

2,081,652.

Original Filed Dec. 3, 1934



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2,081,652

SYNCHRONIZING AND SPEED CONTROL
SYSTEM AND MECHANISM

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Original application December 3, 1934, Serial No. 755,742. Divided and this application November 14, 1935, Serial No. 49,766

7 Claims. (Cl. 172-293)

This invention relates to synchronizing and speed control systems and mechanisms, and more particularly to such systems and mechanisms as those utilized for governing the operation of a plurality of electric highway traffic signal controllers in situations where it is desirable to maintain preselected speeds and coordination of operation between such controllers while permitting variations of durations and/or characteristics of components entering into cycles of changes of signal aspects irrespective of the character of electric current utilized.

Such synchronizing and speed control systems and mechanisms heretofore available for governing the operation of highway traffic controllers have embodied characteristics which precluded variations of cycle durations as well as accurate synchronism therebetween and, to attain most perfect results, have necessitated utilization of electric current of special character.

Furthermore, the complex and intricate character of synchronizing and speed control systems and mechanisms which have heretofore been supplied for such service has resulted in the design and utilization of mechanism subject to disarrangement and, when disarranged, requiring highly skilled services for effecting repair and readjustment.

It is therefore an important object of this invention to provide such systems and mechanisms for associating a local highway traffic signal controller with a master timer, which systems and mechanisms are capable of periodically and automatically effecting and maintaining synchronical relationship between said local controller and said master timer by synchronizing the operation and correcting the operating speed of said local controller.

Another important object of this invention is to provide such systems and mechanisms which are capable of periodically and automatically effecting needed revisions in the operating speed of said local controller, whereby to maintain substantially synchronical speed between the operation of said local controller and that of said master timer.

Another object of this invention is to provide such systems and mechanisms for association with a local highway traffic signal controller as will be capable of periodically and automatically effecting revisions in the speed of operation of such local controller necessary to compensate for any change in speed therein such as may result from atmospheric temperature variations or otherwise.

Another important object of this invention is to provide such systems and mechanisms in association with local highway traffic signal controllers at a plurality of traffic lane intersections whereby to govern the operating speeds of the respective controller in such relationship to a master timer as to cause displays of signal aspects at respective lane intersections facilitating progressive movement of traffic.

Another important object of this invention is to provide such systems and mechanisms for association with local highway traffic signal controllers at a plurality of traffic lane intersections whereby to establish, periodically and automatically, concurrent attainment of predetermined synchronizing stages of respective controllers and thereafter act to maintain predetermined relationships between ensuing operative stages of respective controllers through automatic accomplishment of needed operating speed revisions at each local controller.

Another important object of this invention is to provide such systems and mechanisms which, irrespective of the character of the electric current employed for actuation thereof, may be utilized for establishing the times of occurrence of a predetermined operative stage and for maintaining predetermined relationships between such stage and other operative stages.

A further important object of this invention is to provide such improved systems and mechanisms which, for the accomplishment of all, any one or any group of the foregoing objects shall be of greater effectiveness and reliability, composed of a smaller number of parts severally characterized by strength, durability and facility of assemblage, as well as amenable to a lower cost of manufacture.

Other and more specific objects and advantages will appear in the following description of an illustrative embodiment of this invention, or will be apparent to those skilled in this art.

A traffic signal system including a local highway traffic signal controller of a type with which this invention may be employed is fully shown and described in the co-pending application of Harrison Irving Turner and Carl Ludwig Anderson, the present applicants, filed December 3rd, 1934, Serial No. 755,742, for Signal Controlling and duration varying systems and mechanisms therefor, in which application this invention was originally disclosed and of which application this is a division.

Detailed description of the circuits and mech-

anism of such traffic signal system will therefore be herein omitted.

In a preferred embodiment of this invention, the foregoing objects and others ancillary thereto are preferably accomplished as follows:

A master timer comprises mechanism for electrically energizing and deenergizing two channels which are associated with one or more local highway traffic signal controllers; such energizations and deenergizations of channels occurring independently at regular predetermined intervals and continuing for regular predetermined durations.

Such highway traffic signal controllers may be of any desired type which is governed by a variable speed motor. In accordance with this invention, speed regulating means is associated with the motor of each such controller, which regulating means preferably comprises electrically operable actuating means, a speed revision determining cam, and contacts for actuation by the respective cams.

Said actuating means preferably comprises two motors applied for actuating mechanism associated with the controller motor so that respective ones of said driving means motors may be energized for effecting increase or decrease of the operating speed of its associated controller motor.

Should the speed of the controller governing motor be such as to cause attainment of a predetermined stage in the operation of the speed revision determining cam substantially in advance of a time preestablished therefor by the master timer, one of the master timer channels will be energized whereby one of the speed regulating motors will be energized to effect mechanism alterations such as will retard the operating speed of the controller governing motor.

Should the controller governing motor so operate as to cause attainment of another predetermined stage in the operation of the speed revision determining cam at a time substantially later than that preestablished therefor by the master timer, said one of the master timer channels will be energized whereby the other of the speed regulating motors will be energized to effect mechanism alterations such as will increase or accelerate the operating speed of the controller governing motor.

Should said controller governing motor so operate as to cause attainment of still another predetermined stage in the operation of the speed revision determining cam at a time substantially co-extensive with the time during which said one of the master timer channels is energized, neither of the speed regulating motors will be energized and operation of the controller governing motor will continue without alteration of the speed thereof.

A synchronizing cam is associated with the remaining master timer channel and, upon attaining a predetermined stage, interrupts the normal current supply path to the controller governing motor whereupon should said motor be out of synchronism by a substantial amount it will be brought to rest and will be restarted only upon deenergization of said remaining master timer channel. Such deenergization will result in effective establishment of a special current supply path for said motor.

Should the synchronizing cam attain the foregoing predetermined stage substantially simultaneously with or immediately following the deenergization of the said remaining master timer

channel, the current supply to the variable speed motor will be transferred from the normal path to the special path without interruption in operation of the variable speed motor.

For the purpose of facilitating a ready understanding of this invention and what are considered to be its novel characteristics, an embodiment thereof is represented in the annexed drawing and hereinafter described, however, such embodiment, though practical, is by no means the only one which the invention may assume, wherefore the invention is not confined to any strict conformity with the more or less diagrammatic representation of the drawing but may be changed and modified in various particulars so long as such changes and modifications make no material departures from the invention, as more particularly set forth in the annexed claims.

In the accompanying drawing, reference characters employed in the aforementioned application of which this is a division have been largely so employed as to facilitate comparison therewith, and like parts are designated by the same reference characters throughout the several views in which

Figure 1 is a schematic "across-the-line" representation of circuit connections combined with a diagrammatic presentation of mechanisms and an arrangement of parts embodying this invention; and

Fig. 2 is a composite chart representative of various operating and circuit characteristics of an embodiment of this invention in comparison with those of a master timer.

In Fig. 1 of the drawing, mechanism and circuits indicated below a dash line *h* are for association with a local traffic signal controller. Such circuits and mechanism comprise a shaft 204 rotatable for establishing signal cycle durations and times of occurrence thereof for the associated local controller such as will be in predetermined relationship to cycles of other like controllers.

The shaft 204 is driven by means of an electric motor which may be of a type operable by direct current or of a type operable by alternating current. For convenience, such motor is indicated in the drawing as an alternating current induction type motor M1 comprising an electromagnet 290, a disc 292, a shaft 294, a worm gear 296 and a worm wheel 298; said wheel 298 being secured to shaft 204 for effecting rotation thereof together with a gear 300 also fixed upon said shaft.

A gear 300', driven by the gear 300, is secured to a shaft 304 and acts therethrough to drive two cams which will be herein respectively referred to as the "synchronizing cam" 306 and the "speed control cam" 308.

Contacts 480, 482 and 484 are associated with cam 306 and contacts 490, 492 and 494 are associated with the cam 308.

Cam 306 comprises a cut-away portion 306' while cam 308 comprises a full raised portion 308'', a semi-raised portion 308' and a depressed or cut-away portion 308'''.

The contact 480 associated with the cam 306 is situated between the contacts 482 and 484 and is biased for movement away from the former and into engagement with the latter; said contacts 482 and 484 being so positioned with relation to said contact 480, that, in the course of the movement thereof, said contact 480 will make with one before breaking with the other.

The cam 306 is situated in the path of the free

end of said contact 480, for holding same in engagement with said contact 482, except when the cut-away portion 306' of said cam is situated in the path of the end of said contact 480, at which time its bias will cause it to move into engagement with contact 484 and away from contact 482.

The contact 490 associated with the cam 308 is situated between the contacts 492 and 494 and is biased for movement away from the former and into engagement with the latter; said contacts 492 and 494 being so positioned with relation to said contact 490 that, in the course of the movement thereof, said contact 490 will break with one before making with the other.

The cam 308 is situated in the path of the free end of said contact 490 for holding same in engagement with said contact 492 when the full raised portion 308'' of said cam is situated in the path of the end of said contact 490; for holding said contact 490, against the urge of its bias, in an intermediate or non-contacting position when the semi-raised portion 308' of said cam is situated in the path of said end; and for permitting said contact to move, responsive to the urge of its bias, into engagement with contact 494 and away from contact 492 when the depressed or cut-away portion 308''' of said cam is situated in the path of said contact.

It is preferable that the gears 300, 300' shall be of such character that simultaneous and synchronous movement will be imparted to the shafts 204 and 304 and the parts carried thereby to the end that a cycle of the local controller, as determined by the rotation of the shaft 204, will coincide in all respects with a cycle of the cams 306 and 308 carried by the shaft 304.

The motor M1 has a shading coil 290' rotatable with a shaft 310 for effecting revisions of the torque applied to the disc 292, in a well known manner.

Should motor M1 be of a direct current type, as hereinbefore suggested, the shaft 310 in rotating may serve to revise the torque of the motor M1 by effecting revisions in circuit resistance in any well known manner.

A disc 322 drives the shaft 310 through beveled gears 314 and 316 and is so associated with the electromagnets M2 and M3 that the excitation of one of said electromagnets will cause said disc to rotate said shaft in one direction and the excitation of the other of said electromagnets will cause rotation of said shaft in opposite direction. For convenience in description, the electromagnet M2 and the portion of the disc 322 associated therewith will be herein referred to as "motor M2" and the electromagnet M3 and its associated portion of the disc 322 will be herein referred to as "motor M3".

From the foregoing it will be evident that energization of motor M2 will cause rotation of the coil 290' in one direction, and energization of the motor M3 will cause rotation of said coil in the opposite direction.

The permanent magnet 318 is associated with disc 292, in a manner well understood by those skilled in the art, to serve as a magnetic brake and thereby maintain a comparatively slow and uniform speed of rotation of the disc 292 and to further serve to minimize coasting by hastening deceleration when driving current has been cut off.

It will be obvious that direct current motor mechanism may be utilized in place of the al-

ternating current type motors M2 and M3 indicated in the drawing.

Relays 116, 462 and 468 are provided, such relays being remotely controlled as will be hereinafter more fully described. Relays 462 and 468 have electrically interconnected movable contacts 464 and 470, respectively; said contact 464 being for cooperation with a front contact 466 such as to close a circuit upon energization of relay 462 and said contact 470 being for cooperation with two back contacts 472 and 474 to effect closed circuit conditioning upon deenergization of relay 468. Relay 116 has a front contact 104 which is engaged by a movable contact 164 upon energization of said relay 116.

The master timer or controller T indicated in the upper portion of Fig. 1 of the drawing above the dash line *h* comprises a motor M6, of alternating or direct current type, for driving a gear 600 which, in turn, drives a gear 602 secured to a shaft 604. Cams 606 and 608 are also fixed on said shaft 604 and have cut-away portions 606' and 608' and raised portions 606'' and 608'', respectively.

A tracer contact 610 is so associated with the cam 606 and with a contact 612 that, when rotation of said cam carries its raised portion 606'' into the path of said tracer contact, said contact 610 is moved into engagement with said contact 612; and, when said raised portion 606'' is withdrawn and said cut-away portion 606' is presented, said contact 610 is moved out of engagement with said contact 612.

A tracer contact 614 is so associated with the cam 608 and with a contact 616 that, during presentation of the raised portion 608'' of said cam, said tracer contact is separated from said contact 616; and, when said raised portion 608'' is withdrawn and said cut-away portion 608' is presented, said tracer contact is moved to engage said contact 616.

Circuit connections

The electrical connections provided between the mechanisms described are as follows:

Conductors 1000 and 1002 are for conducting energy from a suitable source of electric current supply to the master timer T.

The conductor 1004 leads from conductor 1000 to one terminal of the motor M6, the remaining terminal of motor M6 being connected to conductor 1002 through conductor 1006, closed switch 1008, and adjustable resistance 1010.

The conductor 1012 leads from conductor 1002 to the contacts 612 associated with cam 606, and to the tracer contact 614 associated with cam 608. Conductors 1014 and 1016 lead from contacts 610 and 616 to bus conductors 1032 and 1034 respectively.

A third bus conductor 1030 is connected to source conductor 1000; a fourth bus conductor 1036 is connected to source conductor 1002 through a normally closed switch 1002'''; the four bus conductors 1030, 1032, 1034 and 1036 thence extending from the master timer T to and for parallel connection with the synchronizing and speed control systems and mechanisms of each of one or more local controllers. Such connection to be hereinafter described in connection with the exemplification of such a system and mechanism associated with the single local controller indicated in Fig. 1.

A further connection at the master timer includes the switch 618 which, when closed, con-

nects the conductor 1014 with the conductor 1012.

The connections at the local controller (shown in Fig. 1 below the dash line *h*) comprise the conductors 852 and 822 for conducting energy from a suitable source of supply to such local controller. Such current supply may be either the same as that to which the conductors 1000 and 1002 of the master timer are connected, or one which is independent thereof.

Conductor 838 connects one end of the winding of relay 468 with master timer bus conductor 1032, conductor 840 connects one end of the winding of relay 462 with master timer bus conductor 1034, conductor 836 connects the remaining ends of the windings of relays 468 and 462 with the master timer bus conductor 1030, a conductor 850 connects conductor 836 (and therefore bus 1030) with one end of the winding of relay 116, and a conductor 830 connects the remaining end of such winding to the master timer bus 1036.

At each local controller to be synchronized and speed controlled by master timer T, connections corresponding to conductors 838, 840, 836 and 830 should be made.

Conductor 842 connects source conductor 852 with one terminal of each of the motors M1, M2 and M3; the remaining terminals of which motors are respectively connected by conductors 850, 846 and 848 with contacts 480, 492 and 494.

Conductor 942 connects contact 466 of relay 462 with contact 490 of cam 308; conductor 944 connects contact 474 of relay 468 with contact 484 of cam 306; and conductors 896 and 792 connect contact 472 of relay 468 with contact 482 of cam 306.

A branch of conductor 792 leads to the movable contact 164 of relay 116, and a conductor 808 connects the stationary contact 104 of relay 116 with source conductor 822.

Conductor 820 connects the respective movable contacts 464 and 470 of relays 462 and 468 with source conductor 822.

Operation

Assuming that adjustments are such as to cause the master timer T and the mechanism at the local controller to operate substantially in synchronism and with parts positioned as shown in Fig. 1 of the drawing, current flow will be as follows:

From source conductor 1000, through conductor 1004, motor M6, conductor 1006, switch 1008, adjustable resistance 1010 to current source conductor 1002.

Other current paths effective from current source conductor 1000 are as follows:

From source conductor 1000 through relay 462 by way of conductors 1030, 836, relay 462, conductors 840, 1034 and 1016, contacts 616 and 614, and conductor 1012 to source conductor 1002.

From source conductor 1000 through relay 468 by way of conductors 1030, 836, relay 468, conductors 838, 1032 and 1014, contacts 610 and 612 and conductor 1012 to source conductor 1002.

From source conductor 1000 through relay 116 by way of conductors 1030, 836, 850, relay 116, conductors 830, 1036 and source conductor 1002 through switch 1002''.

Establishment of the current paths thus far described will cause the motor M6 to drive the cams 606 and 608 at a speed determined by the adjustment of the resistance 1010; the relay 116

will be energized, thus causing engagement of the contacts 164, 104; the relay 462 will be energized causing the contact 464 to engage the front contact 466; and contact 470 of relay 468 will be disengaged from its contacts 472 and 474 responsive to energization of its magnet.

From source conductor 852 a current path is provided for causing energization of the motor M1. Such path leads from conductor 852 through conductor 842, winding of motor M1, conductor 950, contacts 480 and 482, conductor 792, contacts 164, 104 and conductor 808 to source conductor 822.

The energization of motor M1 effects rotation of the shaft 294 together with the cams 306 and 308. Such rotation causes the cut-away portion 306' of the cam 306 to be presented to the tracer contact 480, whereupon the previously effective current supply path for the motor M1 is interrupted at contacts 480, 482; the contacts 480, 484 having just previously closed in preparation for the establishment of another current path for subsequent restarting and/or continued operation of said motor.

If, at the time of the interruption of such previously effective current supply path of the motor M1, the cams moving with the shaft 304 are somewhat in advance of synchronism of the master timer T, energization of relay 468 will cause its movable contact 470 to be separated from its stationary contacts 472, 474, and no other energizing current path for motor M1 will be immediately available. The motor M1 will therefore be brought to and maintained at rest until such time as another energizing current path is rendered available through deenergization of relay 468. This stage in the operation of the mechanism is sometimes referred to as "the re-synchronizing period".

Assuming that the master timer T and the shaft 304 and cams 306, 308 are in synchronism at the re-synchronizing period, as would ordinarily be the case, the cam 606 of the master timer T will, as the re-synchronizing period is about to become effective, withdraw its raised portion 606'' and present its cut-away portion 606' to the tracer contact 610, thus permitting this contact to separate from the contact 612, and thereby break the previously effective current path for energization of the relay 468.

Following such deenergization of said relay, its contact 470 moves into engagement with the contacts 472, 474. Two paths are thus made available for supplying energizing current to motor M1. Both of these paths lead from the source conductor 852 through conductor 842, motor M1, conductor 950, contacts 480, 484, conductor 944, contact 474 to movable contact 470 where the two paths branch, one leading through the movable contact 470 and conductor 820 to source conductor 822 and the other leading through the movable contact 470 to contact 472, thence through conductors 896, 792, contacts 164, 104 and conductor 808 to source conductor 822.

The purpose of these two paths in parallel will be hereinafter more fully explained in connection with the description of the operation of the mechanism without the supervision of a master timer.

When the motor M1 thus resumes rotation of the shafts 294, 304 and of the cams 306, 308, the cut-away portion 306' will be withdrawn and the raised portion of the cam 306 will be presented for engagement with the tracer contact 480; which contact 480 will therefore move into

engagement with the contact 482 and thereby close the originally described energizing current path for motor M1, which path will thereafter remain closed until the cut-away portion 306' of cam 306 is again presented to the tracer contact 480, at the next re-synchronizing period; contact 480 being moved away from contact 484 after it has engaged contact 482.

It will be observed that the contour of the cam 606 is such as to maintain the contacts 610, 612 in closed relationship throughout approximately three-quarters of each revolution of the shaft 604, upon which said cam is fixed; and that the contour of the cam 608 is such as to permit closure of the contacts 614, 616 during approximately 6% of its rotation, incidental to the latter portion of the closure of the contacts 610, 612.

During the closure of the contacts 610, 612, just referred to, a current path is effective from source conductor 1000, through conductors 1030, 836, relay 468, conductors 838, 1014, contacts 610, 612 and conductor 1012 to source conductor 1002, for energizing relay 468.

Similarly, during closure of the contacts 614, 616, a current path is effective from source conductor 1000, through conductors 1030, 836, relay 462, conductors 840, 1034, 1016, contacts 616, 614 and conductor 1012 to source conductor 1002 for energizing relay 462.

The relative times of occurrence and durations of energizations and deenergizations of the relays 462 and 468, as well as the consequences thereof under various conditions, are graphically represented in the charts of Fig. 2.

Between horizontal dashed lines 550 and 652, in the upper portion of the chart of Fig. 2, are lines 660, 660' and 662 representative of the significant results of the operation of the master timer T in establishing times of occurrence and durations of re-synchronizing and speed regulating periods; between horizontal dashed lines 652 and 654, the lines 664, 666, 668, 670 are representative of the significant results of the operation of a local controller in synchronism with the master timer T, in terms of the conditioning thereof for response to the current path revisions incidental to the operation of said timer; between horizontal dashed lines 654 and 656 the lines 664', 666', 668' and 670' correspondingly indicate results effective in a local controller operating at a speed slower than that which would maintain an intended relationship thereof with the master timer; and between horizontal dashed lines 656 and 658 the lines 664'', 666'', 668'' and 670'' correspondingly indicate results effective in a local controller operating at a speed faster than that which would maintain an intended relationship thereof with the master timer.

The space between the dashed vertical lines 620 and 620' is representative of the time of one revolution of the shaft 604 together with the cams 606 and 608 moving therewith, and hence of the intended time for a cycle of signal presentations. The vertical dashed lines 622, 624, 626, 628, 630, 632 and 634 are spaced from the line 620 at distances respectively representative of approximately 4%, 25%, 50%, 75%, 90%, 92% and 98% of the duration of a signal presentation cycle.

Returning now to a consideration of the significant results of the operation of the master timer T, and associating such results with the representations thereof in Fig. 2,—the line 660', extending from vertical line 620 to the vertical line 624, is representative of the time of occur-

rence within the cycle, and the duration, of the separation of the contacts 610, 612 due to withdrawal of the raised portion of the cam 606, together with the consequent deenergization of the relay 468, the contact 470 of which therefore moves into engagement with its contacts 472 and 474. For want of a better term, the phrase "Special Supply for Motor M1" has been applied to this line on the drawing.

The portion of the cycle during which the contact 470 is out of engagement with the contacts 472, 474 is indicated by the line 660. The line 662, extending from vertical line 632 to vertical line 634, is representative of the time of occurrence within the cycle, and the duration, of the closure of the contacts 464, 466 of the relay 462, resultant from withdrawal of the raised portion of the cam 608 from the contact 614, which thereupon engages the contact 616.

The line 666, extending from vertical line 622 to vertical line 620', is representative of the portion of the time occupied by one cycle of the operation of the master timer T, during which portion a local controller operating in synchronism with said timer will have its contact 480 held in connection with its contact 482 by the raised portion of its cam 306; the line 664, extending from vertical line 620 to vertical line 622, is representative of the portion of such cycle during which the contact 480 is permitted (by withdrawal of the raised portion of the cam 306) to engage the contact 484.

The line 668, which also extends from vertical line 620 to the vertical line 622, is representative of the portion of said cycle during which the full raised portion 308'' of the cam 308 causes the contact 490 to engage the contact 492; and the line 670 is representative of the portion of said cycle during which said contact 490 is permitted to engage the contact 494, through presentation of the depressed portion 308' of said cam 308 thereto. In the portion of such cycle represented by the space between the vertical lines 630 and 620', the contact 490 is supported by the semi-raised surface 308' in such a position that it does not engage either contact 492 or 494, and for this reason neither line 668 nor line 670 extends through this space.

Lines 664', 666', 668' and 670' are representative of lines 664, 666, 668 and 670, respectively, for a local controller which is operating at a speed insufficient to maintain it in synchronism with the master timer; and the lines 664'', 666'', 668'' and 670'' are correspondingly representative for a local controller which is operating at a speed exceeding that which would maintain it in synchronism with the master timer.

Results of relay and contact positionings just described, in view of the current paths established therebetween as hereinbefore more fully explained, may be summarized as follows:

A local controller operating in synchronism with the master timer will maintain continuous operation of its motor M1, and its motors M2 and M3 will not be energized. The continuous operation of the motor M1 will be effected for the reason that (as represented by the synchronous inception of the lines 660' and 664 in Fig. 2) upon each occurrence of the resynchronizing period, the current path through the contact 484 will be completed because the relay 468 is deenergized whenever the cut-away portion 306' of the cam 306 is presented to its contact 480, and said contact 480 has thereupon moved into engagement with said contact 484 and away

from the contact 482. Furthermore, the non-energization of the motors M2 and M3 will result from the positioning of the contact 490 (by the semi-raised portion 308' of the cam 300) out of engagement with the contacts 492 and 494, throughout the time when relay 462 is energized by closure of the master timer contacts 614, 616, resultant from presentation of the cut-away portion 608' of its associated cam 600. Such cyclic relationship is indicated by the absence of lines 608 and 670 in the portion of the cycle occupied by the line 662, and by recurrence of the lines 664 and 668 in relationship to vertical line 620' identical with that of such lines to the vertical line 620.

A local controller operating at a speed somewhat less (say not more than 20% slower) than that necessary for keeping it in synchronism with the master timer T, will maintain continuous operation of its motor M1 and its motor M2 will not be energized. However, its motor M3 will be energized during a portion of the cycle for the purpose of revising the adjustment of the shaft 310, and parts controlled thereby, in order that the speed of the motor M1 may be accelerated.

The continuous operation of the motor M1 will be effected for the reason that whenever the cut-away portion 306' of its associated cam 300 is presented to its contact 480, and said contact 480 has thereupon moved into engagement with the contact 484 and away from the contact 482, the current path through the contact 484 will be completed because the relay 468 is at such time deenergized due to the contacts 610, 612 of the master timer being separated by withdrawal of the raised portion of the cam 606. This is represented by the left-hand one of the lines 664' which, starting at vertical line 620 simultaneously with the left-hand one of the lines 660', falls entirely within the portion of the cycle occupied by the latter line; and the recurrence or right-hand one of the lines 664' starts to the right of the vertical line 620', and, although not having its inception simultaneously with that of the associated one of the lines 660', nevertheless falls entirely within that portion of the cycle which is represented by said line 660'.

The non-energization of the motor M2 results from positioning of the contact 490 away from the contact 492, throughout the energization of the relay 462 caused by closure of master timer contacts 614, 616, because the full raised portion 308'' of the cam 300 does not at that time engage said contact 490. Inasmuch, however, as the time required from the start of the cycle for the cam 300 to carry its semi-raised portion 308' into engagement with the contact 490 (as represented by line 670') exceeds the intended time (as represented by line 670) to the extent by which said line 670' projects to the right of the vertical line 620, the contact 490 is permitted to remain in connection with the contact 494 during a portion of the closure of the contacts 484, 486 of relay 462, (which portion is represented by the amount by which 670' extends to the right of line 622 and is therefore concurrent with a part of the line 662) throughout which portion the motor M3 will act through the shaft 320, the gears 316, 314 to so rotate the shaft 310 as to cause acceleration of the motor M1.

The accelerating action of motor M1 will be repeated, as just described, at the corresponding point in each succeeding cycle, until the speed of the motor M1 has been so increased as to cause

the cycle of the local controller mechanism operated thereby to catch up with its intended relationship with the cycle of the master timer. It is evident that, in bringing about this result, the speed of the motor M1 will have been so increased that, once the cycle of the local controller has overtaken its intended relationship to the master timer, the speed of the motor M1 will exceed that which would maintain such relationship. Action will therefore ensue, in a manner which will hereinafter be more fully explained, for suitably decreasing the speed of said motor M1.

The current path for energizing the motor M3, as just referred to, is as follows:

From source conductor 852 through conductor 842, motor M3, conductor 848, contacts 494, 490, conductor 942, contacts 466, 464 and conductor 820 to source conductor 822.

A local controller, operating at a speed greater than that necessary for keeping it in synchronism with the master timer T, will have the operation of its motor M1 suspended during a portion of each cycle, and its motor M3 will not be energized. However, its motor M2 will be energized during a portion of the cycle for the purpose of revising the adjustment of the shaft 310 and the parts controlled thereby, in order that the speed of the motor M1 may be retarded.

The suspension of the operation of the motor M1 will occur when the cut-away portion 306' of its associated cam 300 is presented to its contact 480, and such contact has thereupon moved into engagement with the contact 484 and away from the contact 482; because the current path through the contact 484 will then be interrupted at the relay 468, energization of which will be sustained due to the contacts 610, 612 of the master timer T remaining closed pending withdrawal of the raised portion of the cam 606.

Upon deenergization of the relay 468, energization of the motor M1 will be resumed, so that it will drive the mechanism operable thereby until a corresponding stage is attained in the next succeeding cycle. This is represented in Fig. 2 by line 664'', which is shown as starting at a point in the cycle corresponding with the termination of the line 666'' and extending to the vertical line 622'.

The portion of the line 664'' between its inception and the vertical line 620 represents that portion of the cycle of the master timer during which the motor M1 is deenergized, and that portion of said line 664'' which extends between lines 620' and 622' represents that portion of said cycle during which the motor M1 is energized through the retracted positioning of the relay contact 470, as represented by line 660'.

The non-energization of the motor M3 results from positioning of the contact 490 away from contact 494 throughout the energization of the relay 462, as represented by the line 662.

The energization of the motor M2 results from the closure of the contacts 490, 492 during a portion of the energization of the relay 462, as indicated in Fig. 2 by the distance which the line 668'' extends to the left of the vertical line 624. Throughout such energization, said motor M2 will so rotate the shaft 310 as to cause retardation of the motor M1. Such retardation will thereafter be repeated in the corresponding stage of each succeeding cycle until the speed of the motor M1 has been so decreased that the stage of the cycle of the local controller assumes its intended relationship to the cycle of the master

timer. It is evident that, in bringing about this result, the speed of the motor M1 will have been so decreased that, once the cycle of the local controller has thus attained intended relationship with the master timer, the speed of said motor M1 will be insufficient to maintain such relationship. Action will therefore ensue in a manner hereinbefore more fully described for suitably increasing the speed of motor M1.

The current path for energizing the motor M2 as just referred to is as follows:

From source conductor 852 through conductor 842, motor M2, conductor 946, contacts 492, 490, conductor 942, contacts 466, 464 and conductor 820 to source conductor 822.

Under ordinary operating conditions, the regulating actions which have just been described are not of extensive amplitude. If, however, a local controller has, by any means, gotten greatly out of step with the master timer, so that extensive rotation of the shaft 310 occurs before an approximation of synchronism is attained, a so-called "hunting" action of the speed controlling mechanism of progressively decreasing amplitude will continue until an adjustment of the shaft 310 has been attained which will cause operation of the motor M1 at a speed such that the cycle of the local controller will substantially coincide with that of the master timer.

If it is desired to lengthen or shorten the cycle time of the associated controllers, this may be done by varying the resistance 1010 at the master timer whereupon the speed of the motor M6 will be correspondingly altered, with resultant revision of the positionings of the speed regulating shading coils 290' of the motor M1 of all local controllers, in a manner hereinbefore more fully explained.

Should it be desired that the operation of the local controller be suspended, switch 618 should be moved to closed position, thus effecting continuous energization of relay 468 to cut off the normal current supply to motor M1. Furthermore, switch 1002' should be opened to permit deenergization of relay 116, thus opening the path through contacts 164, 104 to motor M1.

In practical use, it has been found desirable that all current paths for the signal lights, motors, relays, etc., which lead from each local controller to source conductor 822 shall pass through its associated contacts 164, 104. Such practice enables the deenergization of relay 116 during energization of relay 468 to effect complete suspension of all activities of the associated local controller and its synchronizing and speed control system and mechanism, and to extinguish the signal lights.

The foregoing descriptions have been, for the most part, based upon the assumption that mechanism such as that shown below the dashed line *h* in Fig. 1 is to be utilized in conjunction with a master timer such as that shown above the dashed line *h* in Fig. 1; however, controllers supervised or governed in accordance with this invention may be placed in service without providing any connection therefrom with a master timer, as when installed at an isolated intersection or location so remotely situated with reference to other intersections or points needing traffic control as to in no way require master timer supervision.

Controllers supervised or governed in accordance with this invention, as hereinbefore more fully described, will maintain efficient operation even in the event of discontinuance of a previ-

ously effective resynchronizing or other connection with a master timer. Thus, should the benefits of a master timer be dispensed with or should power failure or circuit trouble interrupt the supervision of the local controller mechanism, such mechanism would continue operating at the speed last determined by the positioning of the shading coil 290'; motor M1 being continuously energized, irrespective of the positioning of contact 480, because of continuous deenergization of relay 468 and resultant engagement of its movable contact 470 with the stationary contacts 472 and 474. In such an event, if all of the current paths for the signal lamps, motors and relays of the local controller pass through conductors 164, 104, (as hereinbefore indicated as desirable) current flow for such motors, lamps and relays from source conductor 822 will pass uninterruptedly from such conductor 822 through conductor 820, contacts 470 and 472, conductors 896 and 792 to contact 164 at which point the path branches to lead through the various motors, lamps, relays and controlling circuits to the source conductor 852.

It will be evident from the foregoing that this invention might have been illustrated in the accompanying drawing as embodied in any one of many different kinds of mechanism. That which has been selected for use as illustrative of the invention has been chosen as a matter of convenience, and not because it exhausts the scope of the invention in its application to the various uses for which it is suited. Furthermore, it should be remembered that various features of this invention may be advantageously utilized singly or in groups containing less than all of said features.

The explanations hereinbefore given as to illustrative applications of this invention to certain of the many possible uses thereof, when considered in connection with the accompanying drawing, are believed to be fully sufficient to enable those skilled in this art to readily apply this invention to all situations to which it is suited.

Claim is made to, and it is desired to secure by Letters Patent of the United States of America, all generic and specific features of the invention shown by the accompanying drawing and as hereinbefore more fully described, including all features which may, as a matter of language, be said to fall between the scope of any of the following claims.

We claim:

1. In a synchronizing and speed control system, means for periodically formulating impulses in respective ones of two channels, controlled mechanism having a predetermined cycle of operation and including a variable speed driving motor, means associated with one of said channels and rendered effective during each cycle of said mechanism for synchronizing said mechanism responsive to impulses of said formulating means in said one of said channels, means associated with and rendered responsive to impulses in the other of said channels at predetermined stages in each said cycle for increasing or decreasing the speed of the driving motor resultant from premature or tardy time of attainment of such stages in the operating cycle of said mechanism with respect to the time of occurrence of impulses in said other channel whereby the speed of said motor will be governed for substantially maintaining predetermined relationship between formulation of impulses and cycles of controlled mechanism operation.

2. In a synchronizing and speed control system, 75

means for periodically formulating impulses in respective ones of two channels, controlled mechanism having a predetermined cycle of operation and including a variable speed driving motor, means associated with one of said channels and effective during each cycle of said mechanism for synchronizing said mechanism responsive to impulses of said formulating means in said one of said channels, means associated with and responsive to impulses in the other of said channels for increasing or decreasing the speed of the driving motor resultant from premature or tardy time of attainment of predetermined stages in the operating cycle of said mechanism with respect to the time of occurrence of impulses in said other channel whereby the speed of said motor will be governed for substantially maintaining predetermined relationship between formulation of impulses and cycles of controlled mechanism operation.

3. In a synchronizing and speed control system, means for periodically formulating impulses, controlled mechanism having a predetermined cycle of operation and including a variable speed driving motor, means effective during each cycle of said mechanism for stopping said variable speed driving motor, means responsive to said impulses for rendering said stopping means ineffective when said driving motor is substantially in step with said periodic impulses, means responsive to said impulses for increasing or decreasing the speed of said driving motor resultant from premature or tardy time of attainment of predetermined stages in the operating cycle of said mechanism with respect to the time of occurrence of said impulses whereby the speed of said motor will be governed for substantially maintaining predetermined relationship between formulation of impulses and cycles of controlled mechanism operation.

4. In a synchronizing and speed control system, means for periodically formulating impulses in respective ones of two channels, controlled mechanism including a variable speed driving motor, means associated with one of said channels and rendered effective incidental to operation of said mechanism for synchronizing said mechanism responsive to impulses of said formulating means in said one of said channels, means associated with and rendered responsive to impulses in the other of said channels at predetermined stages in the operation of said mechanism for increasing or decreasing the speed of said driving motor resultant from premature or tardy time of attainment of such stages with respect to the time of occurrence of impulses in said other channel whereby the speed of said motor will be governed for substantially maintaining predetermined relationship between formulation of impulses and attainment of such stages of controlled mechanism operation.

5. In a synchronizing and speed control system, a master timer comprising a constant speed driving motor, a shaft driven by said motor, cams secured to said shaft, contacts associated with said cams and periodically actuated thereby, a re-

synchronizing channel periodically energized and deenergized responsive to contacts associated with one of said cams, and a speed control channel periodically energized and deenergized responsive to contacts associated with another one of said cams; a controlled mechanism comprising a variable speed motor, a shaft driven by said mechanism motor, cams secured to said mechanism shaft, contacts associated with said mechanism cams and periodically actuated thereby, means associating said re-synchronizing channel with the contacts associated with one of said mechanism cams for rendering said re-synchronizing channel effective to synchronize said mechanism during a concurrent predetermined conditioning of said re-synchronizing channel and of the contacts associated with said one of said mechanism cams, means associating said speed control channel with the contacts associated with another of said mechanism cams for rendering said speed control channel effectively associated for causing alteration of the speed of said variable speed motor during a concurrent predetermined conditioning of said speed control channel and of the contacts associated with said other one of said mechanism cams and means responsive to said effective association therewith of said speed control channel for altering the speed of said variable speed motor.

6. In a synchronizing and speed control system, means for periodically formulating impulses, a controlled mechanism having a cycle of operation of predetermined length and including a variable speed driving motor, means effective during each cycle of said mechanism for synchronizing the cycles of said mechanism responsive to said formulating means impulses, means mechanically connected with said driving motor and responsive to said impulses for exerting a force to cause increase or decrease in the speed of said driving motor resultant from premature or tardy time of attainment of predetermined stages in the operating cycle of said mechanism with respect to the time of occurrence of said impulses whereby the speed of said motor will be governed for substantially maintaining predetermined relationship between formulation of impulses in the cycles of controlled mechanism operation.

7. In a synchronizing and speed control system, the combination of periodic impulse formulating means, means for controlling the speed of the periodic impulses, controlled means including a driving motor having a shading coil movable for effecting adjustments in the speed thereof, a second motor for moving said shading coil in one direction or the other, means jointly responsive to impulses of said formulating means and to said controlled means for causing said second motor to move said shading coil in one direction or the other, and means responsive to lack of synchronization between the impulse formulating means and the controlled means for deenergizing the shading coil.

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