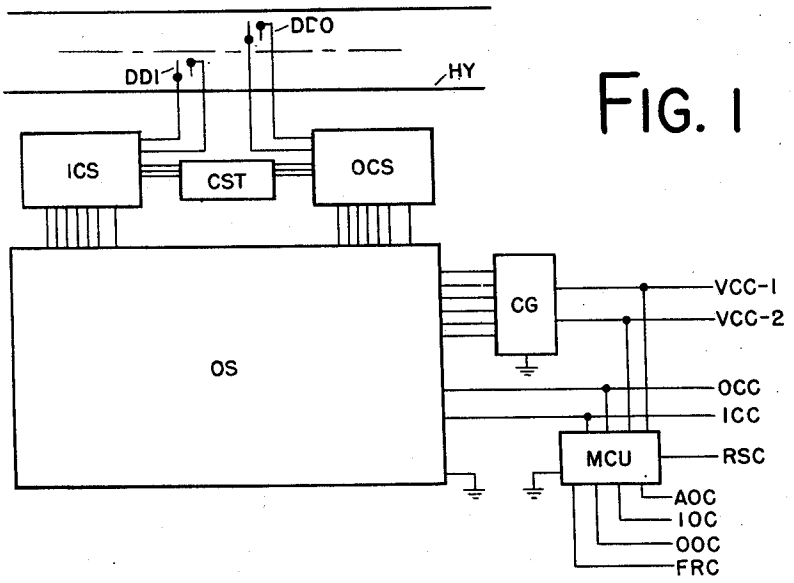


FIG. 1

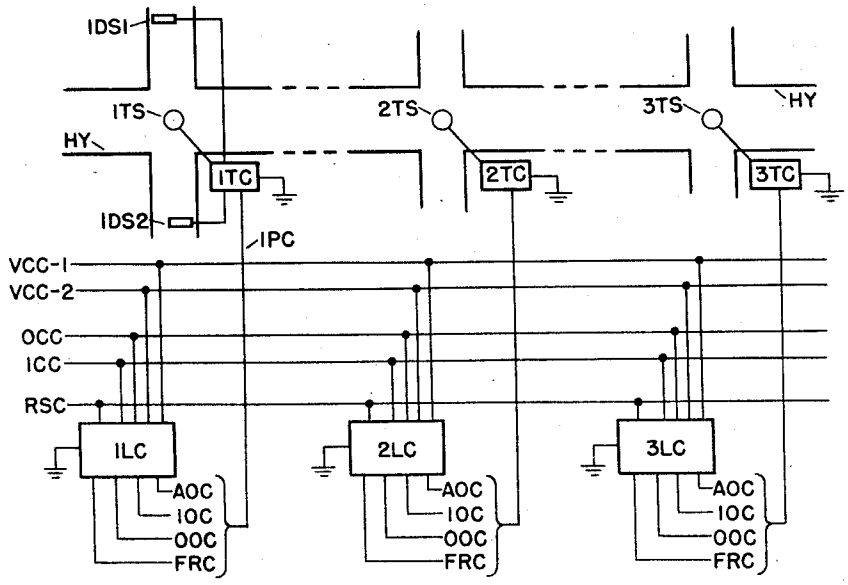


FIG. 2

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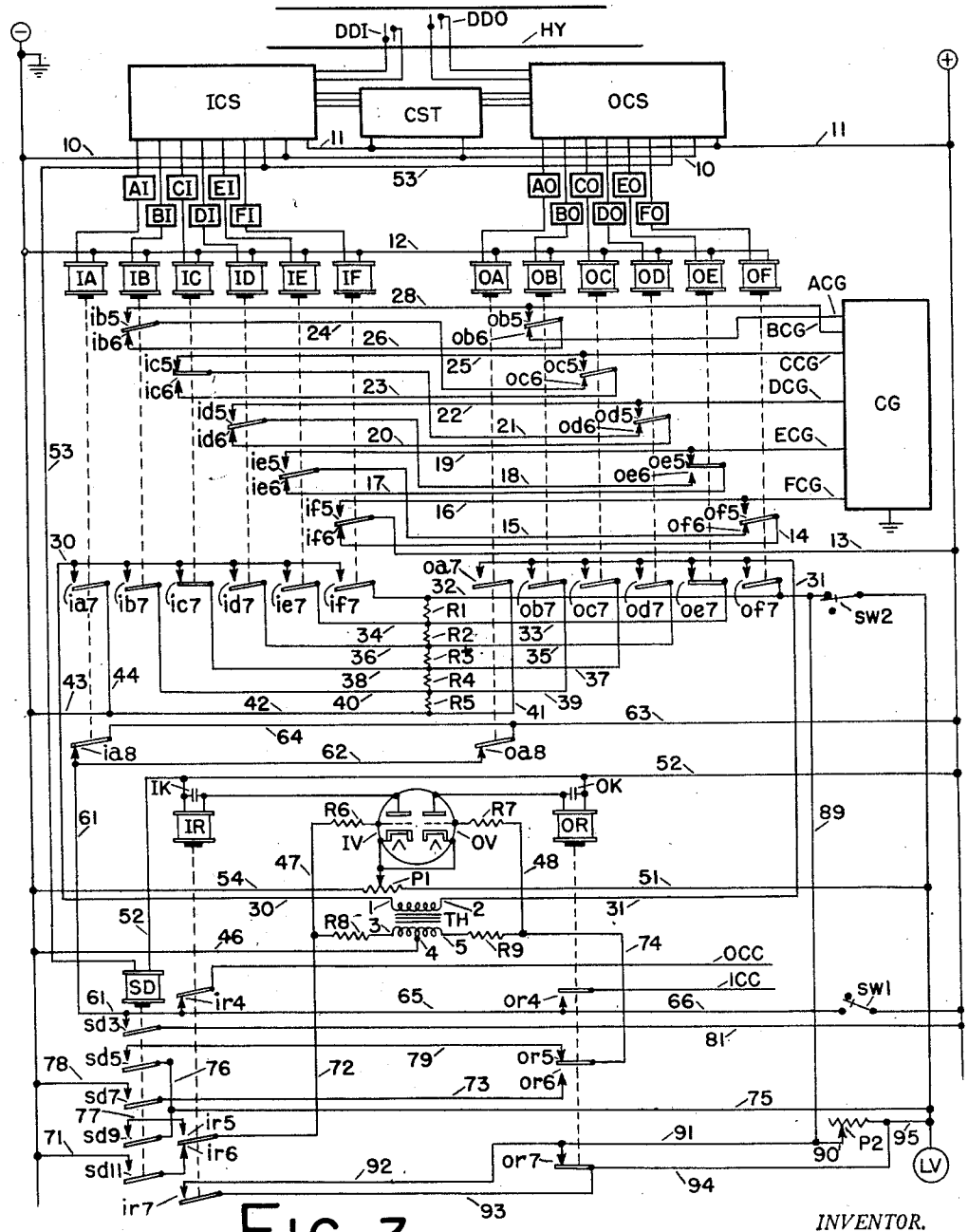


FIG. 3

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TRAFFIC ACTUATED CONTROL APPARATUS

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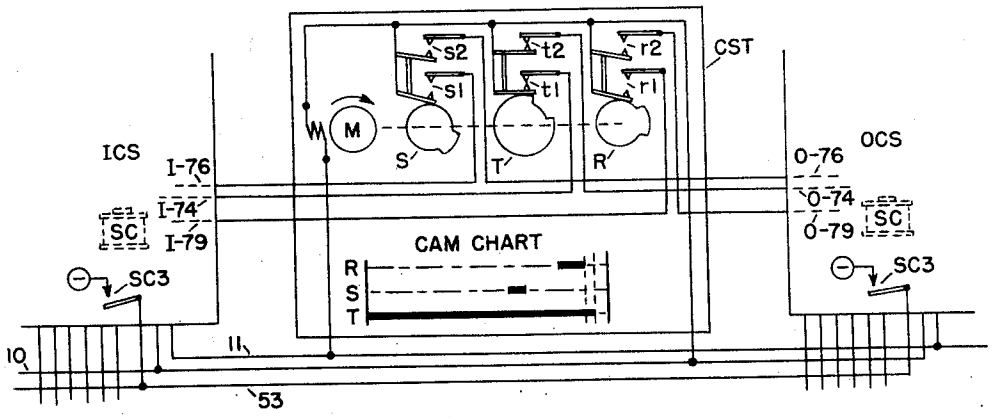


FIG. 4

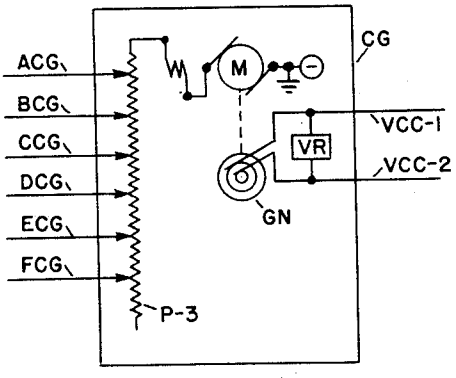


FIG. 5

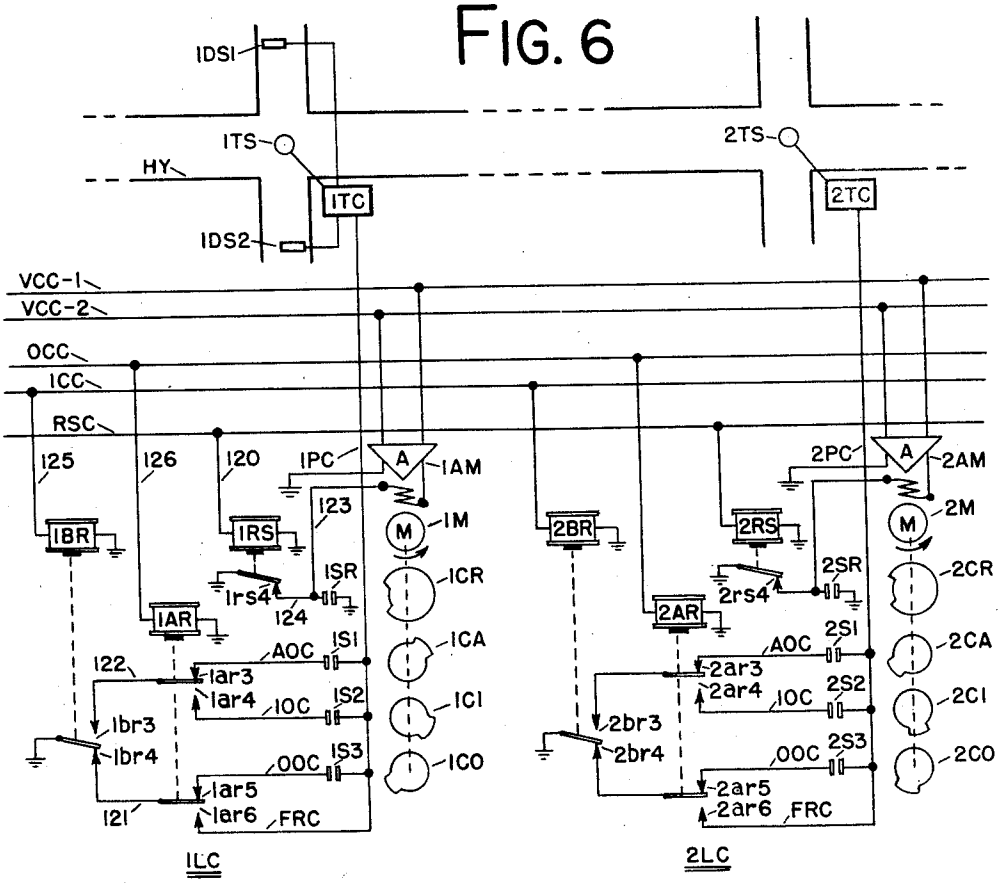
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TRAFFIC ACTUATED CONTROL APPARATUS

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FIG. 6



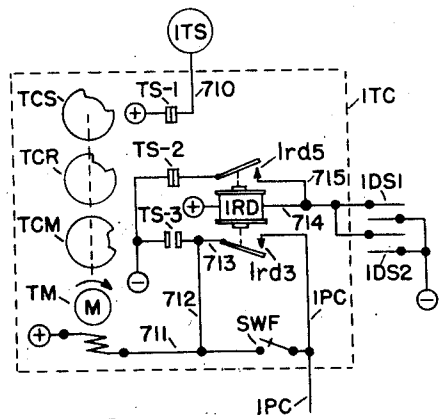


FIG. 7

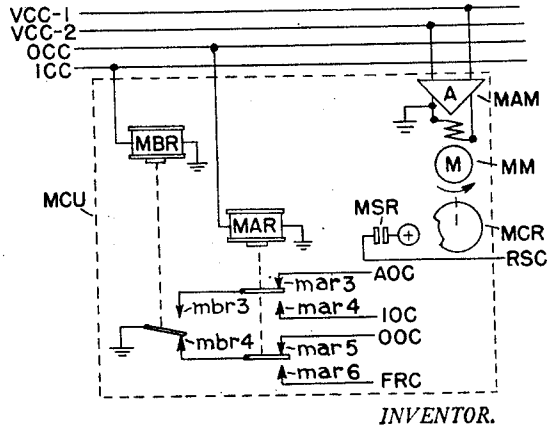


FIG. 8

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UNITED STATES PATENT OFFICE

2,542,978

TRAFFIC ACTUATED CONTROL APPARATUS

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Application August 16, 1949, Serial No. 110,559

19 Claims. (Cl. 177—19)

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This invention relates to traffic actuated control apparatus and methods, and more particularly to apparatus for automatic selection among several coordinated traffic signal timing patterns in response to a sampling of traffic conditions by traffic actuation.

From one aspect the invention relates to apparatus for selection among traffic signal offset systems for one or the other of two traffic directions or for both directions along a roadway in response to traffic actuation by traffic in the respective directions, as for example inbound and outbound traffic directions.

From another aspect the invention relates to apparatus for selection among such offset systems in response to the relative positions of two cycle selectors, one for each traffic direction, and each adapted to select one of a scale of cycle positions in response to traffic actuation in its direction over a scale of traffic volume per unit time period.

From a further aspect the invention relates to apparatus for selection of the higher of two cycle positions selected individually by two traffic actuated cycle selectors from their respective similar scales of cycle positions, one for each of two traffic directions, where different cycle positions are selected by the two cycle selectors, and for selection of the same cycle position where corresponding cycle positions are selected by the two cycle selectors.

Various types of systems are well known for coordination of traffic movement through a series of traffic signals along a street or highway. Certain systems of this type provide for the cross-traffic periods at successive traffic signals along the highway to come in at progressively later time periods in proceeding along the highway in a given direction for example so that the green signal period available for the highway traffic at the succession of intersections appears to travel along the highway and thus permits fleets of cars to proceed at the designed speed of the system through the series of traffic signals with a minimum of stopping for accommodation of cross traffic. Such traffic signal control systems are often referred to as "progressive systems."

The time lag between any given common reference point in any representative traffic signal cycle in a progressive system and the appearance of the desired corresponding point in the cycle of an individual traffic signal in the system is often referred to as the offset for that signal, and it is already well known to provide one set of offsets for inbound traffic movement in the morning into the center of a city for example, with another set

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of offsets for the outbound traffic movement which usually characterizes the heavy traffic flow periods of the late afternoon. In addition a third set of offsets for average or best two-way progressive traffic movement is often provided for the periods of the day when it is anticipated that the traffic is not predominantly in one direction.

One difficulty in such systems however has been that the peak periods of inbound and outbound traffic do not always occur at the same times on corresponding days on week days or on week ends for example and various weather conditions and the occurrence of public events attracting considerable amounts of traffic will vary the traffic patterns from time to time so that any means of setting up in advance a program of the selection of the proper offsets and traffic control cycles for various times of day and various days of the week is unable to adjust for these irregular variations.

It is also already known to provide apparatus for selection, by traffic actuation at a suitable traffic sampling point, between different types or lengths of traffic control cycles for the traffic signal system or to adjust the timing of the overall traffic signal system step by step at short time intervals to accommodate the actual traffic variations as they occur. Apparatus of this character is sometimes referred to as a traffic cycle selector and my Patent No. 2,288,601 dated July 7, 1942 is directed to such apparatus.

In one embodiment of the present invention selection between inbound offset, outbound offset and average offset is made in accordance with the relative positions of two cycle selectors, which may be of the form disclosed in the Patent 2,288,601 referred to for example, as somewhat modified as pointed out hereinbelow. According to one aspect of the invention one cycle selector and an associated traffic actuated detector unit are provided for inbound traffic at an appropriate sampling point on the highway common to the series of signalized intersections which it is desired to control under the overall traffic signal system, and another such cycle selector and associated detector unit are provided for outbound traffic at an appropriate sampling point which is preferably but not necessarily at the same point as the inbound traffic sampling point. For purposes of adjusting and checking the operation of the system under actual traffic conditions it has been found convenient to locate the inbound and outbound detector units on opposite sides of the highway at a single location at or near the location of the cycle selector

apparatus and offset selector apparatus and associated apparatus serving as a master control system for supervising the operation of the individual traffic signal controllers at the individual signalized intersections along the highway.

In some cases the preferred location of the cycle selector and offset selector apparatus may be near the middle of the series of traffic signals along the highway and in other cases the preferred location may be near one end of the series, in accordance with the best traffic sampling conditions.

In the operation of the selector apparatus from its broader aspects the inbound and outbound traffic streams are respectively in effect measured or counted over a time period and during such time period the individual cycle selectors remain on a given traffic control time cycle for master control of the various individual traffic signal controllers. Near the end of such traffic sampling time period the individual cycle selectors determine whether to remain on the same cycle or to change to a longer cycle or to a shorter cycle in accordance with the traffic counted, for example. If the traffic counted is substantially the same as in the preceding sampling time period the cycle selector remains on the same cycle but if the traffic has increased substantially the cycle selector will select the next higher or longer cycle in the series, or if the traffic count has decreased substantially the cycle selector will select the next lower or shorter cycle in the series for the next sampling time period. At the end of each sampling time period the counting of traffic is reset and another sampling time period is started.

Each cycle selector has a number of different cycles to select from. The Patent 2,288,601 referred to illustrates six cycles or cycle positions A to F for example although it is obvious that more or less could be provided if desired.

The present apparatus provides a means of selecting among the inbound and outbound offset systems in accordance with the positions of the inbound and outbound cycle selectors. For example if the inbound and outbound cycle selectors are both on the same or corresponding cycle positions, indicating substantially the same traffic flow in each direction, the offset selector apparatus in accordance with one aspect of the present invention would select the average offset. Similarly in one form of the invention if the inbound and outbound cycle selectors are not more than one cycle position apart the offset selector will continue to select the average offset. On the other hand if for example the inbound and outbound cycle selectors are two or more cycle positions apart the offset selector will select the higher of the two offsets. Thus if the inbound cycle selector is two cycle positions higher than the outbound cycle selector the inbound offset will be selected by the offset selector, but if the outbound cycle selector is two or more cycle positions higher than the inbound cycle selector the outbound offset will be selected by the offset selector.

As described later herein the offset selector can be adjusted to switch to the proper inbound or outbound offset when the cycle selectors are one cycle position apart if desired, or it can be adjusted to switch to the proper inbound or outbound offset when the cycle selectors are three or more cycle positions apart if desired, instead of the two cycle position separation adjustment just described for example.

During a large part of the day at most traffic signal systems along a street or highway there is no predominantly heavy traffic in either one direction along the highway and the average offset is in general best suited for such relatively balanced traffic since it is designed to provide best for traffic movement in both directions through the series of signals. In sampling traffic for any relatively short time period it is obvious that there may be momentary or brief periods of increased traffic in one direction which are not truly representative of a continuing condition or even of a trend toward such continuing condition. Under such circumstances it has been found desirable to provide greater stability in the system by requiring the cycle selectors to be more than one position apart before a change to either inbound or outbound offset and this is the preferred form of the invention.

It will also be appreciated that the general level of traffic will vary considerably throughout the day and night and that it may be desirable under circumstances of moderate traffic but predominantly inbound traffic as may occur in the early evening hours for example to have the system on an inbound offset but at a total cycle length of average or moderate length somewhat between the longest and the shortest cycles. It will be understood by those skilled in the art that the most desirable cycle length is related to the speed and volume of traffic through a series of traffic signals, the cycle length being approximately inversely proportional to such speed for best two-way progressive traffic movement for example, and it will also be understood that as the volume of traffic increases the speed of traffic tends to decrease and a greater cycle length is needed to clear the traffic. Thus longer time cycles are better adapted to care for the greater traffic volumes and the lower speeds that ordinarily accompany such greater traffic volumes.

Thus at some times it will be desirable to operate the signal system on an inbound offset but on a relatively long time cycle and other times on an inbound offset at a moderate or shorter time cycle while at still other times it will be desirable to operate the system on an outbound offset for longer or shorter time cycles.

Thus the present apparatus according to the present invention is designed to provide for selection of offsets up and down the scale of a number of different cycle lengths so that whichever direction of traffic is predominant will be the controlling factor and obtain a preferential offset and at the same time obtain an appropriate cycle length. The apparatus is also designed to accommodate average or relatively balanced traffic and to provide for the selection of appropriate cycle length and adjustment of such cycle length in accordance with the actual demands of traffic up and down the scale even if the traffic remains sufficiently balanced to required an average offset.

Therefore it is an object of the invention to provide apparatus and methods for automatic selection and adjustment of cycle length and offset to best accommodate the volume of traffic in opposite directions through a series of traffic control signals.

It is another object of the invention to select automatically among inbound, outbound and average offsets in response to sampling of inbound and outbound traffic.

It is a further object to select among appropriate traffic signal timing systems for traffic pri-

marily in one direction, or traffic primarily in the opposite direction or for traffic in both directions along a roadway in response to actuation by traffic in the respective directions.

It is another object to provide an average non-preferential offset for traffic along a roadway in response to substantially balanced traffic in both directions along such roadway, and to change to a preferential offset for one or the other of such directions in response to predominant traffic in the corresponding direction, and to bias such selection of offset by maintaining such preferential offset on less predominant traffic than that required to change to such preferential offset.

It is a further object to select among preferential offsets for each direction and non-preferential offset for both directions along a roadway in accordance with the relative positions of two cycle selectors for the respective directions and each operated by traffic actuation in its direction to assume one of a scale of positions corresponding to a scale of low to high time rate of traffic actuations.

It is a further object to provide automatic selection among preferential offsets for one direction or the opposite direction or a non-preferential offset for both directions, in response to predominant traffic in one direction, or in the opposite direction, or substantially balanced traffic in both directions, respectively over a considerable range of cycle lengths for the traffic signaling time cycle at a series of traffic signals.

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

Fig. 1 illustrates in schematic or block diagram form, a traffic control system employing apparatus according to one embodiment of the invention.

Fig. 2 similarly illustrates a series of intersections along a highway together with the individual traffic signals and associated controls and connections with the master control apparatus of Fig. 1.

Fig. 3 illustrates a circuit diagram for the offset selector and associated apparatus in accordance with one preferred form of the invention.

Fig. 4 illustrates a circuit diagram of the cycle selector timer employed in common for two associated cycle selectors.

Fig. 5 illustrates schematically one form of cycle generator which may be employed for variable frequency power in the master control apparatus.

Fig. 6 shows circuit diagrams and offset cam arrangements for two local cycle-offset units of the master control apparatus for controlling the cycle length and offset of two traffic signal controllers.

Fig. 7 illustrates a circuit diagram of one form of traffic signal controller which may be operated on a traffic actuated basis or on a fixed time basis, under control of the master control apparatus.

Fig. 8 illustrates schematically the circuit diagram of a master control unit for controlling the resynchronization circuit for the local control units.

Referring now to Fig. 1 in more detail a section of a roadway HY is illustrated extending from left to right along the upper part of the figure, with the center line of the roadway indicated by a dot-dash line. This roadway section illustrated may be a part of a street or highway for example

extending through a series of intersections provided with traffic signals.

In one side of the roadway a traffic actuatable detector unit DDI, indicated schematically as a pair of contacts, is located in the path of traffic in one direction which will be referred to as the inbound traffic direction for convenience of reference. In the other side of the roadway a similar detector unit DDO is located in the path of traffic in the opposite direction which will be referred to as the outbound traffic direction. These detector units may be of any well known type adapted to close a pair of contacts upon passage of a vehicle thereover, for example.

The apparatus schematically indicated in Fig. 1 represents in general the master control apparatus for a series of traffic signals and associated individual controllers at the several intersections along the highway HY. Several of such intersections are illustrated schematically in Fig. 2 for example, showing the traffic signals 1TS, 2TS and 3TS and associated controllers 1TC, 2TC and 3TC respectively, with local cycle-offset units 1LC, 2LC and 3LC.

Returning to Fig. 1 the master control apparatus includes for example an inbound cycle selector designated ICS and an outbound cycle selector designated OCS, connected to the respective inbound and outbound detectors DDI and DDO.

Instead of each cycle selector incorporating a separate timer for setting up the traffic sampling period as in my Patent 2,288,601 previously mentioned, for the purpose of the present invention it is preferable to employ a common timer to control the traffic sampling time period for both of the cycle selectors ICS and OCS, and this common timer is illustrated schematically by the block CST between these two cycle selectors and connected to them.

Below the two cycle selectors is a block designated OS illustrating the offset selector apparatus which controls the proper output circuits ICC, OCC shown at the right for providing the appropriate offset system for the traffic signals in accordance with the relative positions of the two cycle selectors, as controlled by the inbound and outbound traffic detectors.

Each of the cycle selectors ICS and OCS is illustrated as having six output connections, corresponding to the six cycle positions A, B, C, D, E, F of the Patent 2,288,601 referred to, and in the present invention these six cycle position connections are illustrated in Fig. 1 as extending into the block below designated OS for the offset selector unit. In addition to these connections a seventh connection from each of the cycle selectors to the offset selector unit is illustrated which is in addition to those provided in the Patent 2,288,601 referred to, and is for the purpose of indicating to the offset selector when either of the two cycle selectors ICS or OCS is stepping down from a higher to a lower cycle position, as for example from cycle E to cycle D, as will be further explained in more detail below.

As will later be further explained the inbound cycle selector ICS will apply electric power on one of its cycle position output circuits of its A to F cycle scale in accordance with the cycle it is selecting at the moment in response to its measurement of traffic actuating the traffic detector DDI. Correspondingly the outbound cycle selector OCS will apply power on one of its six cycle position circuits of its A to F cycle scale in accordance with the cycle it is selecting in response to its measurement of traffic actuating

the detector DDO. Thus these output circuits from the cycle selectors provide input control circuits to the offset selector OS according to which the offset selector provides power on its appropriate output circuits ICC, OCC to provide selection of the appropriate offset for the traffic signal system.

As will also later be described the apparatus can be applied to a traffic signal system in which the individual signals are controlled entirely on a timed basis from the master controller so that the master controller alone is controlled by the traffic actuation, and such traffic actuation may come only from the inbound and outbound traffic detectors DDI and DDO for example.

The apparatus may also be employed however in connection with a traffic signal system in which one or more of the individual traffic signals is controlled jointly by the master controller and by local traffic actuation by means of one or more traffic detectors local to the individual intersections in accordance with one or another of various well-known types of traffic actuated traffic signal systems.

Traffic signal systems of the first type are often referred to as fixed time or pretimed traffic signal systems and those of the second type are often referred to as traffic actuated signal systems.

Particularly where the apparatus is applied to traffic actuated signal systems the offset selector apparatus and its associated output circuits are preferably arranged to provide a means of disconnecting the individual traffic signal controllers from supervision of the master control under certain traffic conditions so that they can respond locally without delay to the traffic actuation of the local traffic detectors. Such operation becomes desirable for example in extremely light traffic as may occur in the late night hours or occasionally at other times during the day. It will be appreciated that if the flow of traffic becomes so light that there is no particular traffic pattern and there are only occasional isolated cars traveling along the highway, with frequent occurrence of several successive traffic signal cycles at the various intersections without any interruption of the highway traffic in absence of cross-traffic and thus lack of cross-traffic actuation, it becomes unnecessary to provide for any progressive flow of traffic through the series of intersections and consequently unnecessary to provide any master control of the timing of the individual traffic signal controllers. It will also be appreciated that in event of failure of the master control apparatus alone it will be desirable to free the individual traffic signal controllers from master control. This is accomplished in one preferred aspect of the invention by releasing the local traffic signal controllers from master control by disconnecting power from both of the circuits ICC and OCC.

The master control time cycle for the different offsets and for the various traffic signal controllers may be provided entirely from the master control point by direct connection individually to the several traffic signal controllers or may be provided by running the output circuits ICC and OCC to the several intersections, and providing individual local cycle and offset units between the master control and the local signal control but located at each local signal controller to time the proper master control time cycle for the individual local controller, under the supervision of the master controller.

Various systems of control are well-known for this purpose. For example the individual local offset and cycle units may be operated by synchronous motors so as to operate each such local unit in step with the master control, and such local unit may be resynchronized once per cycle with the master control. Each such individual control unit may be operated on a long or short cycle in accordance with long or short master control cycles so that the total time cycle of all of the individual traffic signal controllers can be controlled by the master control, as will be more fully described below.

To the right of the offset selector OS in Fig. 1 there is illustrated schematically a cycle generator unit CG which serves as a master timer for control of the master time cycle for the several individual traffic signal controllers at the several intersections. This cycle generator CG is shown connected to six output circuits from the right of the offset selector OS corresponding to the scale of six cycle positions A through F for example. This cycle generator CG may be of the master timer type illustrated in the Patent 2,288,601 for example, employing six timing motors for six time cycles of various length, in general progressively longer over the scale of A to F for example, and providing individual output circuits to various individual intersection controllers as disclosed in the Patent 2,288,601 mentioned. However this cycle generator may alternatively provide an output of variable frequency cycle power to operate individual synchronous motors in cycle control timing units associated with or forming a part of the individual traffic signal controllers at the several intersections as indicated in Fig. 2, and in such case may have the variable frequency power output circuit VCC–1, VCC–2 as illustrated in Fig. 1.

The output circuits ICC and OCC extending to the right from the offset selector OS represent circuits which are individually actuated to provide the inbound offset control or outbound offset control respectively for the various individual controllers at the various intersections for example. As will be described more fully below, this arrangement permits the choice of four different offsets or cycle control combinations by these two circuits ICC and OCC, by means of which the inbound offset can be provided by actuation of ICC alone, the outbound offset can be provided by actuation of OCC alone, an average or two-way offset can be provided by actuation of both circuits ICC and OCC together, and still another offset or means of releasing the individual intersection controllers from master control coordination to permit them to operate independently for emergency or extremely light traffic conditions if desired, may be provided by absence of actuation of either of the circuits ICC and OCC.

If it is desired to provide individual offset circuits at the master control apparatus or in common for the several intersections this can be done by the provision of a master cycle unit as indicated schematically by the block designated MCU at the lower right of Fig. 1 which has input circuits above, connecting with the output circuits ICC and OCC of the offset selector, and has output circuits below designated IOC, OOC, AOC, and FRC to indicate schematically the inbound offset, outbound offset, average offset and independent or free operation circuits respectively previously mentioned.

This master cycle unit MCU is also connected

by other input leads shown at the top to the variable frequency power output circuit VCC1 and VCC2 of the cycle generator CG, in order to operate the master cycle unit on longer or shorter cycles in accordance with lower or higher frequency cycle power from the cycle generator. The master cycle unit MCU also provides preferably a resynchronizing circuit shown as circuit RSC extending from the right side of the master cycle unit. This resynchronizing circuit preferably extends to all of the individual cycle offset units associated with the individual intersection signal controllers to assure prompt resynchronization in the event of individual controllers or cycle units getting temporarily out of step as a result of power failure or the like.

The circuits OCC, ICC and RSC employ a ground return from the individual intersection control units in the form illustrated but may alternatively employ a common wire return if desired.

Referring now to Fig. 2, three intersections are shown as illustrative of a series of intersections along the highway HY. Individual traffic signals for the individual intersections are indicated schematically at 1TS, 2TS and 3TS, and their associated controllers are indicated as 1TC, 2TC and 3TC respectively. One or more of the controllers may be of the traffic actuated type as indicated in the case of 1TC for example which is connected with detectors 1DS1 and 1DS2 in the side road approaches to the intersection. It will be appreciated that the controllers may alternatively be of the so-called fixed time or non-traffic actuated type, which proceeds through its cycle automatically under control of the master cycle control apparatus from receipt of the actuating release impulses to start the individual controller from its rest position at the proper offset depending upon which of the offset circuits is actuated by the offset selector apparatus in the master control apparatus.

In similar manner the traffic actuated controller will proceed through its cycle of signal indications to accord right of way to the side street and to the highway and come to rest normally with the right of way accorded to the highway until a combination of two events occurs: first, the actuation of one of the side street traffic detectors and second, the receipt of the permissive or release impulse at the proper offset in accordance with which of the offset circuits is actuated in the master control apparatus.

One form of local traffic signal controller under the control of a master control apparatus, is shown more fully in Fig. 7 and described later in connection with this figure.

Referring now to Fig. 3 which shows the detailed circuit of the offset selector unit, the highway HY and the traffic sampling detectors DDI and DDO for inbound and outbound traffic are shown schematically again at the top of this figure together with the schematic showing of their associated cycle selectors ICS and OCS and the common traffic sampling period timer CST.

Alternating current power supply wires are shown at the left and right sides of Fig. 3, the A. C. power wire at the right being designated by a plus sign in a circle and the A. C. ground or return wire at the left being designated by a minus sign in a circle. This plus or positive wire preferably provides A. C. at normal supply service voltage with respect to the minus or negative wire at the left for convenience. However a lower voltage A. C. supply with respect to the negative wire is also preferably provided in such case by the wire at the right designated LV in a circle for some connections as described below. Connections for power supply to the cycle selectors ICS and OCS and to the timer CST are provided via wire 10 to negative power at the left and via wire 11 to positive power at the right.

The connections from the inbound and outbound cycle selectors ICS and OCS are made from their respective cycle position terminals to the respective input circuits of the offset selector below for the several cycle positions. The output terminals of the inbound cycle selector ICS for its several cycle positions are designated AI, BI, CI, DI, EI, and FI and the corresponding output terminals for the outbound cycle selector OCS are designated AO, BO, CO, DO, EO and FO. Input circuits are connected from these terminals to the operating coils of relays in the offset selector individual to each of these circuits. These input circuits are connected to one side of the coil for each of the relays IA, IB, IC, ID, IE, and IF respectively from the respective output terminals AI through FI of the inbound cycle selector ICS. Input circuits for the relays OA, OB, OC, OD, OE, and OF in the offset selector OCS are similarly connected from the respective output terminals AO through FO of the outbound cycle selector OCS. The other side of the coils of all of these relays are connected via wire 12 to the A. C. negative lead at the left side of the figure.

During the traffic sampling period timed by the common timer CST each of the cycle selectors rests in one of its several cycle positions in accordance with a count of the traffic actuations of its associated traffic detector, and near the end of the traffic sampling period determines whether it will step up to the next higher cycle in the series from A to F or remain on the same cycle or step down to the next lower cycle for the next traffic sampling time period.

Each of the cycle selectors connects A. C. power to the one of its output circuits and terminals corresponding to the cycle position it is then selecting and maintains power on this output terminal until the shift is made to another output terminal near the end of one of the traffic sampling time periods.

For purpose of illustration in Fig. 2, it is assumed that the inbound cycle selector ICS is in its cycle position C and the outbound cycle selector is in its cycle position E for example, and A. C. plus power will thus be provided over circuits CI and EO and relays IC and OE in the offset selector will be energized and the remaining relays IA, IB, ID, IE and IF of the inbound group and OA, OB, OC, OD, and OF of the outbound group will be deenergized as shown in Fig. 3.

Each of these relays is provided with a group of contacts operated by the associated coil and arranged in a vertical line below the coil with a broken line indicating the several contacts associated with their operating coil. When the coil of the relay is energized the several armatures of the contacts are pulled toward the coil away from the contacts on the far side of the armature and toward the contacts on the near side of the armature with respect to the coil, thus closing the latter contacts and opening the contacts on the far side.

In the case of all the relays in this figure the contacts below the armature, that is those on the far side of the armatures, are designated with even number reference numbers and are

opened only when the relay is energized, and such contacts will be referred to as break contacts in accordance with widespread practice of those skilled in the art. The contacts on the upper side of the armature, that is those nearer the relay coil, are closed only when the associated relay is energized, and will be referred to as make contacts in accordance with widespread practice in the art. These latter make contacts are designated by odd number reference numbers in the figure. In some cases, a common armature is employed for a make contact and a break contact, as shown for contacts *ib*5 and *ib*6 for example.

The relay IA is provided with the make contact *ia*7 and the break contact *ia*8. The relay IB is provided with the make contacts *ib*5, *ib*7 and the break contact *ib*6. The relay IC is provided with the make contacts *ic*5 and *ic*7 and the break contact *ic*6. The relay ID is provided with the make contacts *id*5, *id*7 and the break contact *id*6. The relay IE is provided with the make contacts *ie*5, *ie*7 and the break contact *ie*6. The relay IF is provided with the make contacts *if*5, *if*7 the break contact *if*6. The respective relays OA, OB, OC, OD, OE, and OF of the outbound group are provided with corresponding contacts respectively with corresponding reference numbers but with the prefixes *oa, ob, oc, od, oe* and *of* respectively.

A group of circuits employing the contacts *ib*5 through *if*6 and the contacts *ob*5 through *of*6 are shown in the upper part of the offset selector in the figure, and this group of circuits extend to the right in the figure into the left side of a cycle generator indicated schematically by the block CG. Power is applied from the offset selector to the cycle generator over only one of these circuits at any one time, corresponding to the highest cycle position assumed by either of the cycle selectors ICS and OCS at that time. For example, with relay IC energized by cycle selector ICS being in its C cycle position and relay OE energized by the cycle selector OCS being in its cycle E position as previously assumed, then power will be supplied from the positive power wire at the right of Fig. 3 via wire **13**, break contact *if*6, wire **14**, break contact *of*6, wire **15**, break contact *ie*6, wire **17**, make contact *oe*5, wire ECG to the cycle generator CG, thus energizing this wire, while the other wires ACG, BCG, CCG, DCG, and FCG remain deenergized.

However if it is assumed for example that both of the cycle selectors ICS and OCS are in their A cycle position then relays IA and OA only will be energized in the inbound and outbound groups and power will be applied from the positive power wire via wire **13**, break contact *if*6, wire **14**, break contact *of*6, wire **15**, break contact *ie*6, wire **17**, break contact *oe*6, wire **18**, break contact *id*6, wire **20**, break contact *od*6, wire **21**, break contact *ic*6, wire **23**, break contact *oc*6, wire **24**, break contact *ib*6, wire **26**, break contact *ob*6 to wire ACG to cycle generator CG, and the remaining wires BCG, CCG, DSG, ECG, and FCG will be deenergized.

The above group of circuits between the relay contacts *ib*5 through *if*6 and *ob*5 through *of*6 for the circuits ACG through FCG to the cycle generator CG include the following. One circuit connects contacts *ib*5 and *ob*5 in parallel via wire **28** to wire BCG. Another circuit connects contacts *ib*6 via wire **26** to the common armature of contacts *ob*5 and *ob*6, and the contact *ob*6 is connected to wire ACG. Another circuit connects contact *ic*5 via wire **25** to contact *oc*5 and to wire CCG. Another circuit connects contact *ic*6 via wire **23** to the common armature of contacts *oc*5 and *oc*6, the contact *oc*6 being connected via wire **24** to the common armature of contacts *ib*5 and *ib*6. Another circuit connects contact *id*5 via wire **22** to contact *od*5 and to wire DCG. Another circuit connects contact *id*6 via wire **20** to the common armature of contacts *od*6 and *od*5 and the contact *od*6 is in turn connected via wire **21** to the common armature of the contacts *ic*5 and *ic*6. Another circuit connects contact *ie*5 via wire **19** to contact *oe*5 and to wire ECG. Another circuit connects contact *ie*6 via wire **17** to the common armature of contacts *oe*5 and *oe*6, and the contact *oe*6 is connected via wire **18** to the common armature of contacts *id*5 and *id*6. Another circuit connects contact *if*5 via wire **16** to contact *of*5 and to wire FCG. Another circuit connects the contact *if*6 via wire **14** to the common armature of contacts *of*5 and *of*6, and the contact *of*6 is in turn connected via wire **15** to the common armature of contacts *ie*5 and *ie*6. Another circuit connects plus power via wire **13** to the common armature of the contacts *if*5 and *if*6.

Another group of circuits employ the contact groups *ia*7 through *if*7 and *oa*7 through *of*7. These circuits are associated with the selection of the inbound or outbound offset output circuits ICC and OCC in accordance with the relative positions of the two cycle selectors ICS and OCS as indicated by the closing of one of the contacts in the inbound and one of the contacts in the outbound group just mentioned. This selection of the offset circuits is accomplished by the selective operation of one or the other of the two relays IR and OR shown to the left and right of two triode tube sections IV and OV shown having a common tube envelope in the lower part of Fig. 3. It will be obvious that these tube sections could be in separate envelopes but are shown in the preferred form with a common envelope.

The relay OR is in the anode circuit of the tube section OV and the relay IR is in the anode circuit of the tube section IV, each tube section being controlled by its own grid. The grid voltage for the tube sections is controlled from the output winding TH3—4—5 of the transformer TH shown below the tube sections IV and OV in accordance with the polarity and relative value of A. C. potential applied across the primary or input winding TH1—2 of the transformer TH connected via the wires **30** and **31** to the inbound and outbound relay contact groups *ia*7 through *if*7 and *oa*7 through *of*7 and by the group of circuits from the armatures of these make contacts to taps on a potentiometer formed by a series of resistors R1, R2, R3, R4, R5 shown arranged vertically at the middle of Fig. 3.

The left side TH—1 of the input winding of the transformer TH is connected via wire **30** in parallel to the upper sides of the several contacts *ia*7, *ib*7, *ic*7, *id*7, *ie*7 and *if*7. The opposite side TH—2 of the input winding of the transformer TH is connected via wire **31** in parallel to the upper sides of the several make contacts *oa*7, *ob*7, *oc*7, *od*7, *oe*7 and *of*7. The armatures comprising the lower sides of the make contacts *of*7 and *if*7 are connected in parallel via wire **32** to the upper end of resistor R1 and also via switch SW2 to the low voltage A. C.

power wire LV at the right side of the figure. Wire 33 connects the armature of contact *oe*7 with the common tap between resistors R1 and R2.

This common tap is also connected via wire 34 to the armature of contact *ie*7. The armature of contact *od*7 is connected via wire 35 to the tap between resistor R2 and resistor R3, this tap in turn being connected via wire 36 to the armature *id*7. The armature of contact *oc*7 is connected via wire 37 to the common tap between resistors R3 and R4, which tap is also connected via wire 38 to the armature of contact *ic*7. The armature of contact *ob*7 is connected via wire 39 to the common tap between resistors R4 and R5, which tap is also connected via wire 40 to the armature of contact *ib*7. The armature of contact *oa*7 is connected via wire 41 to the lower end of resistor R5 which is also connected via wires 42 and 44 to the armature of contact *ia*7. This lower end of resistor R5 is the lower end of the potentiometer formed by the resistors R1 to R5, and is also connected via wires 42 and 43 to the negative power wire at the left of the figure. These resistors R1 to R5 are preferably of the same value and together in series provide a potentiometer between the A. C. power line LV at the right and the negative A. C. power line at the left.

In the operation of the offset selector, one of the group of contacts *oa*7 to *of*7 will be closed in accordance with the cycle position in which the outbound cycle selector OCS is resting at any one time, and one of the group of contacts *ia*7 to *if*7 will be closed in accordance with the cycle position in which the inbound cycle selector ICS is resting at the same time. By virtue of the closure of one of the outbound group of these contacts the right side of the input of transformer TH will be connected via wire 31, via the closed contact to a particular tap on the potentiometer provided by the resistors R1 to R5. Correspondingly the closure of one of the inbound group of these contacts will connect the left side of the input of transformer TH via wire 30 and the closed inbound contact to a particular tap on the potentiometer R1 to R5.

For example if the cycle selector ICS is in the top cycle position F and the cycle selector OCS is in the bottom cycle position A then the contact *if*7 will be closed and connect the left side of the input of transformer TH to the upper end of resistor R1, and the contact *oa*7 will be closed to connect the right side of input of transformer TH to the lower end of resistor R5 so that the full low voltage A. C. potential between the positive side LV and the negative power wire will be connected across the transformer TH input with the polarity such that the left side of this input winding will be connected to the A. C. power line LV and the right side of the input winding will be connected to the negative side of the A. C. power line.

However if for example the cycle selector ICS is in its lowest cycle position A and the cycle selector OCS is in its top cycle position F the conditions will be reversed and the left side of the input winding of transformer TH will be connected via closed contact *ia*7 to the negative A. C. power line at the lower end of resistor R5, and the right side of the input winding of the transformer TH will be connected via the closed contact *of*7 to the A. C. power line LV and the upper end of resistor R1, thus connecting the full low voltage A. C. potential across the input winding again but with reverse polarity as compared with the condition previously recited.

If as originally assumed for illustration the cycle selectors ICS and OCS are in positions C and E respectively then contacts *ic*7 and *oe*7 will be closed as shown in Fig. 3, and the left side of input winding TH1—2 will be connected via wire 30, contact *ic*7 and wire 38 to the tap between resistors R3 and R4, and the right side of input winding TH1—2 will be connected via wire 31, contact *oe*7, wire 33, to the tap between resistors R1 and R2.

It will be clear from an inspection of the circuit arrangements described for the contact groups *ia*7 to *if*7 and *oa*7 to *of*7 and the potentiometer R1 to R5 that if the cycle selectors ICS and OCS are in the same cycle positions both ends of the input winding of transformer TH will be connected to the same tap on the potentiometer R1—R5 and there will be no A. C. power supplied to this input winding, but to the extent that either of the cycle selectors ICS or OCS is above the other in its scale of cycle positions A to F its particular end of the transformer input winding will be connected to a higher A. C. power potential than the other end, and the farther apart the cycle selectors are on their corresponding scales of cycle positions the higher will be the A. C. potential difference applied to the input winding, so that both the polarity and the potential difference applied to this input winding are determined by the relative positions of the two cycle selectors.

The control effect just described on the input winding of transformer TH is employed to control the triode sections IV and OV through their respective control grids, by connection of the latter to the output winding TH3—5 of the transformer TH, so that neither of the anode circuits of these triode sections are conducting if no potential difference is applied to the input winding TH1—2 or if only a very low potential is applied to this winding as in the case of the two cycle selectors ICS and OCS being in substantially corresponding cycle positions. However one or the other of the anode circuits of these triode sections will be made conducting by the effect of the transformer TH on the respective control grids by sufficient potential difference applied to the input winding TH1—2 and in accordance with the polarity of this potential difference. For example, if the inbound cycle selector ICS is substantially higher in the scale of cycle positions than the outbound cycle selector OCS, the polarity and potential difference applied to the input winding TH1—2 will be such as to operate in conjunction with the polarity and magnitude of the cathode to ground and anode to ground voltages on triode sections IV and OV so as to make the anode circuit of IV conducting and the anode circuit of OV nonconducting. On the other hand if cycle selector OCS is in a substantially higher scale position than cycle selector ICS the potential and polarity applied to the input winding TH1—2 will be reversed to make triode OV conducting and triode IV nonconducting.

The grid control of the triode sections IV and OV is provided by connection with the output winding TH3—5 of transformer TH, the middle of this output winding at TH4 being connected via wire 46 to the negative A. C. power line. The left end TH3 of this output winding is connected via resistor R8, wire 47 and resistor R6 to the control grid of the triode section IV. The

right end TH5 of this output winding is connected via resistor R9, wire 48, resistor R7 to the control grid of the triode section OV.

The anode circuits of triodes IV and OV are connected to the positive side of the A. C. line via the respective coils IR and OR and wire 52. The cathodes of these sections are connected to potentiometer P1 to obtain from the low voltage A. C. circuit LV a cathode supply potential having the same polarity as the A. C. positive line and of magnitude as determined by potentiometer P1. When the potential across winding TH1—2 is zero or some low value, the grids are set negative relative to the cathodes to such an extent as to have both triode sections IV and OV in a non-conducting state when wire 52 is positive with respect to ground. Both triode sections will be non-conducting when wire 52 is negative with respect to ground.

The polarity and magnitude of the voltage applied to transformer winding TH1—2 determines the polarity and magnitude of the grid voltage applied to the two triodes with respect to ground. The voltages applied to the two grids are 180 degrees out of phase and therefore only one section can become conducting with any given applied voltage to the primary of transformer TH1—2. One section will have a negative potential applied to the grid with respect to ground in addition to the positive potential between the cathode and ground during the time that the anode voltage is positive with respect to ground and therefore remains non-conducting. As a result of a positive grid voltage of sufficient magnitude with respect to ground to overcome the effect of the positive cathode potential with respect to ground in the other section this other section will become conducting since the A. C. potential applied to the anode is positive during this time.

The magnitude of the voltage across winding TH1—2 required to make one of the triodes conducting is determined by the magnitude of the voltage on both cathodes as set by potentiometer P1. One end of this potentiometer is connected to A. C. negative power via wire 54 and the other end is connected via wire 51 to A. C. power wire LV.

Thus the number of cycle positions separation between the two cycle selectors ICS and OCS required to make one of the triodes conducting is adjustable by means of potentiometer P1 so that the selection of one or the other of the two anode circuits of the triode sections IV and OV to select one or the other of the two directional offset output circuits can be made to depend on a relatively small difference in traffic in the two directions or on a relatively large difference, as desired by the traffic authorities. Thus the selection of a preferential offset for one direction can be made to depend on the offset selector for that direction being one, or two, or more positions above the cycle selector for the other direction.

Also as will be more fully described below this adjustment determines the extent to which the intermediate or average offset is maintained for some degree of separation of the cycle selectors on their scale of cycle positions since in one preferred arrangement according to the invention if neither inbound nor outbound offset is selected, as by both of the anode circuits of the triode sections IV and OV being non-conducting then the intermediate or average offset is selected. This latter selection of the average offset may be made for the cycle selectors ICS and OCS being at or near the same cycle position over the whole scale from A to F, or may be made only when either cycle selector is higher than cycle position A, as desired. In the latter form of the invention a fourth offset or free independent operation for example may be provided by both of the cycle selectors being in the lowest cycle position A, but the intermediate or average offset provided with the cycle selectors in substantially corresponding cycle positions higher than A.

The selection of preferential offset for one or the other direction or of average offset, in accordance with the degree of separation of the two cycle selectors in their scales of cycle positions has just been described with switch SW2 in its closed position as shown in Fig. 3.

If switch SW2 is in its open position the degree of separation of the two cycle selectors required to change from average to preferential offset can be made greater than the degree required to maintain such preferential offset against change back to average offset. This biasing action is sometimes desirable to increase the stability of the system of offset selection against too frequent shift of offset under rapidly varying traffic conditions for example.

This biasing action is obtained by means of the adjustable potentiometer P2 in cooperation with potentiometer P1 and the contacts of the relays IR and OR, as will be more fully described below.

With this biasing control, if two cycle positions separation is required to select initially the outbound offset then the operation of the relay OR in this selection can be made to affect the control of the grid circuits for the triodes IV and OV to maintain this offset selection even though the outbound cycle selector should step down one step to reduce the separation between the cycle selectors to one cycle position for example. With the switch SW2 open to provide this biasing action the degree of biasing action can be controlled by adjustment of the relative positions by the two potentiometers P1 and P2. With the outbound offset selected for example the potentiometer P1 can be adjusted to determine the number of positions separation between the cycle selectors for shifting back to average offset. Then having made that shift the number of positions necessary to shift again to outbound offset for example can be determined by adjusting of the potentiometer P2 and thereby a greater separation can thus be provided for an initial shift to a preferential offset than is required to maintain such preferential offset.

This biasing action is obtained with the switch SW2 open to make effective the following circuits shown in the lower part of Fig. 3. The right side of the potentiometer P—2 is connected via wire 95 to the low voltage A. C. power LV. The right side of the potentiometer P2 is also connected via wire 94 to the armature of make contact *or*1 of relay OR, and via wire 93 to the armature of the make contact *ir*1 of relay IR. Potentiometer P2 as shown serves as a variable resistance.

The variable arm of potentiometer P2 is connected via wire 90 and wire 89 to wire 32, which in turn is connected to the upper end of the potentiometer R1—R5. This arm of potentiometer P2 is also connected via wire 99, wire 91 to the make contact *or*1, and also via wire 92 to the make contact *ir*1. Thus when either

of these make contacts is closed by the energization of the associated relay IR or OR, the potentiometer P2 will be shunted and the A. C. voltage applied to potentiometer R1—R5 will be greater than with both contacts *ir*7 and *or*7 open.

Under the condition of either relay IR or OR energized, the potentiometer P1 can be used to set the degree of separation of the two cycle selectors that will just maintain the preferential offset. At a smaller degree of separation the offset selector will return to average offset, under which condition relays OR and IR will both be deenergized, thereby opening the shunting of potentiometer P2 by either contact *or*7 or *ir*7. The total voltage across potentiometer R1—R5 is now less than the condition where potentiometer P2 was shunted, the amount of reduction of voltage depending upon the amount of resistance of potentiometer P2 included in the circuit. With this reduced voltage operating in potentiometer R1—R5 the degree of separation of the two cycle selectors which will be sufficient to cause either of the relays OR or IR to become energized again and select a preferential offset, will be greater.

The selection of the offsets by actuation of the respective output circuits ICC and OCC is accomplished by operation of the respective relays IR and OR, which are connected in the anode circuits of the respective triodes IV and OV, the circuits ICC and OCC being controlled by contacts on these relays. The circuit OCC is connected through a break contact *ir*4 of relay IR. When this break contact *ir*4 is closed, as when relay IR is deenergized, the circuit OCC is connected via contact *ir*4, and wire 61 to the break contact *ia*8 of relay IA, and is also connected via wire 61 and wire 62 to the break contact *oa*8 of relay OA. When cycle selector ICS is in any cycle position other than cycle position A the break contact *ia*8 will be closed and connect positive power via wire 63, wire 64, contact *ia*8 to wire 61, and when cycle selector OCS is in any cycle position other than its cycle position A, then contact *oa*8 will be closed and positive power will be connected via wire 63, contact *oa*8, wire 62 to wire 61. Thus if either cycle selector is off of its cycle position A, then wire 61 will have positive power and will supply this positive power over either one or both of the contacts *ir*4 or *or*4 if either one or both of these contacts is closed.

If cycle selector ICS is in a sufficiently higher cycle position than cycle selector OCS, then relay IR will be energized and relay OR will be deenergized. Thus contact *ir*4 will be open and contact *or*4 will be closed, and the positive power previously described as applied under this condition to wire 61 will also be applied via wire 65 and the closed contact *or*4 to the output offset circuit ICC. Under this condition the contact *ir*4 will be open so that the output offset circuit OCC will be disconnected from the positive power on wire 61.

If on the other hand cycle selector OCS is in a sufficiently higher cycle position than cycle selector ICS, then relay OR will be energized and relay IR will be deenergized, and in this latter condition the output offset circuit OCC will be energized by the closed contact *ir*4 from the positive power on wire 61 as previously described and the output offset circuit ICC will be deenergized because of the open contact *or*4.

If the offset selectors ICS and OCS are not sufficiently far apart in cycle positions however to energize either relay IR or OR in the anode circuits of triode IV and OV, then with both of these relays deenergized both contacts *ir*4 and *or*4 will be closed and if either cycle selector is off of its lowest cycle A position, one of the contacts *ia*8 and *oa*8 will be closed as previously described and positive A. C. power will be applied to wire 61 and via contacts *ir*4 and *or*4 to energize both output circuits OCC and ICC.

In the event that it is desired to employ the condition of deenergization of both of the output circuits OCC and ICC as a control for free operation of the individual controllers or for a fourth offset of a type different from the other three offsets for outbound traffic, inbound traffic and average traffic for example, the positioning of both cycle selectors ICS and OCS in the A cycle position will open both contacts *ia*8 and *oa*3 and thus disconnect wire 61 from the A. C. positive power on wire 63, and with switch SW1 in the open position shown in Fig. 3 no A. C. positive power will be supplied to either of contacts *ir*4 or *or*4 and A. C. power will therefore be disconnected from the output circuits OCC and ICC even though both of the relays IR and OR are deenergized with both cycle selectors ICS and OCS in position A.

If it is desired however to provide the same average cycle offset with both cycle selectors in position A as with both cycle selectors in any one of the other cycle positions the switch SW1 can be closed and thus connect positive power via switch SW1 and wire 66 to contact *or*4 and via wire 65 to contact *ir*4 so that both output circuits OCC and ICC will be energized even with both cycle selectors in the cycle A position despite the opening of both contacts *ia*8 and *oa*8.

The voltage applies to potentiometer R1—R5 is sufficient so that for any number of positions of separation of the cycle selectors required for a preferential offset selection the change of separation to such number of positions from one less number will produce a change at the grid of one of the triodes to switch that triode from nonconducting to conducting condition.

To limit the grid current drawn by the conducting triode in the event of a large voltage on transformer TH, due to the cycle selectors being several positions apart for example, or due to operation of relay SD, the resistors R6 and R7 are employed in the grid circuits of triodes IV and OV respectively.

Resistor R8 between wire 47 and transformer terminal TH3, and resistor R9 between wire 48 and transformer terminal TH5, limit the current through transformer TH and the current from the power supply LV when relay SD is operated.

In order to improve the operation of relays IR and OR on the A. C. power positive excursions the capacitors IK and OK are preferably connected across the coils of relays IR and OR respectively.

At the lower left in Fig. 3 a relay SD is shown which is provided with make contacts *sd*3, *sd*5, *sd*7, *sd*9, and *sd*11. The right side of the coil of relay SD is connected via wire 52 to the A. C. positive power wire and the left side of this coil is connected via wire 53 to output circuits in parallel from the two cycle selectors ICS and OCS. As will more fully appear by reference to Fig. 4 each of these output circuits connects wire 53 with a make contact on a relay SC in its associated cycle selector. Each cycle selector

as disclosed in the aforementioned Patent 2,288,601 incorporates a relay SC which is energized only during the stepping down operation of that cycle selector.

For the purpose of the present invention where a cycle selector is employed of the type having a cyclic switch which has a six step scale of cycle positions and is stepped forward rapidly five positions in order to produce the equivalent of stepping backward one position, as described in the Patent 2,288,601, an additional make contact is preferably provided in each cycle selector on its relay SC. This make contact, which is designated *sc*3, will supply negative A. C. power via wire **53** to the left side of the coil of relay SD and thus energize relay SD when either one or both of the cycle selectors ICS and OCS is stepping down.

An alternate arrangement for energizing relay SD may be employed by connecting the wire **53** to the input circuits providing the step down pulse from the common cycle selector sampling period timer CST to the respective cycle selectors ICS and OCS. This alternate arrangement will avoid the provision of additional contacts on the cycle selector relays SC but will cause the energization of relay SD at each actuation of the step down pulse circuit from this common timer CST whether or not either of the cycle selectors is actually stepping down at that time.

With either of these alternate methods of energizing relay SD the purpose of so energizing relay SD is to control circuits to maintain the offset selection in its proper condition during any stepping down operation of the cycle selectors where the cycle selector is of the type that has a six step scale of cycle positions and steps forward rapidly five steps in order to step down one step for example. It will be obvious under such conditions that the cycle selector stepping down will step successively through all of the intervening positions and thus may energize momentarily in sequence the several relays of the IA to IF or OA to OF groups. Since this action would produce artificial transcient conditions of different combinations of cycle positions for the two cycle selectors and corresponding conditions of potential and polarity on the transformer TH and on the control grids of triodes IV and OV as previously described, it is desirable to provide for maintaining the triodes IV and OV and their respective relays IR and OR in whatever condition they were at the beginning of this stepping down operation. In other words, during the stepping down operation of either of the cycle selectors, in order to avoid any transient effects the relays IR and OR are maintained in the same condition as at the beginning of the stepping down operation by the operation of relay SD and its contacts in cooperation with the contacts *ir***5** and *ir***6** of relay IR and the contacts *or***5** and *or***6** of relay OR as will now be described.

Assume for example that both cycle selectors ICS and OCS have been in cycle position C and cycle selector ICS now starts stepping down to cycle position B upon receipt of the step down pulse from the common timer CST. It is assumed that the cycle selector OCS has received sufficient traffic actuations to hold it in its cycle position C and prevent it from stepping down to cycle B at the time of receipt of the step down pulse from the timer CST. Under these conditions when the step down pulse is first received with cycle selectors ICS and OCS both in the cycle C position the relays IR and OR will both be deenergized and will thus have their make contacts *ir***5** and *or***5** open and break contacts *ir***6** and *or***6** closed respectively. Therefore under these conditions negative A. C. power will be supplied via wire **71**, make contact *sd***11**, break contact *ir***6**, and wire **72** to resistor R8 and to wire **47** and resistor R6 to maintain a sufficiently low or substantially ground grid potential on the triode section IV to maintain its anode circuit nonconducting and maintain relay IR deenergized throughout the stepdown operation during which the relay SD is energized. Also under these conditions negative A. C. power is supplied via wire **72**, make contact *sd***7**, wire **73**, break contact *or***6**, wire **74** to resistor R9 and to wire **48** and resistor R7, to apply a sufficiently low or substantially ground grid potential to the triode section OV to maintain its anode circuit at a very low conduction or substantially nonconducting level so as to keep the relay OR deenergized during the step down operation.

It will now be assumed for example that the cycle selectors ICS and OCS are in cycle positions E and C respectively at the beginning of the stepdown operation of either of the cycle selectors and that relay IR is energized and relay OR deenergized. Then as soon as relay SD is energized at the beginning of the stepdown operation low voltage positive A. C. from wire LV for example will be applied via wire **75** and wire **76**, via wire **77**, make contact *sd***9**, via make contact *ir***5**, wire **72**, wire **47** to resistor R6 for the grid of triode section, IV to apply a sufficiently positive potential on the grid to maintain the triode section IV conducting for energization of its anode circuit despite any opposite potentials supplied to the transformer TH by the transient separations of the cycle selectors with respect to their cycle positions during the step down operation of either one. Under the conditions just assumed with cycle selectors ICS and OCS in positions E and C respectively, relay OR is maintained deenergized during stepdown operation by the circuit previously described over make contact *sd***7** and break contact *or***6** to maintain substantially ground or low grid potential on triode section IV.

If it is now assumed that the cycle selectors ICS and OCS are in cycle positions C and E respectively for example, with relay IR deenergized and relay OR energized as shown in Fig. 3, immediately before the start of step-down operation of either cycle selector, then relay OR will be maintained energized, during the stepdown operation, by the following circuit. Low voltage A. C. positive power is applied from wire LV via wire **75**, wire **76**, make contact *sd***5**, wire **79**, make contact *or***5**, wire **74** and wire **48** through resistor R7 to the grid of triode section OV so as to maintain a sufficiently high positive voltage on this control grid to maintain the triode section OV conducting to hold relay OR energized during the step-down operation. Relay IR is maintained deenergized under the present assumed conditions by the previously described circuit supplying negative A. C. power via wire **71**, make contact *sd***11**, break contact *ir***6**, wire **72** and wire **47** through resistor R6 to the control grid of triode section IV.

Thus as descibed above the relays IR and OR are maintained in whatever condition of energization of either one energized or both deenergized these relays had immediately prior to the beginning of the step-down operation. This is con-

trolled by the relay SD to maintain this holding condition throughout the step-down operation and then release it so that at the end of the step-down operation the relays IR and OR assume whatever condition of energization and deenergization is needed to correspond with the new steady state positions of the cycle selectors ICS and OCS.

It will be appreciated that if a cycle selector employing a reversible stepping switch is used instead of a cycle selector which steps forward five steps in order to step down one step in a repeated scale of six positions, then the relay SD and its associated circuits via the contacts *ir*5, *ir*6, *or*5 and *or*6 will not be necessary, since in this case the step-down will be directly from one cycle position to the next lower cycle position without intervening transient conditions.

In this connection a further protective circuit is provided in connection with step-down operation by the make contact *sd*3 of relay SD in order to connect positive A. C. power via wire 81 and contact *sd*3 to wires 61 and 65 so as to maintain A. C. power to contacts *ir*4 and *or*4 during step-down operation of one of the cycle selectors while the other is resting in the cycle A position. This auxiliary supply of A. C. power to contacts *ir*4 and *or*4 under this condition will maintain the power supplied to either or both of the circuits OCC and ICC in accordance with the opened or closed condition of the respective contacts *ir*4 and *or*4 corresponding to the energized or deenergized conditions of their associated relays IR and OR at the beginning of the step-down operation. It will be appreciated that if one of the cycle selectors happens to be resting in its cycle A position while the other cycle selector happens to be stepping down by stepping ahead five steps from one intermediate cycle position to another intermediate lower cycle position the second cycle selector will momentarily pass through its cycle A position in such step-down operation and this would momentarily disconnect the power supply via the contacts *ir*4 and *or*4 for the circuit ICC to OCC unless this auxiliary power supply via wire 81 and contact *sd*3 were provided at this time.

It will also be appreciated that this circuit via contact *sd*3 and wire 81 could also be eliminated if a reversible type of stepping switch is employed in the cycle selectors so the step-down operation could be made directly down one step instead of by stepping up one less step than the total number of steps in a repeated scale of positions, as previously described.

Referring now to Fig. 4 there is shown the circuit and cam diagram for the common sampling period timer CST employed for the two cycle selectors ICS and OCS. These cycle selectors are indicated at the left and right of Fig. 4, and enough of the external connecting wires are indicated schematically in Fig. 4 as in Fig. 1 and Fig. 3 to correlate these units of the master control apparatus as shown in the several figures.

As in the previously mentioned Patent 2,288,601 relating to a single cycle selector employing a single sampling period timer, the present common sampling period timer CST employs a continuously operating motor M and the cams S, T, and R operated by this motor, as shown inside the block designated CST in Fig. 4. These cams open and close periodically the respective contacts S1, T1 and R1, in a traffic sampling period time cycle as indicated by the cam contour and the accompanying cam chart showing by the heavy black lines the approximate points in the sampling period at which these contacts are closed.

It will be noted in Fig. 4 that the contacts S1, T1 and R1 connect to wires leading to the left into the inbound cycle selector ICS in which they are designated I–76, I–74 and I–79 respectively to indicate the corresponding wires 76, 74, 79 in the cycle selector circuit shown in the above mentioned Patent 2,288,601. In connection with the present invention, which employs two cycle selectors, the additional cam contacts S2, T2 and R2 are provided, to be operated by the cams S, T, and R respectively at the same times as contacts S1, T1 and R1, and these added contacts S2, T2 and R2 are connected respectively to the wires extending to the right into the outbound cycle selector OCS, these wires being designated O–76, O–74, and O–79 respectively to correspond with the wires 76, 74 and 79 of the cycle selector circuit of Patent 2,288,601 as previously mentioned.

One side of the motor is connected to A. C. positive power via wire 11 and the other side of the motor and the cam following members of all the cam contacts are connected to negative A. C. power via wire 10, so that negative power is applied to the wires to both cycle selectors when the associated cam contacts are closed, but these circuits are separated from each other when the associated cam contacts are open.

As more fully described in the above mentioned Patent 2,288,601 the sampling period timer may provide a sampling time period of approximately six minutes by one revolution of its cams for example, and during this sampling time period it maintains contacts T1 and T2 closed except at the end of the period at which time the contacts are opened briefly to release a counting limit relay in connection with reset of the traffic counting to start a new sampling period. The cam S closes its contacts S1 and S2 very briefly at a point somewhat before the end of the sampling time period to potentialize the cycle selectors to step up to the next higher cycle position if sufficient traffic has been counted at that time. The cam R closes its contacts R1 and R2 just prior to the end of the sampling time period to potentialize the cycle selectors to step down to the next lower cycle position if insufficient traffic has been counted at this time. The cam R and its contacts R1 and R2 also serve to reset the traffic counting for the succeeding sampling time period. Although both cycle selectors are potentialized to step up or down as just described, each cycle selector steps up or down or remains unchanged in accordance with its own traffic counting independent of the other.

The relay contacts SC3 shown in the cycle selectors in Fig. 4 are connected to wire 53, which extends to one side of the coil of relay SD in Fig. 3 to operate the latter as previously described. The relay contacts SC3 are make contacts and are associated with the coils of the relay SC shown in phantom in the two cycle selectors ICS and OCS. The relay SC is energized briefly when its associated cycle selector is stepping down to a lower cycle position.

Referring now to Fig. 5 a circuit arrangement for one form of the cycle generator CG is shown, employing a series A. C. motor designated M and associated A. C. generator driven by the motor M. The speed of the motor M and generator GN is varied by the several circuits ACG, BCG, CCG, DCG, ECG, FCG connected by adjustable taps

on the potentiometer P3 shown in the left side of the block CG. This potentiometer P3 provides resistance in series with the motor circuit, the amount of such resistance being varied in accordance with the particular one of the several circuits ACG through FCG energized from A. C. positive power through the operation of the offset selector OS as described in connection with Fig. 3. The offset selector will energize only one of these circuits at a time from A. C. power in accordance with the highest position assumed at that time by either of the cycle selectors ICS or OCS. The A. C. power thus applied via one of these circuits will extend from the associated tap on the potentiometer P3 through the upper part of the potentiometer P3 to the left side of the motor M, the right side of this motor being connected to negative A. C. power. Thus the speed of the motor will be varied and the speed of the generator will be correspondingly varied to vary the frequency of the A. C. output of the generator as supplied to the output circuit VCC—1 and VCC—2. A voltage regulator VR is preferably connected across the circuit VCC—1 and VCC—2 to maintain a substantially constant voltage output for the varying frequency.

For the particular conditions illustrated in Fig. 3 with cycle selector ICS in position C and cycle selector OCS in position E, the cycle length output control wire ECG from the offset selector will be energized from A. C. positive power as previously described in connection with Fig. 3, and this wire will supply this A. C. power to a relatively high resistance point on the potentiometer P3 in Fig. 5 to drive the motor relatively slowly in the cycle generator CG so that a relatively low frequency output will be suppleid on the wires VCC—1 and VCC—2 from the generator GN.

Referring now to Fig. 6 two representative intersections along the highway HY are again shown, together with the master control wires extending along the highway, providing the variable cycle power circuit VCC—1 and VCC—2 and the offset control circuits OCC and ICC, as well as the resynchronizing circuit RSC as previously described. In addition in Fig. 6 however one form of the circuit of the local cycle-offset control unit is shown. The circuit is shown for each of two local control units 1LC and 2LC, illustrating that the circuits may be the same although the positions of the cams or other suitable devices for providing the individual offsets for the individual traffic controllers may be different at different intersections.

Thus the circuit and cam arrangement for the local cycle offset unit 1LC is shown at the left of Fig. 6 and the circuit and cam arrangement for the unit 2LC is shown at the right. The two cam arrangements illustrate two different sets of offsets for the two traffic controllers 1TC and 2TC for the respective signals 1TS and 2TS, as will be noted from the different positions illustrated for the respective sets of cams.

Referring now to the circuit for the local offset unit 1LC at the left of Fig. 6, three relays are shown 1BR, 1AR and 1RS, the designation of the relay being applied to the coil and the associated contacts being indicated by a broken line extending from the coils to the armatures of the contacts as previously described and illustrated in connection with Fig. 3. To the right of the relays a motor driven group of cams 1CR, 1CA, 1CI, and 1CO are shown, and to the left of these cams a group of cam contacts, operated by the respective cams, are shown and designated 1SR, 1S1, 1S2 and 1S3.

The several cams are rotated by the synchronous motor 1M which is energized preferably via an amplifier 1AM from the variable cycle leads VCC—1 and VCC—2 to which it is connected as shown. The right side of the output of the amplifier is continuously connected to the coil of the motor 1M and the left side of the amplifier output is connected to ground, and is completed to the motor coil via a break contact 1rs4 of relay 1RS, and a cam contact 1SR connected in parallel by wire 124, either of which contacts may complete the circuit over a wire 123 to the motor coil. The motor 1M is operated at a slow or fast rate as desired in accordance with the relatively low or relatively high frequency power on the variable frequency power circuit VCC—1 and VCC—2, so long as either cam contact 1SR or relay contact 1rs4 is closed.

Resynchronization is provided once per cycle by the cooperative action of these contacts with relay 1RS being under control of the master control unit MCU of Fig. 1 and Fig. 8. The latter unit contains a resynchronization control cam MCR. For best continuity of service cam MCR is shaped to open its contacts MSR for a slightly longer period than the local unit cams 1CR and 2CR for example. The internal apparatus and wiring of the master control unit MCU is shown in Fig. 8.

The master control resynchronization cam MCR will close its associated contacts MSR throughout all but a small part of its cycle and open these contacts briefly for this small part of its cycle. The notched portion of cam 1CR shown at the left of the cam is illustrative of the part of the cycle during which the contacts 1SR are opened. Thus it will be understood that the cams 1CR and 2CR of Fig. 6 will be rotating in synchronism with the similar cam MCR in Fig. 8. When cam MCR opens its contacts positive power will be disconnected from the resynchronizing wire RSC common to the several intersections along the highway HY. This deenergization of wire RSC will deenergize relays 1RS and 2RS as shown in Fig. 6, thus closing the break contacts 1rs4 and 2rs4 to complete the left side of the coil circuits from the motors 1M and 2M respectively to their respective amplifiers.

Thus if by reason of a momentary power failure or some other factor the motor 1M and its associated cam group were to fall behind the master control unit MCU, the cam 1CR would open its contacts 1SR at the end of its cycle in the approximate position shown in Fig. 6, and if it is sufficiently behind the master control cam MCR the latter will already have reenergized wire RSC and relay 1RS and thus already have opened the contacts 1rs4 so that the motor 1M will be disconnected from power and stop until the master control unit completes its cycle to reopen contacts MSR and deenergize wire RSC. At such time, with the deenergization of the wire RSC and relay 1RS, power will be reapplied to the motor 1M via the break contacts 1rs4, and the cam 1CR and the associated cams below will be restarted in synchronism with the master control unit again.

On the other hand if the local control unit 1LC should by any circumstance be ahead of the master control unit MCU then as soon as the cam 1CR reaches the approximate position shown in Fig. 6 in its cycle it will stop the motor 1M by

opening the contacts 1SR, since it is assumed that the corresponding cam MCR in the master control unit has not yet opened its associated cam contacts at this time to deenergize wire RSC and thus the contact *1rs4* is open. The motor 1M will thus remain at rest until the master control cam MCR reaches a position corresponding with 1CR, at which time the cam MCR will open its contacts, deenergize RSC and relay 1RS to reconnect power to the motor 1M via contacts *1rs4* as previously described, and the local unit 1LC will then proceed through its cycle in synchronism with its master control unit MCU.

The relays 1BR and 1AR in the local cycle offset unit 1LC, are provided with contacts as follows. Relay 1BR has the make contact *1br3* and the break contact *1br4* operated by a common armature. The relay 1AR has the make contact *1ar3* and the break contact *1ar4* operated by a common armature, and the make contact *1ar5* and the break contact *1ar6* operated by a common armature.

The offset control circuits for the offset cam contacts 1S1, 1S2 and 1S3 are connected to be placed into operation by the contacts of relays 1BR and 1AR in accordance with the actuation of the circuits ICC and OCC by which these relays are controlled in accordance with the selection of offset by the offset selector OS as described in connection with Fig. 3.

Thus with the circuit ICC deenergized and the circuit OCC energized as illustrated in Fig. 3 for the assumed condition of the inbound cycle selector in its cycle position C and the outbound cycle selector in its cycle position E, the relay 1BR will be deenergized and the relay 1AR will be energized as illustrated in Fig. 6. Under this condition ground or A. C. negative power will be applied via break contact *1br4*, wire 121, make contact *1ar5*, wire OOC to cam contact 1S3. The remaining circuits AOC and IOC to the cam contacts 1S1 and 1S2 will be disconnected from negative power because of open contacts *1br3* and *1ar4* respectively. Also the wire FRC will be disconnected from the A. C. negative power because of the open contact *1ar6*. Thus the only one of these four circuits receiving negative power via the contacts of relays 1BR and 1AR, is the circuit OOC, connected with the cam contacts 1S3. These contacts 1S3 are opened and closed cyclically in accordance with the contour of cam 1CO which is determined as desired for the outbound offset for the associated traffic controller 1TC and its traffic signal 1TS. With the circuit conditions with the outbound circuit OCC only energized as just described the cam contacts 1S3 will cyclically apply negative power for brief periods via wire 1PC to the traffic controller 1TC, under control of the outbound offset cam 1CO0.

If it is assumed however that the offset selector OS is selecting an inbound offset in response to heavier inbound traffic, then the circuit ICC will be energized and the circuit OCC deenergized. Under these latter conditions the relay 1BR will be energized and the relay 1AR will be deenergized. Then the relay contact *1br4* will be open, thus disconnecting A. C. negative or grounded power from the wire OOC as well as the wire FRC, and relay contact *1br3* will be closed, thus connecting this power via the wire 122 and break contact *1ar4* to wire IOC and cam contacts 1S2 which are under the control of the inbound cam 1CI. With make contact *1ar3* open under these conditions the wire AOC is also disconnected from the negative power and thus the inbound offset cam contacts 1S2 are the only ones effective to connect negative power to the traffic controller 1TC via the wire 1PC, thus making only the inbound offset effective for this controller.

If it is now assumed however that the average or intermediate offset is being selected by the offset selector due to substantially balanced traffic actuations in opposite directions along the highway HY, then both wires OCC and ICC will be energized and both relays 1BR and 1AR will be energized. Under these assumed conditions negative power will be supplied via make contact *1br3*, wire 122 and make contact *1ar3* to wire AOC and the cam contact 1S1 operated by the average offset cam 1CA. Since break contacts *1br4* and *1ar4* are open under the latter assumed conditions the other circuits IOC, OCC and FRC can not supply the negative power to wire 1PC; and the wire AOC is the only one which can supply negative power via cam contacts 1S1 and wire 1PC to traffic controller 1TC so that the latter is controlled on the average offset by the cam 1CA.

If it is assumed however that both wires OCC and ICC are deenergized, as for example by selection of free offset operation in accordance with both cycle selectors ICS and OCS being in their cycle A positions, then both relays 1BR and 1AR will be deenergized, and the wire FRC will be supplied with negative power via break contact *1br4*, wire 121 and break contact *1ar6*. Wire FRC thus supplies negative power directly and continuously via wire 1PC to the traffic controller 1TC under these conditions and the cam contacts 1S1, 1S2, 1S3 are obviously ineffective to control wire 1PC.

Thus in accordance with the selection of the offset control circuits OCC and ICC by the offset selector in response to a determination of the time rates of traffic actuation in the respective directions along highway HY, each local cycle offset unit will provide appropriate offset control to its local traffic controller by means of an offset control cam in the local cycle offset unit which is maintained in synchronism with the master control unit; and in the event of extremely light traffic conditions or any interruption of power on both circuits OCC and ICC, each local cycle offset unit will provide free or independent operation of the local traffic controller. It will be appreciated that the circuit for the local cycle offset units 2LC, 3LC and the like are the same as described for the unit 1LC, except for the relay and contact designations which are coded for the respective units as indicated in Fig. 6 for 2LC.

Referring now to Fig. 7 the circuit of one form of traffic controller 1TC is illustrated schematically. This circuit is primarily that of a simple form of a traffic actuated controller but is provided with a switch SWF which can be closed to convert the controller from traffic actuated to fixed time operation if desired, and thus serves to illustrate both forms of operation under control of the several offset systems via the wire 1PC shown entering the lower part of the rectangle 1TC.

The controller 1TC as illustrated in Fig. 7 is provided with a synchronous motor TM and a series of cams rotated by this motor. Three cams TCS, TCR and TCM are shown in Fig. 7. The cam TCS is illustrative of one of a group of cams ordinarily provided in a traffic controller unit for operating the several signal circuits of the traffic signal 1TS providing preferably the usual green, yellow and red signals for the respective intersecting streets. Since the cam controlled operation of such signal circuits is already well-known

as disclosed in the Patent 2,279,896 of H. A. Wilcox for example, only one of such cams is illustrated in Fig. 8 as TCS to correlate the positions of the other cams TCR and TCM with respect to the highway green signal period, the cam TCS controlling the cam contacts TS–1 shown at the right of the cam to control the highway green signal of the traffic signal 1TS via wire 710. The cam TCS is shown near the end of the highway green signal period with positive A. C. power connected via the cam contacts TS–1 and the wire 710 to the traffic signal 1TS.

The cams TCM and TCR control the operation of the motor TM driving the several cams under control of relay 1RD and the wire 1PC on the local cycle offset unit 1LC of the master control apparatus. The motor TM is preferably of the synchronous type and has the left side of its coil connected to A. C. positive power, and the right side of its coil connected via wire 711 and wire 712 to the junction 713 connected between the relay contact 1rd3 and the cam contact TS–3. The latter cam contact is controlled by the cam TCM which, as indicated by its contour, opens the cam contact TS–3 near the end of the highway green period provided by cam TCS. With the cam contacts TS–3 open as shown the motor is able to receive negative power for operation only via the relay contact 1rd3 or the switch SWF from the wire 1PC from the local cycle offset unit 1LC. If traffic actuated operation of the controller 1TC is assumed, the switch SWF will be open as shown in Fig. 7, and thus the motor TM will receive negative power for its operation in the position shown only via the relay contact 1rd3. This relay contact is controlled by the relay 1RD which in turn is controlled by the traffic actuated detector switches 1DS1 and 1DS2 which are shown connected in parallel. These are the detector switches which are located in the side street approaches to the intersection controlled by the signal 1TS and the controller 1TC.

The left side of the coil 1RD is connected to positive power and the right side of this coil is connected via wire 714, and either of the detector switches 1DS1 or 1DS2 to negative power if one of the latter switches is closed by traffic actuation. Momentary closure of one of the latter switches by traffic actuation by a vehicle approaching on the side road for example will momentarily energize the relay 1RD by applying negative power to the right side of its coil via wire 714. In the position of the cams shown, after such initial actuation, the relay 1RD will be maintained energized via wire 715 and its make contact 1rd5 and the cam contact TS–2 to negative power, the latter cam contact being controlled by the cam TCR and being closed at this time.

Energization of relay 1RD as described will close its contact 1rd3, and with the cam positions as shown near the end of the highway green period, will connect the right side of the motor TM via wire 711, wire 712, junction 713, relay make contact 1rd3 to wire 1PC. The wire 1PC will have negative (grounded) A. C. power applied to it via one of the cam contacts 1S1, 1S2, or 1S3 of the local cycle offset unit 1LC, depending upon which offset is operative as selected by the offset selector as previously described in connection with Fig. 3, unless free operation is being selected by the offset selector, in which latter case the wire FRC in the local cycle offset unit 1LC will supply negative power continuously over circuit 1PC.

Assuming for example that the outbound offset is being selected with the cycle selectors ICS and OCS in their positions C and E respectively as previously described, then the cam ICO in Fig. 6 will periodically close its contact 1S3 for a brief period once per cycle and connect the A. C. negative or grounded power for this brief period via wire 1PC to the controller 1TC. This brief period is sometimes referred to as the permissive period for the controller 1TC, and the application of power for the permissive period is referred to as the permissive pulse, this pulse being provided by whichever of the offset circuits AOC, IOC, OOC or FRC is operated in connection with the selection of offsets by the offset selector.

Thus when the permissive pulse of negative power is provided on the wire 1PC and the relay 1RD is energized in the traffic controller 1TC by traffic actuation for example, this negative power supplied by the permissive pulse on wire 1PC is connected via contact 1rd3, and wires 712 and 711, to the motor TM to start the motor. The operation of the motor rotates the cams TCM, TCR, and TCS in a clockwise direction as shown to start these cams through one traffic control cycle for the signal 1TS. The cam TCS deenergized the wire 710 to disconnect the highway green signal and the cams of the controller 1TC continue through their cycle providing a side street green period and then a highway green period before returning to rest in the position shown in Fig. 7 near the end of the highway green period. During this cycle of operation the cam TCR opens its contacts TS–2 during the side street green period and deenergizes the relay 1RD, thus reopening the contacts 1rd3 and 1rd5 and preparing the relay for subsequent traffic actuation.

The motor TM is operated initially from its rest position shown in Fig. 7 via the contact 1rd3 and wire 1PC as previously described, but as soon as cam TCM has rotated out of the rest position shown it will close its contacts TS–3 and apply negative power via wire 712 and 711 to maintain the motor TM operating throughout the remainder of the traffic signal cycle until the cam TCM reaches again its rest position shown, at which time the motor will be stopped by the reopening of the cam contact TS–3 unless there has been a subsequent traffic actuation of reenergize relay 1RD and the permissive negative power is again available on wire 1PC.

The operation of the controller 1TC as a fixed time or non-traffic actuated controller is illustrated for example if the switch SWF is closed in Fig. 7, which will connect the permissive pulse wire 1PC directly to the motor TM via the wire 711. It will be obvious that the permissive pulse via wire 1PC must be of sufficient length to enable the motor TM to drive the cam TCM out of the rest position and reclose its contacts TS–3.

It will be appreciated that the motor TM may be operated if desired from the variable frequency power wires VCC–1 and VCC–2 via an amplifier similar to the amplifier 1AM of Fig. 6 for example to automatically vary the time cycle of the cams TCS, TCR and TCM and the corresponding time cycle of the traffic signal 1TS in accordance with the shorter and longer time cycles provided from the cycle generator CG in the master control apparatus of Fig. 1 and Fig. 3. In this form of operation the left side of the motor TM is connected to the right side of the amplifier instead of directly to positive A. C. power.

It will be appreciated that the traffic controller cams may be operated step-by-step by a ratchet

and solenoid mechanism under the control of rotary dial actuated switches operated by motor TM instead of the direct drive of the cams by motor TM as shown. One form of such operation is shown in the Wilcox Patent 2,279,896 referred to above.

It will also be appreciated that rotary dial switch units may be employed in place of the individual offset cams ICA, ICI and ICO and their associated cam contacts if desired, in the local cycle offset unit ILC.

Although a cycle generator of a type employing a variable speed motor-generator is illustrated in Fig. 5 it will be appreciated by those skilled in the art that an electronic variable frequency generator may be used if desired, such as the familiar audio frequency generator employed in electrical laboratories, in the cycle generator in place of the motor-generator unit shown.

Although a number of alternate forms of arrangements of apparatus according to the invention have been pointed out above it will be obvious to those skilled in the art that other modifications of the apparatus or in the arrangement or character of its parts may be made without departing from the spirit of the invention.

I claim:

1. In a traffic control system, preferential offset control circuits individual to each of two directions along a roadway, means for counting traffic per unit time individually in each of such directions, and means for actuating the control circuit for either direction in response to measurement of a substantially higher rate of traffic per unit time for that direction as compared with the other direction.

2. In a traffic control system, preferential offset control circuit means individual to each of two directions along a roadway, non-preferential offset control circuit means for traffic in both of such directions, means for counting traffic per unit time individually in each of such directions, means for actuating the preferential offset circuit means for either one direction alone in response to measurement of a substantially higher rate of traffic per unit time for such one direction, and means for actuating the non-preferential offset circuit means in response to measurement of substantially the same rate of traffic per unit time in both directions.

3. A structure as in claim 2, and including means controlled by actuation of one alone of said preferential offset circuit means to bias said circuit actuating means to maintain such one circuit means actuated for a smaller differential traffic rate than that for actuating it initially.

4. In a traffic control system having two preferential offset systems, one for each of two opposite directions along a roadway, the combination of traffic actuated means individual to each of such directions, means for measuring the time rate of traffic actuations of the respective traffic actuated means, and means controlled by said measuring means for selecting the preferential offset system for whichever direction has a predominating rate of traffic actuations, and time controlled means for periodically resetting said measuring means.

5. In a traffic control system having a cycle selector and associated traffic actuated means for each of two traffic directions along a roadway, each such cycle selector having a multiplicity of output circuits representing a scale of cycle positions any one of which may be assumed by the cycle selector corresponding to a time rate of traffic actuations of its associated traffic actuated means, an offset selector apparatus having input circuits for connection to the output circuits for the respective cycle selectors to be actuated thereby in accordance with the positions assumed by said cycle selectors, said offset selector apparatus also including output circuits for preferential offset systems for the respective traffic directions, and means forming a part of said offset selector apparatus to actuate the one output circuit for whichever direction has a materially higher scale input circuit actuated.

6. A structure as in claim 5, and including means for predetermining at more than one the number of positions of separation of said cycle selectors for such selection of one preferential offset.

7. A structure as in claim 5 and including means for providing an adjustable degree of separation of the positions assumed by the two cycle selectors for selection of either one preferential offset.

8. A structure as in claim 5, and including a multiplicity of output circuits from said offset selector apparatus corresponding to the scale of cycle positions of the cycle selectors and means for actuating only one of said last named output circuits at a time in accordance with the highest cycle position assumed at such time by either of the cycle selectors.

9. A structure as in claim 5, and including a multiplicity of output circuits for providing a selection of cycle lengths over a scale corresponding to the cycle positions of such cycle selectors, and means forming a part of said offset selector apparatus to actuate only one of said last named output circuits at a time corresponding to the highest cycle position assumed at such time by either of the cycle selectors.

10. A structure as in claim 5, and including output circuit means for an offset system for traffic in both directions and means forming a part of said offset selector apparatus to actuate the last named output circuit means in response to actuation of input circuits for substantially the same cycle positions for the two cycle selectors except for both of said cycle selectors being in their lowest position on their scale of positions, and additional output circuit means for a system of offset control to permit individual traffic signal controllers to run through their cycles independently, and means for actuating said additional output circuit in response to actuation of input circuits for the lowest cycle position for both cycle selectors.

11. A structure as in claim 5, and including output circuit means for an offset system for traffic in both directions and means forming a part of said offset selector apparatus to actuate the last named output circuit means in response to actuation of input circuits for substantially the same cycle positions for the two cycle selectors.

12. Selector apparatus for traffic control systems, including input circuit means actuatable to represent a scale of low to high traffic flow rates for one traffic direction, second input circuit means actuatable to represent a substantially similar scale of low to high traffic flow rates for a second traffic direction, output circuit means for a control system favoring traffic in the first direction, second output circuit means for a control system favoring traffic in the second direction, and third output circuit means for a control system providing for substantially balanced traffic movement in both directions, and means

interconnecting said input circuit means with said output circuit means to actuate said first output circuit means alone in response to actuation of said first input circuit means at a substantially higher traffic flow rate than said second input circuit means and to actuate the second output circuit means alone in response to actuation of said second input means at a substantially higher traffic flow rate than said first input circuit means, and said interconnecting means also including means to actuate said third output circuit means in response to actuation of the first and second input circuit means at substantially the same traffic flow rate.

13. Selector apparatus as in claim 12 and in which said interconnecting circuit means includes an impedance element the impedance of which is controlled by said input circuit means in accordance with the relative positions of said input circuit means on their respective scales of traffic flow rates, and an impedance responsive device controlled by said impedance element to switch among said several output circuit means as aforesaid.

14. Selector apparatus as in claim 12 and in which said interconnecting circuit means includes a potentiometer element corresponding to the scale of traffic rate of flow of said input circuit means, a potential responsive element differentially responsive to predetermined potential of opposite polarity, and connecting means controlled by the respective input circuit means to connect potential from various points on said potentiometer to said potential responsive element to apply a potential difference to the latter of degree characteristic of the degree of separation of the respective input circuit means as actuated along their respective scales of traffic rate of flow and of polarity characteristic of the higher of the two input circuit means on the scale of traffic flow rate.

15. In an offset selector apparatus, a multiplicity of input circuits including corresponding groups for each of two traffic directions and representing substantially corresponding scales of traffic flow values, output circuit means providing for traffic signal system offsets individual to the two directions and an intermediate offset for bi-directional traffic, and selector means forming a part of said apparatus for receiving actuations from the respective input circuit groups to actuate the output circuit for a directional offset in response to actuation of a materially higher scale input circuit for the corresponding direction group than for the other direction group, and means forming a part of said selector means for actuating the intermediate output circuit means in response to actuation of input circuits of substantially the same scale position for the two directions.

16. In an offset selector apparatus as in claim 15, said selector means including a series of impedance elements connected to provide a multitap potentiometer, a potential responsive element differentially responsive to potential of different polarity, connections between the respective input circuits and said taps, and means actuated by said potential responsive element to actuate said output circuits in response to the actuation of the respective input circuits.

17. In an offset selector apparatus as in claim 15, said selector means including a series of impedance elements connected to provide a multitap potentiometer between A. C. power and ground terminals a transformer having input and output windings, switch means individual to and controlled by the respective input circuits for the respective directions and including one switch for each direction for each position on the scale of traffic flow values and operable in response to actuation of its controlling input circuit to connect the corresponding tap on the potentiometer to the input winding of said transformer, the switches for one traffic direction connecting to one end of said input winding and the switches for the second traffic direction connecting to the opposite end of said input winding, a connection from a center tap on said output winding to ground, two triode tube sections, connections between one end of said output winding and the grid of one said section and between the other end of said output winding and the grid of said other section, connections between the cathodes of both sections and an A. C. potential intermediate said power and ground terminals, and anode circuits individual to the two triode sections and controlled by the respective grids to actuate one anode circuit only in response to connection to a substantially higher scale potentiometer tap for the first direction than for the second direction and to actuate the other anode circuit only in response to connection to a substantially higher scale potentiometer tap for the second direction than for the first direction, whereby neither of said anode circuits will be actuated in response to connection to substantially the same scale tap on the potentiometer for two directions, and means for actuating the respective output circuits for the respective directions in response to actuation of the respective anode circuits and for actuating the intermediate output circuit in response to non-actuation of both said anode circuits.

18. In a selector apparatus responsive to the relative positions of two cycle selectors each having a scale of cycle positions which it assumes one at a time for a traffic sampling time period in accordance with traffic sampled in a different one of two traffic directions in a preceding such time period, a first group of relays and input circuits for actuation of said relays individually in response to the position assumed by a first of said cycle selectors, a second group of relays and input circuits for actuation of said latter relays individually in response to the position assumed by the second of said cycle selectors, contact means forming a part of the respective relays to be operated by actuation thereof, a series of impedance elements connected between A. C. power and return terminals to provide a potentiometer with a multiplicity of taps, a transformer having input and output windings, a plurality of circuits connecting one end of said input winding to the respective taps on said potentiometer, each circuit including one of said contact means closed by actuation of its associated relay of the first group, another plurality of circuits connecting the other end of said input winding with said respective taps, and each including one of said contact means closed by actuation of its associated relay of the second group, a connection from the center of the output winding to said A. C. return terminal, two triode tube sections, a connection from a potential intermediate said A. C. power and return terminals to the cathodes of both said sections, anode circuits individual to the two tube sections, connections between the respective ends of the output winding and the control grids of the respective sections for actuating one anode circuit in response to a pre-

determined A. C. potential of one polarity corresponding to actuation of a first group relay at a higher scale potentiometer tap than a second group relay and for actuating the other anode circuit in response to a predetermined A. C. potential of the opposite polarity corresponding to actuation of a second group relay at a higher scale potentiometer tap than a first group relay.

19. In a selector apparatus as in claim 18, output circuit means actuated in response only to both said anode circuits being in non-actuated condition as by actuation of relays in both groups at substantially the same potentiometer scale tap.

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